Survival Analysis of the Effect of Season at Calving, Lactation Number and Breeding on Days Open in Dairy Cattle

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ABSTRAK

TAUFIK, E. dan W. SURIYASATAPHORN. 2008. Analisis survival dari pengaruh musim saat melahirkan, jumlah laktasi dan pemuliaan terhadap masa kosong pada sapi perah di Propinsi Khon Khaen, Thailand. *JITV* 13(3): 214-220.

Tujuan dari kajian ini adalah untuk mengevaluasi pengaruh musim saat melahirkan, jumlah laktasi dan pemuliaan terhadap masa kosong (jeda waktu antara melahirkan anak dengan bunting kembali) pada sapi perah dengan menggunakan model Cox proportional hazards sebagai metode analisis survival. Data contoh diambil dari 143 ekor sapi perah betina dewasa dari 6 peternakan yang berlokasi di Propinsi Khon Khaen, arah Timur Laut Thailand. Data tersebut kemudian diklasifikasikan sebagai identitas peternakan (FID), identitas sapi perah betina dewasa (CID), tanggal beranak (CDA), tanggal terakhir pengambilan data kondisi sapi (LAF), persentase Holstein-Friesian dalam pemuliaan (PHF), jumlah laktasi (LAN) dan kebuntingan (1 = bunting, 0=tidak bunting). Masa kosong merupakan selisih antara LAF dengan CDA dan CDA telah digunakan untuk menentukan musim saat melahirkan. Hasil kajian menunjukkan bahwa berdasarkan Kaplan-Meier survivorship percentiles, nilai median masa kosong untuk seluruh sapi perah yang dikaji adalah 210 hari, sedangkan untuk sapi perah yang beranak di musim panas dan selain musim panas masing-masing adalah 231 dan 210 hari. Adapun nilai median masa kosong untuk sapi perah yang beranak pada laktasi pertama dan pada laktasi kedua atau lebih masing-masing adalah 226 dan 207 hari. Nilai median masa kosong untuk sapi perah dengan persentase darah Holstein-Friesian hasil pemuliaan $\leq$75% adalah 211 hari dan 206 hari untuk sapi dengan persentase Holstein-Friesian >75%. Hasil regresi dengan menggunakan Cox proportional-hazard terhadap data masa kosong sapi perah asal Khon Khaen menunjukkan bahwa sapi perah yang beranak di musim hujan dan musim dingin memiliki peluang masing-masing 1,28 dan 1,76 kali lebih besar untuk bunting dibanding sapi perah yang beranak di musim panas, walaupun perbedaannya tidak signifikan. Sementara itu, sapi perah yang telah mengalami masa laktasi dua kali atau lebih memiliki peluang 1,54 kali lebih besar untuk bunting dibandingkan dengan sapi perah yang baru satu kali laktasi, hanya saja peluang ini tidak signifikan secara statistik (P = 0,1725). Adapun sapi perah dengan persentase darah Holstein Friesian >75% memiliki peluang yang nyata 1,17 kali lebih besar untuk bunting dibandingkan dengan sapi perah yang memiliki persentase darah Holstein Friesian $\leq$75%.

Kata Kunci: Analisis Survival, Model Cox Proportional Hazard, Sapi Perah, Masa Kosong

ABSTRACT

TAUFIK, E. and W. SURIYASATAPHORN. 2008. Survival analysis of the effect of season at calving, lactation number and breeding on days open in dairy cattle at Khon Khaen Province, Thailand. *JITV* 13(3): 214-220.

