Odds Ratio and Probability of Conception of Holstein Friesian Dairy Cows in the Kingdom of Saudi Arabia

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ABSTRACT : Logistic Regression Analysis was used to compute the odds ratio (OR) and probability of conception of Holstein dairy cows of AL-MARAIE company. Data consisted of 103,778 reproductive records collected from three farms in the central region in the Kingdom of Saudi Arabia. Records were classified according to lactation number, season of calving and milk level. At first lactation, OR of first service was 0.63 of other services and probability of pregnancy from first services was 0.39. Odds ratio increased to 1.72 at fourth lactation or probability of conception reached 0.63. The probability of conception increased from 0.39 for cows inseminated at first services to 0.75 at fifth service insemination. Odds ratio of cows calving in winter were higher than those calving in summer. Odds ratio of conception of low producing cows is about twice as likely to occur from first service as from other services. However, OR of conception of high producing cows was higher than one (probability=0.56) from first service and increased to 1.63 (probability=0.65) from third service. Odds ratio was in favor of the right uterus horn where probability of conception from first service was slightly greater than 50% in first and second lactations and less than 50% in favor of left horn in later lactations. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 3 : 308-313)***

Key Words : Conception, Odd Ratio, Holstein Cattle, Logistic Regression

INTRODUCTION

Reproductive efficiency of a dairy cow is a complex trait that has a dramatic impact on the herd profitability. Conception is one of the most important aspects that affect reproductive efficiency. High conception rate from first service is a desirable goal in the breeding program of dairy cattle. Nevertheless, conception from subsequent services is a management routine that always practiced in dairy herds to achieve more pregnancies and calvings.

Butler and Smith (1989) reported a decline in conception rate of first service from 66% in 1950 to an average 50% in 1973. However, second service conception declined from 56% to 48%. That decline was explained by the inverse relationship of conception rate to milk yield.

Nebel and McGilliard (1992) reported first service conception rates of 57%, 38% and 17% for milk levels <7,250, 7,250-9,750 and >9,750 liters, respectively. The difference Between high and low producing cows in conception rate from first service was slightly less than twice that reported By Spadling et al. (1975) for the highest versus lowest yielding cows (39% vs. 20.5%).

Higher milk yield was associated with lower conception rate, suggesting that metabolic demands of higher yield reduced fertility of high producing cows. Olds et al. (1979) reported similar reduction in reproductive performance with increasing total yield to 120 d of lactation. However, other investigators (Everett et al., 1966; Hansen et al., 1983) found no relationship between peak yield production and fertility. Although influenced by many factors, conception rate or number of breeding is more inherently associated with physiological function and is a more desirable indicator of reproductive function, specifically cows yielding more milk had lower conception rate as reported by Faust et al. (1989), Hillers et al. (1984) and spadling et al. (1975).

Limited information is available about conception in uterine horns in dairy cows. EchtenKamp (2002) found that between 55 and 60% of ovulation occurred from the right ovary and consequently slightly more pregnancies should occur in the right horn. Furthermore, the migration of Bovine embryos between uterine horns is very rare. Hafez (2000) reported that follicles ovulate on the right ovary about 60% of the time and on the left ovary about 40% of the time. Ovulation occurs more frequently from the ovary opposite to the uterine horn that previously carried fetus. French (2002) found similar results and stated that any deviation from 60 to 40% pregnancy at right and left horns would mean more missing in the breeding target. It is note worthy to mention that in camelids (camels, alpaca and lama, vicuna and guanacos) the ovulation rate from each ovary is 50:50 yet, 95% of all pregnancies are in the left horn. Moreover, embryos placed into the right horn subsequently migrate to the left as reported by (Fernades-Baca et al., 1970; Skidmore et al., 1996).

The objective of this study is two-fold :

i) Using logistic regression analysis to evaluate pregnancy from:

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Received January 29, 2004; Accepted October 4, 2004

- First service and subsequent services.
- Right horn and left horn.

ii) Using maximum likelihood analysis of variance to examine the effect of farm, lactation number, season of calving and milk level on pregnancy occurrence.

