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# The Rates and Patterns of Survivorship and Disease in a University Dairy Herd

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SUMMARY

The rates and patterns of disease occurrence and survivorship were determined over a six year period in a university operated dairy herd. Of the ten diseases selected for study, clinical mastitis occurred most frequently with an incidence rate of 10.1% and displaced abomasum occurred least frequently with an incidence rate of 4.4%. The occurrence of all diseases except those of the ovary was associated with the age of the cow. Mastitis, pneumonia and cystic graafian follicles tended to reoccur in the same cow after the initial occurrence.

The average culling rate was 25.6% and the median number of years cows survived in the herd was 3.4 years.

Methods for calculating the various rates and survivorship are described and their interpretation discussed.

RÉSUMÉ

**Le taux et le profil d'incidence des maladies et de survie, au sein d'un troupeau laitier appartenant à une université**

Cette expérience visait à déterminer, sur une période de six ans et au sein d'un troupeau laitier appartenant à une université, le taux et le profil d'incidence des maladies et de survie. Parmi les dix maladies choisies à cette fin, la mammite manifesta le taux d'incidence le plus élevé, soit 10,1%, contrairement au déplacement de la caillette dont le taux d'incidence n'atteignit que 4,4%. L'incidence de toutes ces maladies, à l'exception de celles des ovaires, s'avéra reliée à l'âge des vaches. La mammite, la pneumonie et les kystes folliculaires manifestèrent une tendance à la récidive.

Le taux moyen d'élimination s'établissait à 25,6% et le nombre moyen d'années durant lesquelles les vaches demeurèrent dans le troupeau s'élevait à 3,4 ans.

Les auteurs décrivent les méthodes qu'ils utilisèrent pour effectuer leurs calculs et ils en commentent l'interprétation.

## INTRODUCTION

Veterinarians having preventive medicine programs with dairy farming clients, are concerned with: level of productivity, in terms of milk and/or calves, survivorship and disease patterns in the herds. Discussions of these topics are available in the literature. However, there is a shortage of quantitative data on disease and productivity and their interrelationship.

The purpose of this study was to apply standard statistical and demographic techniques to determine the level and pattern of culling and disease in a university operated dairy herd. Estimates of duration of stay in the herd (survivorship) were also made.

## MATERIALS AND METHODS

The data for this study were based on cows in the University of Guelph Elora Dairy Herd (EDH) and were obtained from the Medical Case Abstract System (MEDCAS) at the Ontario Veterinary College (7), the Dairy Herd Improvement Association records, courtesy of the Ontario Ministry of Agriculture and Food and the individual cow records at the EDH.

*Disease Rates and Patterns* — Data were obtained on ten clinical diseases or syndromes including cystic graafian follicles, ovarian hypofunction, metritis (metritis, endometritis and pyometritis), retained fetal membranes, hypocalcemia, ketosis, mastitis (clinical), pneumonia, displaced abomasum and foot problems (any abnormality distal to the carpal or tarsal joint). Only the initial occurrence (diagnosis) of each disease was counted, each occurrence representing one case.

The rates of disease were calculated for all cows in the EDH on or after January 1, 1970 through

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December 31, 1975. The total number of cases of each disease was used as the numerator. The denominator was formed by counting each cow once for each year that cow was in the herd. No cows were credited with time spent in the herd prior to 1966. Because of the possibility of only a few cases at each age, the ages were grouped into $2<4$, $4<7$, $7<10$ and $\geqslant 10$ years of age. The formula used to calculate the morbidity rate was:

$$\text{Morbidity rate} = \frac{\text{Total number of cases, by age group}}{\text{Total number of cow years, by age group}}$$

The chi-square test for linear trend was used to assess any association of risk of disease with age (9).

A frequency table with the number of occurrences per cow, of each disease, was created. The poisson test was used to ascertain if there was a tendency of a disease to reoccur after the first presentation in the same cow (20). Only cows entering the herd on or subsequent to January 1, 1970 and remaining in the herd two or more years, were included.

