Effect of Health Status on Culling and Reproductive Performance of Holstein Cows

P. A. OLTENACU, J. H. BRITT, R. K. BRAUN, and R. W. MELLENBERGER
Department of Animal Science
North Carolina State University
Raleigh 27695-7621

ABSTRACT

Data were from 492 cows that calved between October 1976 and May 1977 in eight Holstein herds in Michigan. Cows were classified as those without any health-related problems during lactation; those with minor reproductive health problems not serious enough to require veterinary treatment; and those with health problems severe enough to require veterinary treatment.

Among primiparous cows 4.4, 16.2, and 19.1% were culled from healthy, minor, and problem groups, whereas among multiparous cows, these percentages were 11.2, 19.1, and 31.7. Among healthy cows 33.3, 38.9, and 27.8% of total culls were classified as production, reproduction, and other. Among minor and problem cows, these percentages were 31.6, 42.1, and 26.3 and 22.6, 58.5, and 18.9. The odds of being culled were 4.3 and 5.2 times as great as for first lactation cows in minor and problem groups and 1.9 and 3.7 times as great as for older cows in the two health-problem groups.

Primiparous cows in healthy group averaged 50 days to first detected estrus, 68 days to first service, and 95 days open. Least squares means for performance of primiparous cows in minor and problem groups and of multiparous cows in healthy, minor, and problem groups, as deviations from healthy cows, was days to first service, 9.1, 24.0, 2.0, 12.1, and 9.1; and days open, -7.0, 15.2, -9.1, 1.8, and 12.6. Primiparous cows with health problems were at a higher risk of being culled than multiparous cows with health problems.

INTRODUCTION

Percentage of cows culled annually, or turnover rate, plays a significant role in determining economic performance of a dairy enterprise. Clark and Bratton (5) analyzed records of 337 New York dairy farms for turnover ranging from 15 to 40%. They reported (5) highest income per operator and per cow per year for herds with 25 to 29% turnover.

Cows leaving the herd are culled either voluntarily, with low production, poor type, and dairy purposes being major reasons, or involuntarily, with health problems such as reproductive disorders or mastitis being major causes.

As a herd goal of health management, Morrow (15) suggested that involuntary, or forced, culling should be kept below 10% to bring about longer productive life, to permit herd expansion, and to create opportunity for more intense selective culling. Benefits from longer productive life are derived from increase of milk production associated with age, decrease of depreciation per cow per year, and decrease of number of replacements needed to maintain herd size. In general, raising replacements is an unprofitable activity in herds that do not sell breeding stock (22), so “fewer needed” translates into economic advantage for the dairy farm. Renkema and Stelwagen (19) studied economic importance of reducing

Received September 29, 1983.

2 Department of Animal Science, Cornell University, Ithaca, NY 14853.
3 Reprint requests.
4 Department of Preventive Medicine, College of Veterinary Medicine, University of Florida, Gainesville, FL 32610.
5 Department of Animal Science, Michigan State University, East Lansing, MI 48824.

1984 J Dairy Sci 67:1783-1792 1783
replacement rate through improved health and concluded that increasing average productive life from 3.3 to 5.3 lactations by reduced involuntary culling could result in 20% more earned income per cow per year.

Unsatisfactory reproductive performance is recognized by dairy farmers (11) and researchers (1, 3, 23) as the major cause for involuntary culling. Unsatisfactory reproductive performance results from inadequate management (18) and from effects of reproductive disorders on cow fertility. Foote et al. (10) noted a significant decline of breeding efficiency associated with reproductive disorders, especially metritis, pyometra, and ovarian cysts beyond 60 days in lactation. Similar conclusions of others (4, 9, 17, 20) indicated the importance of health status, particular reproductive health, for a herd's reproductive performance and culling rate. Consequently, strengthening herd health management in general and reproductive health management in particular is an avenue for decreasing turnover.

To assess the potential role of herd health management in controlling turnover, quantitative knowledge of the interrelationships between health status, reproductive performance, and culling outcome are needed. Our objective was to determine, under an adequate herd health management program currently available in many dairy herds, effects of health status on cow removal and reproductive performance.