MATERIALS AND METHODS

Two data files were collected from three dairy farms of AL-MARAIE company in the central region of the Kingdom of Saudi Arabia. The data were collected during the period from 1991 to 1999. The first file consisted of 103,776 records included information such as farm name, animal identification number, lactation number, reproductive traits like pregnancy code, horn of pregnancy (right or left), service number and calving date. The second file included 17,966 records each with farm name, animal identification, lactation number and production traits like actual milk production.

Files were sorted and merged by lactation within cow number within farm number. Cows were grouped according to calving date into two seasons winter (S1) for cows calved from October to March and summer (S2) for cows calved from April to September, Milk records were divided into two milk production levels: level one (ML1) for cows with production ≤ 9,500 liters, and level two (ML2), for cows with milk production >9,500 liters.

Data were edited such that analysis included records of age at first calving ≥24 month. Lactation that began with an abortion or in which milking was interrupted by injury or sickness was discarded. Reproduction traits were coded as binary traits, for example: first service conception was coded 1 if the cow conceived on first service and 0 otherwise; services 6 to 10 were considered as the fifth service.

Statistical analysis

The Logistic regression model was used to examine the relationship between one or more independent variable (1st service versus other services) and the log odds of the binary outcome variable (pregnancy and non-pregnancy). The specific form of the logistic regression model as described by Hosmer and Lemeshow (2000) is:

$$\prod(x) = \frac{e^{B_0+B_1x}}{1+e^{B_0+B_1x}}$$

With logit transformation.

$$g(x) = \mathrm{Ln}\left(\frac{\prod(x)}{1-\prod(x)}\right) = B_0+B_1x$$

Thus g (x) is linear in its parameters,
with a dichotomous variable $y/x = \prod(x)+\varepsilon$
if $y = 1$ then $\varepsilon = 1-\prod(x)$ with probability $\prod(x)$,
if $y = 0$ then $\varepsilon = .-\prod(x)$ with probability $1-\prod(x)$,
so $\prod(x).\sim\mathrm{Bin}\ [0, \prod(x)\times 1-\prod(x)]$

And the Odd Ratio (OR) is the rate of the odds for x=1 to the odds for x=0.

Thus, the odds of the outcome being present among cows with x=1 is defined as

$\prod(1)/[1-\prod(1)]$, similarly, the odds of the outcome being present among cows with x=0 is defined as $\prod(0)/[1-\prod(0)]$. Then the odd ratio, is defined as

$$OR = \frac{\prod(1)1/[1-\prod(1)]}{\prod(0)/[1-\prod(0)]}$$

while $$\prod(1) = \frac{e^{B0+B1}}{1+e^{B0+B1}}$$

and $$\prod(0) = \frac{e^{B0}}{1+e^{B0}}$$

Then OR will be simplified as e^{B1}
And the probability of a certain event $\prod(x)$

Pregnancy from 1st service = 1/1+OR (pregnancy)

First service conception rate was coded 1 if the cow conceived on first service and 0 otherwise.

The pair of observations (Xi, Yi) i=1,……, n are independent where Yi denotes the value of a dichotomous outcome variable and Xi is the value of the independent variable for ith cow. Furthermore, we assume that the outcome has been coded as 1 (if cow conceived) or 0 otherwise.

The likehood function is obtained as the product of n terms of the like hood function of pair (Xi, Yi) is as follows:

$\prod(Xi)^{yi}[1-\prod(Xi)]^{1-yi}$ then
$l(B) = \prod^{n}_{i=1}\prod(Xi)^{yi}[1-\prod(Xi)]^{1-yi}$

And the log likelihood, which is easier mathematically to work with, is defined as

$$L(B) = \ln[l(B)] = \Sigma^{n}_{i=1}\{y_i \ln[\prod(Xi)]+(1-Y_i)\ln[1-\prod(Xi)]\}$$

To find B=(Bo, B1) that maximizing L (B) we differentiate L (B) with respect to Bo and B1 and set the resulting express on equal to zero. So the likehood equation are:

Table 1. Odd Ratio of pregnancy from service number (A/O) and type of uterine horn (R/L) by lactation number, milk level and season of calving

