A survey of the causes of mortality in adult mink, with emphasis on the lactation period

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Abstract

A study of the pattern and relative frequency of diseases in adult female mink during the lactation period was undertaken. All adult females that died between parturition (April/May) and July 1, 1990, from 48 farms in southern Ontario were selected for study, and the cause of death was determined by gross necropsy. In addition, the cause of death was determined by gross necropsy for all adults and weaned kits that died on one farm between April 1988 and March 1989.

The mortality rate among farms in the 1990 study, for adult females during the lactation period, ranged from 0.2% to 10.1%, with a median of 1.9%. Nursing disease (56%) was the most common diagnosis, followed by mastitis (11%), metritis (8%), and dystocia (7%). *Escherichia coli* and *Staphylococcus* spp. were the most frequent isolates from the cases of mastitis. In the 1988/1989 study, the mortality rate was highest from May to July, with a large increase in June as a result of nursing disease.

Résumé

Étude des causes de mortalité chez le vison adulte durant la période de lactation

Un schéma et la fréquence relative des maladies survenant en période de lactation chez le vison femelle adulte sont discutés dans la présente étude. La cause de la mortalité a pu être déterminée lors d'une dissection anatomique macroscopique effectuée sur tous les visons femelles adultes, morts entre avril et juillet 1990. Les animaux provenaient de 48 fermes du sud-ouest ontarien. De plus, une autopsie macroscopique a été effectuée sur tous les animaux provenant d'un élevage de visons, adultes ou jeunes sevrés, morts entre avril 1988 et mars 1989, pour déterminer les causes de mortalité.

Le taux de mortalité dans ces fermes pour la période de 1990 a été de 0,2 à 10,1 % chez les femelles adultes en lactation pour une valeur médiane de 1,9 %. Les maladies reliées à l'allaitement représentent le diagnostic le plus fréquent (56 %), suivi de la mammite (11 %), de la métrite (8 %) et des problèmes de dystocie (7 %). Les deux agents les plus fréquemment isolés lors de mammite étaient *E. coli* et *Staphylococcus* spp. Pour la période 1988–1989, le taux de mortalité a été le plus haut durant le mois de mai à juillet avec une forte augmentation en juin, ce qui correspondait à la période des maladies reliées à l'allaitement. *(Traduit par Dr Thérèse Lanthier)*

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Introduction

In the early literature on diseases of mink, nutritional deficiencies and infectious diseases associated with specific agents, such as distemper and mink viral enteritis, were emphasized (1,2). Over the years, better understanding of the nutritional requirements of mink and the development of several vaccines have resulted in a great reduction in the number of losses attributable to these diseases. Recent literature from Scandinavia suggests that diseases associated with reproduction, Aleutian disease, urolithiasis, and nonspecific infections of the lungs and intestine are now the most common causes of death in adults, although neonatal mortality constitutes the greatest source of loss overall (3,4). In adult mink, the disorders commonly associated with reproduction are nursing disease, mastitis, dystocia, and metritis (3). For operations in North America, the relative impact of the various diseases that occur in mink, in terms of total losses to the industry per year, has never been quantified.

The objective of the initial phase of this study was to assess the relative frequency of diseases occurring in mink through an opinion survey of Canadian farmers, and through a necropsy survey of all mortality that occurred on one farm over one year.

Based on the results of the initial phase, it was decided that further study of mortality of adult females during the lactation period was warranted. The objective of the second phase was to determine the pattern of occurrence and relative frequency of diseases that occurred in adult females during the lactation period, through the use of a large cross-sectional sample of farms in Ontario.

This paper will focus on the diseases in adults and juveniles; data pertaining to unweaned kits are presented in another report (5).

Materials and methods

There were three components to this study. A mail survey of all Canadian mink farmers (n = 516) was undertaken in 1988, asking respondents to name the three diseases most commonly occurring in mink on their farm. All nonrespondents were sent one follow-up notice. The 66 farmers participating in the lactation period mortality study (see below) were asked the question again, in person.

