Hematologic Survey of Cattle on the Island of Jersey, with Reference to the Reported Incidence of Lymphosarcoma (Leukemia)

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SUMMARY

Bovine leukemia in calves has not occurred for over 10 years on Jersey in the Channel islands, according to interviews with veterinary and agricultural officials. Results of a hematologic survey of 434 cattle from 71 herds on the island of Jersey indicated that lymphocytosis was rare and, since lymphocytosis frequently occurred in normal cattle in herds with several infected cattle, the results of this hematologic study support the epizootiologic evidence of a rare occurrence of leukemia. If a viral agent(s) is a causal factor(s), this population of cattle may never have been exposed because of isolation for 100 years. Other factors, however, such as size of total population, size of herd, and genetic susceptibility, may be responsible for the rare occurrence of leukemia.

The Jersey breed of cattle originated sometime after the earthquake of 709 A.D. which probably caused the severance of Jersey from the mainland of Europe.[3] A law enacted in 1864 prohibited outcrossing with alien cattle[1]; thus, the uniqueness of today's Jersey cattle has developed from more than 30 generations of breeding Jersey Island cattle among themselves. Department of Agriculture, States of Jersey, officials initiated a disease control program many decades ago.[2] Several diseases are reportable, meat inspection is rigidly enforced, and veterinarians necropsy most cattle that die. Brucellosis, tuberculosis, and foot-and-mouth disease have been eliminated; infectious bovine rhinotracheitis and infectious pododermatitis have never been reported. The isolated location and governmental legislation prohibiting importation of cattle for slaughter are partly responsible for success in development and maintenance of an effective disease control program in Jersey.

No isolated group of cattle is known to be free of leukemia (leukosis) but, if such a population existed, it would be of great interest to workers doing research on leukemia. Leukemia in young

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animals and that in the form referred to as "skin leukosis" usually have a sporadic occurrence, whereas the disease in adult animals is enzootic.[15] Whether a causal factor(s) also differs, is merely a point of speculation. However, if bovine leukemia is caused by an infectious agent(s) as has been postulated,[6] isolated populations of cattle may be leukemia-free.

This report is the compilation of information from interviews with Island veterinarians and agricultural officials and the results of a survey of blood samples from Jersey, Channel Island (CI), cattle. Significance of cattle isolation in relationship to incidence of the disease and detection of prodromal signs of bovine leukemia by hematologic studies are discussed.

Materials and Methods

Practicing veterinarians* (including one of the authors) were interviewed in 1963 and again in 1966. Interviews with States of Jersey agricultural officials revealed that all cattle are inspected at slaughter by a veterinary meat inspector. The number of cattle slaughtered varied from 1,259 in 1958 to 887 in 1965, with an annual average of approximately 1,100, one-half of which were young calves (Table 1). For the years 1958 through 1965, approximately 400 cattle, over one-half of which were young calves, died of disease each year. Most of the cows and young calves that died of disease were sent to the States of Jersey disposal plant where they were necropsied.

In February, 1964, all Jersey veterinarians participated in the collection of blood samples. On routine visits to farms, each veterinary practitioner was requested to obtain a prescribed number of blood samples from cattle of various ages, so that the estimated total number of samples would represent approximately 5% of the total cattle population. Blood samples were collected from cattle located on 71 of the island's 793 farms (evenly distributed geographically), each having 3 to 95 cattle, with an average of 21 cattle per herd. This contrasted with the island's total 793 herds that ranged in size from 1 to 95 cattle, with an average of 11 cattle per herd.

In all, 434 blood samples were collected (Table 2). The actual number of all cattle in the population by age was obtained from the Jersey Herd Book after the completion of the study.* The goal of sampling 5% of the cattle population was achieved, although some variation was noticed among the different age groups. Of the cattle in the oldest age group (over 5 years), 10% were sampled because it was anticipated that there would be more cattle in this age group than there were. It was realized, in retrospect, that this was due to relatively fewer cattle in this age category — perhaps the result of the higher export rate, primarily of the younger cattle, to satisfy the demand for Jersey cattle that occurred after World War II and continued through the 1950's. This export ultimately led to a decreased number of aged cattle. Also, the proportion of samples from cattle in the youngest age group (birth to one-half year) was less than expected, and this occurred because one shipment of blood was delayed en route to our laboratory and was, therefore, unusable.