**MATERIALS AND METHODS**

Data were from eight Holstein herds in Michigan in which a total of 492 cows calved between October 1976 and May 1977. Cows were monitored from parturition until conception and subsequent parturition or removal from the herd (16). Herds ranged in size from 50 to 150 milking cows and represented several types of housing and milking systems from tie-stall facilities to loose-housing, free-stall units where cows were milked in herringbone parlors. Each herd was visited on alternate weeks of the experimental period. Each cow was examined by rectal palpation between 8 and 21 days after parturition and reexamined during the subsequent farm visit. Condition of the reproductive tract at each palpation was recorded. Data on problems at calving, status of the reproductive tract, dates of insemination, pregnancy diagnosis, and reproductive or other health problems with associated veterinary treatments also were recorded.

Cows were classified: healthy group (HEALTHY) including cows with no health problems during the lactation covered by the study; minor reproductive problem group (MNRPROB) including cows with abnormal parturition (dystocia, twin birth, retained placenta, abortion, and calf dead at birth), or abnormal discharge during the first 6 wk postpartum (bloody or infectious discharge) but not serious enough to require veterinary treatment; and major health problem group (MJRPROB) including cows with various severe health problems and that were given veterinary assistance and treatment.

Assessment of severity of health problems and the decision to treat were jointly by a veterinary practitioner and dairy producer. Most of the cows in MJRPROB were treated for reproductive-related problems such as cystic ovaries, uterine infection, or anestrus with only 20 cows, or 11% of the cows in the group, treated for nonreproductive health problems such as mastitis or metabolic disorders.

Reason of removal, as stated by the dairy producer, was recorded for each cow leaving the herd during the lactation covered by the study. The following reasons were considered: low production, milking problems, and poor type, all referred to as production; reproductive problems, referred to as reproduction; and death, injuries, mastitis, or other health problems referred to as other. Some restrictions were used before the reason for removal given by the dairy producer was accepted. Of particular importance was reproductive culling, and culling for reproduction was accepted as a reason only if at least one attempt was made to breed the cow before culling.

The following traits describing reproductive performance were considered in this study: number of days from parturition to first estrus (FSTESTR), number of days from parturition to first service (FSTSERV), number of days from parturition to conception (DAYSOPN), number of services per pregnancy (SRV/PGN), and pregnancy rate at first service (FSTPGN%).

Average milk yield for the first four Dairy Herd Improvement test days (AVGMILK) described average milk yield of a cow for approximately the first 100 days of lactation.
TABLE 1. Measures of reproductive performance and culling by parity and health status.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Measure</th>
<th>Lactation = 1</th>
<th>Lactation ≥ 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HEALTHY &lt;sup&gt;a&lt;/sup&gt;</td>
<td>MNRPROB</td>
</tr>
<tr>
<td>No. cows</td>
<td></td>
<td>69</td>
<td>37</td>
</tr>
<tr>
<td>FSTESTR &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>105</td>
<td>126</td>
</tr>
<tr>
<td>FTSERV &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>68</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>121</td>
<td>146</td>
</tr>
<tr>
<td>DAYSOPN &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>48</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>302</td>
<td>157</td>
</tr>
<tr>
<td>SRV/PGN &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.0</td>
<td>.6</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>6.0</td>
<td>3.0</td>
</tr>
<tr>
<td>FSTPGN% &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>59</td>
<td>68</td>
</tr>
<tr>
<td>%CULLED &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>4.4</td>
<td>16.2</td>
</tr>
<tr>
<td>%CLDRP &lt;sup&gt;b&lt;/sup&gt;</td>
<td>Average</td>
<td>1.5</td>
<td>2.7</td>
</tr>
<tr>
<td>FS &lt;sup&gt;c&lt;/sup&gt;</td>
<td>Average</td>
<td>87</td>
<td>97</td>
</tr>
</tbody>
</table>

<sup>a</sup>Cows with no health problems during lactation (HEALTHY), cows with reproductive health problems not severe enough to require treatment (MNRPROB), and cows with health problems requiring veterinary treatment (MJRPROB).

<sup>b</sup>FSTESTR = days from calving to first estrus, FTSERV = days from calving to first service, DAYSOPN = days from calving to conception, SRV/PGN = services per pregnancy, FSTPGN% = conception rate at first service, %CULLED = percentage culled, %CLDRP = percentage culled for reproduction.