Lactation no./ SN	A1		A2		A3		A4		A5	
	A1/O1	R/L	A2/O2	R/L	A3/O3	R/L	A3/O3	R/L	A5/O5	R/L
L1	0.633	1.024	1.233	0.952	1.473	0.967	1.681	1.010	2.945	0.723
L2	1.232	1.014	1.272	1.009	1.093	1.018	0.939	1.032	0.801	1.066
L3	1.506	0.989	1.466	0.981	1.183	0.961	0.972	1.017	0.834	1.107
L4	1.720	0.885	1.735	0.881	1.552	0.871	1.331	0.890	1.144	0.894
L5	1.495	0.913	1.501	0.895	1.384	0.792	1.212	0.686	1.039	0.501
S_1	1.321	0.993	1.604	0.981	1.462	0.977	1.213	1.006	0.937	1.056
S_2	0.914	0.975	0.982	0.943	0.887	0.909	0.817	0.917	0.768	0.905
My1	1.904	1.019	2.756	1.100	3.569	1.063	6.242	1.116	22.321	1.021
My2	1.283	1.034	1.614	1.021	1.627	0.964	1.475	0.848	1.298	0.898

A1, A2,……,A5= services 1,2,……,5; L1, L2….., L5 = Lactation 1, …… , 5.
O1 = Number of pregnancy from A2,…..A5. O2= Number of pregnancy from A3,…..A5.
O3 = Number of pregnancy from A4, A5. O4=Number of pregnancy from A5.
S_1 = cows calved in winter season. S_2=cows calved in summer season.
My1 = milk yield<9,500 liter. My2=milk yield>9,500 liter.
R = pregnancy in right horn. L=pregnancy in left horn.

$$\sum [Yi-\prod (Xi)] = 0$$

and $$\sum xi [Yi - \prod (Xi)] = 0$$

Where the summation is one i varying from 1 to n.

The solution of likelihood equation is called the maximum likelihood estimate and can be obtained using an iterative weighted least squares procedures as described by McCullagh and Nelder (1989). Available nonlinear-logistic regression software in SAS package was used to estimate Bo, Bi and the odd ratio.

RESULTS AND DISCUSSION

Table 1 shows the odd ratio (OR), which is the probability of pregnancy divided by the probability of non-pregnancy. In other words, the odd ratio of conception from first service (a predictor) tells the relative amount by which the odds of pregnancy greater than 1.00 or less than 1.00 when the value of predictor (first service increased by one unit).

At first lactation, OR for first service was 0.63 of other services, i.e conception from 1st service was 63% of conception from other services. In probability, pregnancy occurred from first service with 39%, OR of first service reached 1.720 at fourth lactation thus probability of conception was 0.63, close results were obtained by Butler and Smith (1989) who found that conception rate from first service ranged from 40% at 1,951 to 66% at 1,975. Higher values of conception was observed by Oltenacu et al. (1991) where conception from first service in virgin Heifers was 0.65 for Swedish Red and white Breed and 0.48 for Swedish black and white cows.

Nebel and McGilliard (1993) reported a 45% conception rate from first service of 4,550 herds with mean Milk yield 7,953 kg. Conception rate from first service decreased by 23% when milk level increased to 9,545 kg, and additional decrease in conception from first service occurred for herds in the highest yield group.

Despite conception occurs from the last service, OR from first and second services versus other services increased to 1.233; thus, the probability of pregnancy from second services increased to 0.55. Moreover, OR increased as more services were needed to induce conception, reaching a value 2.945, at fifth service, which corresponds to a probability of 0.75. Accordingly, the probability of conception increased from 0.39 in cows inseminated from first service to 0.75 at fifth service insemination.

Odd ratio for second service increased with age from 1.233 at first lactation to 1.735 at fourth lactation. Odd ratio at second lactation for the third service was 1.093 (A3) which is less than OR 1.272 of second service (A2). However, the number of pregnancies from the third service (A_3) was 22,976 compared with 19,202 pregnancies from second service (A2) out of 31,403 total numbers of pregnant and non pregnant cows. Butlen and Smith (1989) reported conception rate ranging from 48 to 56% in cows from the first two services In Japanese Black Cows Hiroshi et al. (2002) found that, the average number of service per conception was 1.41+0.82 and a highly significant effect was found for both year of calving and calving number (age).

Odd ratio increased as more services were used to induce pregnancy, reaching a value of 2.945 when fifth service were used for conception; in other words, conception from the fifth service (A5) was three times the conception from other services (A6, A7,… A10).