Samples of blood (5 ml.) were collected into vials, each of which contained 5 mg. of ethylenedisodiumtetraacetate. Coverglass smears were made within 1 hour. The smears and whole blood sam-

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TABLE 1—Number of Jersey (Channel Islands) Cattle Slaughtered and Carcasses Inspected During An 8-Year Period

Year	No. slaughtered		Total No. of carcasses inspected
	Cows	Calves	
1958	516	743	1,259
1959	442	789	1,277
1960	542	660	1,242
1961	770	531	1,101
1962	723	371	1,094
1963	804	280	1,084
1964	549	270	939
1965	355	532	887

*Report of the Jersey Herd Book Committee for the year 1964, St. Helier, Jersey, Channel Islands.

TABLE 2—Total Jersey (Channel Islands) Cattle Population in February, 1964, by Age, Number, and Percentage Sampled

Group No.	Age (yr.)	No. in group	No. of cattle sampled	Percentage of groups sampled	Percentage of total samples
1	0-½	670	18	2.7	4.1
2	½-1	942	59	6.3	13.6
3	1-2	1,674	91	5.4	21.0
4	2-3	1,485	67	4.5	15.4
5	3-4	1,624	46	2.8	10.6
6	4-5	1,630	55	3.4	12.7
7	5	958	98	10.2	22.6
Total (Av.)		8,983	434	(4.8)	100.0

ples were transported (under refrigeration) by airplane to our laboratory. Blood examinations were usually completed within 36, and always 48 hours after collection. Leishman's stain was applied to the blood smears, and differential cell counts were determined by standard methods.[17] Blood dilutions were made with automatic diluters,* and cell counts were made with an electronic cell counter.** Packed cell volume was determined by microhematocrit and hemoglobin by the cyanmethemoglobin method.

Results

Over 10 years ago, a diagnosis of pseudo-Hodgkin's disease (lymphocytic leukemia) was confirmed histologically in a 6-month-old Jersey CI calf. Since then, there have been no reports of leukemia in Jersey CI cattle.

Means ($\bar{X}$) and standard deviations (Sx) for total and differential leukocytic counts were estimated (Table 3). The mean white blood cell, lymphocytic, and normal lymphocytic values first increased and then decreased with age. Atypical lymphocytic values decreased steadily and were less commonly observed in cattle older than 2 years. Little change was seen in mean values for neutrophils and basophils, but eosinophils increased and monocytes decreased. The Sx decreased for white blood cells and lymphocytic counts in the cattle in the oldest age group; otherwise, for other cell factors, the Sx did not indicate a trend.

Histograms, demonstrating the distributions of the logarithms to the base 10 of the mean total lymphocytic counts (in thousands) by age (Fig. 1), indicated that, within each age group, total lymphcytic counts had approximately log normal distribution. The histograms also demonstrated the increasing, followed by the decreasing, mean lymphocytic counts with age. Assuming normal distributions for total lymphocytic counts, the upper 99.74% limits ($\bar{X} + 3$ Sx) were computed for each age group, for normal, and log normal distributions (Table 4). With the use of these limits,

*Research Specialties Co., Richmond, Calif.
**Model A, Coulter Electronics, Chicago.

TABLE 3—Means ($\bar{X}$) and Standard Deviations (Sx) of Absolute Leukocytic Counts (in Thousands) for Jersey (Channel Islands) Cattle By Age

