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GENETIC RESISTANCE TO LEUKAEMIA IN BLACK-AND-WHITE CATTLE

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Abstract

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Data obtained from 1312 Black-and-White cows of 75 bulls from different farms shows that bulls transmitted different levels of resistance or susceptibility to leukaemia to their daughters. It can be used in practice for early elimination of bulls which are genetically predisposed to leukaemia. The h^2 of leukaemia resistance was 0.13. Relationship between blood groups, transferrins, postalbumins, amylase, $\varkappa$Cn, α_{s_1}-Cn, β-Cn (caseins) and β-Lg phenotypes and leukaemia was also analyzed. In cows secreting $\varkappa$Cn AA types there is a significantly lower incidence of leukaemia than in cows producing $\varkappa$Cn BB or AB types. The frequency of $Y_2D'G'I'$ allele in cows with leukaemia was very high. The differences for the other phenotypes were not significant.

Resistance, leukaemia, cattle, polymorphism.

Leukaemia is a major animal disease. A significant percentage of domestic and wildlife animal cases was described by Engelbreth – Holm (1942) and Wiesner (1967). Hereditary predisposition to disease is transmitted according to monogenic mode with three pairs of alleles, the susceptibility to different forms is thought to be due to dominant ones (Götze and Ziegenhagen 1953; Böttger 1954).

Very extensive work on this subject has been carried out by Ernst and his coworkers. They found (Ernst et al. 1973a, 1974) that the percentage of progeny (daughters) with positive results from matings between susceptible sires and dams was high (14.2 %). The percentage of daughters with positive results of leukaemic test from matings between resistant sires and dams was small (6.3 %). The h^2 of differences in predisposition to bovine leukaemia is estimated to be 0.1622. These results were obtained from population of about 50 000 cows. The workers suggested that these should be taken into account in selection for lower incidence of bovine leukaemia.

Prior to the report of Ernst et al. (1973b) little was known concerning any of the genetic markers of resistance to leukaemia in cattle. In the Brown Latvian cattle, these workers demonstrated that the frequency of antigens *B*, Y_2, *D'*, *P'* were about 5–12 % lower and the frequency of antigens C, S, U were about 3–11 % higher in animals with leukaemia ($n = 2495$).

In addition, in the same breed (36 245 cows) Karlikov et al. (1978) demonstrated that animals which are carriers of the allele *BIP'* have a significantly lower incidence of leukaemia than cows with other blood group genes. These findings led to the suggestion that it seems possible to perform the selective breeding of *BIP'* bulls in order to decrease the incidence of bovine leukosis.

Klimov et al. (1974) indicated that there is in cows of Black-and-White, Red Steppe and Ayrshire breeds with Tf DD, Tf AA and Tf EE phenotypes a significantly higher incidence of leukaemia than in cows with the other phenotypes. These results were not entirely in agreement with those of Joomkov et al. (1978). They analyzed the relationship between phenotypes of transferrins, ceruloplasmins, amylase and carbonic anhydrase and incidence of leukaemia in Black-and-White cattle and found that the frequency of Tf A or Tf AA allele or phenotypes increases in leukae-

mic cows. On the other hand, according to Bussol and Meshcheryakov (1978) the relationship between Tf and Hb phenotypes and incidence of leukaemia in Black-and-White cows was not significant.

The current studies are an attempt to obtain differences in the transmitting ability of resistance and susceptibility to leukaemia in sires and to find differences in haematological diagnosis of leukaemia according to the blood groups and phenotypes of blood serum and milk proteins and enzymes in cows.

Materials and Methods

Leukaemia was diagnosed according to the key by the Veterinary Hygiene Research Station. The whole population was tested twice: at the beginning and at the end of a six-months period. The Black-and-White cows were taken from different farms. The total data included 1312 daughters of 75 sires. The whole population was naturally exposed to the pathogen.

Taking as a criterion the percentage of daughters with positive results, the sires were divided into three groups:

Group	The percentage of sires' daughters with positive results
I	$50 \geq$
II	$49-21$
III	≤ 20

Only sires with five or more daughters were used.

The h^2 of leukaemia resistance was calculated by half-sib correlation (Cochran 1943; Lusch et al. 1948).

