The effects of PGF$_{2\alpha}$, season, and interval between AI and pregnancy testing varied significantly among herds. These effects appear to be symmetric in their distributions about their means. The risk of day of palpation on calving is herd dependent and small compared with other herd factors. 

(Key words: pregnancy attrition, rectal palpation, herd)

Abbreviation key: INT = the length of interval (days) from AI date until scheduled date of pregnancy examination, OC = the outcome of calving (1 = yes, 0 = no).

INTRODUCTION

Pregnancy diagnosis by rectal palpation is integral in programs to optimize dairy production (25, 27). Early detection of nonpregnancy should lead to earlier intervention and consequently shorter, more economical calving in-
tervals. The early determination of nonpregnancy is considered to be economically desirable (14, 19, 25, 27), but several studies (1, 12, 20, 24, 28) have suggested that testing of pregnant cows early in pregnancy by rectal palpation increases the risk of abortion. The results of a recent study (23), however, suggested that cows tested by rectal palpation earlier in pregnancy had lower risk of abortion.

Several difficulties are involved in design of studies of abortion attributable to palpation. Confounding by multiple abortion risk factors is difficult to control. Following single matings appropriately timed, conception rate in cows is very high, usually approaching 100%. However, calving rate is often <50%; the reduction of embryos is associated with a multitude of risk factors (3, 4, 5, 6, 16) that make a cow diagnosed as pregnant early (close to 30 d post-AI) more likely to abort than a herdmate diagnosed later as pregnant. The increased risk of abortion is due partly to the extra time that the embryo is at risk (differential time at risk) and partly due to the higher rate of fetal loss per day earlier in pregnancy (3, 4, 5, 6, 16). The differential time at risk becomes a problem with a study designed to follow only pregnant cows (20, 28). A second problem with this design is that veterinarians testing for pregnancy can simultaneously make an errant nonpregnant (false-negative) diagnosis and reduce the likelihood of that cow continuing to gestate (with treatment with PGF$_2$$. The expected date of pregnancy testing was determined after herd strategies for pregnancy testing were studied. The minimum number of days post-AI until pregnancy testing was identified for each farm. Cows were expected to be pregnancy tested during the first scheduled date of pregnancy examination after this minimum value for INT. Records of cows that were neither pregnancy tested by their assigned value for INT nor recorded as returned to estrus by their assigned value for INT were removed from analyses. Cows that were not managed in a manner consistent with the farm strategy may represent a systematically different population. Following discern-
ment of herd strategies by inspection of cow records, herds with \( \geq 30 \) pregnancy tests occurring between d 30 and 65 were selected for further study. The regression models were applied to 7105 first AI on 65 farms.

When treatments with PGF\(_{2\alpha}\) or one of its analogs were recorded, AI occurring within 7 d following a treatment were considered to have been influenced by that treatment. A variable was created for season, for which AI between June 21 and September 21 were considered to be at risk of altered rate of calving. The herd variable was treated as a fixed effect by creation of 64 indicator variables (17).

The initial model (main effects model) used logistic regression to evaluate the outcome of calving (OC; 1 = yes, 0 = no) as a function of herd, season, INT, and treatment with PGF\(_{2\alpha}\). For the second step, the two-way interactions involving herd were tested for entry into the main effects model. The third step modeled the dependent variable OC as a function of INT, season, and treatment with PGF\(_{2\alpha}\) within each herd. Herds that rarely used PGF\(_{2\alpha}\) (\( \leq 5 \) treatments recorded) were fitted with a two-variable model regressing OC as a function of INT and season. For 1 herd, maximum likelihood methods failed to determine a solution with the default convergence criteria of a commonly used logistic regression program (22). For this herd, the model was refitted with OC a function of one variable, INT. The estimates of the log odds ratio herd, INT, treatment with PGF\(_{2\alpha}\), and season were plotted against number of herds in frequency histograms. The distribution of effects was described with an overall mean and standard deviation; the estimates for each herd were weighted equally.