Age (yr.)	White blood cells		Total lymphocytes		Normal lymphocytes		Atypical lymphocytes		Neutrophils		Eosinophils		Monocytes		Basophils	
	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx
0-½	9.35	2.32	6.72	1.48	6.37	1.37	0.35	0.23	1.56	0.75	0.10	0.14	0.78	0.26	0.06	0.06
½-1	9.56	2.24	7.21	1.79	6.88	1.68	0.33	0.23	1.30	0.71	0.25	0.27	0.72	0.35	0.07	0.08
1-2	8.84	2.11	6.34	1.61	6.09	1.54	0.25	0.20	1.42	0.67	0.44	0.44	0.58	0.28	0.08	0.10
2-3	8.09	2.35	5.24	1.75	5.04	1.69	0.20	0.18	1.51	0.95	0.66	0.73	0.62	0.30	0.06	0.08
3-4	7.33	2.37	4.43	1.65	4.27	1.61	0.16	0.14	1.50	1.23	0.72	0.61	0.61	0.33	0.05	0.06
4-5	6.66	2.28	3.94	1.62	3.79	1.57	0.15	0.12	1.56	0.82	0.55	0.33	0.57	0.30	0.04	0.05
≥ 5	6.18	1.89	3.26	1.10	3.09	1.03	0.14	0.13	1.66	0.99	0.64	0.44	0.56	0.37	0.05	0.06

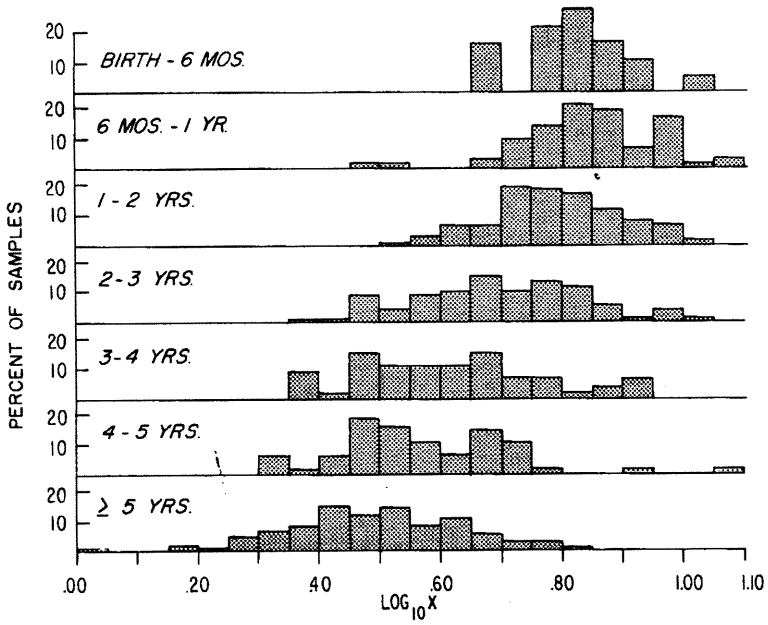

Fig. 1—Distribution of the total lymphocytic counts in Jersey, Channel Island, cattle by age ($\log_{10} \times$ x 10—3).

TABLE 4—Upper 99.74% Limits for Total Lymphocytic Count (in Thousands) Based on Normal and Log Normal Distribution by Age of Jersey (Channel Islands) Cattle

Group No.	Age (yr.)	No. of samples	Normal	Log normal
1	0-½	18	11.16	12.53
2	½-1	59	12.58	15.31
3	1-2	91	11.17	13.10
4	2-3	67	10.49	13.42
5	3-4	46	9.38	11.89
6	4-5	55	8.80	10.18
7	5	98	6.56	8.48

a 4½-year-old cow with a lymphocytic count of 12.24 $\times$ 10^3 and a 7-year-old cow with a lymphocytic count of 6.72 $\times$ 10^3 cells per cubic millimeter of blood were the only cattle determined to have lymphocytosis. With the use of log normal distribution for lymphocytes and the upper 99.74% limits as the cut-off points, only the 4½-year-old cow had lymphocytosis.

The $\overline{X}$ and Sx values for red blood cell count and their indexes, mean cell volume, mean cell hemoglobin, and mean cell hemoglobin concentration are shown (Table 5). Mean values for red blood cells decreased with age, whereas those for packed cell volume and hemoglobin did not. As expected, mean cell volume and mean cell hemoglobin increased, whereas mean cell hemoglobin concentration did not. The Sx for the values, with the possible exception of red blood cells, did not indicate any trends with age.

