Analysis of some factors affecting fertility levels in a high-producing dairy herd in south-western Japan

Muhammad YUSUF, Toshihiko NAKAO, Su T. LONG and Gokarna GAUTAM

Department of Veterinary Medicine, Faculty of Agriculture, Yamaguchi University, Yamaguchi, Japan

ABSTRACT

The present study aimed to know whether all cows have been showing declining fertility or only a proportion of cows are attributed to the declining fertility, and to describe factors affecting the level of fertility. A total of 131 cows calved from February 2005 to December 2007 in a dairy herd were examined. Fourteen cows were excluded from the study because of early culling. Of the remaining 117 cows, 47 (40%) conceived within 115 days postpartum after 1–3 artificial insemination (AI) (normal fertility cows), 42 (36%) conceived after 115 days postpartum following 1–3 AI or were culled after 1–2 (sub-fertility cows/culled), and 28 (24%) were inseminated more than three times without detectable genital tract abnormalities (repeat breeders). Calving to conception interval in the normal fertility group was 72 ± 3 days, while in the sub-fertility/culled and repeat breeding groups the intervals were 170 ± 8 and 259 ± 16 days, respectively. Endometritis was the risk factor for sub-fertility/culled (odds ratio (OR) = 3.76). Prolonged luteal phase (OR = 4.08), delayed first ovulation (OR = 6.02), and delayed corpus luteum formation after AI (OR = 8.55) were the risk factors for repeat breeding.

In conclusion, 60% cows showed reduced fertility in a herd, while the other 40% had normal fertility. Uterine infection and some ovarian disorders contributed to reduced fertility.

Key words: dairy cows, fertility level, repeat breeder, reproductive performance, sub-fertility.

INTRODUCTION

Poor reproductive efficiency in dairy cattle is a worldwide problem affecting the dairy industry (Lucy 2001). The fertility of lactating cows has been reported as declining during the past 3 decades (Caraviello et al. 2006). The root cause of the declining fertility is probably a combination of a variety of physiological and management factors that have an additive effect on reproductive efficiency (Lucy 2001). Some of the problems in reproductive efficiency may be due to the increase in size of dairy operations and decreased management of individual dairy cows (Wiltbank et al. 2006). However, specific causes of the decline are not clear, but multiple factors have likely contributed (Washburn et al. 2002; Roche 2006).

Since multi-factors contribute to declining fertility in dairy cows (Washburn et al. 2002; Roche 2006), it is assumed that some cows in any subpopulation in a herd are still having normal fertility. We hypothesized therefore that not all cows in a herd show declining fertility, but only a proportion of cows have had poor reproductive performance. If only a proportion of cows have had poor reproductive performance, attributed to declining fertility at the herd level, we need to pay specific attention to these cows to improve the herd fertility.

The present study aimed to understand whether all cows have been showing declining fertility or only a proportion of cows can be attributed to declining fertility, and to describe factors affecting the level of fertility.

MATERIALS AND METHODS

Animals

The study was conducted in a commercial dairy herd of high-producing Holstein Friesian cows with average milk yield of 10 200 kg/cow/lactation in Yamaguchi Prefecture, a south-western region of Japan. The number of cows in lactation in the herd ranged between 55 and 65. A total of 131 cows with parity one to parity six which calved all the year round from February 2005 to December 2007 were used. The cows were kept in free-stall barns with sawdust and wood shavings for bedding and were milked twice a day. Data of milk yield within 30 days after calving, between days 31 and 60, and between days 61 and 90, and a 305-day milk

Correspondence: Toshihiko Nakao, Department of Veterinary Medicine, Faculty of Agriculture, Yamaguchi University, Yoshida 1677-1, Yamaguchi 753-8515, Japan. (Email: tnakao@yamaguchi-u.ac.jp)

Received 11 May 2009; accepted for publication 13 November 2009.

© 2010 The Authors
Journal compilation © 2010 Japanese Society of Animal Science
yield were obtained from the herd’s owner. The cows were fed with total mixed ration consisting of grass or corn silage and hay, concentrate and mineral supplements.