The objective of this study was to evaluate the effect of season on calving, lactation number and breeding on days open (interval between calving and conception) in dairy cattle by using Cox proportional hazards model as a survival analysis method. The data were sampled from 143 cows at 6 farms located in Khon Kaen Province, North-Eastern Thailand and classified as farm identification (FID), cow identification (CID), calving date (CDA), date at last follow up (LAF), percentage of Holstein-Friesian (PHF), lactation number (LAN) and conception (1 = concieve, 0 = not concieve). Time of days open was calculated by subtracting LAF by CDA and CDA was used to determine season of calving. The result showed that based on Kaplan-Meier survivorship percentiles, overall median days open of cattle were at 210, whereas median days open for the cow calved in summer was 231 and 204 for the cow calved in other season. Median days open for the cow calved with one lactation was 226 and 207 for the cow with two lactation and more. Median days open for the cow with percentage of Holstein-Friesian $\leq$75% was 211 and 206 for the cow with percentage of Holstein-Friesian >75%. The result from Cox proportional-hazard regression of days open for Khon Khaen dairy cows showed that cows that calved in rainy and winter had a greater chance of 1.28 times and 1.76 times, respectively, of becoming pregnant than those calved in summer, although the difference was insignificant and cows with lactation number two or more were marginally had 1.54 times chance to get pregnant compare to cows with one lactation number, even though this chance was not statistically significant (P = 0.1725), whereas cows with percentage of Holstein Friesian >75% had significantly greater chance 1.17 times more to get pregnant compare to those with percentage of Holstein Friesian $\leq$75%.

Key Words: Survival Analysis, Cox Proportional Hazard Model, Dairy Cow, Days Open

INTRODUCTION

The most common reason for culling in dairy herds is caused by poor reproductive performance (DURR, 1997; PRYCE *et al.*, 1997; SWEDISH DAIRY ASSOCIATION, 2002). Low fertility, lower production per day, higher insemination costs and higher replacement costs due to increased culling are the main variable costs related to low fertility. Cow with good fertility is characterized by short period time of days open, has a high probability of becoming pregnant when inseminated at the correct time, shows strong signs of estrus, and has the ability to carry the resulting fetus to term. Among the potential measures that can be used to describe these complex traits is days open or interval between calving and last insemination (CLI). The trait CLI is a measure that is a combination of return to cyclicity, the expression of estrus, and the ability to conceive (conception rate). If insemination dates are available, CLI can be used in breeding programs, which is the case in some countries (MARK *et al.*, 2001; SCHNEIDER *et al.*, 2005).

Survival analysis is an alternative method for analyzing reproductive traits recorded as time intervals (ALLORE *et al.*, 2001). Survival analysis or Cox proportional hazard model is a statistical method for studying the occurrence and timing of events, where the outcome variable corresponds to a measure of time elapsed from a starting point until the occurrence of a certain event (SCHNEIDER *et al.*, 2005). The length of this interval is not always known, because competing events may occur before the occurrence of the event under study. One of the main advantages of survival analysis is that it could retain the information from cows that are culled before conception or not pregnant by the time the data recording was completed. Thus, records from pregnant (uncensored) and non-pregnant (censored) cows can be treated jointly and included in the analysis, making proper use of all the available information. Within the field of fertility in dairy cattle, survival analysis has been applied to study: 1) the effects of diseases on days to conception (LEE *et al.*, 1989; HARMAN *et al.*, 1996b), 2) the relationship between body condition scoring (BCS) and postpartum reproductive efficiency (SURIYASATHAPORN *et al.*, 1998), and 3) the effect of early lactation milk yield on days open (HARMAN *et al.*, 1996a). 4) The effects of calving season and milk yield on pregnancy risk and income (FARIN *et al.*, 1994).

Terminology using in most studies on survival analysis are survival time, failed case, censored case, hazard's function, hazard ratio, life table, Kaplan-Meier curve, and Cox's proportional hazard model (SURIYASATHAPORN, 2006). At the beginning, survival analysis is involved an event of death. Nowadays, survival analysis can be used for any event. Therefore,

time-event analysis or Cox's proportional-hazards models are used instead of survival analysis in some studies (SURIYASATHAPORN *et al.*, 1998).

