Age, Breed and Seasonal Patterns in the Occurrence of Ten Dairy Cow Diseases: A Case Control Study

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ABSTRACT

A total of 5,990 occurences of the diseases abomasal displacement, cystic graafian follicles, endometritis, hypocalcemia, ketosis, mastitis, metritis, ovarian hypofunction, pyometra and retained placenta were included in a case control study. The study was based on a hospital population of Holstein, Ayrshire, Guernsey and Jersey cows who were at least two years of age. The data were retrieved from computer storage of material abstracted for the Veterinary Medical Data Program. The transcription of data from original case records to these abstracts was examined as a source of error. An attempt was made to define each of the diseases by reference to random samples of the clinical records. Using the log-odds method, trends were noted for the youngest cows to be at increased risk of the reproductive diseases and for the Guernsey cows to be at increased risk of the uterine diseases. There was a tendency for peaks in disease occurrences in the winter (as opposed to summer) months.

RÉSUMÉ

Cette étude portait sur un contrôle de cas et elle en incluait 5,990 qui se rapportaient aux maladies suivantes: déplacement de la caillette, follicules ovariens kystiques, endométrite, hypocalcémie, acétonémie, mammite, métrite, hypofonctionnement ovarien, pyomètre et rétention placentaire. Elle se basait sur des cas d'hospitalisation impliquant des vaches âgées d'au moins deux ans et appartenant aux races suivantes: Holstein, Ayrshire, Guernsey et Jersey. Les données provenaient de celles d'un ordinateur résumées pour le programme des données médicales vétérinaires de l'Université de Guelph. On vérifia les erreurs qui auraient pu se glisser lors de la programmation des données recueillies à partir des dossiers cliniques. On s'efforça de définir chacune des maladies en se référant à des cas choisis au hasard dans les dossiers cliniques. En utilisant la méthode du risque relatif probable, on réalisa que les plus jeunes vaches manifestaient une tendance à être plus sujettes aux maladies de la reproduction, tandis que les vaches Guernsey semblaient plus sujettes aux maladies utérines. On nota aussi que l'incidence des maladies en cause tendait à atteindre un sommet durant l'hiver plutôt qu'au cours des mois d'été.

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INTRODUCTION

Abomasal displacement, cystic graafian follicles, endometritis, hypocalcemia, ketosis, mastitis, metritis, ovarian hypofunction, pyometra and retained placenta are important diseases of dairy cows. Knowledge of the epidemiology of these ten diseases would assist clinicians in making diagnoses and researchers in designing experiments. Unfortunately the effects of age, breed and season on the incidence of these diseases have not been completely defined.

There are two problems with the literature on the epidemiology of the diseases named above. First, there is a general lack of information. There are only occasional references to increased occurrences of abomasal displacement, cystic graafian follicles and ovarian hypofunction in the winter months and to increased susceptibilities of Jerseys to hypocalcemia and Guernseys to ketosis (2, 13, 21). Cystic graafian follicles are reported to occur with increased frequency from the second through fifth lactations and retained placenta increases in occurrence with age, while hypocalcemia is reported to be most common in the third through seventh lactations (2, 13, 21). The second problem is that it is often unclear whether statements of disease epidemiology are based on measurements of disease incidence or of incidence rates. "Incidence" is a simple count of disease occurrences in a population. "Incidence rate" relates a disease count to the size of the population at risk of developing the disease. An incidence rate is therefore a probability statement of the risk of disease occurrence and is more useful than simple incidence in indicating risk factors associated with the occurrence of disease.

The purpose of this study was to evaluate age and breed as risk factors in these ten diseases of dairy cows and to determine any seasonal patterns of occurrence, using data from the routine clinical records of the Ontario Veterinary College (OVC).

MATERIALS AND METHODS

EXPERIMENTAL POPULATION

The experimental population was restricted to female Holstein, Ayrshire, Guernsey and Jersey cattle who were at least two years old and who had one of the ten diseases of interest diagnosed by OVC clinicians between January 1, 1970 and June 30, 1975.