A necropsy survey of all deaths that occurred on one farm, from April 1988 to March 1989 was done. The breeding herd consisted of 3,082 pastel, brown, dark, violet, sapphire, and blush color mink that were known to be free of Aleutian disease. For each adult and (weaned) kit death, the date of death and color phase were recorded, the animal was weighed, and a gross necropsy was performed. If indicated by the presence of gross lesions, organ samples were cultured aero-

bically on blood agar and MacConkey's agar at 37°C for 48 hours, and bacterial isolates were identified by standard methods (6). Smears of lymph nodes from animals with gross lesions consistent with tuberculosis were stained with the Ziehl-Neelsen stain for acid fast organisms.

Only one diagnosis reflecting the most probable cause of death was recorded per female. The diagnostic criteria for the most common causes of death were as follows. Nursing disease was diagnosed in adult females if death occurred after 35 days of lactation and less than one week after weaning the kits, and there were no pathological changes other than emaciation or dehydration. Mastitis was diagnosed if there was swelling with abscessation or necrosis of any of the mammary glands. Dystocia was diagnosed if a fetus was lodged in the distal uterus or vagina. Metritis was diagnosed if the uterus did not involute after parturition, and contained a dead kit, placenta, or necrotic debris. Pyothorax was diagnosed if the thorax contained purulent exudate. Urolithiasis was diagnosed if there was urinary obstruction due to the presence of urinary calculi in the urethra or bladder. Systemic infection was diagnosed if there was moderate to heavy growth of the same bacterium from two or more organs and supportive gross lesions were present. Animals for which the cause of death could not be determined were classed as "no diagnosis".

The cause-specific mortality rate for each of the diagnoses was calculated as the number of deaths divided by the average population at risk. The mortality rate per color phase was calculated for the major infectious diseases taken as a group (i.e. mastitis, pyothorax, metritis, and subcutaneous or internal abscessation). The relative risk for each color phase, using pastel as a reference, was also determined, and a Chi-square test was performed to test the significance of the difference among colors. Sapphire, violet, and blush color mink are homozygous for the Aleutian color gene, and were analyzed together.

A survey of all mortality of adult females that occurred between parturition (late April to early May) and July 1, 1990 on 71 of the 98 farms in Ontario with more than 100 breeding females was conducted. These farms were selected primarily on the basis of their proximity to Guelph. All adult females that died were frozen by the farmers and their date of death was recorded. Gross necropsies were later performed at the Ontario Veterinary College, using the same diagnostic criteria described above for the 1989 study. Samples from 35 animals with mastitis from 14 farms were cultured aerobically on blood agar and MacConkey's agar, and antimicrobial sensitivity testing was performed on 18 isolates (Sceptor system, Becton Dickinson, Towson, Maryland, USA). Testing for Aleutian disease was not done, but the majority of the farms were known to be free of Aleutian disease (B. Tapscott, personal communication). The overall mortality rate per farm was calculated as the total number of deaths over the study period, divided by the number of breeding females. Cause-specific mortality rates for each farm were not calculated. A multiple regression model was used to test the statistical significance of the difference in weight at death between nursing disease cases and all other causes of death after 35 days of lactation (7).

Table 1. Relative frequency of responses by ranchers to the question: what are the three most common diseases occurring in mink on your farm?

Disease	Percentage of responses 1988 survey[a]	1990 survey[b]
Urolithiasis	21	32
Nursing disease	15	22
Pneumonia	13	11
Aleutian disease	11	2
Mastitis	8	6
Cystitis	8	10
Neck abscesses	7	2
Diarrhea	6	0
Tyrosinemia	2	2
Fatty liver	0	4
Other	9	9

[a]Mail survey of all Canadian mink farmers. A total of 129 farmers (25% response rate) listed 184 diseases
[b]In-person questionnaire of Ontario farmers. A total of 66 farms (93% response rate) listed 95 diseases

In both mortality surveys, the data were entered into a computer database using Database III+ (Ashton-Tate, Torrance, California, USA), and the frequency counts were made using Statistix 3.1 (Analytical Software, St. Paul, Minnesota, USA).

