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DEVELOPMENT OF PREDICTIVE MODEL FOR DAUGHTER PREGNANCY RATE IN CROSSBRED CATTLE

Sunil Kumar*, Dalal, D.S., Pander, B.L., Patil, C.S. and Sandeep Kumar
Department of Animal Genetics and Breeding, College of Veterinary Sciences,
Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, 125 004, India
*Corresponding author: Sunil Kumar, sunnydayzz92@gmail.com

ABSTRACT

The present study was carried out on first lactation records of 333 crossbred cows over a period of 24 years from 1991 to 2014 to develop a predictive model of daughter pregnancy rate (DPR). The data pertaining to various reproduction traits viz., age at first calving (AFC; days), first service period (FSP; days), number of services per first conception (NS/FCON) and waiting period (WP; days) were collected. The developed models were in different combination of one, two, three and four reproduction traits. Fifteen regression models were developed each for cows having Voluntary waiting period 42, 63, 84 and 105 days. Among these fifteen models, model II, having only one independent reproduction trait *i.e.* First Service Period was found to be the best based on four criterion values. Using model II, four linear equations were developed *viz*., DPR 42 = 0.003 (264 – FSP), DPR 63 = 0.004 (259 – FSP), DPR 84 = 0.005 (230 – FSP) and DPR 105 = 0.005 (277 – FSP). Voluntary waiting period of 63 days was found to be the optimum period for getting best DPR.

KEYWORDS: Fertility, Regression, Voluntary waiting period.

INTRODUCTION

India has cattle population of 183.7 million. Out of which, crossbred cattle population is 36.8 million and indigenous cattle population is 146.9 million. Total number of female crossbred cattle of India is 31.2 million. Total milk production of India in 2012-2013 was 132.4 million tons. Share of milk production of India in 2012-2013 by exotic/ crossbred cows was 24% and that of indigenous/non-descript was 21% (BAHS 2014). Although, population of indigenous cattle is more but contribution in milk production is quite higher from crossbred cattle. Fertility is calculated using various indicators such as number of days open, conception rate, and interval between two successive calvings (Van Raden *et al.,* 2004; Evans *et al.,* 2006; Adamec *et al.,* 2006). These indicators are influenced by fertility of the animal as well as other herd management factors like heat detection and the length of the voluntary waiting period (VWP). There has been a decline in fertility of animals due to their selection based on production traits. It's well known that unfavorable genetic correlations exist between yield and fertility (Dematawewa and Berger, 1998). Thus, it seems necessary to incorporate fertility traits in selection decisions to counter the adverse effects. Improvement of fertility in dairy animals has become the key objective for selection programs in recent years. Many countries have incorporated fertility traits along with production traits for the genetic evaluation of dairy animals such as daughter pregnancy rate (DPR) which depends upon service period (SP) and voluntary waiting period. Documentation of the data, methods, and genetic parameters used in most of these national evaluations was reported by Interbull (2003). Decision to inseminate a cow after calving is very important as it decides the future reproductive performance. Sufficient rest period should be given to cow so that proper involution of uterus occurs and animal regains its health to support pregnancy.

Although VWP varies within and across different herds, making the assumption that VWP is fixed permits to make comparisons among animals (Norman *et al*., 2009). So, the present study was conducted to develop a predictive model of daughter pregnancy rate for crossbred cattle and to standardize the VWP for getting best DPR in the herd.

MATERIALS & METHODS

The first lactation records of 333 crossbred cows were obtained from the history-cum-pedigree sheets maintained over the period from 1991 to 2014 in the Department of Animal Genetics and Breeding, LUVAS, Hisar. The reproduction traits under study were age at first calving (AFC), first service period (FSP), number of services per first conception (NS/FCON) and waiting period (WP).

Estimation of waiting period

The waiting period is the time period between calving and when the management of the herd decides the cow is ready for breeding and it gives the cow some time to resume normal ovarian cyclicity. The waiting period or days to first service is the initial phase of lactation during which no insemination occurs *i.e.* interval between calving and time to first artificial insemination. The average waiting period of the herd was 100.85±4.20 days. Based on minimum WP, 333 crossbred animals were classified in four groups having minimum WP as 42 days, 63 days, 84 days and 105 days and numbers of animals in these groups were 318,245,164 and 118, respectively.