Although a few of the patients seen by the Large Animal Clinic may have come from farther away, most of the cows in the study were from farms located within a 20-mile radius of Guelph. This district includes parts of Wellington and Waterloo counties. The area has, in long-term averages, a mean monthly low temperature of -5.8°C in February, a mean monthly high temperature of 20.8°C in July, a mean annual rainfall of 71.6 cm and a mean annual snowfall of 135.6 cm (5). Dairy farmers tend to house their cattle in stanchion barns and use artificial breeding. The principal roughage fed is corn or hay silage, with access to pasture in the summer. Approximately one half of the regular OVC dairy farm clients use the Record of Performance (ROP) program (Personal communication. Prof. R. A. Curtis, Department of Clinical Studies, OVC, Spring, 1976).

STUDY DESIGN AND DATA ANALYSIS

The diseases included in this study were the most common diagnoses made within the indicated time and patient restrictions. A "case" was defined as a single disease incident in a cow. During the five and one-half year interval it was possible for one cow to contribute more than one case of the same disease. It was also possible for her to contribute cases of more than one disease. No special analysis or control was made for multiple case cows nor was any distinction made between cases generated by Farm Service clinicians (as the majority of cases were) and those generated by members of the Large Animal Clinic.

The case control study design was used (14). For each of the diseases the experimental population was divided into two groups: those suffering from the disease in question (cases) and those suffering from the other nine diseases (controls). The rates of exposure of the two groups to various hypothetical risk factors (age, breed and season) were then compared.

The analysis of age and of breed as risk factors for each disease was by means of the log-odds method (9). The "small cell-size correction factor" of +0.5 was used in all of these calculations. Each single age group or breed in turn was designated the "factor-positive" group and was compared to the pooled data for the other three age or breed "levels" as the "factor-negative" group. This method of analysis produces an "odds ratio" or estimated relative risk, which indicates the risk of disease in factor-positive individuals relative to the risk of disease in factor-negative individuals. When data are organized in a fourfold table as in Fig. 1 the calculation of a simple odds ratio is: odds ratio = ad/bc. An odds ratio of "1" indicates that the factor examined does not alter risk. An odds ratio of

	Have Disease of Concern	Do Not Have Disease of Concern
Factor Present	a_i	b_i
Factor Absent	c_i	d_i
Total animals by group	$a_i + c_i$	$b_i + d_i$
Proportion with factors	$a_i/(a_i + c_i)$	$b_i/(b_i + d_i)$

Odds ratio $= a_i d_i / b_i c_i$

Fig. 1. Typical data presentation in contingency table format.

"2" suggests twice the risk of disease when the factor is present compared to when it is absent.

The log-odds method of analysis allows the control of suspected confounding variables. The data are first organized into one 2 x 2 table for each level of the confounding variable and a simple odds ratio is calculated at each of these levels. (The levels are represented by the subscript 'i' in Fig. 1.) These individual odds ratios are then tested for homogeneity, that is, the odds ratios are tested to see if they indicate a similar relationship between the factor and the disease at each level of the confounding variable. If homogeneity is indicated, a summary odds ratio is then calculated. If homogeneity is not indicated, then there is an interaction between the factor and the confounding variable and a summary odds ratio is not calculated. In this study, breed was controlled as the confounding variable in the analyses of age-disease relationships and age was controlled in the breed-disease analysis. For all tests of significance, the level of significance was set at $\alpha = 0.05$.

The possibility of seasonal trends in disease diagnoses was examined by inspecting graphs of monthly case counts, based on date of discharge. To correct for seasonal variations in total diagnoses of all diseases the monthly count of cases of each disease in each year was first expressed as a percentage of all cases of the ten diseases in the same month-year. A graph of mean monthly cases as a percentage of all cases was then plotted for each disease. If this graph suggested a seasonal trend, then a three month moving average was also graphed.

Data Collection

Data on age, breed and discharge date were retrieved from the Medical Case Abstract System (MEDCAS) at the University of Guelph. This computer data storage system is a spinoff of the Veterinary Medical Data Program (VMDP). A general review of the VMDP has been published recently (18).