Results

One hundred and twenty-nine farmers (25%) responded to the 1988 mail survey, and 66 farmers (93%) responded to the 1990 survey. Results from both surveys were similar. Urinary disorders (urolithiasis, cystitis) and diseases associated with lactation (nursing disease, mastitis) were cited as those most commonly encountered (Table 1).

In the 1988–1989 study of mortality on one farm, the annual mortality rate, excluding preweaning losses, was 6.8% (n = 369 deaths) among females and 2.2% (n = 68 deaths) among males. The mortality rate in females was highest from May to July, with a large increase because of nursing disease in June (Figure 1). The most common diagnoses in females are listed in Table 2. Mink carrying the Aleutian color gene were five times as likely to develop infectious disease as pastel color phase mink (Table 3). The rate in dark and brown color phase mink was also higher than in the pastel color mink, but the difference was not statistically significant.

In the 1990 study, 48 of the 71 farms consistently recorded the date of death for submissions, and were able to provide basic information on carcasses that were not submitted. These farms represented 49% of all farms with more than 100 breeding females in the province. Data from the other 23 farms were not included in the results.

A total of 811 carcasses was submitted, and accounted for 80% of the total mortality in adult females from the start of parturition until July 1. Most of the carcasses that were not submitted had bloated in the

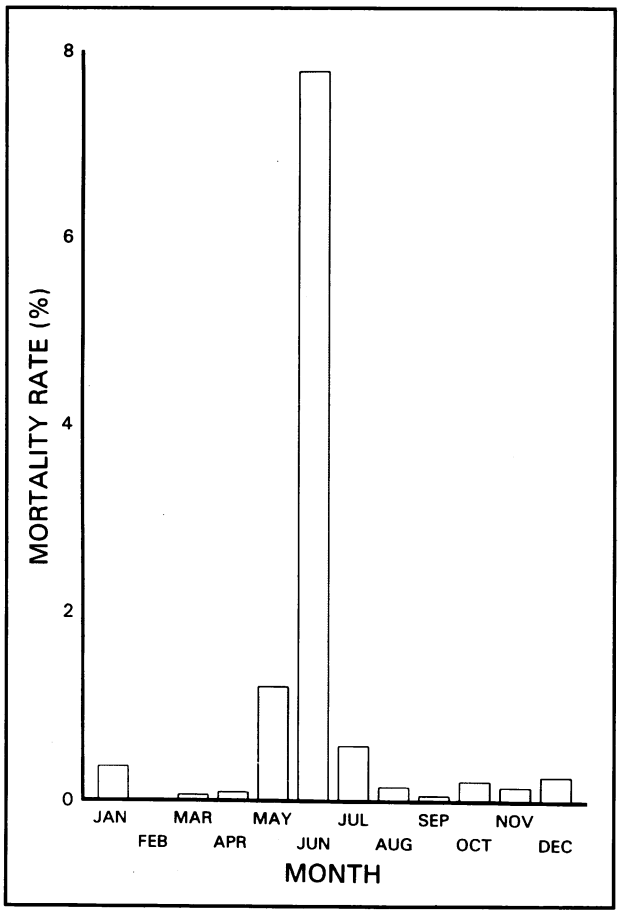

Figure 1. Monthly mortality rate for female mink (adults and weaned kits) on one farm in 1988/1989 (n = 369).