<sup>c</sup>Fertility Status, combining FSTCNP%, SRV/PGN, DAYSOPN, and %CULLED. For details see (9) and text.
To estimate effects of parity and health status on traits, data were analyzed by least squares analysis of variance (2). The following model described an observation:

\[ Y_{ijk} = \mu + H_i + (P \times HS)_j + E_{ijk} \]

where \( Y_{ijk} \) is the \( ijk \)th observation of trait; \( \mu \) is overall mean; \( H_i \) is effect of \( i \)th herd (\( i=1, \ldots, 8 \)); \( (P \times HS)_j \) is effect of \( j \)th combination of parity by health status (\( j=1, \ldots, 6 \)); and \( E_{ijk} \) represents the residual association with \( ijk \)th observation. Three health status groups, already defined, and two parities, cows in first lactation and cows in second or greater lactation, combined to give six subclasses of parity by health status. All factors in the model were fixed except residual, \( E_{ijk} \), which was normally and independently distributed with mean zero and variance \( \sigma^2 E \).

To determine if distribution of cows in three health status groups was affected by parity and if culling outcome was dependent upon health status, \( \chi^2 \) tests for independence (24) were on appropriate two-way distribution tables.

**RESULTS AND DISCUSSION**

Percentage of cows culled for all reasons (%CULLED) and for reproductive reasons only and several statistics for FSTESTR, FSTSERV, DAYSOPN, FSTPGN%, and SRV/PGN for all cows and for groups of cows classified by parity and health status are in Table 1. Turnover was 18.3%, and half of all cows culled were removed for reasons related to reproduction. This turnover rate is low vis-a-vis the 25 to 30% removal rate prevailing in Northeast (5) and Midwest (1) but is characteristic for well-managed herds on a veterinary health program, comparing with the 20% turnover reported by Morrow (14, 15) for such herds. Excellent management of these herds also is reflected in superior reproductive performance, with averages of 58 days for FSTESTR, 75 days for FSTSERV, 95 days for DAYSOPN, and 1.5 services for SRV/PGN. For cows in first lactation AVGMILK was 24.2 kg and for cows in second or later lactation it was 31.3 kg. Extended by factors for lactations in progress published by Keown and Van Vleck (12), estimated 305-day milk yield for cows was 6500 kg for cows in first lactation and 8000 kg for cows in second or later lactation.

**Overall Culling**

Culling in these herds was from two to five times as great among cows with health problems as among cows in the HEALTHY group (Table 1). The least squares solutions for effect of parity and health status on %CULLED (Figure 1) are deviations from percentage of cows removed among first-lactation cows in HEALTHY group. Among first-lactation cows, 12 and 15% more cows were removed from MNRPROB and MJRPROB health status groups than from HEALTHY group. For multiparous cows 6.6, 15.9, and 27.4% more cows were culled from HEALTHY, MNRPROB, and MJRPROB groups than culling among first-lactation cows in HEALTHY group.

Total culling of 18.3% can be subdivided by reasons for removal given by dairy producers as follows: 4.9% culling for low production, milking problems, or poor type; 9.4% culling for problems related to reproduction; and 4.1% for death, injuries, mastitis, or other health prob-

---

Journal of Dairy Science Vol. 67, No. 8, 1984
HEALTH AND REPRODUCTION

lems. Amount of culling perceived by the dairy producers for reasons related to production or reproduction is in line with 4 to 7% culling for production and 8 to 12% culling for reproduction (1, 3, 25). We concluded that relatively low total culling in these herds was mainly the result of reduced forced culling for health problems other than reproduction. Culling for mastitis especially was low and was probably the result of a good program of mastitis control.

Age, Health, and Culling

To investigate if distribution of cows in three health status classes (HEALTHY, MNRPROB, and MJRPROB) was affected by age, a \( \chi^2 \) test for independence between parity groups (cows in first lactation and cows in second or greater lactation) and health status was performed. The \( \chi^2 = 7.41 \) with 2 df was significant (\( P<.02 \)), and the hypothesis of independence was rejected. This test confirmed statistically the trend generally prevailing in the literature of increased incidence of health problems with increasing age (1, 5, 8, 23).

