A LINEAR MODEL APPROACH TO MONITOR A.I. BULLS FOR FERTILITY

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SUMMARY

A linear model suitable for use by individual artificial insemination (AI) units to obtain fertility ratings of AI bulls in service was developed. The model for 90 day non-return rate (90-d NRR) accounted for the service bull, age of service bull at the time of semen collection, technician and random herd-year-seasons. The program was applied to obtain fertility ratings of 228 Holstein AI bulls for 90-d NRR from a data set containing 205,046 first services on Holstein cows from one AI unit in Canada over of period of four years. All breedings were assumed to be random matings on different parity cows across herds. Differences in fertility rating solutions (FRS) for 90-d NRR of AI bulls ranged from -0.22 to +0.31. Prediction of fertility of young AI bulls and accurate rating of proven bulls is feasible with the computing facilities of AI studs and will be useful to the dairy industry.

INTRODUCTION

Maintaining a high level of fertility among bulls in AI service is very important to achieve high conception rates in cows. The most frequently used measure of fertility in bulls is non-return rate (NRR) to service within a specified time following a particular insemination. The NRR is mostly used by AI units for monitoring bulls for fertility problems within the units, for example, a 60 to 90 day non-return rate (60-90-d NRR) which is the percentage of 'successful' breedings in comparison to the total number of services credited to each bull. No consideration is given to any known environmental factors which might influence a particular service. Several studies have shown that NRR is an overestimate of the true conception rate and is biased by several non-genetic factors (Oltenacu and Foot (1976), Syrstad (1981), Taylor et al. (1985), Jansen (1986) and Nadarajah et al. (1988)). The present study was undertaken to develop and test models to rank AI bulls for fertility as well as for evaluating AI technicians.

MATERIALS AND METHODS

A total of 249,267 first insemination records on Holstein cows of different parities bred to Holstein bulls were collected by one Canadian AI unit during 1985 - 89. In the first instance, NRR for individual bulls was computed as 60-90-d NRR using the traditional procedure of three "calendar" months. The "calendar" 60-90 day method for computing NRR does not account for 7 % of the cows that returned for a second service within 90 days from the first breeding date. Therefore, for this study the NRR of bulls was redefined as 90-d NRR which would count 90 days from the first breeding date of each cow. Any service to a cow within 14 days of the first service date was considered as a quick repeat within that cycle and was ignored in the computation. From subsets of data considering those bulls which had at least 50 services in each year, non-return rates on days 35, 55, 75, and 90 were also computed for preliminary examination. To determine the association between these measures of NRR's for individual bulls, correlations among 35, 55, 75 and 90 day NRR's were calculated and compared within each year.

For the final analyses the data were further edited to have at least 20 or more services recorded for each bull and technician with a minimum of three records per herd-year-season subclass. There were 205,046 service records of cows involving 228 AI bulls and 185 technicians. The mixed linear model was :

$$Y_{ijkmn} = \mu + h_i + a_j + b_k + t_m + e_{ijkmn}$$

where Y_{ijkmn} is the observation on the 90-d NRR of a service (0 or 1) assigned to the service bull, μ is the population mean, h_i is the random effect of the ith herd-year-season of breeding assumed NID $(0,\sigma^2_h)$, a_j is the fixed effect of the jth age of the AI bull at the time of semen collection, b_k is the fixed effect of the kth service bull, t_m is the fixed effect of the mth AI technician, and e_{ijkmn} is the random residual error assumed NID $(0,I\sigma^2_e)$. The herd-year-season was treated as random because of confounding of technicians within herds. A variance ratio of 2.2 was added to the diagonal of the herd-year-season subclass during the final analysis. The bulls were categorized into ten age groups where the last group consisted of bulls which were greater than nine years. In this analysis, the bulls were treated as fixed to minimize any selection bias and to make specific inferences only about the bulls attached to a stud. All other unknown effects not accounted in the model, particularly the cow effects which are associated with individual matings, were assumed to have random influence on all matings. By absorbing the random herd-year-season effects with 19,581 levels into the fixed effects equations and by inverting the coefficient matrix after imposing the necessary restrictions, the solutions for age effects, AI bulls and technicians were computed. Product-moment and rank correlations were computed between the fertility ratings of AI bulls for 90-d NRR and the raw measures of 60-90-d NRR and 90-d NRR respectively.