Table 2. Annual mortality rates (1988–1989) for the most common diseases in female mink, excluding preweaning losses, on one farm in southern Ontario

Diagnosis	Number of deaths	Mortality rate[a] (%)
Nursing disease	124	4.0
Mastitis	68	2.2
Pyothorax	36	0.4
Misc. infections[b]	28	0.3
Dystocia	7	0.2
Metritis	4	0.1
Urolithiasis	3	0.04

[a]For nursing disease, mastitis, dystocia, and metritis, only lactating females were included in the calculation of the mortality rate (n = 3,083); for the other diseases, weaned female kits were also included (n = 7,206)
[b]Including subcutaneous abscesses, systemic bacterial infections, tuberculosis, and peritonitis

heat during the peak incidence of nursing disease in June. Of the nonsubmitted carcasses, 30% were known to be immediate postweaning losses.

The overall mortality rate of mink during the lactation period among the 48 farms ranged from 0.2% to 10.1% (nonsubmitted mortalities included). Low mortality rates were most common (Figure 2), with the median rate equal to 1.9%.

Table 3. Mortality rate attributable to infectious disease[a], by color phase, in adult female mink on one farm in 1988–1989

Color phase	n	Mortality rate (%)	Relative risk[b]	p value
Pastel	1,235	1.0	—	—
Light mutations[c]	1,547	4.7	5.0	<0.005
Dark	97	2.1	2.1	0.65
Brown	204	2.0	2.0	0.40

[a]Includes mastitis, pyothorax, subcutaneous abscesses, and metritis
[b]Relative to the pastel color phase
[c]Mink carrying the Aleutian color gene, including sapphire, violet, and blush color phases

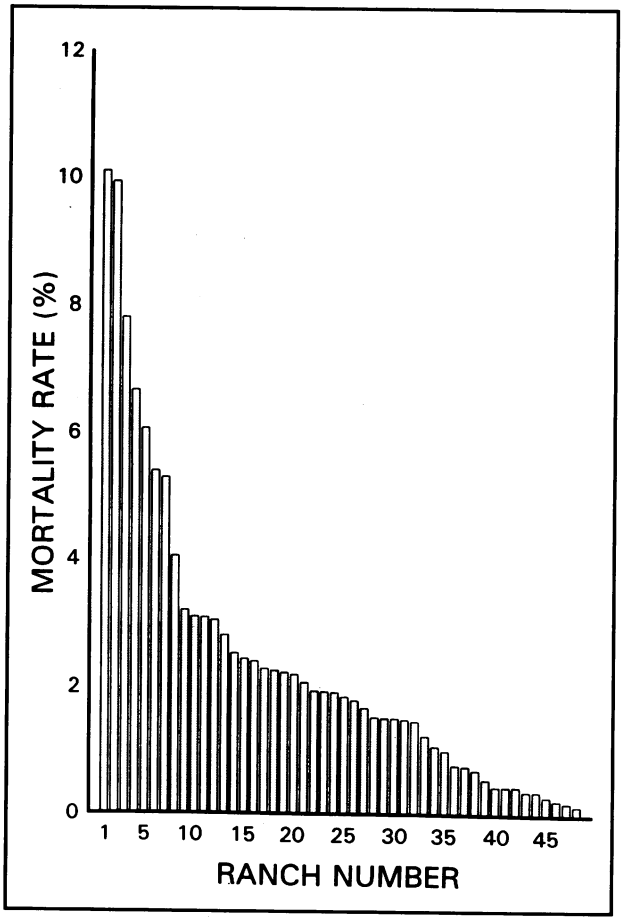

Figure 2. Mortality rates observed from May 25 to July 1, 1990, for adult female mink on 48 farms in southern Ontario.

Nursing disease was the most frequent diagnosis among submitted animals (57%), and 92% of farms had at least one case. All ages and color phases of mink were affected. There was a distinct clustering of nursing disease cases during the sixth week of lactation (Figure 3). The average weight at death of females with nursing disease was significantly less than the average weight of lactating females that died of all other causes ($p < 0.001$) as shown in Figure 4.