**Estrous detection and artificial insemination (AI)**

Cows were observed twice a day for estrus with the help of tail painting around milking time at 07.00 and 17.00 hours, when cows were moving to and from the milking parlor, or were awaiting for milking in the holding yards. Duration of observation of cows for estrus was approximately 2 h in the morning and in the afternoon. A cow was considered in standing estrus or standing to be mounted by another cow if she did not avoid the mount and did not turn and butt or attack the mounting cow. Cows detected in standing estrus were inseminated artificially by the farmer using rectovaginal technique with frozen / thawed semen from proven Holstein Friesian sires. If cows were detected in standing estrus at the morning milking, AI was conducted 3–6 h later, and if they showed standing estrus at the afternoon milking, they were inseminated 2–4 h later.

**Regular reproductive examination**

The herd was visited once a month for reproductive examination. Postpartum cows before the service period, anestrous cows during the service period (after 40 days postpartum) and cows with repeat breeding were listed for clinical reproductive examination, including vaginoscopy and palpation per rectum. Cows within 29 days after AI were not palpated and only vaginoscopically examined. The cows not observed in estrus until day 30 or more after insemination were palpated or ultrasonography per rectum was performed to determine pregnancy status. Vaginoscopy was conducted using a glass speculum (4 cm in diameter and 35 cm in length) with the help of external light. The cervical and/or vaginal discharge was collected into a plastic Petri dish using a plastic pipette. Endometritis was clinically diagnosed based on the characteristics of the discharge. Microscopic examination of the discharge to diagnose subclinical endometritis was not conducted. The discharge was considered normal if it was clear or slightly cloudy without any pus flecks and no foul smell. Mucopurulent (approximately 50% pus and 50% mucus) or purulent (>50% pus) discharge was considered abnormal, indicating endometritis (LeBlanc et al. 2002; Sheldon et al. 2006; Gautam et al. 2009). Cases having vaginal contents with the presence of urine or urine-mixed mucus were defined as urovaginal (Gautam & Nakao 2009).

Transrectal palpation of the genitalia was conducted to check for presence of follicles, larger than 10 mm in diameter, corpora lutea and/or ovarian cysts, and for uterine conditions. The ovarian cyst was identified as one or more follicle-like structures >25 mm in diameter without co-existence of CL. The ovaries without any palpable structures of a Graafian follicle in pre-ovulatory size and/or CL were considered to be inactive. The diagnosis based on palpation was confirmed later by milk progesterone profiles. Milk samples were collected twice a week (Monday and Thursday) starting at approximately 1 week after calving. Milk samplings were continued through postpartum and service periods until the cows became pregnant or were culled. Approximately 10 mL of foremilk was collected from four quarters at morning milking into a plastic tube (1.5 cm in diameter and 10.5 cm in length) and 15 mg potassium dichromate added (Wako Pure Chemical Industries, Ltd, Osaka, Japan) and was stored at 4°C. Samples were sent to our laboratory every 2 weeks for progesterone assay. Progesterone concentrations in whole milk were analyzed using direct ELISA (Isobe et al. 2004).

Milk progesterone profiles were used to assess the postpartum ovarian activity of each cow. First ovulation occurred within 35 days after calving followed by two or more regular ovarian cycles was considered as normal resumption. Delayed first ovulation beyond 35 days after calving due to inactive ovaries or follicular cysts, prolonged luteal phase (progesterone levels remained elevated for >20 days without a preceding insemination) after first or second ovulation (Opsomer et al. 2000), irregular ovarian cycles within 80 days postpartum, were considered as abnormal resumption.

Differences in luteal functions after AI were assessed by progesterone profiles to screen the factors affecting the incidences of sub-fertility/culled and repeat breeding in comparison with normal fertility. Normal luteal function was defined as progesterone concentration in whole milk reaching 5.0 ng/mL within 5 days after insemination and ≥10.0 ng/mL thereafter during the luteal phase (Isobe et al. 2004; Mann et al. 2005). When progesterone concentration increased to 5.0 ng/mL within 5 days after AI, and did not rise to 10.0 ng/mL through the mid- and late-luteal phases, this was considered as insufficient luteal function. Delayed CL formation was defined as the rise of progesterone concentration delayed between days 6 and 11 after AI (Kimura et al. 1987; Hommeida et al. 2004).