A \( \chi^2 \) test for independence was also to determine statistical association between health status and culling outcome with two outcome classes considered, i.e., cows surviving to next parturition and cows culled during current lactation. The test \( \chi^2 = 25.7 \) with 2 df was significant (\( P<.005 \)), and the hypothesis of independence was rejected.

Effect of health status as a risk factor upon cow removal also was evaluated by odds ratio (OR), attributable rate (AR), and attributable proportion (AP) measures (26). These measures for first-lactation cows and for cows in second or later lactation are in Table 2.

The OR compares the odds of a cow in MNRPROB or MJRPROB group being culled to the odds of a cow from the HEALTHY group being culled. The OR in Table 2 show that, compared with HEALTHY cows of similar parity, cows with health problems in first lactation are at higher risk of being culled than if they are in second or later lactation. These OR show also that for first-lactation cows, risk of being culled associated with minor and major health problems is similar (4.3 vs. 5.2). However, for older cows, MJRPROB group is at relatively higher risk than MNRPROB (3.7 vs. 1.9). These results compare with higher risk associated with health problems reported by Cobo-Abren (6, 7).

The AR measures culling rate among cows in a health problem group over and above culling rate among healthy cows of same age group. The AR in Table 2 show largest percentage of additional culling among older cows in MJRPROB group, with AR of 20.5%.

The AP measures proportion of cows culled from a health-status parity group that can be attributed to health problems of the group. The AP in Table 2 show that for first-lactation cows 73.2 and 77.2% of the culling decisions can be

<table>
<thead>
<tr>
<th>Parity health status groups</th>
<th>Odds ratio</th>
<th>Attributable rate</th>
<th>Attributable proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNRPROB vs. HEALTHY</td>
<td>4.3</td>
<td>11.9</td>
<td>73.2</td>
</tr>
<tr>
<td>MJRPROB vs. HEALTHY</td>
<td>5.2</td>
<td>14.7</td>
<td>77.2</td>
</tr>
<tr>
<td>Second or later lactation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNRPROB vs. HEALTHY</td>
<td>1.9</td>
<td>7.9</td>
<td>41.4</td>
</tr>
<tr>
<td>MJRPROB vs. HEALTHY</td>
<td>3.7</td>
<td>20.5</td>
<td>64.7</td>
</tr>
</tbody>
</table>

\[a\] Cows with no health problems during the lactation in the study (HEALTHY); cows with reproductive related problems not severe enough to require treatment (MNRPROB); and cows with health problems that required veterinary assistance and treatment (MJRPROB).

Journal of Dairy Science Vol. 67, No. 8, 1984
attributed to health problems. Health status plays a less prominent role in culling decisions for older cows with AP 41.4 and 64.7%.

All risk measures in Table 2 should be interpreted with existing differences in culling rate and incidence of health problems between first-lactation and older cows in mind. In these data, culling rate was 11.5% for first lactation and 21.2% for older cows, whereas proportion of cows with minor or major health problems was 53.4% for first lactation and 61.1% for older cows. When these differences are considered, the conclusion from Table 2 is that cows with health problems, compared to healthy cows in the same age group, are at a considerably higher risk of being culled in first lactation than in second or later lactations.

Distribution of cows culled for various reasons, in percentages of total removal rate among cows in various health-status groups, is in Table 3. Data in this table show that as severity of health problems increased, proportion of cows culled for reproductive reasons also increased from 38.9% of all culls among HEALTHY cows to 42.1 and 58.5% of all culls among cows in MNRPROB and MJRPROB health-status groups. To determine statistical association between health-status and distribution of cows culled by reason of removal, a $\chi^2$ test for independence was performed. The test $\chi^2 = 2.83$, with 4 df, resulted in the hypothesis of independence being accepted.

**Time of Culling and Milk Yield**

For a more complete evaluation of culling strategy, days postpartum when cows actually were removed from the herd (DAYSOUT) and their milk production measured by AVGMILK also were investigated. Averages for these measures for cows culled (classified by reason of removal), parity, and health-status are in Table 4. In general, data in Table 4 show that first-lactation culls left the herd earlier in lactation than culls from second or later lactation.