The aim of Cox's proportional hazard model is to assess hazard ratio, HR (analogous to risk ratio or relative risk), that uses to estimate the ratio of the rates of intended event (in this study was pregnancy) at the particular value compared with both rates at a reference value, respectively. That is to say, if the pregnancy risk at a particular value was >1, it meant that the pregnancy rate of the particular value was higher than the pregnancy rate of the reference value (SURIYASATHAPORN, 2006).

According to LEE (1984), in general survivor function is very useful to explore the data and become familiar with it. However, it is becomes a bit limited when survival depends upon many covariates. To solve this problem, the hazard function was used. Hazard function (instantaneous hazard, force of mortality) denoted by λ (t), is the risk that an event will occur during a very short time interval (s (t)) at time t, given the subject did not have an event before that time. The very popular regression in survival analysis using hazard function is Cox's proportional hazard model. Proportional hazards regression is computed using the ranks of the survival times. While it is useful for studying the relationships among the covariates, it can't be used to build prediction equations.

Therefore, the goal of the analysis is to assess the HR. For categorical variable, HR is the ratio of hazard of the particular value and a reference value or the so-called baseline hazard. The assessed HR (analogous to risk ratio or relative risk), is used to estimate the ratio of the rates of event of interest at the particular value compared with the rate at a reference value.

The main objective of this study was to evaluate the effect of season at calving, lactation number and breeding on days open (interval between calving and conception) in dairy cattle from dairy farm at Khon Khaen Province, Thailand by using Cox proportional-hazard regression. In juncture, this study was also aimed to show that this type of survival analysis can be used to analyze the interaction between farm animal characteristics and their environment which is involving time and occurrence of the event of interest.

MATERIALS AND METHODS

Data collection

Data were collected from 143 cows at 6 farms located in Khon Kaen Province, north-eastern Thailand. Farm identification (FID), cow identification (CID), calving date (CDA), date at last follow up (LAF), percentage of Holstein-Friesian (PHF), lactation number (LAN) and event of interest (1 = conception, 0

= not conception) (event) were recorded by MS-EXCEL.

Outcome and explanatory variables

The outcome variable (dependent factor) in this study was survival time of days open which is the interval between the calving date (CDA) and date at last follow up (LAF). The censoring variable defined by SURIYASATAPHORN *et al.* (1998) that cow did not conceive within 184 days postpartum but still present at that point in time was used to classify event of interest (event 1 = conception, 0 = not conception). Whereas the explanatory variables (independent factors) were season at calving (summer, rainy and winter) which was determined from CDA, lactation number (Par1 and Par2) and percentage of Holstein Friesian breed in the animal (per_HF1 ($\leq$75%) and per_HF2 (> 75%)).

Statistical analysis

Cox proportional hazards models were used to examine effects of calving season, lactation number and percentage of Holstein Friesian breed in the animal on days open (the outcome variable). Following addition and deletion of individual variables in the model, the maximum likelihood ratio statistic was examined for shifts in magnitude. The final model included the main effects of lactation number, calving season, and percentage of Holstein Friesian breed.

The other survival function calls corresponding estimate of the survivor function S(t). This method is very similar to the life table estimator apart from number at risk. This is the Kaplan-Meier estimate of the survivor function which is presented in the Kaplan-Maier curve. The Kaplan-Maier curve depicted the association between survivorship S (t) and survival time (in this study case, time = days open and event = pregnancy). From this function and curve, the median of days open for overall sample as well as for each grouping of explanatory variable was determined.

In the analysis, independent variables were treated as categorical variables rather than continuous. Lactation number (LAN) data were categorized into one lactation (par1=1 as baseline) and else (two lactation or more; par2=0), calving seasons were divided into summer (as baseline), rainy and winter. In northern Thailand, summer is between March to May (temperature: 20-38^{0}C); rainy is between June to October (temperature: 22-34^{0}C) and winter is between November to February (temperature: 11-33^{0}C). Breed of Holstein-Friesian was categorized into per_HF1 ($\leq$75%) and per_HF2 (> 75%). The P value from Log Likelihood Chi-square of overall model will be used to assess the differences between categories in one independent variable.