Daughter pregnancy rate

Daughter pregnancy rate measures how quickly cows become pregnant again after calving. It is defined as the percentage of non pregnant cows that become pregnant during each 21 days period, because each estrus cycle represents one chance for an animal to become pregnant. The daughter pregnancy rate is calculated as suggested by USDA (2003). Values of DPR42, DPR63, DPR84 and DPR105 were estimated.

Development of predictive model

The multiple regression analysis (Draper and Smith, 1987) was carried out for prediction of daughter pregnancy rate:

$$\hat{Y} = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e_i$$

Where, $\hat{Y}$ is estimated daughter pregnancy rate, as is the intercept, b_1,b_2, b_3 and b_4 are partial regression coefficients, X_1, X_2, X_3 and X_4 are AFC, FSP, NS / FCON, WP and e_i is random residual error, NID $(0,\sigma^2_e)$.

Fifteen models were developed by using all possible combination of four independent reproduction traits for prediction of Daughter Pregnancy Rate (DPR). Four criterion values *i.e*. Coefficient of determination (R^2), Akaike information criterion (AIC), Bayesian information criterion (BIC) and mean sum of squares due to error (MSSe) were used to decide which model is optimum. Optimum model is said to have high R^2, lowest AIC value (Akaike, 1974), BIC value (Schwarz, 1978) and minimum mean sum of squares due to error (Kebede and Gebrestadik, 2010).

RESULTS & DISCUSSION

Using multiple regression analysis fifteen models were developed for prediction of each DPR (DPR42, DPR63, DPR84, and DPR105). The developed models were in different combination of one, two, three and four reproduction traits and are presented in Table 1 and 2 respectively.

Taking in to consideration of all criterion values *i.e*. R^2, MSSe, AIC and BIC, model II having one independent variable *i.e*. FSP was found to be the best model for DPR 42 because the criterion values obtained by model II were not significantly different from the values obtained by true model which included all the reproduction traits (Model XV). The results for DPR 63 (Table 1) also indicated that model II obtained R^2, MSSe, AIC and BIC values as 53, 0.067, -888.71 and -1070.13, respectively which were comparable with the corresponding values obtained by model XV (57, 0.063, -889.26 and -1070.85, respectively). Similar was the case with DPR84 and DPR105. Present study revealed that FSP alone could predict the DPR42, DPR 63, DPR84 and DPR 105 with 53, 53, 54 and 58 percent accuracy of prediction, respectively.

TABLE 1: Regression equations for prediction of DPR63 along with criterion values

MODEL NO.	TRAITS	P	INTERCEPT	AFC	FSP	NS/ FCON	WP	R^2 (%)	MSSe	AIC	BIC
I	AFC	2	0.171	0.0001	-	-	-	0.8	0.141	-789.78	-951.01
II	FSP	2	1.035	-	-0.004	-	-	53	0.067	-888.71	-1070.13
III	NS/FCON	2	0.620	-	-	-0.127	-	17	0.118	-828.49	-997.61
IV	WP	2	0.809	-	-	-	-0.004	21	0.112	-834.04	-1004.30
V	AFC,FSP	3	1.004	0.00002	-0.004	-	-	53	0.067	-886.71	-1067.74
VI	AFC,NS/FCON	3	0.485	0.0001	-	-0.126	-	17	0.118	-826.49	-995.22
VII	AFC,WP	3	0.663	0.0001	-	-	-0.004	22	0.112	-832.04	-1001.91
VIII	FSP,NS/FCON	3	1.041	-	-0.004	-0.15	-	53	0.067	-886.71	-1067.74
IX	FSP,WP	3	1.095	-	-0.004	-	-0.001	54	0.066	-888.31	-1069.66
X	NS/FCON,WP	3	1.264	-	-	-0.170	-0.005	50	0.071	-880.54	-1060.31
XI	AFC,FSP, NS/FCON	4	1.013	0.00001	-0.004	0.005	-	53	0.067	-884.71	-1065.35
XII	AFC,FSP,WP	4	1.065	0.00002	-0.004	-	-0.001	54	0.066	-886.31	-1067.28
XIII	AFC,NS/FCON, WP	4	1.225	0.00002	-	-0.170	-0.005	50	0.072	-877.06	-1056.13
XIV	FSP,NS/FCON, WP	4	1.207	-	-0.003	-0.076	-0.002	56	0.062	-892.97	-1075.29
XV	AFC,FSP, NS/FCON,WP	5	1.189	0.00001	-0.003	-0.076	-0.002	57	0.063	-889.26	-1070.85