*Survivorship Studies* — All cows (except for four) leaving the EDH during the period January 1, 1970 to December 31, 1976 were designated as "culled" cows. Age-specific culling rates, by year, were calculated using culling rates observed during each of the seven years from 1970 to 1976. These were designated as current culling rates and the formula was as follows:

$$\text{Current culling rate} = \frac{\text{Number of cows of age "a" culled during a given year}}{\text{Number of cows of age "a" observed at the beginning of a given year (January 1), minus one half of the no. of cows of age "a" sold during the year}}$$

In addition, cows were grouped according to the year of entry into the EDH from 1970 to 1976 and each group was designated as a separate cohort. The culling rates experienced by each of these cohorts were calculated in a manner similar to that used for the current culling rates. The formula was as follows:

$$\text{Cohort culling rate} = \frac{\text{Number of cows from that cohort culled each year subsequent to herd entry}}{\text{Number of cows from that cohort in the EDH on January 1 of that year minus one half of the no. of cows sold, from that cohort, that year}}$$

The averages of the current age-specific culling rates for the years 1970-76 were used to develop a life table (15). This life table presents the average

TABLE I
AGE-SPECIFIC RATES OF TEN DISEASES FOR COWS IN THE ELORA DAIRY HERD FROM 1970 TO 1975

| Disease | Age Group | | | | Average | Trend with Age[a] |
|---|---|---|---|---|---|---|
| | 2<4 | 4<7 | 7<10 | ⩾10 | | |
| Cystic graafian follicles | 0.081 | 0.084 | 0.076 | 0.074 | 0.081 | None |
| Displaced abomasum | 0.028 | 0.047 | 0.076 | 0.074 | 0.044 | 0.008 |
| Foot problems | 0.053 | 0.043 | 0.108 | 0.074 | 0.056 | 0.007[b] |
| Hypocalcemia | 0.005 | 0.043 | 0.178 | 0.185 | 0.049 | 0.030[b] |
| Ketosis | 0.016 | 0.069 | 0.043 | 0.111 | 0.045 | 0.009[b] |
| Mastitis | 0.065 | 0.106 | 0.162 | 0.296 | 0.101 | 0.022 |
| Metritis | 0.071 | 0.076 | 0.097 | 0.222 | 0.079 | 0.010 |
| Ovarian hypofunction | 0.056 | 0.045 | 0.054 | 0.074 | 0.051 | None |
| Pneumonia | 0.081 | 0.026 | 0.016 | 0.111 | 0.049 | -0.009[b] |
| Retained placenta | 0.051 | 0.060 | 0.054 | 0.222 | 0.059 | 0.007[b] |

[a]Only those trends (slopes) significant at $p \leqslant 0.05$ are listed.

[b]NL=The trends were not linear with age (9).

TABLE II
THE FREQUENCY OF OCCURRENCE OF SPECIFIED DISEASES IN 199 COWS[a] IN THE ELORA DAIRY HERD DURING THE PERIOD 1970-1976

| Disease | Number of Occurrences | | | | | | | Poisson Test for Clustering |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| Mastitis | 147 | 33 | 14 | 5 | 0 | 0 | 0 | 20.55[b] |
| Pneumonia | 180 | 14 | 2 | 2 | 0 | 1 | 0 | 10.20[b] |
| Metritis | 157 | 35 | 5 | 2 | 0 | 0 | 0 | 0.98 |
| Retained placenta | 167 | 29 | 3 | 0 | 0 | 0 | 0 | 0.07 |
| Cystic graafian follicles | 163 | 26 | 9 | 0 | 0 | 0 | 1 | 8.91[b] |
| Ovarian hypofunction | 169 | 27 | 3 | 0 | 0 | 0 | 0 | 0.23 |
| Ketosis | 166 | 27 | 5 | 1 | 0 | 0 | 0 | 2.83 |
| Displaced abomasum | 171 | 26 | 2 | 0 | 0 | 0 | 0 | 0.002 |
| Hypocalcemia | 174 | 21 | 1 | 2 | 1 | 0 | 0 | 2.89 |
| Foot problems | 173 | 22 | 3 | 1 | 0 | 0 | 0 | 2.35 |

[a]Only cows in the herd two or more years were included.

[b]Significant at $p \leq 0.05$ (20).

number of years of life in the EDH remaining for cows at each age. In addition, data from the seven cohorts of cows were used to create a follow-up life table (15). The follow-up life table presents the probability of a cow surviving a specified number of years in the herd and was used to estimate the median number of years cows survived in the EDH.