The Cox proportional-hazards model was used to examine the effects of baseline and follow-up variables on the outcome variables. The goal of the analysis was to assess the hazard ratio (HR) of the particular value compared with a reference value (HR1). The assessed HR (analogous to risk ratio or relative risk in epidemiology; LEE, 1984), was used to estimate the ratio of the rates of pregnancy at the particular value compared with rates at a reference value. That is to say, if the pregnancy risk at a particular value was >1, it means that the pregnancy rate of the particular value was higher than the pregnancy rate of the reference value. Statistical software package of *Statistix 8®* was used for the statistical analysis.

## RESULTS AND DISCUSSION

Kaplan-Maier Curve

The Kaplan-Maier curve for overall survival time and event from this study result is shown in Figure 1. Based on Kaplan-Meier survivorship percentiles, in overall, median days open of dairy cattle was at 210. This median of days open was higher compared to the mean of days open of dairy cattle in the northern part of Thailand which was 131 days as reported by PUNYAPORNWITHAYA and TEEPATIMAKORN (2004). But it was relatively similar to the report by SONDIPHIPOJ *et al.* (1999) that the mean of days open of pure breed Holstein Friesian imported from Canada to Thailand at Chiang Mai Livestock Research Center was 201 days.

Based on Kaplan-Meier survivor-ship percentiles, median days open for the cow calved in summer was 231 and 204 for the cow calved in other season (Figure 2). There was no significant difference between groups (summer and else) since two samples survival test by Cox-Mantel test resulted P = 0.2621.

Median days open for the cow calved with one lactation was 226 and 207 for the cow with two lactation and more (Figure 3). Based on two samples survival test by Cox-Mantel test, P=0.60581, it means there was no significant difference between groups of cow with one lactation and more.

Median days open for the cow with percentage of Holstein-Friesian $\leq$75% was 211 and 206 for the cow with percentage of Holstein-Friesian >75% (Figure 4).

