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AN ATTEMPT TO ESTABLISH GENETICALLY CONDITIONED SUSCEPTIBILITY OF CATTLE TO LYMPHATIC LEUKAEMIA[1]

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Summary. The investigations were based on the data concerning sanitary conditions and the origin of 8360 dairy cows of Lowland Black-and-White breed from 73 State Farms. The frequency of lymphatic leukaemia cases depending on the origin of cows has been analysed. Lymphatic leukaemia was diagnosed in 15.48% of cows. Statistically significant ($p=0.01$) differences concerning the frequency of the investigated disease were observed between the progeny of particular bulls. It was also clear (statistically significant at $p=0.01$) that the morbidity to leukaemia was also influenced by sanitary conditions of mothers. The estimated coefficient of the inheritance of susceptibility to leukaemia amounted to 0.26 (when using the method of variance analysis of paternal factor) and 0.76 (when using the mother-daughter regression method).

An increased interest to leukaemia type diseases resulting from an alarming frequency of cases both in human beings and in animals has been observed in the whole world for some years (Mussgay Kaaden 1978, Robertson et al. 1977). In livestock the disease affects mainly cattle and poultry but in the case of cattle it is most often lymphatic leukaemia. In some countries lymphatic leukaemia of cattle takes an enzootic form causing significant economic losses (Donham et al. 1977, Nachmanson 1971, Pietuchov 1975, Tyler 1978). Moreover, according to many authors (Aleksandrowicz 1977) animal leukaemias, including lymphatic leukaemia of cattle, can result in accumulation of oncogenic viruses which may be dangerous for genetically predisposed people living under conditions favourable for the development of the disease.

Lymphatic leukaemia of cattle is an infectious disease caused by viruses (oncornavirus of C type of the *Retroviridae* family) (Kita 1980, Ressang et al. 1980). However, the development and the course of the disease depend on the genetically conditioned predisposition of the animal, on the way of infection, the number of the viruses in the environment and their virulence as well as on the animal age, the course of pregnancy and parturition, on feeding conditions and on all the factors which influence the environmental conditions unfavourably (Grundboeck 1975).

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Many authors (Grimshaw et al. 1980, Haremski 1969, Wiesner 1965) point out to the fact that most frequently animals from 4 to 8 - 9 years old, i.e. at the age of their highest productivity, become victims of lymphatic leukaemia. The fact that leukaemia manifests itself in adult animals already having a progeny (in the case of cows it is a few calves, but in the case of bulls it can even be a few thousand) create a great difficulty in the control of the disease. In the light of complex etiology of cattle leukaemia the main problem that arises is to find proper methods preventing and controlling the disease. Since none of known veterinary means and methods show expected results, the problem of inheriting the susceptibility to the disease by animals becomes more and more important. It was observed many times that progeny of ill cows become victims of leukaemia more often than the progeny of healthy ones (Ernst et al. 1973, Haremski 1969, Wiesner 1965). The fact of existing leukaemia-free families of cows as well as leukaemic families were reported by many authors (Auzinia 1976, Larson et al. 1970, Wittman 1968). The problem of getting by bulls a hereditary susceptibility to leukaemia has not been fully explained yet. Some scientists (Straub et al. 1974, Zavertjaev 1974) assume the existence of such a possibility on the basis of the fact that progeny of some bulls are more often victims of the disease than progeny of others. Such a situation is not likely to be a result of transference of the virus of cattle leukaemia by the bull semen since the investigations did not show the presence of the virus in the semen of bulls with leukaemia. Furthermore, freezing and unfreezing (Ferrer 1977) used for semen preservation destroy the virus of cattle leukaemia. On the other hand, some authors (Haremski 1969, Wiesner 1965) did not observe any clear influence of leukaemic bulls on the occurrences of the disease among their daughters.

The lack of a univocal opinion on the hereditary basis of cattle susceptibility to lymphatic leukaemia inclined the author to undertake these investigations, the results of which are presented below.