New disease occurrences and "rechecks" were not clearly distinguished in MEDCAS. Because we wished to count only new occurrences and not rechecks, an editing program was implemented in which the discharge dates of all listings of a single disease under a single patient number were examined. If multiple listings occurred within a specified recheck period, only the earliest was retained for the final list of cases of each disease. The intervals for the recheck period were ten days for abomasal displacement, ketosis and mastitis, 21 days for cystic graafian follicles and endometritis and 270 days for the remaining diseases.

After the initial edit, the data were then examined manually for inconsistencies in age and breed codes under a single patient number. If age-group designations were not consistent with the dates of the listings (e.g. a cow growing younger) or if more than one breed code was indicated, then all data under that patient number were removed from the entire study.

Data Verification

The data used in this study were originally collected for other purposes. Therefore, each disease was described with regard to information in the clinical records such as: typical major signs and procedures, relationship between discharge date and calving date, duration of the disease prior to diagnosis and actual words used by clinicians to "name" the disease. The types and rates of errors that occurred in transcribing data from the original clinical records to the computer storage banks also were noted. For these purposes, the clinical records of a computer generated random sample of 30 cases from each of the ten disease case lists was examined (total: 300

cases). If records could not be found, the numbers not found were noted and generalizations were made from the records that were found. In no instance was an alternative record examined. A computer statement was considered to be verified if the same information was explicitly stated in the clinical record of the appropriate date. The computer listings for the sampled 300 cases were corrected if minor errors were evident after examining the clinical records. The case was deleted if the transcription of the diagnosis was incorrect. No attempt was made to judge whether a clinician's diagnosis was appropriate nor were adjustments made in the total case summaries to correct for error rates.

In the final case totals there were 5,413 Holsteins, 67 Ayrshires, 283 Guernseys and 227 Jerseys. In the age groups, 2 – <4, 4 – <7, 7 – <10 and ≥10, there were 1289, 2675, 1447 and 579 cases, respectively.[1] It was recognized that because of this distribution, the comparisons involving nonHolstein case groups were to predominantly Holstein control groups.

[1]Age-by-breed and month-by-year distributions for each disease are available from the authors upon request.

RESULTS

Table I shows the original number of cases, numbers removed in the recheck and editing procedures and the final number of cases of each disease.

The results of the transcription verification procedure are shown in Table II. Most of the discrepancies in discharge dates were traced to a single problem: the records librarian was processing records in monthly batches and occasionally entered the processing date in place of the discharge date. When this happened, the date in the computer list was one month after the date in the original record. The MEDCAS code diagnosis term "ovarian hypofunction" was not found in the sample of clinical records, thus the number of verifications of transcription of the named diagnosis was zero. However, of the 25 records examined, 24 listed the specific diagnosis as "repeat breeder", "problem breeder" or "anestrus".

The summary odds ratios by age and by breed for each of the ten diseases are listed in Tables III and IV. The summary odds ratios are read and interpreted similarly to simple odds ratios, with the understand-