The P-value from two samples survival test by Cox-Mantel test was P=0.6243, it meant there was no significant difference between groups of cow with percentage of Holstein-Friesian $\leq$75% and with percentage of Holstein-Friesian >75%.
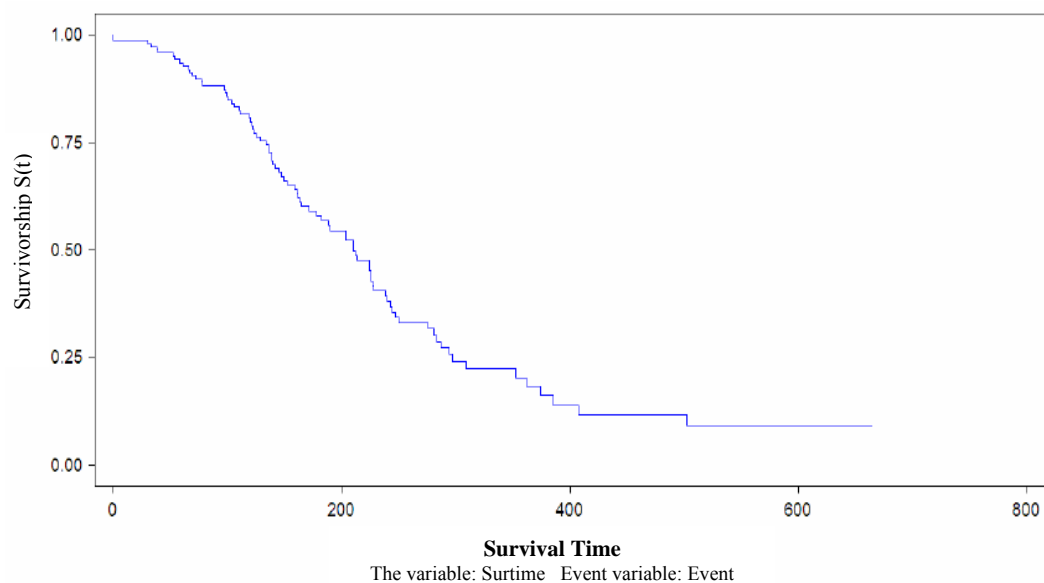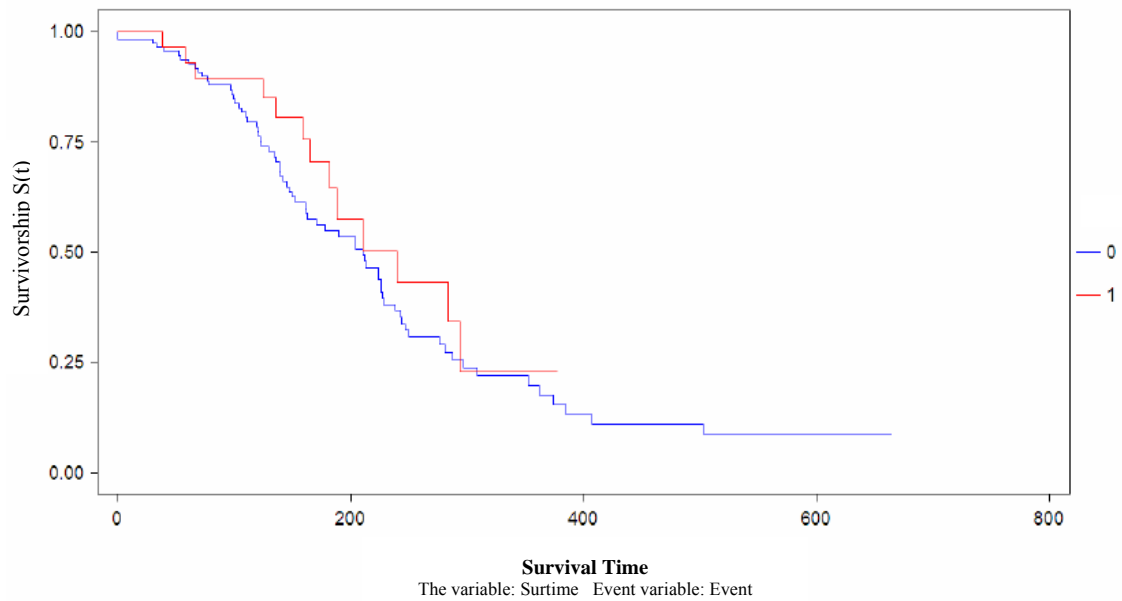
Figure 1. The Kaplan-Maier curve for survival time (day) and event for overall model