**Classification of cows based on fertility level**

The cows were classified into three groups according to different fertility levels. Normal fertility cows were defined as those which conceived within 115 days postpartum after 1–3 AI. Cows conceiving beyond 115 days postpartum after 1–3 services or culled after 115 days postpartum following 1–2 infertile services, were considered as cows with sub-fertility/ culled. Repeat breeders (RB) were those inseminated more than three times but not conceiving by these inseminations within the same lactation (Barlett et al. 1986) and having no detectable genital tract abnormalities (Katagiri & Takahashi 2004).

Artificial insemination submission rates ≤85 days postpartum were defined as the percentages of cows inseminated within 85 days postpartum in cows to be bred during the same period (Shrestha et al. 2004). Pregnancy rates ≤85, ≤115, ≤150, ≤210 and ≤300 days postpartum were defined as the percentages of cows that became pregnant within 85, 115, 150, 210 and 300 days postpartum, respectively.
Statistical analysis
The incidences of normal fertility, sub-fertility/culled, and repeat breeding were calculated as the total number of normal fertility cows, sub-fertility/culled cows, and repeat breeders divided by the total number of cows examined during the study period. All statistical analyses were performed using the statistical package SPSS 12.0 for windows (SPSS Inc., Chicago, IL, USA). A repeated measures analysis of variance (ANOVA) was used to analyze the recurrence of fertility levels between previous and next lactations. Differences in percentages of cows with different types of resumption of postpartum ovarian cycles within 80 days were analyzed by Chi-square test. AI submission rate within 85 days postpartum, first AI conception rate, pregnancy rate within 85, 115, 150, 210 and 300 days postpartum, and percentages of cows which conceived eventually among the three groups with different fertility levels were analyzed using Chi-square test or Fisher’s exact test. Effects of parity, season of calving, and season of first AI were analyzed using Chi-square test. The differences in intervals from calving to conception, number of services per conception, days to first AI among different groups, BCS, and milk yield among the three groups were analyzed using one-way ANOVA. A multivariable logistic regression model was used to analyze possible factors affecting the incidences of sub-fertility/culled and repeat breeding.

RESULTS
Of 131 cows, 14 (11%) were culled within 115 days postpartum due mainly to mastitis. The remaining 117 cows were further analyzed for the levels of fertility, reproductive performance and factors affecting the fertility levels.

Over the study period, AI submission rate within 85 days postpartum and first AI conception rate in the herd were 68% and 24%, respectively, and calving to conception interval and number of AI per conception were 141 ± 9 and 2.8 ± 0.2 days, respectively (Table 1). First AI was conducted from 23–218 days postpartum (±SEM) with an average of 75 ± 3 days.

Proportion of cows with different fertility levels
Proportion of cows with normal fertility was 40%. In the same period the proportion of sub-fertility/culled cows and repeat breeders were 36% and 24%, respectively (Table 1). Of 40 cows which were used for more than one lactation, the level of fertility in the previous lactation did not show consistency (P = 0.493) to the following lactation. The cows with normal fertility or sub-fertility/culled or repeat breeding in the previous lactation were not likely to be repeated with the same fertility level in the next lactation, resulting in high interaction (P < 0.01) between level of fertility and lactation time. Hence, further calculation of reproductive performance and factors associated with the level of fertility were based on lactation.

Resumption of postpartum ovarian cyclicity within 80 days
Of 117 cows which were used in the present study, 56% had normal resumption of postpartum ovarian cyclicity within 80 days and the remaining 44% had abnormal resumption. The percentages of cows with normal resumption in sub-fertility/culled and repeat breeding groups were lower (P < 0.05) than in the normal fertility group (48% and 43% vs 72%) (Table 1).

Reproductive performance of the cows with different fertility levels
A group of cows with normal fertility had 55% first AI conception rate, and their calving to conception intervals and services per conception were 72 ± 3 and 1.5 ± 0.1 days, respectively. In sub-fertility/culled and

Table 1  Resumption of postpartum ovarian cyclicity within 80 days and reproductive performance in normal fertility cows, sub-fertility/culled cows, and repeat breeders