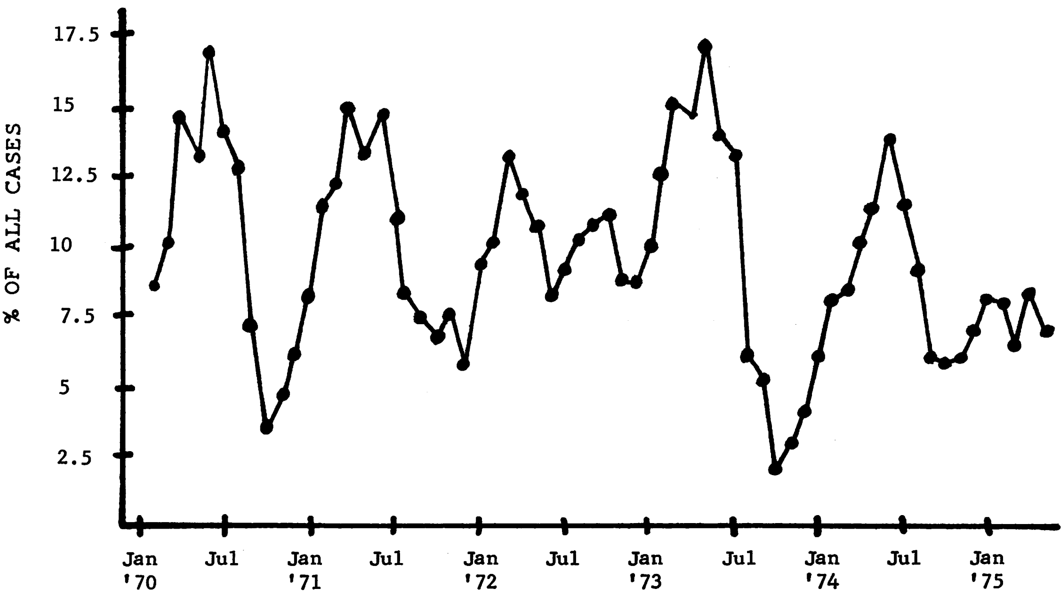

Fig. 2. Monthly occurrence of abomasal displacement in dairy cows, three month moving average (number of cases expressed as percentage of total cases of all ten diseases in same month). (MEDCAS data, OVC, January 1970-June 1975).

ing that the data were homogeneous across all levels of the controlled confounding variable. For example, cows have a significantly higher risk of abomasal displacement between four and seven years of age than at any other time and significantly lower risk from ten years of age on (Table III). Where Tables III and IV read "NH" the data were not homogeneous and could not be summarized. Instead, there was significant interaction between at least one age level and one breed and the significant individual odds ratios for these interactions are shown in Table V. For example, the individual odds ratios at each breed level for 2 –<4 year old cows developing cystic graafian follicles were not homogeneous (NH, Table III). Table V indicates that this was due to a significantly increased risk of cystic follicles in two to four year old cows who were also Jerseys. The odds ratios for the other breeds at this age were not significantly different from 1.00.

For all diseases, the relationship between season and case numbers was highly variable and can be taken only as suggestive of trends. These trends are indicated in Table VI. Figures 2 and 3 are graphs of three month moving averages of the number of cases of a specific disease relative to the number of cases of all diseases. Fig. 2 for abomasal displacement, shows one of the clearest seasonal patterns of the study. The graph for retained placenta, Fig. 3, does not indicate any obvious seasonal pattern. The graph of mean monthly cases for retained placenta had suggested a summertime peak in cases but this was obviously influenced by just two years, 1970 and 1971. In 1972 the Farm Service instituted a policy of only treating retained placentas when there were also signs of systemic disease, thus the number of cases recorded at OVC dropped drastically because of the stricter criterion.

DISCUSSION

The disease descriptions from the verification procedure were consistent with standard descriptions (2, 21) of abomasal displacement, cystic graafian follicles, hypocalcemia, ketosis, mastitis and retained placenta. However, it was not possible to determine durations of any of the ten diseases prior to diagnosis. It was not possible to determine from the case records how the clinical distinction had been made between endometritis, metritis and pyometra. It has been suggested that these are variations of the same basic disease entity and that distinction should only be made on the basis of estrous cycle disturbances and histological examinations (7, 11, 21). Our study revealed similar epidemiological patterns for these three diseases. Finally, the description procedure showed that the ovarian hypofunction code has been used as a general category for miscellaneous infertility diagnoses rather than as a code to indicate a specific clinical entity such as "anestrus with inactive ovaries".

TABLE I. Original Numbers of Cases, Number Removed, and the Final Numbers of Cases, of Ten Dairy Cow Diseases. (MEDCAS data, OVC, January 1970-June 1975)

Disease	Original No. Cases	No. Cases Removed as : Rechecks[a]	Inconsistent[b]	Final No. Cases
Abomasal displacement	666	97	22	547
Cystic graafian follicle	1061	122	128	811
Endometritis	701	111	68	522
Hypocalcemia	1274	195	126	953
Ketosis	585	123	33	429
Mastitis	1197	397	83	717
Metritis	849	195	73	581
Ovarian hypofunction	824	126	91	607
Pyometra	283	97	26	160
Retained placenta	961	244	54	663
			Total =	5,990

[a]Cases eliminated by the computer program because they were repeated diagnoses within specified recheck periods
[b]Cases eliminated by hand because the data under the patient number were inconsistent