## RESULTS

The age-specific rates of disease are shown in Table I. Mastitis (clinical) occurred most frequently (10.1%); whereas, displaced abomasum occurred least frequently (4.4%). The rate (risk) of all diseases, except those of the ovaries, changed with age. Pneumonia occurred more frequently in younger than in older cows; whereas, the remaining diseases occurred more frequently as age increased. The poisson test indicated a significant ($p \leq 0.05$) clustering of disease per cow for mastitis, pneumonia and cystic graafian follicles (Table II).

Three hundred and twenty-four cows were culled between 1970 and 1976. The culling rates varied considerably by age within year, but tended to increase with age. The yearly averages were quite variable (Table III).

Table IV summarizes the results of culling in cohorts by year. A high proportion of cows first calving in 1972 (16%), were culled that same year, while no cows were culled during the year of entry among those entering in 1973. There was a tendency for the rates to increase with each additional year in the herd, and there were no obvious differences between cohorts. The average of the cohort culling rates for the first year through the seventh year in the herd were: 0.061, 0.187, 0.247, 0.214, 0.302, 0.482 and 0.583 respectively.

The "expectancy of life" based on cows in the EDH during 1970-76 is shown in Table V. The greatest decrease in life expectancy for cows less than 11 years of age occurs at three years of age.

The survivorship of cows entering the EDH, subsequent to January 1, 1970 is shown in Table VI. The probability of surviving a specified number of years in the herd is shown in the column titled "$P_x$." The median years of survivorship (the point at which $P_x = 0.5$) was 3.4 years.

## DISCUSSION

The EDH is a university operated dairy herd and as such may be somewhat atypical of other dairy herds in Ontario. Thus, the disease rates and culling rates may or may not represent the current status or optimal levels of disease and culling in other dairy herds. Nevertheless, we believe that the observed associations between age, and culling or disease, are likely representative of age effects in other dairy herds. More importantly, veterinarians and animal scientists need to be aware of the levels and patterns of disease and/or culling in herds

TABLE III
AGE-SPECIFIC CURRENT CULLING RATES BY YEAR, FOR COWS IN THE ELORA DAIRY HERD, DURING THE PERIOD 1970-1976

| Age in Years | Probability not surviving in the herd/year | | | | | | | Average by Age[a] |
|---|---|---|---|---|---|---|---|---|
| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | |
| 2 | 0.013 | 0.023 | 0.222 | 0.000 | 0.000 | 0.057 | 0.105 | 0.060 |
| 3 | 0.155 | 0.163 | 0.302 | 0.255 | 0.091 | 0.171 | 0.228 | 0.195 |
| 4 | 0.115 | 0.217 | 0.190 | 0.276 | 0.111 | 0.129 | 0.290 | 0.190 |
| 5 | 0.285 | 0.428 | 0.190 | 0.137 | 0.250 | 0.036 | 0.500 | 0.261 |
| 6 | 0.286 | 0.300 | 0.363 | 0.296 | 0.097 | 0.307 | 0.545 | 0.313 |
| 7 | 0.454 | 0.750 | 0.333 | 0.250 | 0.250 | 0.343 | 0.307 | 0.384 |
| 8 | 0.125 | 0.333 | 0.666 | 0.333 | 0.143 | 0.273 | 0.200 | 0.296 |
| 9 | 0.600 | 0.600 | 0.666 | 1.000 | 0.000 | 0.250 | 0.222 | 0.478 |
| 10 | 0.428 | 0.000 | 0.000 | 0.500 | 1.000 | 0.000 | 0.000 | 0.275 |
| 10+ | 1.000 | 0.333 | 0.000 | 0.666 | 0.000 | 0.000 | 1.000 | 0.428 |
| Average by year[b] | 0.281 | 0.294 | 0.281 | 0.297 | 0.142 | 0.155 | 0.342 | 0.256 |

[b]Directly standardized rates — using average population distribution (15).

under their control, in order to adequately assess the productivity — real and potential — of these herds. The methods utilized in this study should be of value in this regard.