<table>
<thead>
<tr>
<th></th>
<th>Normal fertility cows</th>
<th>Sub- fertility cows/culled</th>
<th>Repeat breeders</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of lactations examined (%)</td>
<td>47 (40)</td>
<td>42 (36)</td>
<td>28 (24)</td>
<td>117</td>
</tr>
<tr>
<td>Resumption of postpartum ovarian cyclicity ≤80 days (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>72a</td>
<td>48a</td>
<td>43a</td>
<td>56</td>
</tr>
<tr>
<td>Delayed first ovulation</td>
<td>9a</td>
<td>17a</td>
<td>25a</td>
<td>16</td>
</tr>
<tr>
<td>Prolonged luteal phase</td>
<td>15a</td>
<td>26a</td>
<td>29a</td>
<td>22</td>
</tr>
<tr>
<td>Others</td>
<td>4</td>
<td>10</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>AI submission rate ≤85 days (%)</td>
<td>94a</td>
<td>50a</td>
<td>50a</td>
<td>68</td>
</tr>
<tr>
<td>Days to first AI (mean ± SEM)</td>
<td>56a ± 3</td>
<td>87a ± 4</td>
<td>88a ± 8</td>
<td>75 ± 3</td>
</tr>
<tr>
<td>First AI conception rate (%)</td>
<td>55a (26/47)</td>
<td>5a (2/42)</td>
<td>0a (0/28)</td>
<td>24 (28/117)</td>
</tr>
<tr>
<td>Pregnancy rate within 300 days postpartum (%)</td>
<td>100</td>
<td>67</td>
<td>50</td>
<td>76</td>
</tr>
<tr>
<td>Total number of cows conceived (%)</td>
<td>47 (100)a</td>
<td>28 (67)b</td>
<td>21 (75)c</td>
<td>96 (82)</td>
</tr>
<tr>
<td>Calving to conception interval (days) (mean ± SEM)</td>
<td>72a ± 3</td>
<td>170a ± 8</td>
<td>259a ± 16</td>
<td>141 ± 9</td>
</tr>
<tr>
<td>No. of AI per conception (mean ± SEM)</td>
<td>1.9 ± 0.1</td>
<td>2.4 ± 0.1</td>
<td>6.1 ± 0.6</td>
<td>2.8 ± 0.2</td>
</tr>
</tbody>
</table>

a,b,cValues in a row with different superscripts differ (P < 0.01). a Values in a row with different superscripts differ (P < 0.05). AI, artificial insemination.
Factors affecting the incidences of sub-fertility/culled and repeat breeding

Binary logistic regression for significant factors affecting the incidences of sub-fertility/culled and repeat breeding is shown in Table 2. Endometritis (odds ratio (OR) = 3.76) was the risk factor for sub-fertility/culled, while prolonged luteal phase before service period (OR = 4.08), delayed first ovulation due to follicular cyst (OR = 6.02), and delayed CL formation after AI (OR = 8.55) were the risk factors for the incidence of repeat breeding in a high-producing dairy herd. The incidence of sub-fertility/culled in a group of cows with parities four or more was significantly higher than in groups of cows in their first or second lactations (P < 0.01). Spring and summer-calving cows showed significantly higher incidence of sub-fertility/culled (P < 0.01) than winter-calving cows. Spring-calving cows also showed a significantly higher incidence of repeat breeding than summer-calving cows. The incidence of repeat breeding in cows first bred in spring and summer was higher (P < 0.05) than those first inseminated in autumn (Fig. 1).

The mean BCS values (±SEM) in normal fertility cows, sub-fertility/culled cows and repeat breeders within 30 days after calving were 3.02 ± 0.26, 2.92 ± 0.21 and 2.90 ± 0.24, respectively. The BCS values within 30 days postpartum did not change significantly at 31–60 days and 61–90 days postpartum in each group. The 305-day milk yield (±SEM) did not differ significantly among normal fertility cows, sub-fertility/culled cows, and repeat breeders: 10 737 ± 317, 10 511 ± 402, and 11 383 ± 403 kg/cow, respectively.