RESULTS AND DISCUSSION

Raw 60-90-d NRR and 90-d NRR:

The overall average 90-d NRR was 65 % which is about 3 % lower than the average 60-90-d NRR calculated using the "calendar" months. The means and standard deviations of bulls (with 50 or more services /year) for NRR at different post breeding time periods are presented in Table 1. The average NRR's drifted downward as number of days from first breeding increased. There were wide differences between NRR's computed at days 35 and 90 . Table 2 shows the correlations between all combinations of NRR's year by year. Except for those involving 35 and 90 day NRR's all other correlations were fairly high and satisfactory. The correlations between 75 and 90-d NRR's were particularly very high. The rank correlation between 60-90-d NRR and 90-d NRR was 0.90.

Linear Model Fertility ratings for 90-d NRR:
The effects of service bull and technician on 90-d NRR were significant ($p<.05$). Age of bull effect was approaching significance ($p<.1$). Bulls up to four years of age exhibited greater fertility (3 to 4 %) than older bulls. Fertility rate declined with age, and declined most sharply after 7 years. Decreased fertility rate with increased age was also observed by Murray et al. (1978) in a previous study utilizing AI breeding records across Canada.

The solutions for herd-year-season subclasses showed a deviation of 23 % about the mean. The data indicate the necessity for adjustment for herd-year-season effects. The fertility rating solutions (FRS) for bulls showed a null mean and variance of .004 among service bulls after adjusting for environmental effects in the model. The FRS of AI bulls for 90-d NRR ranged from -0.22 to +0.31. As suggested by Davidson and Farver (1980), semen from high fertility bulls may have an advantage in settling cows with a single service. Furthermore, Syrstad (1982) and Raheja et al. (1989) reported a favourable correlation between bulls' NRR's and their daughters' conception rates. This benefits the dairy industry if selection of bulls for high fertility could leave progeny with superior reproductive performance in future generations. Hence, the existence of sizable differences for FRS among bulls for 90-d NRR as found in this study should help dairymen to improve fertility in their herds. The solutions for technicians ranged from -0.37 to +0.40 with a standard deviation of 0.1 for 90-d NRR. This model should improve the accuracy of technician rankings which are important quality control measures in many countries with AI technician services. Accurate herd-year-solutions may be used to educate farmers and assist in trouble shooting.

The estimates of rank correlations between the FRS of bulls for 90-d NRR obtained from the linear model and their corresponding raw measures of 60-90d NRR and 90-d NRR were .68 and .70 respectively. The results clearly indicate that adjustment for effects in the linear model (ie. herd-year-season, age of bull and technician) is very important in ranking AI bulls for fertility.

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Table 1. Average yearly NRR's of bulls with at least 50 services

Year	# of Bulls	Average NRR+ Std. Deviation			
		35d	55d	75d	90d
86	99	.83±.04	.73±.05	.67±.06	.65±.06
87	95	.83±.04	.73±.05	.66±.06	.64±.07
88	84	.83±.05	.73±.06	.67±.07	.65±.07
89	58	.84±.04	.73±.05	.67±.05	.65±.05

Table 2. Correlations among different NRR computations for bulls by year.

Year		55d	75d	90d
86	35d	.85	.78	.77
	55d		.94	.92
	75d			.98
87	35d	.86	.82	.79
	55d		.93	.89
	75d			.98
88	35d	.92	.89	.86
	55d		.95	.93
	75d			.98
89	35d	.80	.74	.69
	55d		.84	.80
	75d			.93