A previous paper (7) reviewed the diagnostic criteria (as found in MEDCAS) for most of the diseases in this study, and the authors noted a great variability in the recorded criteria. These authors concluded that infections of the uterus could all be pooled into one category: namely, metritis. Further, the diagnostic category ovarian hypofunction was a catch-all category and basically described repeat breeder cows not ovarian hypofunction as described by Roberts (17). Ketosis in most instances, was secondary to other syndromes. Another factor to bear in mind when making comparisons with other work is whether or not the diagnosis refers to only clinical or to both clinical and subclinical disease. This problem is most acute for diseases like mastitis and ketosis.

The frequency of occurrence of the diseases in this study was between four and ten percent per cow year. These levels of disease appear consistent with the majority of references in the literature (6). With the exception of the ovarian diseases and pneumonia, the occurrence of all diseases increased directly with age. In many cases, the increase was not purely linear. However, we did not attempt to transform the data or use curvilinear methods in order to obtain a better fit.

The rate of occurrence of cystic graafian follicles (CGF), appeared to be unrelated to the age of a cow. This is in agreement with other workers' findings (4, 7, 12, 17). A significant reoccurrence of CGF after the initial case was noted in our study although Menge *et al.*(14) stated that cystic ovaries did not tend to reoccur in the same cow.

The rate of occurrence of abomasal displacement increased with age. Martin (13) found no significant difference but inferred a tendency to increased risk in older cows. Robertson (18), Svendsen (22) and Erb (8) reported that four to six year old cows were at increased risk. There was no tendency for repeat occurrences of the disease in affected cows. The latter is not surprising given that in surgical correction of most instances of displaced abomasum, the abomasum is sutured to the abdominal floor.

The average rate of foot problems in cows in our study was 5.6% and the risk of foot problems increased with age. There was no tendency for repeat occurrences of foot problems in affected cows.

The rate of hypocalcemia clearly increased with

TABLE IV
COHORT CULLING RATES FOR COWS IN THE ELORA DAIRY HERD DURING THE PERIOD 1970-1976

| Year of Exit | Year of Entry into the Elora Dairy Herd | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 |
| 1970 | 0.048 | | | | | | |
| 1971 | 0.152 | 0.054 | | | | | |
| 1972 | 0.258 | 0.302 | 0.160 | | | | |
| 1973 | 0.204 | 0.243 | 0.143 | 0.000 | | | |
| 1974 | 0.231 | 0.107 | 0.167 | 0.083 | 0.031 | | |
| 1975 | 0.060 | 0.120 | 0.100 | 0.182 | 0.161 | 0.086 | |
| 1976 | 0.583 | 0.364 | 0.556 | 0.444 | 0.385 | 0.281 | 0.050 |

TABLE V

CURRENT LIFE TABLE FOR COWS IN THE ELORA DAIRY HERD DURING THE PERIOD 1970-1976

| Age (x) | ${}_nq_x$ | $l_x$ | ${}_nC_x$ | ${}_nL_x$ | $T_x$ | $e_x$ |
|---|---|---|---|---|---|---|
| 2 | 0.060 | 10000 | 600 | 9700 | 40363 | 4.03 |
| 3 | 0.195 | 9400 | 1833 | 8484 | 30663 | 3.26 |
| 4 | 0.190 | 7567 | 1438 | 6848 | 22179 | 2.93 |
| 5 | 0.261 | 6129 | 1600 | 5329 | 15331 | 2.50 |
| 6 | 0.313 | 4529 | 1418 | 3820 | 10002 | 2.21 |
| 7 | 0.384 | 3111 | 1195 | 2514 | 6182 | 1.99 |
| 8 | 0.296 | 1916 | 567 | 1633 | 3668 | 1.91 |
| 9 | 0.478 | 1349 | 645 | 1027 | 2035 | 1.51 |
| 10 | 0.275 | 704 | 194 | 607 | 1008 | 1.43 |
| 10+ | 0.428 | 510 | 218 | 401 | 401 | 0.78 |

$x$ Age in years.

${}_nq_x$ Probability of being culled between x and x+1 years for those cows alive at x.

$l_x$ Number of cows, in a hypothetical population, alive at x.

${}_nC_x$ Number of cows culled in the interval x to x+1 years.

${}_nL_x$ Total number of years of life, contributed in the interval x to x+1 years, by those cows reaching age x.

$$ {}_nL_x = l_x - 0.5({}_nC_x) $$

$T_x$ Accumulated years of life after age x for those $l_x$ alive at x.