DISCUSSION

The present study showed that cows in a dairy herd can be classified into three different groups based on different fertility levels: normal fertility cows, sub-fertility/culled cows, and repeat breeders. In this herd, 40% of cows had normal fertility, which became pregnant within 115 days postpartum after 1–3 AI, while the other 36% (42 cows) showed sub-fertility/culled. Twenty-eight (67%) of 42 cows with sub-fertility/culled conceived after 115 days postpartum after 1–3 AI, while the other 36% (42 cows) showed sub-fertility/culled cows. Twenty-four percent of cows were repeat breeders. Classification of cows in a herd based on different fertility levels has not been reported thus far. Results of this study indi-

![Figure 1](image-url)  
Figure 1  Pregnancy rate in normal fertility cows, sub-fertility/culled cows, and repeat breeders.
cate that not all cows in a herd had reduced fertility. A proportion of cows still maintained normal fertility, while the other group of cows had poor fertility leading to repeat breeding. It is noteworthy that regarding cows used for two or three successive lactations in the current study, it was shown that the previous levels of fertility were not likely to be repeated in the next lactation.

The present study showed that in the normal fertility group 72% of cows had normal resumption. In contrast, in sub-fertility/culled and in repeat breeding groups the percentages of normal resumption were only 48% and 43%, respectively, which were significantly lower than in the normal fertility group \((P < 0.05)\). Lower reproductive performance in cows with abnormal resumption of postpartum ovarian cyclicity has already been reported in a number of studies (Lamming & Darwash 1998; Opsomer et al. 2002; Shrestha et al. 2004).

Results of the present study showed that repeat breeding cows had a very poor reproductive performance. Only 18% of repeat breeders became pregnant within 210 days after calving, and 50% within 300 days postpartum. Of the 13 repeat breeders that were further bred after 300 days postpartum, seven cases eventually became pregnant. Their calving intervals were estimated to be 539 ± 16 (SEM) days. Likewise, 29% and 57% of sub-fertility/culled cows became pregnant within 150 and 210 days after calving, respectively. Estimated calving interval of the group of cows with sub-fertility/culled was 450 ± 8 days. On the other hand, the group of cows with normal fertility had normal reproductive performance with 55% first AI conception rate, 72 ± 3 days calving to conception interval, and estimated calving interval of 352 ± 3 days. In the present study, endometritis was a risk factor for sub-fertility/culled. This result agrees with the previous studies which have shown reduced reproductive performance in cows with endometritis (LeBlanc et al. 2002; Gilbert et al. 2005; Runciman et al. 2008; Gautam et al. 2009).

In this study, subclinical endometritis was not diagnosed and therefore was not included as a risk factor. Substantial impairment of reproductive performance of the affected cows was reflected in the increased days open, reduction in overall proportion of pregnancies, delayed first service, substantially reduced pregnancy rate to first service, and greater number of inseminations per pregnancy (Gilbert et al. 2005). The other factors contributing to the sub-fertility/culled were parity and season of calving. Cows in the fourth or higher lactations were more likely to have sub-fertility/culled compared to those cows in the first to third lactations. This can be explained by higher incidence of clinical endometritis in cows with higher parities in the present study. Cows in the third or greater lactations were at greater risk of clinical endometritis than those cows in their second or first lactation (LeBlanc et al. 2002; Gautam et al. 2009). Similarly, Darwash et al. (1997) reported that cows with higher parities had longer days to first service and days to conception.

Season of calving is one of the important factors for conception (Lucy 2001). Spring and summer-calving cows had higher incidence of sub-fertility/culled than winter-calving cows in the current study. One of the causes of higher incidence of sub-fertility/culled in summer and spring was considered to be heat stress, resulting in longer intervals from calving to first service. Cows suffering from heat stress were reported to have lower oocyte quality (Sartori et al. 2002; Leroy et al. 2008), reduced duration and intensity of estrus, altered follicular development and impaired embryonic development (Jordan 2003). Heat stress also causes higher incidence of abnormal resumption of postpartum ovarian cycles, lower heat detection rate, lower first AI conception rate, and lower pregnancy rate (Kornmatitsuk et al. 2008). Darwash et al. (1997) also reported that cows calving in summer and autumn had longer intervals to first service than those
calving in spring and winter. Although cattle are not seasonal breeders like other ruminants, season influenced resumption of estrous cyclicity (Santos et al. 2009). Alterations in photoperiodic stimulation and nutritional changes associated with specific times of the year are potential explanations for the effect of season or risk of delayed onset of estrous cycles in lactating dairy cows (Santos et al. 2009).

During the study period, approximately 24% of cows in the herd had repeat breeding. This was similar to the study by Bartlett et al. (1986) who investigated the incidence in 3309 lactations of 22 Michigan dairy herds, but higher than that in a Swedish dairy cow population reported by Båge et al. (2002) and Gustafsson and Emanuelson (2002).