The verification procedure indicated that errors in the transcription of diagnoses were uncommon except, as already mentioned, for ovarian hypofunction. Breed data were reliable and we believed that a one month difference in some of the discharge dates, albeit undesirable, would not seriously alter seasonal patterns. Misclassification of age-group data posed a more serious problem. Transcription errors were common. Although the formal description of the age-group codes on the MEDCAS case abstract coding forms is of nonoverlapping groups (17), the ages as they actually appear on the printed coding form do overlap and could be a source of confusion. Other authors have discussed the general theory of misclassification of data (3, 4). Their conclusion, which we have accepted in using the MEDCAS age data, is that if there are similar error rates between comparison groups and the errors occur less than half of the time then the data may be used and the results interpreted as being conservative. In other words, if we erred in using the age data the errors were in the direction of declaring too few rather than too many odds ratios to be significantly different from 1.00.

Other factors could also have influenced our results. The recheck edit was imposed because the MEDCAS does not regularly include information differentiating between initial and recheck diagnoses. Similarly, the edits for inconsistent data could have removed several valid cases because of a single keypunch error. In addition, several potential confounding variables such as concomitant disease and production and management factors were not controlled, although it should be noted that we did control age, breed, sex, reporting institution and type-purpose of the experimental population.

Abomasal displacement, cystic graafian follicles, hypocalcemia, ketosis, mastitis and retained placenta occur in specific temporal relationships to parturition. Therefore, if

TABLE II. Numbers of Verifications of Computer Data by Examination of Random Samples of 30 Clinical Records from each of Ten Dairy Cow Diseases. (MEDCAS data, OVC, January 1970-June 1975)

Disease	No. Found out of 30	No. of Verifications of: Age	Breed	Discharge Date	Diagnosis
Abomasal displacement	29	26	29	25	28
Cystic graafian follicle	24	19	24	18	20
Endometritis	25	22	24	22	23
Hypocalcemia	24	21	24	21	24
Ketosis	24	22	24	14	24
Mastitis	22	17	22	14	22
Metritis	23	20	23	17	22
Ovarian hypofunction	25	18	25	21	0
Pyometra	27	23	27	20	24
Retained placenta	23	20	23	14	22

TABLE III. The Effects of Age on the Occurrence of Ten Diseases of Dairy Cows. The Effects are Measured by Summary Odds Ratios. (MEDAS data, OVC, January 1970-June 1975)

Disease	Age (yrs) 2- <4	4- <7	7- <10	≥10
Abomasal displacement	0.89	1.55[a]	0.82	0.51[a]
Cystic graafian follicles	NH	1.30[a]	0.73[a]	0.84
Endometritis	1.63[a]	0.94	0.69[a]	0.96
Hypocalcemia	0.11[a]	0.71[a]	2.78[a]	2.37[a]
Ketosis	NH	1.67[a]	1.02	0.60[a]
Mastitis	1.02	0.95	1.06	1.09
Metritis	1.48[a]	0.89	0.87	0.87
Ovarian hypofunction	1.99[a]	0.81[a]	0.70[a]	NH
Pyometra	1.21	0.98	0.92	1.19
Retained placenta	>1.00 NH	0.89	0.74[a]	1.03

[a]Significantly different from 1.00 at $p \leq 0.05$
NH: Not homogeneous over all breeds

calvings were more frequent during any season the occurrence of these diseases would be influenced. Determination of calving season wasn't within the scope of this study but there is agreement among OVC clinicians that winter-spring is the busy season for assisted deliveries. Also, a major local supplier of dairy semen for artificial insemination has indicated that their sales volume for all dairy breeds is 15-30% greater in the late spring - early summer than in the fall - winter period (Personal communication. United Breeders Inc., R.R. 5, Guelph, Ontario. July 14 and August 12, 1976). Hence, there may be a modest peak calving season in the late winter - early spring and a disease that is associated with calving could have shown a modest seasonal pattern merely for this reason. However, as shown in Fig. 1, the apparent patterns which we discerned were based on two, three, and even fourfold differences between peak and lull seasons.

The increased risk of abomasal displacement in Ayrshires does not agree with other authors, although the seasonal pattern does (2, 10, 15). The increased risk of displacement in four to six year old cows agrees with statements that this is a disease of adult cattle (2, 10). A previous study (15) from this College reported no difference in average age between displaced and control cows but the data, when analyzed by the methods of this study, suggest an increased risk in seven to nine year old cows.