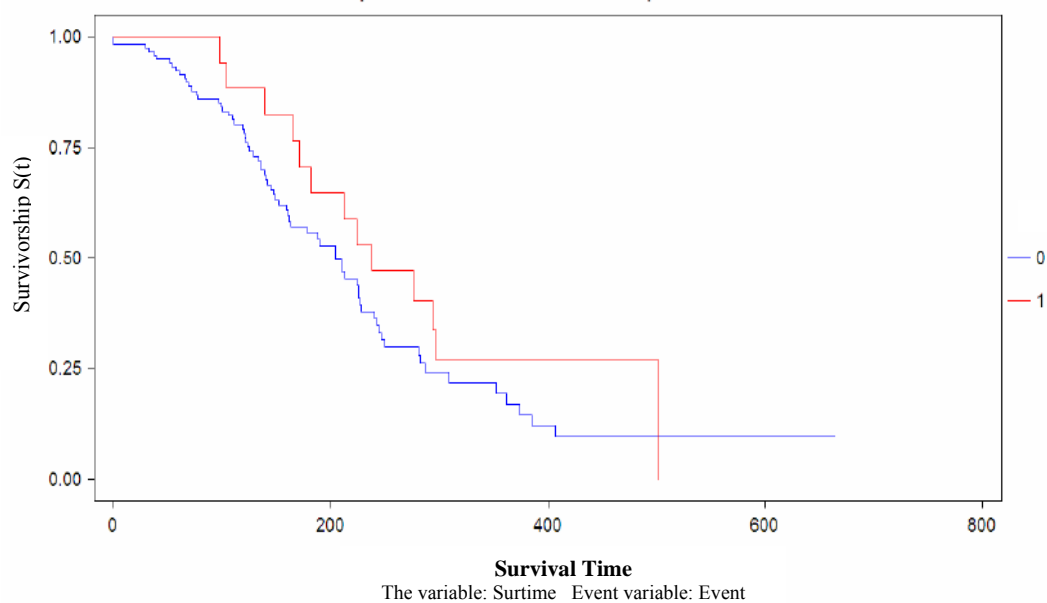
Figure 2. The Kaplan-Maier curve of survival time (day) and event for season {1 = summer as baseline, 0 = else (winter and rainy)}
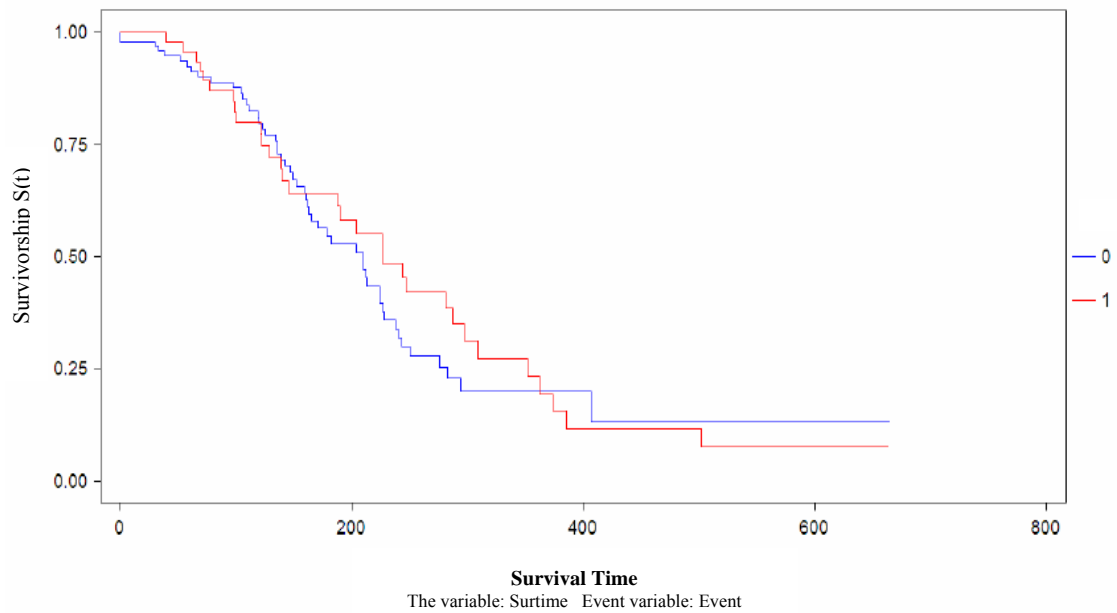
Figure 3. The Kaplan-Maier curve of survival time (day) and event for lactation number {1 = lactation 1 as baseline, 0 = else (lactation 2 and above)}