Diseases associated with parturition accounted for 15% of submissions, and 63% of farms had at least one such case. Almost all deaths due to these diseases

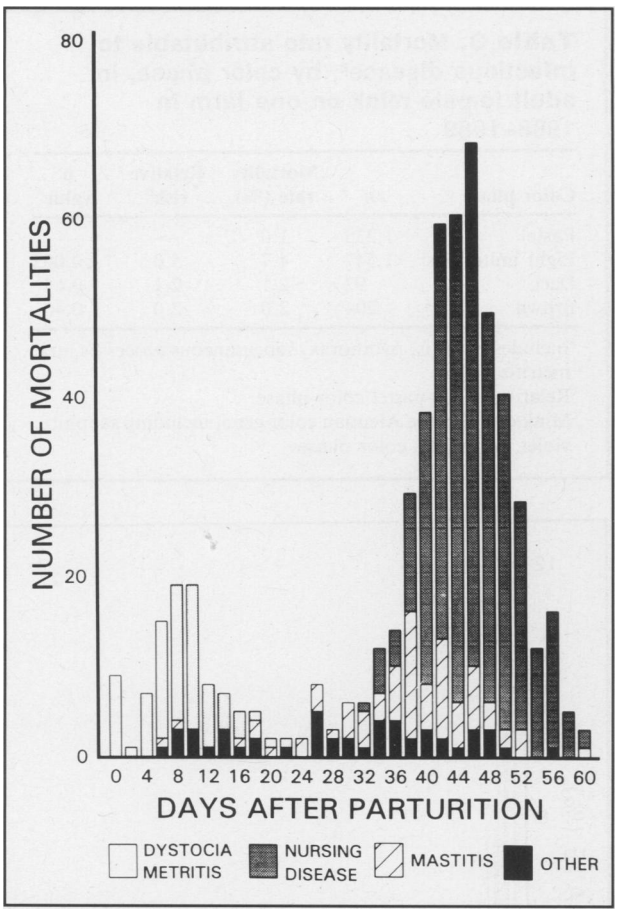

Figure 3. Pattern of occurrence for the major causes of mortality, relative to date of parturition, in adult female mink from 48 farms in southern Ontario (n = 811). The category labelled "other" refers to all other causes of death not listed.

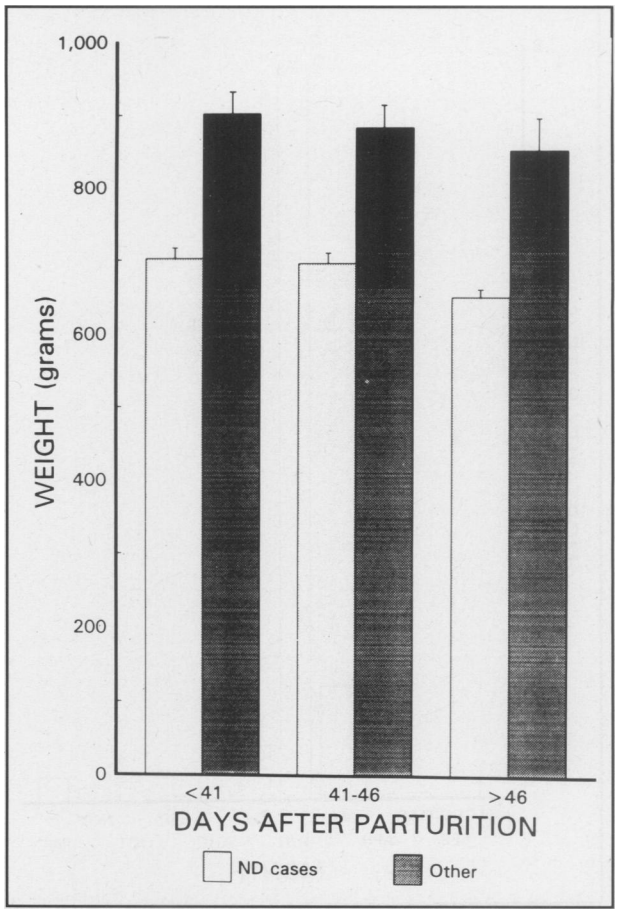

Figure 4. Weight at death, with SE, for 329 nursing disease cases (occurring prior to weaning) and 92 females dying of other causes divided among three time categories, ranging from 35 to 60 days after parturition. Weight and duration of lactation were both significant in a multiple regression model ($p < 0.001$ for both).