MATERIAL AND METHODS

The material was collected in 76 state farms located in the area of the former Gdańsk district (44 farms) and Nowy Dwór district (32 farms). The obtained data concerned 8360 dairy cows of Lowland Black-and-White breed. The information about the origin of cows and their age was obtained from the herdbooks. The results of the routine veterinary haematologic tests for leukaemia done during 1973 - 1976 by the workers of Veterinary Hygiene Institute in Gdańsk were used to evaluate sanitary conditions of cows. With the help of leukaemic key, which includes the age of the animal and results of the tests, all the cows were divided into two groups: 1) leukaemic cows — positive results of at least two succeeding tests at the interval of six months, 2) healthy ones — a negative result of at least one test. On the basis of the collected data the following factors were analysed:

1. The dependence of:

a. Fathers and the susceptibility of their daughters to leukaemia. From 8360 cown, 6944 were selected as the progeny of 73 bulls. The number of animals in groups of paternal half-sister ranged from 33 to 353 cows, the mean number being 95 daughters.

b. Sanitary conditions of mothers and daughters. In the investigated material there were 462 pairs of mother-daughter (924 cows altogether). All mothers and daughters were tested for leukaemia. In both cases (a and b) the statistic analysis was done using the Chi^2 method.

2. The inheritance of susceptibility to leukaemia:

a. Applying the method of the variance analysis of paternal half-sib factor according to the linear formula:

$$x_{ij}=\mu+s_i+e_{ij}\,,$$

where μ — mean general value, s_i — influence of i-numbered father, e_{ij} — chance influence.

The inheritance coefficient of susceptibility to leukaemia was estimated for all the cows as well as for daughters aged 4 - 8 years. This genetic parameter was not estimated for other age groups because of a small number of animals in them. Grouping according to the age was done on the basis of the mean age of ill cows $\bar{x}=6.14\pm2.0018$ years.

b. By the method of progeny-parent (daughter-mother) regression according to the linear formula:

$$x_i=a+b_{xi}+e_i\,,$$

where a — constant value, b — regression coefficient, e_i — chance i-numbered influence.

Since the immunity against a disease belongs to the liminal features (none-or-all) and it appears in the binominal scale, the values of the heredity coefficient (h_b^2) obtained by the method of variance analysis from the paternal factor and by the progeny-parent regression method were converted into normal scale (h^2) according to the formula given by Żuk (1979):

$$h^2=h_b^2\,\frac{p(1-p)}{z^2}\,,$$

where p — indicates a fraction of healthy animals in the population, z — the co-ordinate of the normalized distribution at the point cutting off the p fraction of the population

RESULTS AND DISCUSSION

Out of 8360 dairy cows tested for leukaemia during 1973 - 1976 the disease was diagnosed in 1293 cases (15.48%). The remaining 7066 cows (84.52%) were leukaemia-free. In the herds of particular state farms the morbidity to leukaemia

varied from 2.67 to 36.67%. Similar results were obtained by other authors. For example, Donham (1977) reports that in 21 investigated dairy farms the percentage of leukaemic cows was within 4.2 and 80.0%. Relatively high morbidity to leukaemia were also noted by Dimmock et al. (1979) — 22.3%, Haremski (1969) — 26.95%.

The mean age of all investigated cows was 6.38 years. For the healthy cows it was 6.44 years and for leukaemic ones 6.14. The results correspond to those reported by other authors: Ivanova (1973) — 6.21 years, Pietuchov (1975) — 6.5 years. This conformability as well as the fact that in the investigated material 77.15% of cows with leukaemia were 4 to 8 years old confirm the suggestion put forward by many authors (Grundboeck 1975, Haremski 1969, Pietuchov 1975) that leukaemia most often affects animals of mature age. No statistically significant dependence of the sanitary conditions of cows and their placing on particular farm and district was observed. The possible dependence of lymphatic leukaemia in cows on their origine from particular mothers and fathers was estimated by the Chi^2 test. Highly significant differences in the frequency of leukaemia in daughters of particular bulls were noted (Chi^2 emp.=263.0797). Out of 6944 cows originating from 73 bulls leukaemia was diagnosed in 1048 daughters (15.09%). The lowest morbidity was observed in the group of half-sisters from Trijntjes Diamant 270 K bull (2.04%), while the highest was noted among the daughters of Niemy 850 G bull (39.55%). Figure 1 shows the frequency of leukaemia cases in groups of half-sibs from the same father. Since the number of animals in these groups varied from 33 to 353, the symbol x in the figure means the groups of over 100 daughters. It should be noticed that in a large group of 353 half-sisters from bull No. 10 v.d