TABLE IV. The Effects of Breed, as Measured by Summary Odds Ratios, on the Occurrence of Ten Diseases of Dairy Cows. (MEDCAS data, OVC, January 1970-June 1975)

	Breed			
Disease	**Holstein**	**Ayrshire**	**Guernsey**	**Jersey**
Abomasal displacement	0.97	2.79[a]	0.82	1.07
Cystic graafian follicles	3.61[a]	0.85	0.28[a]	0.48[a]
Endometritis	0.81	1.00	2.45[a]	0.31[a]
Hypocalcemia	<1.00 NH	0.57	0.78	5.35[a]
Ketosis	1.57[a]	1.68	0.61	NH
Mastitis	NH	3.11[a]	0.59[a]	1.72[a]
Metritis	0.86	0.79	1.65[a]	0.91
Ovarian hypofunction	1.80[a]	0.42	NH	0.53[a]
Pyometra	0.88	1.18	1.92[a]	1.17
Retained placenta	0.55[a]	3.00[a]	2.85[a]	0.63

[a]Significantly different from 1.00 at $p \leq 0.05$
NH: Not homogeneous over all age groups

TABLE V. Summary of Interactions Between Age and Breed on Ten Diseases of Dairy Cows, Indicated by Significant[a] Individual (nonhomogeneous) Odds Ratios (MEDCAS data, OVC, January 1970-June 1975)

Disease	Age-Group (Yrs)	Breed	Odds-Ratio
Cystic graafian follicles	2 - <4	Jersey	8.03
Hypocalcemia	2 - <4	Holstein	0.26
	4 - <7	Holstein	0.40
	≥ 10	Holstein	0.35
Ketosis	2 - <4	Holstein	0.55
	2 - <4	Jersey	4.26, 3.08[b]
Mastitis	2 - <4	Holstein	2.28
	7 - <10	Holstein	0.63
Ovarian hypofunction	≥10	Guernsey	7.35, 5.84[b]
Retained placenta	2 - >4	Holstein	1.47
	2 - >4	Ayrshire	4.88
	2 - >4	Jersey	6.39

[a]Significantly different from 1.00 at $p \leq 0.05$
[b]Breed was the confounding variable for the 1st value, age for the 2nd