occurred within two weeks of parturition, which resulted in a noticeable peak in mortality at that time (Figure 3). Dystocia and metritis were the most common diagnoses in this group (Table 4); however, two cases of uterine torsion, one of uterine prolapse, and one of rupture of a uterine artery were also observed. In dystocia cases, the typical presentation was a fetus lodged in the distal uterus or vagina in a forward position with its head flexed ventrally against its body. In 40% of metritis cases, a dead kit was present in the uterus, and in many of the others, the placenta was retained. Uterine rupture with peritonitis was a typical sequela of metritis.

Mastitis was the cause of death in 11% of the submissions, and 54% of farms had at least one case. *Escherichia coli* and *Staphylococcus aureus* accounted for 49% and 42%, respectively, of the bacterial isolates from these cases. Antimicrobial sensitivities are given in Table 5. Typically, the affected mammary glands were swollen, and large abscesses and zones of necrosis were present. Mastitis occurred throughout the lactation period, but was most common around the sixth week (Figure 3).

In 12 submissions (1.5%), hepatomegaly, with bright yellow discoloration of the liver and, to a lesser extent, the kidney, was observed. The females were in good bodily condition, and no other lesion was noted. The majority of these cases occurred in the third week of lactation.

Diseases not directly associated with reproduction accounted for 10.2% of submissions. These diseases occurred at low prevalence with little variation throughout the lactation period (Figure 3). Urolithiasis and miscellaneous bacterial infections, especially pyothorax, were the most common diagnoses in this group (Table 4). Perforating duodenal ulceration, hemothorax, hepatic rupture, and intussusception were observed sporadically. Two females had gross lesions suggestive of Aleutian disease.

In 5% of submitted females, the cause of death was not determined.

Discussion

Nursing disease, mastitis, urolithiasis, pyothorax, and subcutaneous abscesses were among the most common diseases in all three components of the study. In addition, Aleutian disease and enteritis (diarrhea) were cited as common diseases in the farmer survey, and dystocia and metritis were frequently diagnosed in the necropsy surveys. The poor response rate in the mail survey (25%), the failure of all farmers in the cross-sectional study to consistently submit all females that

Table 4. Causes of mortality in adult female mink, from May 25 to July 1, 1990, on 48 farms in southern Ontario. Total submissions = 811, representing 80% of actual mortality

Disease	Number of submissions	Proportion of submissions(%)
Nursing disease	458	56.5
Mastitis	87	10.7
Dystocia	54	6.7
Metritis	62	7.7
Pyothorax	40	4.9
Urolithiasis	16	2.0
Misc. infections[a]	15	1.9
Hepatopathy	12	1.5
Other	28	3.5
No diagnosis	39	4.8

[a]Including subcutaneous abscesses, peritonitis, tentative mycobacteriosis, and tentative Aleutian disease

Table 5. Resistance of bacterial isolates from 18 cases of mastitis to four commonly used antibiotics

Antibiotic	Percentage resistant *E. coli* (n = 11)	Percentage resistant *Staph. aureus* (n = 7)
Penicillin[a]	100	43
Erythromycin[a]	100	29
Tetracycline[a]	45	100
Gentamicin[b]	0	0

[a]Used prophylactically in the feed, as well as on an individual animal basis
[b]Used on an individual animal basis only

died, and the reliance on gross necropsies to determine the cause of death in the mortality surveys are all potential sources of bias. However, the consistency of the findings suggests that our estimates of the relative occurrence of diseases in Ontario mink are reasonable. This is further supported by the results of other systematic necropsy surveys (3,4).