Discussion

With the established States of Jersey disease control program, one would expect leukemia to be reported at a rate of 1 to 2 animals per year if the occurrence was similar to other areas.[18] However, the expected occurrence of leukemia in Jersey CI cattle (3 years or younger), as elsewhere, would be only about 1:100,000 cattle, or 1 leukemic animal would be expected once every 10 years, which is essentially the observed rate. Yet, Cotchin[5] and, more recently, Jarrett *et al.*[9] reported both the calf form and the thymic form were the most frequently encountered types of leukemia in Great Britain, which may mean there is a lower incidence in young Jersey CI cattle. On the other hand, one would expect an occurrence of about 1 to 2 cases per year in the group of cattle 3 years and older and if the disease

TABLE 5—Means ($\bar{X}$) and Standard Deviations (Sx) for Erythrocytic Values in Jersey (Channel Islands) Cattle by Age

Age (yr.)	Red blood cells (No./cmm.)		Packed cell volume (%)		Hemoglobin (Gm./100 ml.)		Mean cell volume (CM)		Mean cell hemoglobin (μMg.)		Mean cell hemoglobin concentration (%)	
	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx	$\bar{X}$	Sx
0-½	7.27	1.48	33.9	4.70	10.33	1.41	47.5	5.91	14.5	2.10	30.6	2.16
½-1	6.04	0.94	30.3	2.49	9.49	1.02	50.9	6.02	15.9	1.99	31.3	1.88
1-2	5.53	0.99	30.3	3.94	9.72	1.46	55.7	7.73	17.9	2.58	32.1	2.31
2-3	5.00	0.72	29.1	3.46	9.40	1.06	58.8	7.21	19.1	2.41	32.4	2.32
3-4	4.94	0.70	29.8	3.22	9.67	1.23	60.9	5.37	19.7	1.71	32.4	2.29
4-5	4.94	0.84	30.2	3.74	9.62	1.52	62.0	7.57	19.7	2.62	31.8	2.52
> 5	4.79	0.75	30.4	3.75	9.76	1.48	64.3	6.67	20.6	2.47	32.0	2.17

showed up in herds with several cases, the expected rate would be greater. Several factors may be responsible for low rates of leukemia in older Jersey CI cattle.

If bovine leukemia is caused by an infective agent(s), prevention from contact with infected alien cattle may be one factor responsible for the rarity of the disease in island cattle. Recently, it has been suggested that bovine leukemia may be transmitted by milk[14,20] which, if substantiated, would parallel natural transmissions of some murine leukemias.[8,11,12] One must also consider that, since Jersey CI herds are, in general, small, there might be less chance for a leukemogenic agent(s) to be perpetuated.[4] Since alien cattle have not been bred to Jersey cows for about 30 generations, island cattle may be genetically resistant, however, observations made elsewhere indicate that cattle of the Jersey breed frequently have leukemia.[19] Nevertheless, certain families of cattle may have a greater susceptibility,[13] as do certain strains of mice.

Leukocytic other than lymphocytic cell counts for Jersey CI cattle were similar to those recorded for foreign Jersey cattle.[17] The erythrocytic counts and hemoglobin values were smaller than those recorded for Jersey cattle raised in California, but similar to values of Jersey cattle reared in England.[7] Nutritional differences may account for the variations in mean erythrocytic and hemoglobin values.

Three years after the initial examination was made, the cow with the greatest lymphocytic count (12.24×10^3) had a normal count of 3.92×10^3. The cause of the transient lymphocytosis is unknown. Evidence of a low lymphocytosis rate among Jersey CI cattle supports the epizootiologic evidence that leukemia in adult cattle has never been reported. Lymphocytosis in adult cattle is frequently observed as a preleukemic change in herds with several cases,[19] but some workers have indicated that lymphocytosis in these herds is variable.[13] Thus, these hematologic and epizootiologic studies alone are not evidence enough to prove the absence of the enzootic form of leukemia, although they do support the probability of a rare incidence. Additional long-term epizootiologic studies must be done to determine true bovine leukemia rates. Isolation of a bovine leukemogenic agent(s) must be made before it can be determined whether Jersey CI cattle are free of such an agent(s). In light of recent interest on the comparative aspects of bovine leukemia,[10,16] parallel studies should be conducted on other animal and human populations on Jersey to determine the rate of leukemia. Such a study would be feasible and might prove helpful in gaining a fuller understanding of the disease in man.

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