The DAYSOUT and AVGMILK were used to describe strategy of production culling in these herds. The DAYSOUT and AVGMILK for all culls for production in first lactation were 73 days and 13.3 kg whereas for culls for production in second or later lactation these same measures were 240 days and 23.9 kg. For cows kept in herds, AVGMILK was 24.4 kg and 31.3 kg for first-lactation and older cows. These results indicate that culling for production was a two-stage process summarized: in the first stage dairy farmers culled low producers among first lactation cows, their AVGMILK 11.1 kg lower than for first lactation cows kept in herds, and they removed them from the herd soon after peak lactation. In the second stage, dairy farmers culled low producers among older cows, but the milk differential was smaller with AVGMILK only 7.4 kg lower than for older cows kept in herds, and they removed them from herds later in lactation when daily milk production became unprofitable. Distribution of all production culls by parity was 25% for first lactation and 75% for second or later lactation. This distribution is similar to proportion of the two age groups in these herds, indicating a similar selection intensity for the two steps of production culling.

For culls for production and cows culled for reproductive reasons, time of removal from the

<table>
<thead>
<tr>
<th>Reason for culling</th>
<th>All culls</th>
<th>HEALTHY</th>
<th>MNRPROB</th>
<th>MJRPROB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>26.7</td>
<td>33.3</td>
<td>31.6</td>
<td>22.6</td>
</tr>
<tr>
<td>Reproduction</td>
<td>51.1</td>
<td>38.9</td>
<td>42.1</td>
<td>58.5</td>
</tr>
<tr>
<td>Other health</td>
<td>22.2</td>
<td>27.8</td>
<td>26.3</td>
<td>18.9</td>
</tr>
</tbody>
</table>

* Cows with no health problems (HEALTHY); cows with reproductive related problems not severe enough to require veterinary treatment (MNRPROB); and cows with major health problems that required veterinary treatment (MJRPROB).
herd is largely a management decision. Linear regression of DAYSOUT on AVGMILK for cows culled for production and reproductive reasons is plotted (Figure 2). A close relationship exists between these two variables; thus, we concluded that actual time when a cow designated as a productive or reproductive cull is removed from herds is a function of milk production, and this correlation between milk yield and DAYSOUT is close and positive. Linear regression between two two variables shows a 12-day delay in removal time per 1 kg increase in AVGMILK.

Culling is a complex decision, and in most circumstances there are several contributing factors. Results in Table 4 support this. For reproductive culls, milk yield was lower than for cows of the same parity and health-status that survived in these herds, so lower milk yield was a contributing cause. However, all first-lactation cows culled for production were open, and only 39% of the production culls from second or later lactation were pregnant, so reproductive status also probably contributed to the decision to cull these cows.

Reproductive Traits and Health

To evaluate reproductive performance of cows in health-status groups, several traits generally used to describe reproductive performance were analyzed. Least squares solutions for FSTESTR, FSTSERV, and DAYSOPEN are

| Table 4: Average daily milk (kg) for first four Dairy Herd Improvement test days (AVGMILK) and time (days postpartum) of removal from the herd (DAYSOUT) for cows classified by reason for culling, parity, and health status. |
|-----------------|-----------------|-----------------|-----------------|
| Reason for culling | Lactation = 1 | Lactation = 2 | Lactation > 2 |
| Trait | HEALTHY | MINPROMB | MJPRMB | HEALTHY | MINPROMB | MJPRMB | HEALTHY | MINPROMB | MJPRMB |
| AVGMILK | 16.5 | 26.4 | 23.2 | 12.3 | 25.9 | 21.8 | 9.5 | 28.7 | 24.3 |
| DAYSOUT | 46 | 102 | 198 | 102 | 271 | 272 | 102 | 271 | 272 |

Figure 2. Linear regression of days from parturition to culling (DAYSOUT) on average milk yield for first four Dairy Herd Improvement (DHI) tests (AVGMILK) for all culls.
Figure 3. Least squares solutions for days from parturition to first estrus (FSTESTR), first service (FSTSERV), and conception (DAYSOPEN) expressed as a deviation from performance of the first lactation HEALTHY group. H = HEALTHY, cows without health problems, M = MNRPROB, cows that received treatment by dairy producers, V = MJRPROB, cows that received treatment by veterinarian.