Odd ratio values for winter season was higher than those for summer season for all services per conception A_1, A_2, A_3,….etc. OR‹s for winter season ranged from 0.937 to 0.604. On the other hand, OR's for summer season ranged from 0.768 to 0.914. Badinga et al. (1985) found that

Table 2. Maximum Likelihood Analysis for pregnant cows versus non-pregnant and right horn versus left horn pregnancy

Source of variance	df	x^2			
		1st service		Other services	
		P/N	R/L*	P/N	R/L
Intercept	1	2,317.47**	19.18**	4,603.26**	45.25**
FN	2	23.31**	4.26^{NS}	5.27^{NS}	5.71^{NS}
LN	5	303.27**	14.07*	154.78**	15.58**
S	1	7.60**	1.83^{NS}	5.82**	6.46**
My1	1	0.74^{NS}		7.47**	

FN: farm number. LN: lactation number.
S: season of calving. My1: milk level.
P/N: pregnant cows vs. non pregnant cows.
R/L: pregnancy in right horn vs. pregnancy in the left horn.
* Model did not include milk level.

conception rate ranged from 55% during months of low temperature and humidity and only 10% during months of high temperature and humidity.

Low conception rate in Saudi Arabia (45%) was reported by Salah and Mogawer (1990) and is believed to be mainly due to long summer heat stress resulting in prolonged days open and calving interval, (Ali et al., 1999). Bugnato and Oltenaco (1994) reported that cows which calved in summer (April-September) had lower first service conception and had higher number of services per conception than winter calving (October-March). The decrease in conception rate in summer was due to heat stress of warm months from April to September. Evans et al. (2002) used 74 seasonal spring-calving dairy herds with a potential cow population of 6,783 in the 1999 calving season and found that conception rate from first service was 48%. Similarly Hiroshi et al. (2002) found month of calving effect on the number of service per conception where the average number of conception ranged from 1.39 at summer months to 1.47 at winter months

Table 1 shows that, OR for low producing cows (MY 1) conception is about twice as likely to occur from first service than from other services (probability = 0.65) and using more services, up to five services A_1 to A_5, OR and consequently conception increased to 22 times the conception from other services A_6-$A_{10.}$ However, for high producing cows (my 2) OR from first services was greater than one (1.23) and increased at third service to 1.61; in other words, probability of conception increased from 0.56 for first service to 0.62 for third service. Hillers et al. (1984) found that percentage of conception from first service was not affected by milk production during current or previous lactation and the offsetting effects of stress of high production on conception were mainly due to the good nutritional, health and management programs. On the other hand, Nebel and McGilliard (1993) found first service conception rates of 57%, 38% and 17% for cows with milk level <7,250, 725-9,750 and >9,750, respectively.

Bagnato and Oltenacu (1994) found that higher yield was associated with lower conception rate, suggesting that metabolic demands of higher yield reduced fertility of high-producing cows.

Regarding uterine conception, Table 1 shows OR of conception at the right horn versus conception at the left horn for different numbers of services. OR's were computed from different lactations and seasons of calving and milk level groups. Across Lactations, OR values were slightly in favor of right horn. Probability of conception from the first service, in the first two lactations (OR were 1.024 and 1.014) was slightly greater than 50%. However, conceptions were in favor of left horn in later lactations mainly fourth and fifth lactations (OR<1) where the probability of conception for right horn ranged from 0.33 to 0.42. OR of season of calving groups showed that conception was in favor of the left horn, respectively for summer conception OR<1 and probability of conception for LH were between (0.51 to 0.53).

Odd ratio by milk level Table 1 showed that cows with milk level ≤9,500 liter showed a slightly higher OR in favor of the right horn with different conceptions, and only for the second service for cows with milk level >9,500 liter. Some investigators mentioned that the right ovary is more active than the left one (Hafez, 2000) which might be due to the pressure on the left ovary imposed by the rumen.

Conception in the left uterus resulted in less survival rate of embryos and less number of calves at parturition than right horn conception. Therefore, OR and probability of conception across lactation, season of calving and milk level have not approached 60% to 40% ratios for right and left horn conception (ovulation about 60 to 40% for right and left ovary) which imply a displacement of AI semen at uterus and a clue that AI technician has placed the semen at uterine horns, (French, 2002), which is appropriate deposition of semen during inseminating the cow artificially.