AFC - age at first calving, FSP - first service period, NS/FCON - number of services per first conception, WP – waiting period, P -Number of parameters, R^2 - coefficient of determination, MSSe - mean sum of square due to error, AIC - Akaike information criterion, BIC - Bayesian information criterion

On the basis of all possible combinations, it was concluded that there was slight increase in R^2 value when more number of reproduction traits were included in prediction equation. Similar pattern was observed for rest of criterion values. So, model II having only one independent variable i.e. FSP was judged as the best model. Patil *et al.* (2014) also reported model having only FSP as independent variable as optimum model in Murrah buffaloes. Regression equations using Model II for prediction of DPR42, DPR85 and DPR105 along with criterion values has been given in table 2. So using Model II (having only one independent variable i.e FSP), four linear equations were developed *viz.* DPR 42 = 0.003 (264 – FSP), DPR 63 = 0.004 (259 – FSP), DPR 84 = 0.005 (230 –FSP), DPR 105 = 0.005 (277 – FSP).

Standardization of voluntary waiting period (VWP) for crossbred cattle

Based on four developed optimum models, DPR 42, DPR63, DPR 84 and DPR 105 were predicted. The average and predicted DPR42, DPR 63, DPR 84 and DPR 105 are presented in Table-3. It was found that, using optimum models; the average error was 3% for prediction of DPR 42, 7% for prediction of DPR 63, 4% for prediction of DPR84 and 23 % for prediction of DPR105.

The average values of DPR are equal for DPR63 and DPR84 and slightly higher for DPR105. But with increase in VWP from 63 to 105, there is an increase of 42 days in first service period as well, which is not desirable. So keeping all points in view, *i.e*. fertility of animal and economic considerations, the Voluntary Waiting Period (VWP) of 63 days is ideal after calving of crossbred cattle. Keeping the VWP of 63 days as standard and considering two A.I. to achieve highest conception rate, 105 days first service period should be optimum in crossbred cattle. Divya, P. (2012) standardized waiting period as 52 days in Karan-fries crossbred cattle.

TABLE 2: Regression equations using Model II for prediction of DPR42, DPR85 and DPR105 along with criterion values

Model No.	Traits	P	Intercept	AFC	FSP	NS/ FCON	WP	R^2 (%)	MSSe	AIC	BIC
II	FSP (DPR42)	2	0.793	-	-0.003	-	-	53	0.045	-1220.05	-1219.05
II	FSP(DPR84)	2	1.151	-	-0.005	-	-	54	0.062	-557.28	-556.85
II	FSP(DPR105)	2	1.383	-	-0.005	-	-	58	0.061	-383.81	-383.67

AFC - age at first calving, FSP - first service period, NS/FCON - number of services per first conception, WP – waiting period, P -Number of parameters, R^2 - coefficient of determination, MSSe - mean sum of square due to error, AIC - Akaike information criterion, BIC - Bayesian information criterion

TABLE 3: Average and predicted daughter pregnancy rate (DPR) using best optimum models (Model II)

	DPR 42	DPR 63	DPR 84	DPR105
Average value	0.32	0.37	0.37	0.41
Predicted value	0.35	0.44	0.41	0.64

DeJarnette *et al.* (2007) have well explained that although milk production and days open are both quantitative traits, but days open are more susceptible to management biases. Cows have an opportunity to produce milk each day of lactation; however, opportunity to conceive occurs only once every 21 days in cows and not on each day they are open. For getting one calf per year, the cow should conceive within a period of 85 days post-partum. Generally, a minimal VWP of 45 to 60 day post-partum is recommended allowing for complete uterine involution and resumption of normal ovarian cyclicity to improve the rate of successful conception after AI (Fetrow *et al.,* 2007). The present study also indicated that for getting best daughter pregnancy rate, the voluntary waiting period in crossbred cattle should be 63 days post-partum.Van Raden *et al.* (2004) and Kuhn *et al*.(2004) developed optimum models for the prediction of DPR using days open in Holstein–Friesian cattle. DPRs can be increased by increasing conception rates and/or 21-day service rates. The start and end of the eligible insemination period of individual animals also affects the group DPR. These daughter pregnancy rates (DPRs) indicate economic opportunity for the improvement in dairy cattle reproduction. The study revealed that Model II was best among all the studied models for all DPR. Further, it may be concluded that for getting best daughter pregnancy rate, the voluntary waiting period in crossbred cattle should be 63 days post partum.

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