Reports based on routine submissions to diagnostic laboratories give a much different impression of the relative importance of mink diseases (1,8–11). There is little consistency among these reports, but they tend to emphasize diseases associated with specific agents, particularly distemper, mink viral enteritis, and Aleutian disease. The diseases that were most common in our studies, particularly those associated with reproduction, are notably underrepresented. This is likely due primarily to submission bias, as farmers, after gaining experience with the most common diseases, are less likely to send such animals in for professional diagnosis. Studies based on submissions to diagnostic laboratories may be useful in determining the diseases that are present in a given area, but they are unlikely to reflect the relative frequency of occurrence of those diseases.

Nursing disease was the most frequent diagnosis in both necropsy surveys. In quantifying the impact of this mortality to the industry, it must also be noted that nursing disease specifically involves selected breeding stock, not just kits slated for pelting, and that highly productive females are preferentially affected (i.e. those with large litters) (12). Because of the absence of pathognomonic lesions for nursing disease (13), the postmortem diagnosis must be made by the exclusion of all other diseases. Consequently, there is a concern regarding the specificity of the diagnosis; however, the high incidence and discrete clustering of the cases during the sixth week of lactation (Figure 3) implies that any diagnostic misclassification that may have occurred was of limited importance. The cause of nursing disease is not completely understood, but it is thought to be an exhaustion of body energy stores resulting from a net energy deficit associated with lactation (14,15).

Diseases associated with parturition, primarily dystocia, accounted for 15% of the submissions. The cause of dystocia in mink is not well understood, but in this study it appeared that malpresentation or excessive size of the fetus was the major factor involved.

Mastitis was the cause of death in 11% of submissions, but the true rate of mastitis at the farm level is undoubtedly much higher, as farmers routinely treat this disease successfully with oral and injectable antibiotics, and some females recover without treatment. Therefore, the deaths represent a sample of the most severe cases. *Escherichia coli* and *Staphylococcus aureus* were isolated most frequently, a finding that is consistent with other reports on mastitis in mink (16,17). These bacteria are inhabitants of the local environment of the animals, and they are commonly present on the skin and vagina (17, 18). Infection likely reflects an increase in the number of bacteria as a result of poor hygiene, a breakdown in resistance caused by trauma to the teats, or various systemic problems. The high prevalence of resistance to tetracycline and erythromycin brings into question the common practice of adding these antibiotics to feed for the prevention of mastitis. The resistance pattern in the cases analyzed may not be representative of all cases of mastitis, but it certainly indicates that resistant strains of these organisms are present on many farms. It can be expected that these strains will be selected preferentially if antibiotics continue to be added to the feed.

Diseases not directly associated with reproduction occurred at low relative frequency throughout the lactation period. Pyothorax and urolithiasis were the most common diagnoses in this group. These diseases are reported throughout the year, and on an annual basis, contribute substantially to the overall mortality of mink (3,8). Only two females had gross lesions consistent with those of Aleutian disease, a prevalence that is very low relative to its ranking by mink farmers in Canada and to reports from other countries (4). In part, this is a true reflection of the status of the 48 farms in the study, as the majority were considered to be free of Aleutian disease based on haphazard serological testing. Some cases were undoubtedly missed, however, as histological examinations and serological testing were not done on the females that were necropsied.

Mink carrying the Aleutian color gene had five times the risk of dying of infectious disease than pastel color phase mink in the 1988 mortality survey. This can be attributed to defective neutrophil function and the other immunological deficiencies that comprise the Chediak-Higashi syndrome in mink carrying the Aleutian gene (19).

The mortality rate among farms in the 1990 study was not equal, and the very low rates observed on a number of farms suggest that substantial potential exists for reducing mortality on mink farms. Research should be directed toward determining the factors associated with this difference in incidence among farms, especially for nursing disease, mastitis, and urolithiasis.

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