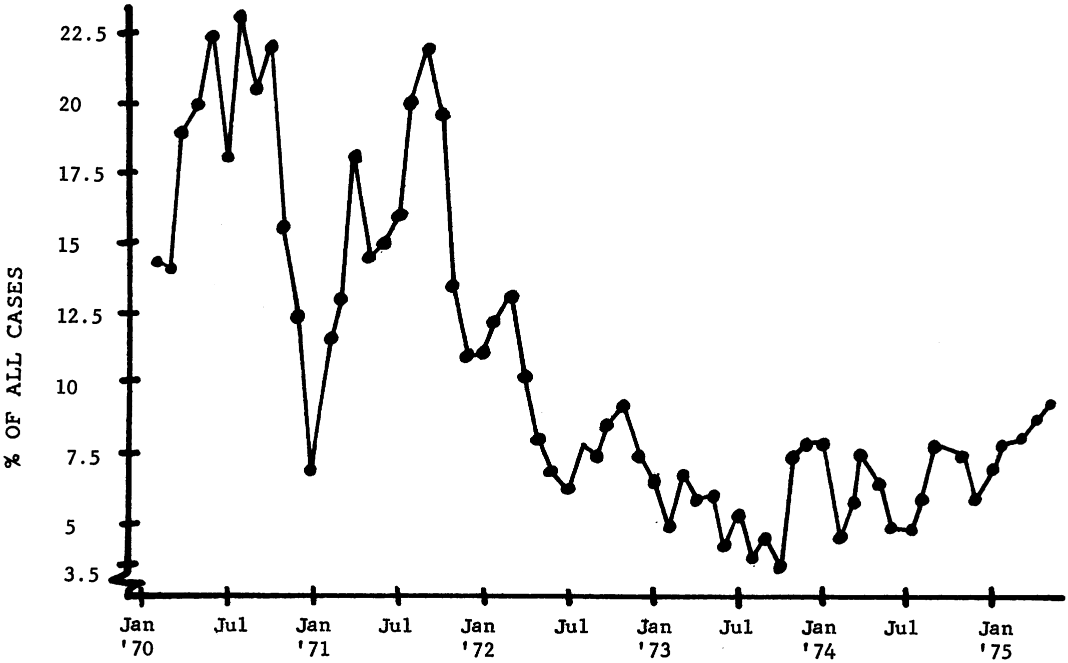

Fig. 3. Monthly occurrence of retained placenta in dairy cows, three month moving average (number of cases expressed as percentage of total cases of all ten diseases in same month). (MEDCAS data, OVC, January 1970-June 1975).

The age and seasonal patterns we found for cystic graafian follicles are in agreement with other authors (12, 13, 20, 21) but the increased risk in Holsteins and the decreased risk in Guernseys contradicts one statement that there was no breed disposition (20).

The age, breed and seasonal patterns reported here for endometritis, metritis and pyometra have not been reported by others (7, 13, 21). The lack of recorded clinical distinctions between these entities and the similarity of their occurrence with respect to age, breed and season suggests that consideration be given to combining these into one diagnostic category.

Our findings for hypocalcemia are in agreement with two previous studies from OVC (6, 24) which involved a different herd and time period from ours and also with what is commonly taught (2).

In our study, we made no distinction between "primary", "nutritional" and "secondary" ketosis. It is interesting to note that one review (1) indicated that the secondary form was especially common after endometritis, mastitis, abomasal displacement and traumatic reticulitis, yet the breed at increased risk of ketosis in our study (Holstein) was not at increased risk of the three contributing diseases also included in the study. This finding of increased risk in Holsteins does not agree with the statement that Guernseys are more susceptible (2) or that Ayrshires are at twice the risk of Holsteins (8). The seasonal pattern found, but not the age pattern, has been mentioned before (2).

TABLE VI. Summary of Seasonal Patterns of Disease Occurrences of Ten Dairy Cow Diseases. (MEDCAS Data, OVC, January 1970-June 1975)

Disease	Peak Season
Abomasal displacement	Spring-early summer
Cystic graafian follicle	Winter
Endometritis	Fall
Hypocalcemia	(None apparent)
Ketosis	Late winter/early spring
Mastitis	(None apparent)
Metritis	Late summer-fall
Ovarian hypofunction	(None apparent)
Pyometra	Fall-winter
Retained placenta	(None apparent)
All (10) diseases, combined	Late winter

Age, breed and seasonal patterns to the occurrence of the general disease "mastitis" are not generally reported, although some of the more specific microbiologically defined forms of mastitis do have some reported patterns (2, 19, 22). The question of microbial etiology was ignored because the microbial diagnoses made within the clinical records tended not to be based on laboratory isolations. In addition, the cases of mastitis in this study were cases seen by veterinarians and would tend to be more severe than average cases within dairy herds.

The breed risks we found for retained placenta were not mentioned by other authors (16, 21, 23). Our findings regarding age-group risks do not agree with two authors who do not agree between themselves. One noted increased incidence with age (21), the other noted that placental retention was more common in the youngest and older cows than in those in their second through fourth lactations (23).

Three interesting trends in these data were noted. First, the youngest cows were only at increased risk of the reproductive diseases. Second, Guernseys were uniformly at increased risk of the "uterine-based" diseases. Some have seen these data and argued that there were few (283) Guernseys included in the study and that they may be primarily members of poorly managed herds. However, Guernseys were *not* at increased risk of mastitis, a disease which could also be considered to occur under conditions of poor management. We feel that this merits further investigation. Third, there was a tendency for more disease occurrences during the winter than the summer.

Identification of factors associated with significantly increased or decreased risk of disease is important for three reasons: 1) to form the basis for further investigations, 2) risk factors should be controlled in studies in which they are not the variables of primary interest and 3) statements of risk are probability statements and as such are useful in the formation of clinical diagnoses. We trust that this study has been useful and that similar studies will be undertaken at other institutions.

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