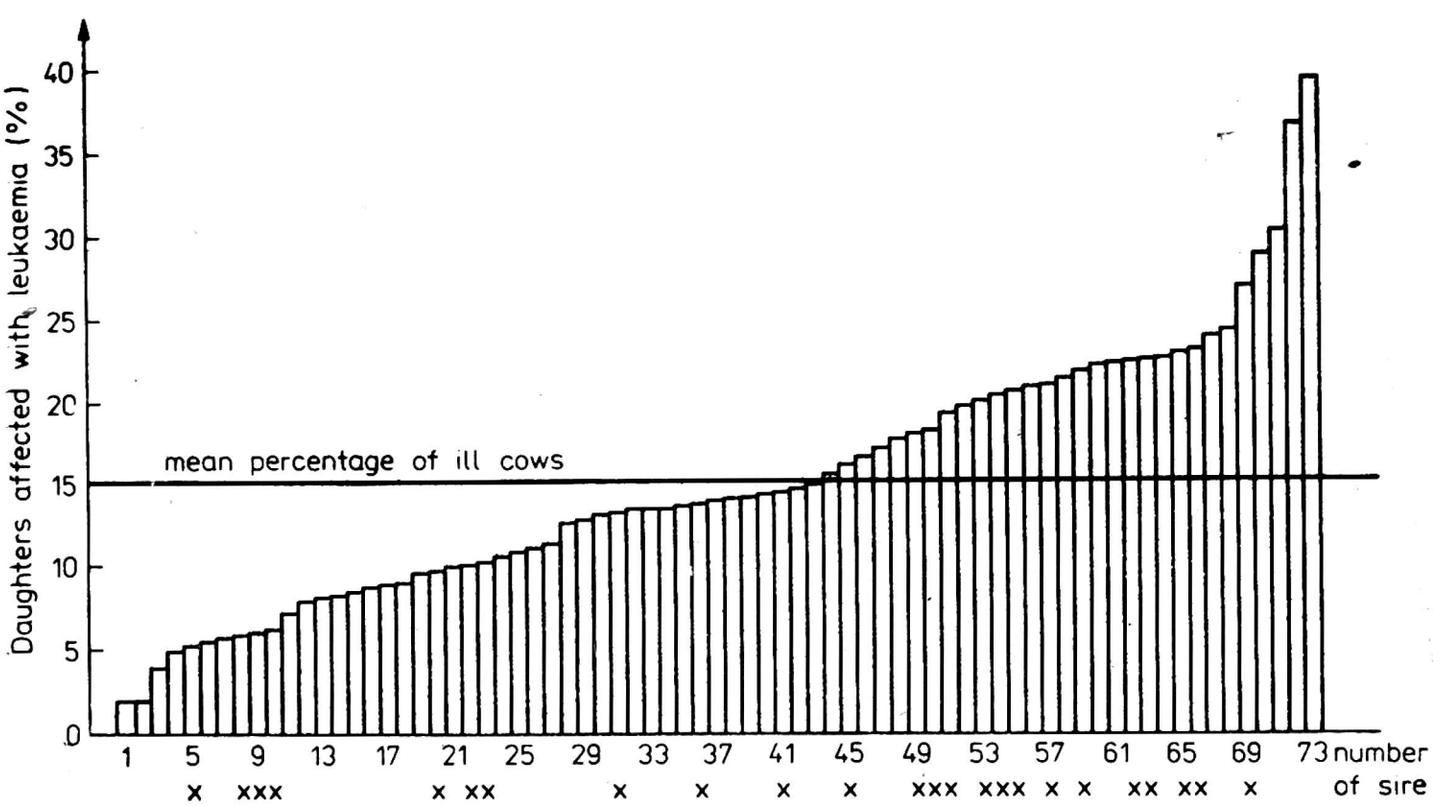

Fig. 1. The frequency of leukaemic cases in daughters from particular sires

X — groups of half-sisters with over 100 cows

Kamp 435 G/K only 22 daughters (6.23%) were affected with leukaemia, while in another group of 273 animals, which were the progeny of bull No. 54 Folio 43 G, the disease was diagnosed in 56 animals (20.51%). The mean values expressed by percentage of leukaemic animals were noted in the groups of daughters from bull No. 22 Alert 37 G/Ko — 10.08%, which constitutes 41 leukaemic cows out of 258, and from bull No. 41 Jaskier 3514 K — 14.5% out of 262 daughters.

The correlation between the occurrence of lymphatic leukaemia in cows and sanitary conditions of their mothers was also proved to be highly significant statistically. In view of that, using the method of variance analysis in the groups of paternal half-sisters and the method of mother-daughter regression, the inheritance coefficient of susceptibility to lypmhatic leukaemia was estimated. Since 70% of cows belonged to the age group including 4 to 8 year-old animals, the hereditary susceptibility to this disease was estimated for all the daughters as well as for all the cows 4 to 8 years old. The coefficient of hereditary susceptibility to leukaemia estimated for the whole investigated material amounted to 0.26, while for cows aged 4 to 8 years — 0.27. Therefore, the results suggest the influence of the genetic assumption of the bull on