$e_x$ Average number of years of life remaining for cows at age x.

$$ e_x = T_x / l_x $$

age (Table V). This, in general, agrees with previous work in southern Ontario (7), that cows being less than seven years of age had a decreased risk, whereas cows older than seven years were at increased risk. There was no tendency for repeat occurrences of hypocalcemia in affected cows. This is possibly related to a preventive treatment with a vitamin D preparation given to all cows, in the EDH, on subsequent calvings after having experienced hypocalcemia. Also, the risk of hypocalcemia increases sharply with age and most of the cows in this aspect of the study were quite young.

The rate of ketosis increased with age. This is in agreement with previous work (7), that cows in southern Ontario, four through six years old, were at increased risk. There was no tendency for repeat occurrences of ketosis in affected cows. It should be noted, that virtually all of the cases of ketosis in our study were secondary in nature, and therefore, the occurrence of ketosis is really a general indicator of diseases which interfere with caloric intake, digestion or feed utilization.

There was a clear increase in the occurrence of clinical mastitis with age. This agrees with the reports of Rendel and Sundberg (16) and with Batra *et al* (3), who studied cows in the EDH. It disagrees with previously reported findings, that young Holsteins in southern Ontario were at increased risk (7). It should be noted that Batra *et al* (3) defined a clinical case of mastitis to be any mammary gland condition requiring the infusion of antibiotics, whereas, in our study a case of clinical mastitis was defined only when diagnosed by a veterinarian. A significant reoccurrence of mastitis after the initial case was noted in agreement with other workers (16).

The incidence rate of metritis increased with age (Table V), which disagrees with previous work (7), that young cows in southern Ontario were at increased risk. There was no tendency for repeat occurrence of metritis in affected cows.

There was no particular pattern in the risk of ovarian hypofunction with age nor was there any tendency for repeat occurrences in the same cow. Obviously, before one can interpret the importance of "ovarian hypofunction," there will need to be refinement and standardization of diagnostic terminology.

Younger cows had higher rates of pneumonia and there was also a significant reoccurrence of pneumonia in the same cow after the initial case was noted.

The occurrence of retained placenta (retained fetal membranes) increased with age. This agrees in part with Wetherill (23) who found that retained placenta was more common in first-calf heifers and in older cows than in cows in their second through fourth lactations. The relatively low rate for the younger cows found in our study may be related to the institutional policy in OVC of only attending cases of retained placenta that were accompanied by systemic signs of disease. This began in 1972 and effected a sharp drop in the number of cases of retained placenta from 1972 on (7). Roberts (17) reported that the incidence rises with age, whereas in previous work, an increased risk in seven through nine year old cows was observed (7). There was no tendency for repeat occurrences of the disease in affected cows in our study, which disagrees with other workers (8).

The culling rates in this study were calculated using life table methods. These methods express

TABLE VI

FOLLOW-UP LIFE TABLE FOR COWS ENTERING THE ELORA DAIRY HERD DURING THE PERIOD 1970-1976

| Interval $x<(x+1)$ | $O_x$ | ${}_nC_x$ | ${}_nW_x$ | ${}_nObs_x$ | ${}_nP.A.R._x$ | ${}_nq_x$ | ${}_np_x$ | $P_x$ | S.E.($P_x$) |
|---|---|---|---|---|---|---|---|---|---|
| 0<1 | 324 | 23 | 0 | 38 | 305 | 0.075 | 0.925 | 0.925 | 0.015 |
| 1<2 | 263 | 50 | 4 | 23 | 249.5 | 0.200 | 0.800 | 0.740 | 0.026 |
| 2<3 | 186 | 46 | 0 | 16 | 178 | 0.258 | 0.742 | 0.549 | 0.031 |
| 3<4 | 124 | 24 | 0 | 10 | 119 | 0.202 | 0.798 | 0.438 | 0.032 |
| 4<5 | 90 | 27 | 0 | 12 | 84 | 0.321 | 0.679 | 0.297 | 0.031 |
| 5<6 | 51 | 26 | 0 | 14 | 44 | 0.591 | 0.409 | 0.122 | 0.025 |
| 6<7 | 11 | 6 | 0 | 5 | 8.5 | 0.706 | 0.294 | 0.036 | 0.020 |

$x<(x+1)$ Survivorship interval after x. x is the completed years of life after entry to the herd.