Oconnor (2002) used non return rate (60-90 non return ratings) as an indirect measure of fertility, and found that technicians with a non return rate to estrus greater than 78% achieved 86% of their dye depositions in the uterine body and had no extrauterine insemination. Insemination by technician with non-return rates below 70% resulted in only 34% of the dye deposition in the uterine body and 31% extrauterine insemination.

Conception of right horn versus left horn contributes to other two areas in dairy reproduction, first: twinning where bilateral conception could occur at both horns or unilateral conception at either. Most dairy farmers are not in favor of twin calving because twinning reduces the herd's overall profitability and reproduction efficiency, (Gregory et al., 1995). The second aspect is that of birth weight difference of calves born from right or left horn, and survival birth; EchternKamp and Gregory (2002) found some effect of uterine location on both of these traits which increased

Table 3. Logistic regression parameters, standard errors and x^2 test for different number of services

Service no.	B_o	se	B_1	se	x^2_{B0}	x^2_{B1}
1	-2.1605	0.0143	0.165	0.0200	22,667**	25.8**
2	-2.2571	0.0205	0.1980	0.0235	12,156.9**	71.25**
3	-2.1685	0.0268	0.0691	0.289	6,532.1**	5.71**
4	-2.0386	0.0346	-0.0769	0.0362	3,467.5**	4.51*
5	-1.9006	0.0449	-0.2186	0.0460	1,794.4**	22.6**

B_0: intercepte coefficient. B_1: slope coefficient. Se : standard error.
x^2_{B0}: Chi-square of intercept. x^2_{B1}: Chi-square of the slope.

(p<0.01) when twins were located in separate uterine horns. Furthermore, if pregnancy of twins occurs in one uterus horn, the chance of freemartainism will be increased.

Table 2 shows the maximum likelihood (ML) analysis for pregnant versus non-pregnant cows from first service and from all different services. In the analysis, the likelihood function express the probability of pregnancy as a function of unknown parameters, of farm number, lactation number, season of calving and milk level, and consequently maximize the probability of obtaining the observed pregnancy occurrence. X^2 (Table 1) test in the response probability of pregnancy is the same across different farms, different lactations, between two seasons of calving and between two milk levels. Significant differences (X^2 with p<0.01) were found between the two responses (pregnancy versus non-pregnancy), from first service, across farms, across lactation, and between two seasons of calving; the differences mainly reflect the managerial effects, age effect and weathering stress. Farm effects have not shown any significant differences when different number of services were used suggesting the elimination of farm management effect by using more services. Significant differences existed between two seasons of calving and across lactation numbers. No significant (p<0.01) differences were found between pregnant and non pregnant cows from first service of the two milk levels and this is mainly due to the fact that large number of heifers unsuccessfully conceived from first service for two milk level groups. And this may be supported by the significant differences between pregnant and non pregnant groups of the two milk levels from of other services.

Estimates of the parameters of logistic regression (Table 3) were computed after fitting the data, of pregnant and non pregnant cows, for different number of services A1, A2,…..,A5. The slope term in logistic regression (B1) represents in prediction, the increase (positive B1) or decrease (negative B1) in risk of pregnancy as independent variable (number of services) increase by one unit.

The estimate of the parameter B_0=y represents the mean of the response variable. B_0 and B_1 can be used to estimate the conditional expectation of pregnancy given the number of services conditional expectation $y/x=B_0+B_1X$. Furthermore, OR can be obtained by computing the exponential of the slope e^{B1}. The value of x^2 value test the significance of each estimate B_0 and B_1. Thus from Table 3 it is obvious that there is a convincing evidence (significant x^2) that number of services is a significant variable in predicting pregnancy.

CONCLUSION

Low odd ratio and consequently low conception rates were observed from first services and more conception occurred as more services are used, up to five services for heifers. Less number of services is required for pregnancy with increasing age, and in those inseminated in winter. High producing cows need more services for conception. Finally pregnancy should be recorded, whether in the right or left horn and whether the majority of pregnancies occur in the left horn, any deviation from 60:40% ratio of right to left horn pregnancy is a sign that the AI technician is missing the breeding target which is the uterine body or right horn and causing delayed breeding. Thus AI inseminators should periodically attend a retraining course to review their techniques, learn new developments, and obtain recommendations regarding AI technique.

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