### RESULTS

The annual number of calvings in study herds ranged between 31 and 1923; most herds were small to moderate (median of 88.6 annual calvings). The distribution of the earliest date post-AI that pregnancy testing began was 36.1 ± 3.4 d (\( \bar{X} \pm SD \)) among 65 herds and ranged from 31 to 45 d post-AI. The mean interval between scheduled dates of pregnancy examination was 19.6 ± 7.8 d and ranged from 3.3 to 36.0 d.

In the main effects model, herd (\( P < .0001 \)) and treatment with PGF\(_{2\alpha}\) (\( P < .01 \)) were significantly associated with OC. The AI following treatments with PGF\(_{2\alpha}\) were less likely to be followed by calving (odds ratio = .81; 95% confidence interval = .69 to .95). The interactions with herd-herd \( \times \) INT (\( P < .05 \)), herd \( \times \) season (\( P < .0001 \)), and herd \( \times \) PGF\(_{2\alpha}\) (\( P < .0005 \))—were significant for entry into the main effects model.

Logistic regression repeated for every herd resulted in convergence and solutions for 64 of 65 herds (Table 1). The single herd that failed to converge had 61 observations and only 8 AI in summer. This farm was refitted with OC as a function of INT. The log odds for INT (SE) was \(-.018 \pm .057\). The distributions of the log odds ratios were symmetric. The mean (± SD) of the log odds ratios for the influence on OC were \( .31 \pm 3.07 \) for herd (Figure 1), \( 0 \pm .07 \) for

### TABLE 1. Distribution (percentiles) of adjusted log odds ratios\(^1\) and corresponding odds ratios.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>25</th>
<th>50</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd(^2)</td>
<td>65</td>
<td>-1.77</td>
<td>-.22</td>
<td>1.27</td>
<td>.17</td>
<td>.80</td>
<td>3.58</td>
</tr>
<tr>
<td>INT(^3)</td>
<td>65</td>
<td>-.03</td>
<td>0</td>
<td>.04</td>
<td>.97</td>
<td>1.00</td>
<td>1.04</td>
</tr>
<tr>
<td>PGF(_{2\alpha})(^4)</td>
<td>32</td>
<td>-.58</td>
<td>-.21</td>
<td>.33</td>
<td>.56</td>
<td>.81</td>
<td>1.39</td>
</tr>
<tr>
<td>Season(^5)</td>
<td>64</td>
<td>-.66</td>
<td>-.03</td>
<td>.36</td>
<td>.52</td>
<td>.97</td>
<td>1.43</td>
</tr>
</tbody>
</table>

\(^1\)Odds ratio for calving versus not calving.

\(^2\)Intercept for herd, with no effect of PGF\(_{2\alpha}\), INT, or season.

\(^3\)Interval between AI date and date of pregnancy examination (days).

\(^4\)AI at PGF\(_{2\alpha}\)-induced estrus versus at noninduced estrus.

\(^5\)The AI in summer versus not in summer.
INT (Figure 2), $-0.18 \pm 0.75$ for treatment with PGF$_{2\alpha}$ (Figure 3), and $-0.13 \pm 0.88$ for season (Figure 4).

**DISCUSSION**

The variable OC was selected as the outcome of interest because of its objectivity. To use abortion (or pregnancy loss) as an outcome requires subjectivity because the abortion must be observed and recorded, or the pregnant condition must be diagnosed during gestation, and then a nonpregnant condition must be diagnosed later. The outcome OC allowed the results of a potentially biased pregnancy test to be ignored. The study design of determining the number of days that cows were bred before planned pregnancy testing performed a number of useful functions. This design avoided confounding by other risk factors that are randomly distributed among values of INT. The design should avoid confounding by age, parity, and other risk factors within herds. The design removed the importance of the outcome of pregnancy diagnosis. The study population includes the cows at risk of false nonpregnant diagnoses. False-negative diagnoses may be followed by management that may reduce pregnancy (e.g., treatment with PGF$_{2\alpha}$). The study population also includes pregnant cows that may be at risk associated with delayed testing (e.g., performing an AI on a cow that is pregnant and not yet tested) (26). The design also allowed adjustment of the calving rate so that no bias was present that was due to differential time at risk.