the frequency of leukaemia in its daughters. The results of the present investigations are similar to those by Zavertjaev (1974) who obtained the value 0.29 for the coefficient of heredity, but they differ from those by Ernst et al. (1973). Table 1 presents the values of the coefficients of hereditary susceptibility to leukaemia estimated in the present investigations as well as in the investigations by other authors. It should be stressed, however, that the investigated material, for which the authors enlisted in Table 1 had estimated this genetic parameter, differed in respect to the breed. Thus Ernst et al. (1971 : 1973 : 1974) estimated the coefficient for Brown Lettish breed, Zavertjaev (1974) for Red cattle breed and Lowland Black-and-White cattle. Apart from these differences there is a marked influence of the genetic assumptions of the bull on the frequency of

Table 1. Coefficient of hereditary susceptibility to the lymphatic leukaemia in cattle (according to the enlisted authors)

Author	Year	The method of estimating heredity coefficient	h^2
Ernst et al.	1971	groups of paternal half-sister	0.189 - 0.479
Ernst et al.	1973	groups of paternal half-sister	0.016 - 0.056
		daughter-mother regression	0.176 - 0.214
Ernst et al.	1974	groups of paternal half-sister	0.162
Zavertjaev	1974	groups of paternal half-sister	0.29
Charon (the parameters estimated in the present paper)	1982	groups of paternal half-sister	0.26
		daughter-mother regression	0.78