Figure 4. The Kaplan-Maier curve of survival time (day) and event for percentage of Holstein-Friesian of cow (1 = ≤75% as baseline, 0 = else >75%)

Table 1. Cox proportional hazards model of days open for Khon Khaen dairy cows

Variable	β	SE β	P	Hazards Ratio
Season at calving				
Summer	-0.01077	0.43537	0.9803	0.99
Rainy	0.24709	0.38000	0.5155	1.28
Winter	0.56794	0.38337	0.1385	1.76
Lactation number				
Par1	-0.02656	0.24399	0.9133	0.97
Par2	0.43231	0.31686	0.1725	1.54
Percentage of Holstein-Friesian				
Per_HF1 (<=75%)	-0.13132	0.000001	0.0000	0.88
Per_HF2 (>75%)	0.15468	0.000001	0.0000	1.17

Season at calving

The result of log likelihood Chi-square of overall model was showed P value = 0.2443, meaning that there was no difference between season. Compared to cows that calved in summer, cows that calved in rainy and winter season were marginally more likely to become pregnant. Cows that calved in rainy and winter had a greater chance of 1.28 times and 1.76 times of becoming pregnant than those that calved in summer, although the difference was not significant. Despite of statistical insignificancy, the research finding was consistent with report by FARIN *et al.* (1994) that cows calving in summer were less likely to become pregnant than cows that calved during the cooler months. This was due to adverse effect of temperature on reproduction performance of dairy cattle. JORDAN (2003) supported this biological phenomenon; he stated that when dairy cattle are subjected to heat stress, reproductive efficiency declines. Cows under heat stress have reduced duration and intensity of estrus, altered follicular development, and impaired embryonic development.

Lactation number

P value from log likelihood Chi-square overall model was more than 0.05 (P = 0.3687), therefore there was no significant difference between lactation numbers. Cows with lactation number 2 or more were marginally had 1.54 times chance to get pregnant compare to cows with one lactation number, even though this chance was not statistically significant (P=0.1725). This result was different with finding

reported by PUNYAPORNWITHAYA and TEEPATIMAKORN (2004) that there was a significant difference between first lactation cows compare to second-third and more than third lactation cows on days open of cows in northern part of Thailand. The difference of statistical significance test result of the data from this study was likely to be associated with the difference of sample size, PUNYAPORNWITHAYA and TEEPATIMAKORN (2004) evaluated the data from 6,125 heads of cow.

But there was similarity of this study finding with the study result reported by PUNYAPORNWITHAYA and TEEPATIMAKORN (2004) that stated cows with more than one lactation had more chance to get pregnant with shorter time of days open than those with only one lactation. On the other hand this finding was in agreement with the result reported by FARIN *et al.* (1994) that there was no significant difference between lactation numbers on days open in North Carolina (USA) Holstein cows.

Percentage of Holstein Friesian (Breeding)

The result of log likelihood Chi-square of overall model gave P value = 0.6243, therefore no difference between percentage of Holstein Friesian breed composition grouping (≤75% and >75%) of cows. There was significant difference between group (P = <0.05), meaning the cows with percentage of Holstein Friesian more than 75% had greater chance 1.17 times more to get pregnant compare to those with percentage of Holstein Friesian less than 75%. It can be said that Holstein Friesian breed is significantly better (P=0.000) in reproductive performance than any other dairy cattle breeds.

CONCLUSIONS

The Kaplan-Meier survivorship percentiles data showed that in overall, median days open of dairy cattle in Khon Kaen Province of northern Thailand was 210 days. Median days open of non baseline variables in the grouping variables were less than baseline variables.

Grouping of independent variables did not give significant difference effect on outcome variables. Cows that calved in rainy and winter had a greater chance of 1.28 times and 1.76 times of becoming pregnant than those that calved in summer, although the difference was not significant. Cows with lactation number 2 or more were marginally had 1.54 times chance to get pregnant compare to cows with one lactation number, even though this chance was not statistically significant. Whereas the cows with percentage of Holstein Friesian more than 75% had significantly (P<0.05) greater chance 1.17 times more to get pregnant compare to those with percentage of Holstein Friesian less than 75%. It was also proved that survival analysis of Cox proportional hazards model can be applied as a tool of analysis to assess interaction between farm's environment and characteristics of animal.

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