$O_x$ Number of cows observed in the herd at x.

${}_nObs_x$ Number of cows observed for a period between x and x+1 years.

${}_nW_x$ Number of cows withdrawn from the herd for unknown reasons, between x and x+1 years.

${}_nC_x$ Number of cows culled or dying between x and x+1 years in the herd.

${}_nP.A.R._x$ Population at risk in the interval $x<x+1$ years $= O_x - {}^1/_2\ ({}_nW_x - {}_nObs_x)$

${}_nq_x$ Probability of cows alive at time x, being culled before year x+1.

${}_np_x$ Probability of cows alive at time x, not being culled before year x+1 (${}_np_x = 1 - {}_nq_x$).

$P_x$ Proportion of cows surviving the interval $x<(x+1)$ years after herd entry (i.e. to the time x+1 years).

$SE(P_x)$ Standard error of $P_x$.

the force of culling at different ages in a consistent probability manner. Current life table techniques are common in human vital statistics and were used to derive the culling rates observed each year from 1970 through 1976. Current methods relate health phenomena and culling at given periods to the environments at those periods. Latent intervals are necessarily ignored, since effects are treated as if they were current characteristics of the age groups as they exist at the point of analysis (21). That is, current culling rates are assumed to be due to current conditions of production, health status, market conditions, etc. Cohort methods, follow a population of individuals born in a given year (in our case, a group of cows entering the herd in a given year) over time. Cohort methods can be used to reveal the effect of those differences in early life experiences that persist through time to manifest themselves only at later ages (21).

Virtually all of the culling rates reported for dairy cattle are based on current life table methods, and most are crude culling rates, i.e. not age-specific. We do not intend that practitioners calculate age-specific culling rates in all their herds. However, the normal changes in rate of culling with age need to be identified. Further, it seems obvious that an average culling rate of 20% has one meaning if 80% of these cows are above five years of age and another meaning if 80% of these cows are less than five years of age.

In our study, the average culling rate, standardized for age to facilitate intraherd comparison, was 25.6%. This rate was in basic agreement with rates reported by other workers (1). There was much year to year variation, but no clear year to year pattern. The age-specific culling rates varied from year to year and with respect to age. Nevertheless, the culling rates tended to increase with age from 6% in two year old cows to 43% in cows being ten years of age or older. It is notable that the largest relative increase occurred at three years of age. The rate appeared to be stable or have a slight decrease at four years of age, whereas, thereafter, the rates increased directly with age.

The age-specific rates for institutional herds reported by Allaire *et al* (1) appear close to those found in our study. These workers reported rates of 0.059, 0.153, 0.179, 0.215, 0.231, 0.247, 0.262, 0.299 and 0.345 for ages two through ten respectively.

The cohort-based culling rates are related to the number of years in the herd after herd entry and are, therefore, not strictly age-specific rates. Nevertheless, most cows enter the herd at between two to three years of age and, therefore, some similarities to the age-specific rates of cross-sectional methods are likely to be observed. For example, the average culling rates for the first through seventh year in the herd, closely resembled the current rates for two to nine year old cows. Once again, the great increase in the culling rates during the second year in the herd (i.e. at three to four years) was evident. The usefulness of cohort-based rates has not been established in veterinary medicine, although they may offer insight into why changes in current rates are occurring.

Follow-up life tables were used to estimate the median survival time of cows after herd entry. Such an approach is necessary because the median survival time cannot, in general, be directly estimated from average culling rates. The median survival time for all 324 cows was 3.4 years. Estimates of survival in other herds vary from 3.4 lactations (10, 19) to 2.9 years (11).

In order to compare our data on culling with other workers who have used an "expectancy of life" approach to estimating survivorship, we used the average current culling rates to develop a complete life table. Again, the greatest decrease in life expectancy occurs at three years of age, as a result of the increase in culling rates previously mentioned. These rates, in general, agree quite well with some reports (2), but are lower than in others (5).