Table 2. Morbidity to leukaemia of cows-daughters of particular bulls

Name and number of bull	Total number of investigated daughters	Number of ill daughters	Per cent of ill daughters
1	2	3	4
Trijntjes Diamant 270 K	49	1	2.04
Ekwador 787 G/Gd	97	2	2.06
Eduard II 92 G/Zg	71	3	4.23
Dąb 383 K	39	2	5.13
Ważny 470 G/Gd	129	7	5.43
Andro 187 G/Gd	36	2	5.56
Annas 389 K	70	4	5.71
Suwer 155 G/Gd	152	9	5.92
Willhem 610 G/Gd	130	8	6.15
Berthus v.d. Kamp 23 435 G/Gd/K	353	22	6.23
Zijlster Ideal 1784 K	68	5	7.35
Bauester Adema 265 K	50	4	8.00
Brytan 388 K	49	4	8.16
DON II 427 K	61	5	8.20
Senior 788 G/Gd	94	8	8.51
Kalwin 414 K	80	7	8.75
Brylant 103 G/Gd	34	3	8.82
Sikkema Rudolf Jan 280 K/553W/Gd	44	4	9.09
Blask 304 K	41	4	9.76
Andrus 447 K	142	14	9.86
Bazalt 204 G/Gd	60	6	10.00
Alert 37 G/Ko	258	26	10.08
Bert 4901 K	124	13	10.48
Eden 385 K	47	5	10.64
Grom 372 K	91	10	10.99
Delfin 205 Wst.	45	5	11.11
Ceres 26 G/Gd	43	5	11.63
Junior 600 G/Gd	63	8	12.70
Sultan 739 G/Gd	70	9	12.86
Camillo 190 G/Gd	53	7	13.21
Final 151 G/Gd	187	25	13.37
Alban 868 G/Gd	74	10	13.51
Grot 213 G/OL/K	37	5	13.51
Camstra Ceres XII 73-G/E/Gd	96	13	13.54
Ader 35 G/Ko	81	11	13.58
Cyklon 318 G/Gd	152	21	13.82
Effys B.B. 4714 K/E	65	9	13.85
Ornea George 4909 K	36	5	13.89
Orzel 212 G/Gd	64	9	14.06
Boukje Adema 268 K	56	8	14.29
Jaskier 3514 K	262	38	14.50
Haubois Rutjes Adema 3 G/Zg	54	8	14.81
Rotterda Sikkema 266 K	33	5	15.15
Jaguar 227 G/Gd	45	7	15.56
Jeleń 429 K	180	29	16.11
Jenot 334 G/Gd	36	6	16.67
Jaśmin 597 G/Gd	52	9	17.30
Perlik 3228 K	45	8	17.78
Patros 148 G/Gd	105	19	18.10
Flisak 342 G/Gd	110	20	18.18
Food 41 G/Gd	291	56	19.24
Gabor 260 K/254 W/Gd	61	12	19.67
Anton II 5031 K	191	38	19.90
Folio 43 G/Gd	273	56	20.51
Alpenbub 3154 K	141	29	20.57
Kandyt 536 G/Gd	58	12	20.69
Forint 42 G/Gd	172	36	20.93

Tab. 2 cont.

1	2	3	4
Estyn 24 G/Wr	47	10	21.28
Jelmar 154 G/Gd	100	22	22.00
Camel 110 G/Gd	68	15	22.06
Dyskobol 410 K	45	10	22.22
Fukacz 198 G/Gd	139	31	22.30
Alman 29 G/Ko	152	34	22.37
Camstra Ceres 404 G/By	67	15	22.39
Aldom 14 G/Ko	192	44	22.92
Dollart 5019 K	104	24	23.08
Paul Juwel 1778 K/E	42	10	23.81
Lunatyk 96 G/Ko	41	10	24.39
Albert 5021 K	145	39	26.90
Campio 70 G/Gd	69	20	28.99
Jawor 79 G/Gd	69	20	28.99
Caro 150 G/Gd	57	21	36.84
Niemy 850 G/Gd	43	17	39.53
TOTAL	6944	1048	15.09

leukaemia occurrence in daughters. This tendency shows a marked similarity to the results obtained by many other authors (Straub et al. 1974, Czymoch, Fortner after Wiesner 1965). Considering the fact that with artificial insemination one bull can have a few or even dozens thousands of progeny and taking into account the opinion of scientists (Straub et al. 1974, Zavertjaev 1974) about an undeniable share of the genetic changeability in forming the cattle immunity against leukaemia, it seems that a greater attention should be paid to this problem while selecting bulls for breeding purposes.