The incidence of repeat breeding (Bulman & Lamming 1978; Bartlett et al. 1986; Stevenson et al. 1990; Båge et al. 2002; Gustafsson & Emanuelson 2002; Pérez-Marín & España 2007; Kendall et al. 2009), its causes (Kimura et al. 1987; Gustafsson 1998; Båge et al. 2002; Gustafsson & Emanuelson 2002; Moss et al. 2002), and its treatment (Morales-Roura et al. 2001; Selvaraju et al. 2002; Villarroel et al. 2004; Kharche & Srivastava 2007; Dochi et al. 2008) have already been reported in a number of studies. However, the causes of the repeat breeding are multifactorial as reported earlier (O’Farrel et al. 1983; Kimura et al. 1987; Silvia 1994; Heuwieser et al. 1997; Pursley et al. 1998; Gustafsson & Emanuelson 2002; Moss et al. 2002). The causes may include inadequate estrous detection (Heuwieser et al. 1997; Pursley et al. 1998) resulting in error in timing of insemination in relation to the onset of standing estrus or insemination of cows that were not in estrus. The other factors may include quality of semen and insemination technique (Hallap et al. 2006; Morrell 2006), uterine and/or cervical/vaginal infections (Moss et al. 2002), endocrine disorders (Gustafsson 1998; Båge et al. 2002), ovulation disorders (Kimura et al. 1987; Silvia 1994), obstructed oviducts, defective ova, anatomical defects of the reproductive tract (Silvia 1994), and early embryonic death (Båge et al. 2002; Villarroel et al. 2004). However, specific causes of repeat breeding are not clear (Gustafsson & Emanuelson 2002; Katagiri & Takahashi 2004). A multifactorial problem involving a number of extrinsic as well as intrinsic factors coupled to the individual animal (Gustafsson & Emanuelson 2002) could also be a cause of the condition. A retrospective case-control study conducted by Moss et al. (2002) described that the risk of repeat breeding was increased with post-calving metritis, stillbirth, and with increasing days taken to reach peak milk yield. Since there are multifactorial causes in the incidence of repeat breeding in dairy cows, it is very difficult to make any generalizations as to predominant causes and each cow must be considered individually (Silvia 1994).

In the present study, prolonged luteal phase before service period, delayed first ovulation due to follicular cysts, and delayed CL formation after AI were the significant factors to cause repeat breeding. Prolonged luteal phase after first or second ovulation postpartum could be caused by uterine diseases (Opsomer et al. 2000) that disrupt prostaglandin production (Crowe 2008). This condition may impair embryonic development through lack of a favorable uterine environment, resulting in poor fertility (Shrestha et al. 2004). The study by Lamming and Darwash (1998) stated that cows with prolonged luteal phase had higher level of late embryonic mortality. Delayed CL formation after AI could be a direct cause of repeat breeding. This may be related to the aging of bull spermatozoa (Dalton et al. 2001; Morrell 2006) and ovum in cows with delayed ovulation.

In conclusion, the fertility levels in a herd can be classified into three different groups: normal fertility cows, sub-fertility/culled cows, and repeat breeders. We found that not all cows in a herd show declining fertility; 40% of cows showed a normal fertility, while the proportion of cows with sub-fertility/culled and repeat breeding were 36% and 24%, respectively. Uterine infection, prolonged luteal phase before the service period, delayed first ovulation due to follicular cysts, and delayed CL formation after AI, contributed to reduced fertility in a dairy herd.

ACKNOWLEDGMENTS

The first author is supported by the Monbukagakusho scholarship of Japan. The author acknowledges the Ministry of Education, Culture, Sports, Science and Technology of Japan. This study was supported by a grant from Japan Livestock Technology Association and grant-in-aid for scientific research from Japan Society for the Promotion of Science (JSPS). The authors are thankful to the farmers in Yamaguchi Prefecture for their cooperation in using their animals in the study.

REFERENCES


Caraviello DZ, Weigel KA, Craven M, Gianola D, Cook NB, Nordlund KV, Fricke PM, Wiltbank MC. 2006. Analysis of
FERTILITY LEVELS IN A DAIRY HERD