Despite the fact that the EDH is a university operated dairy herd, the disease and culling rates during the period 1970-1976 did not differ greatly from those reported for other areas, times and management systems. The methods presented here should be of value to veterinarians who wish to analyse, in some detail, the events in their clients' herds. Such analyses should help pinpoint the problem areas and greatly improve the quality of the advice which veterinarians provide to farmers.

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## REFERENCES

1. ALLAIRE, F.R., H.E. STERWERF and T.M. LUDWICK. Variations in removal reasons and culling rates with age for dairy females. J. Dairy Sci. 60: 254-267. 1977.
2. ANDRUS, D.F., A.E. FREEMAN and B.R. EASTWOOD. Age distribution and herd life expectancy in Iowa dairy herds. J. Dairy Sci. 53: 764-771. 1970.
3. BATRA, T.R., B.J. NONNECKE, F.H.S. NEWBOULD and R.R. HACKER. Incidence of clinical mastitis in a herd of Holstein cows. J. Dairy Sci. 60: 1169-1172. 1977.
4. BIERSCHWAL, C.J. A clinical study of cystic conditions of the bovine ovary. J. Am. vet. med. Ass. 149: 1591-1595. 1966.
5. CANNON, C.Y. and E.N. HANSEN. Expectation of life in dairy cows. J. Dairy Sci. 22: 1025-1032. 1939.
6. COBO-ABREU, R.E. A study of disease, culling and production in the University of Guelph Elora dairy herd. M.Sc. Thesis, University of Guelph. 1978.
7. ERB, H.N. and S.W. MARTIN. Age, breed and seasonal patterns in the occurrence of ten dairy cow diseases: A case control study. Can. J. comp. Med. 42: 1-9. 1978.
8. ERB, R.E., P.M. HINZE, E.M. GILDOW and R.A. MORRISON. Retained fetal membranes — The effect on prolificacy of dairy cattle. J. Am. vet. med. Ass. 133: 489-496. 1958.
9. FLEISS, J.L. Statistical methods for rates and proportions. New York: J. Wiley and Sons. 1973.
10. FOSGATE, O.T. Rate, age and criteria for disposal in a herd of registered Jersey cattle. J. Dairy Sci. 48: 1481-1484. 1965.
11. GILL, G.S. and F.R. ALLAIRE. Relationship of age at first calving, days open, days dry and herd life to a profit function for dairy cattle. J. Dairy Sci. 59: 1131-1139. 1976.
12. KRONFELD, W. Cystic degeneration of the bovine. Georgia vet. 12: 11-18. 1960.
13. MARTIN, S.W. Left abomasal displacement: An epidemiological study. Can. vet. J. 13: 61-68. 1972.
14. MENGE, A.C., S.E. MARES, W.J. TYLER and L.E. CASIDA. Variation and association among post partum reproduction and production characteristics in Holstein-Friesian cattle. J. Dairy Sci. 45: 233-241. 1962.
15. REMINGTON, R.D. and M.A. SCHORK. Statistics with Applications to the Biological and Health Sciences. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1970.
16. RENDEL, J. and T. SUNDBERG. Factors influencing type and incidence of mastitis in Swedish dairy cattle. Acta. vet. scand. 3: 13-32. 1962.
17. ROBERTS, S.J. Veterinary Obstetrics and Genital Diseases. 2nd Edition. Published by the Author. Ithaca, New York. 1971.
18. ROBERTSON, J.M. Left displacement of the bovine abomasum: Epizootiologic factors. Am. J. vet. Res. 29: 421-434. 1968.
19. SHARMA, K.N.S. and S. SHINGH. Estimation of average production life of cattle on a modern dairy farm. Indian J. Anim. Sci. 44: 145-149. 1974.
20. SOKAL, R.R. and F.J. ROHLF. Introduction to Biostatistics. San Francisco, California: W.H. Freeman and Co., 1973.
21. SUSSER, M. Causal Thinking in the Health Sciences. Concepts and Strategies of Epidemiology. New York, London and Toronto: Oxford University Press. 1973.
22. SVENDSEN, P. Etiology and pathogenesis of abomasal displacement in cattle. Nord. VetMed. 21: suppl. 1. 1-60. 1969.
23. WETHERILL, G.D. Retained placenta in the bovine. A brief review. Can. vet. J. 6: 290-294. 1965.