The coefficient of hereditary susceptibility to leukaemia estimated in the present investigations with the help of the mother-daughter regression method amounted to a high value of 0.78. Much lower value of this parameter was obtained by Ernst et al. (1973) — 0.176 - 0.214. Such a high value of the coefficient of heredity for the analysed material results not only from the share of genetic changeability in forming of this feature. Undoubtedly an important part is also played by the effect of maternal influence that means a possibility of transference of the virus of lymphatic leukaemia by a cow to its progeny through placenta or even through the ovum, that was observed by many scientists (Głogowski 1977, Mussgay Kaaden 1978, Tyler 1978, Wiesner 1965). It indicates the advisability of eliminating leukaemic cows which can transfer to their progeny not only genetic assumptions conditioning the susceptibility to this disease, but also the infectious factor itself. This hypothesis is confirmed by results of many authors (Auzinja 1976, Haremski 1969, Larson et al. 1970) who observed leukaemia-free families as well as leukaemic families of animals exposed to the danger of infection with leukaemia virus. It is also confirmed by two or even three times higher frequency of leukaemia cases among the progeny of ill mothers as compared to the progeny of healthy ones. It seems that the results of present investigations as well as the reports of previously mentioned authors justify the need of greater attention to be paid to genetic differences in the cattle susceptibility to leukaemia in order to use this knowledge for cattle breeding.

CONCLUSIONS

1. In the analysed material of 8360 cows lymphatic leukaemia was diagnosed in about 15% of animals. A higher percentage of leukaemia cases (about 20.8%) was noted in the age group of 4 to 8 year — old animals.

2. Statistically significant differences in the frequency of leukaemia were noted among daughters of particular cows and bulls. It can be assumed that it resulted from genetic changeability in the susceptibility to the discussed disease.

3. This assumption is reflected in the coefficient of hereditary susceptibility to leukaemia (h^2 estimated from paternal factor by the variance analysis amounted to 0.26 and by the mother-daughter regression method — 0.78).

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PRÓBA USTALENIA WARUNKOWANYCH GENETYCZNIE SKŁONNOŚCI BYDŁA DO ZACHOROWANIA NA BIAŁACZKĘ LIMFATYCZNĄ

Streszczenie

Do badań wykorzystano dane dotyczące stanu zdrowia i pochodzenia 8360 krów mlecznych rasy nizinnej czarno-białej z 73 Państwowych Gospodarstw Rolnych. Przeanalizowano częstość występowania białaczki limfatycznej w zależności od pochodzenia krów. U 15,48% krów stwierdzono białaczkę limfatyczną. Odnotowano statystycznie istotne ($p=0,01$) różnice w częstości występowania tej choroby między potomstwem określonych buhajów. W sposób wyraźny (statystycznie istotny przy $p=0,01$) zachorowalność krów na białaczkę była uzależniona od stanu zdrowia ich matek.

Współczynnik odziedziczalności skłonności krów do zachorowania na białaczkę oszacowany dla analizowanego materiału wyniósł 0,26 (przy metodzie analizy wariancji z komponentu ojcowskiego) i 0,78 (przy metodzie regresji matka-córka).

ПОПЫТКА ОПРЕДЕЛЕНИЯ ГЕНЕТИЧЕСКИ ОБУСЛОВЛЕННОГО ПРЕДРАСПОЛОЖЕНИЯ КОРОВ К ЛИМФАТИЧЕСКОМУ ЛЕЙКОЗУ

Резюме

В исследованиях были использованы данные, относящиеся к состоянию здоровья и происхождения 8360 молочных коров черно-пестрой породы из 73 сельских хозяйств.

Была проанализирована частота выступления лимфатического лейкоза в зависимости от происхождения коров.

У 15,48% коров обнаружено лейкоз. Были отмечены статистически достоверные ($p=0,01$) различия между потомством определенных производителей в частоте выступления этой болезни. Отчетливо (статистически достоверно при $p=0,01$) на заболеваемость коров лейкозом влияло тоже состояние здоровья их матерей.

Для всего проанализированного материала был определен коэффициент наследственности предрасположения коров к лейкозу равный 0,26 (методом дисперсионного анализа по компонентам производителя) и 0,78 (методом регрессии мать-дочь).