Statistical modeling can be very computationally intensive; therefore, the model-building process was deliberately kept relatively simple. The objective was to study the effect of INT while controlling for potential confounders, including herd, treatment with PGF$_{2\alpha}$, and season. The first model included all of these variables. The second step was to examine the two-way interactions involving herd. All three two-way interactions involving herd (herd $\times$ INT, herd $\times$ PGF$_{2\alpha}$, and herd $\times$ season) were significant for entry into the main effects model. Separate analyses were performed on each herd, and the distribution of effects was presented, which was essentially the same as modeling OC as a function of all three interactions.

The herd effects on the odds ratio can be interpreted as the herd differences on calving rates from first AI. In the main effects model, confounding by herd was controlled by creation of 64 indicator variables and treatment of herd as a fixed effect (17). Inclusion of herd in the analysis controlled for differences in conception rates among herds and controlled for rate of herd embryonic loss other than that associated with other variables in the model.

The interaction term herd $\times$ PGF$_{2\alpha}$ was considered to be a potential confounder because treatments with PGF$_{2\alpha}$ or one of its analogs might affect the day on which cows were bred (and pregnancy tested), and the treatment might alter calving rate. Apparently, the effect of treatment with PGF$_{2\alpha}$ or one of its analogs on subsequent calving rate varies considerably among herds. Pregnancy rate in cows treated with PGF$_{2\alpha}$ or its analogs is the same.
as in untreated cows if estrus detection is used, but, when timed, single AI is used instead of estrus detection, calving rate is lower (9, 15).

In the current study, the main effect of estrus induction by treatment with PGF2α was a reduction in the resulting calving rate. The highly significant herd effect on the relationship between PGF2α treatment and calving rate could have been due to variation among herds in estrus detection. With PGF2α treatment, estrus detection may be improved because a number of cows treated on the same day may show signs of estrus together (11), or estrus detection may be less accurate if the observer expects estrus and selects cows for AI on secondary signs of estrus or based only on a timed interval (no estrus detection) (9, 15). The accuracy of estrus detection that occurs through this range might account for the herd effect on the relationship of treatment with PGF2α with OC.

Season was considered to be a potential confounder because the frequency of pregnancy checking may decrease (thereby increasing value of INT) in summer as infertile matings increase (8, 13). If so, higher values for INT would be associated with lower calving rate. The main effect of season was not significant (P > .1). Not surprisingly, season effects varied significantly among farms because farms were studied from several geographic regions.

The main effect of INT on calving was not significant. However, significant relationships were positive and negative among herds. The herds with negative relationships support a recent report (23) of a less harmful effect of earlier palpation. Thurmond and Picanso (23) suggested that pregnancy testing by rectal palpation may be riskier after placental attachment. Cows confirmed pregnant by palpation may be less likely to be inseminated in response to signs of estrus during pregnancy (7, 10, 26). Palpation techniques should change throughout the usual period of pregnancy testing (21). Chorioallantois is more difficult to detect by rectal palpation before d 40, and detection of an amniotic vesicle by some palpators prior to d 40 may be inherently safer than detection of the chorioallantois (1, 2). Retraction of the uterus during palpation may become more harmful as the weight of the gravid horn increases. The potential harm of earlier palpation could be due to damage to the chorioallantois or the amniotic vesicle (1, 12, 20, 24, 28). Included among the herds in which earlier palpation was associated with lower calving rate were two teaching herds in which palpation was performed by both inexperienced veterinary students and experienced clinicians. If this study had been conducted on these teaching herds alone, early palpation would have been associated with a reduced calving rate. Some herds served by practitioners had the same association with greater statistical significance and larger risk.

**CONCLUSIONS**

The effect of day of palpation on risk to calving is highly herd specific. Within single herds, the contribution of day of palpation on
calving rate was extremely small compared with the effects of herd and the within-herd effects of season and AI following PGF2α-induced estrus. Herds are affected by a multitude of management factors that influence calving rates much more than the embryonic induction of estrus. Herds are affected by a multi-

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REFERENCES


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