Fertility was estimated by pregnancy rate for first service (FSTPGN%). Least squares solutions for cows of different parity and health-status for this trait are in Figure 4. Solutions are deviations from performance of first-lactation cows in HEALTHY. These solutions are unexpected, because FSTPGN% was slightly greater for first-lactation cows in MNRPROB and MJRPROB group than for cows in HEALTHY. The only significant (P<.01) decline of FSTPGN% was among cows in second or later lactation in MJRPROB.

Some solutions in Figure 3 may seem inconsistent. For example, first-lactation cows in MNRPROB had their first estrus detected 4.5 days later and were serviced first 9.1 days later, but they were open 7 fewer days than first-lactation cows in HEALTHY. Discrepancies of the same nature also exist for cows in second or later lactation in HEALTHY. Reasons for these inconsistencies are probably complex, but two most likely factors are differential management applied to cows of different parity and health-status and differences in fertility associated with age and health-status.
Although it was not the objective to determine if cows of different parity and health-status are treated differently in management, some of the results in Table 1 indicate that management practices were different. Maximum numbers of days to first service was influenced by parity and health-status. Compared with HEALTHY, cows in MNRPROB and MJRPROB had maximum FSTSERV greater by 25 and 60 days during first lactation and by 7 and 17 days during second or later lactation. These limits seem to indicate that the dairy producers did not delay deliberately first breeding in cows with health problems to allow time for recovery but rather that policy for first breeding was open-ended and capable of accommodating eventual delay in time when a cow was suitable for breeding as a result of health problems. Maximum number of services and maximum number of open days in Table 1 indicate different management for cows of different parity and health status. Dairy producers seem to favor HEALTHY cows in first lactation, because they were allowed up to six services and a maximum 302 DAYSOPEN, whereas first-lactation cows in MNRPROB and MJRPROB were allowed only three and four services prior to conception with maximum DAYSOPEN of 157 and 246. This practice indicates selection against cows with health problems in first lactation. For older cows, tendency was toward adjusting breeding policy to the decline in fertility caused by health problems, because cows with health problems were allowed more services and longer open periods. Maximum number of services were three, four, and six, and maximum days open 214, 246, and 236 for cows in HEALTHY, MNRPROB, and MJRPROB. With these groups of cows, dairy producers’ efforts seemed to be toward salvaging them, because a more tolerant breeding policy was applied. These evidences of differential treatment are also consistent with risk in Table 2. There is no biological reason to believe that health problems are more critical for younger than for older cows; therefore, differential culling policy is the factor most likely responsible for the higher risk of being culled because of health problems during first lactation.

Because of interactions between biological and management factors, use of any traits considered as a single evaluation of reproductive performance would be misleading. To describe and compare more adequately the reproductive performance of cows grouped by parity and health-status, fertility status (FS), developed by Esslemont and Eddy (9), was used. This index was:

\[
FS = \frac{FSTPGN}{SRV/PGN} - (DAYS\,OPEN - 125) - (%\,CULLED - 25),
\]

and indexes are in Table 1. Except for first-lactation cows in HEALTHY, for which differential management resulted in a higher number of services per conception, FS in Table 1 illustrates the decline of fertility caused by health problems. They also show effects of health related problems on fertility, as measured by FS, is greater for older cows than for first-lactation cows.

ACKNOWLEDGMENTS

This research was supported in part by grants from Abbott Laboratories and VA-NC Select Sires, Inc. We acknowledge the excellent technical assistance by Peter Brodbeck in collecting data. We thank the producers who cooperated in the study.

REFERENCES

9 Esslemont, R. J., and R. G. Eddy. 1977. The con-
11 Hoard’s Dairyman Round Table. 1979. How these dairymen cull their herds. Hoard’s Dairyman 124:1474.
22 Snyder, D. P. 1978. One way or the other, replacement heifers cost money. Hoard’s Dairyman 123:151.

Journal of Dairy Science Vol. 67, No. 8, 1984