The whole population of daughters was divided into two groups. Cows with negative results to the leukaemic test were placed in group I, cows with positive results formed group II.

In order to ascertain an eventual association between the blood group systems and leukaemia morbidity, both groups were characterized in respect of the gene frequencies in blood group system B, FV, J, L, M, Z and blood red cell antigens of A, C and SU systems. The blood group examinations were carried out according to generally accepted methods. The serum set test was used enabling identification of 40 following blood red cell antigens: A_2, H, B_1, B_2, G_2, K, I_1, I_2, O_1, O_x, P, Q, T_1, Y_2, A′, B′, D′, G′, I′, O′, E_1', E_2', G_1'', G_2'', P′, C_2, R_1, W_1, X_2, L′, F, V, J, L, M, S, U, H′, U′, Z.

The gene frequency in biallelic systems was determined by calculating the Chi square root of the recessive alleles frequency. However, in the B and FV systems, the direct counting of particular alleles was used. Genotypes in those systems were determined on the basis of the heredity analysis and phenotype interpretation.

Phenotypes of blood serum transferrins (Tf), postalbumins (Poa) and amylase (Am I) were determined by starch gel electrophoresis according to Smithies (1955) in buffer systems proposed by Geldermann (1970), Tomszewska – Guszkiewicz et al. (1971). Phenotypes of milk proteins $\alpha_{s1}-$Cn, $\varkappa-$Cn, $\beta-$Cn and $\beta-$Lg were determined by starch gel electrophoresis according to Michalak (1969). The effect of selection in relation to polymorphic loci was determined according to Semenova (1976).

The results were statistically analyzed by the Chi square method.

Results

The percentage of sire's daughters with leukaemia are presented in Table 1. The highest percentage of progeny with positive results was in group I (60.00). The percentage of daughters with positive results in group III was low (12.50). The differences between groups were highly significant ($P < 0.001$).

It may be legitimate to suggest that sires and their daughters were susceptible (I) or resistant (III).

The h^2 of leukaemia resistance was 0.13 for half-sib by sires.

In the group system B an occurrence has been stated of 60 alleles in group I of cows and 45 alleles in group II (Table 2). Both the sum of B alleles occurring with the frequency higher than 1% and the homozygosity degree in both studied

Table 1

The incidence of leukaemia in daughters of bulls

Group	No. of bulls	No. of progeny	No of progeny with positive results	Percentage of progeny with positive results
I	21	320	192	60.00
II	44	904	334	39.95
III	10	88	11	12.50
Total	75	1312	537	40.93

Groups		Chi²
I – II	51.27	$P < 0.001$
I – III	62.35	$P < 0.001$
II – III	21.13	$P < 0.001$

Table 2

B-alleles of a frequency higher than 1 % in groups studied

B – alleles	Relative frequency (%)		Chi²
	Group I (–)	Group II (+)	
B	1.14	1.53	
$BG_3KOxY_3A'O'$	7.21	6.15	
$BG_4KOxO'E'_2$	2.45	1.53	
BO_1	2.78	3.07	
BO_1Y_3D'	1.63	1.92	
$BO_xA'I'P'$	1.63	2.69	
$BO_xY_2A'G'P'G''$	4.91	5.00	
G_3O_1	0.65	1.15	
$G_3Y_2E_1'$	11.80	11.92	
$I_1O_xQA'E'_1K'$	2.29	3.46	
I_3	11.47	10.76	
O_1	1.14	0.76	
O_xA'	2.45	0.76	
$O_xY_2D'E'_1O'G''$	1.14	0.38	
PI'	1.31	1.92	
$Y_2D'G'I'$	3.60	6.92	4.36 $P < 0.05$
$Y_2G'G''$	1.80	3.07	
I'	10.65	9.23	
G''	4.91	5.38	
No. of cows	305	130	
Total number of B – alleles	60	45	
Number of B – alleles of a frequency higher than 1 %	18	16	
Sum of alleles of a frequency higher than 1 %	74.3 %	75.7 %	
Heterozygosity degree	5.9 %	6.1 %	

Table 3

The frequencies of κ-Cn in the population studied

Phenotype		Group I (–)	Group II (+)	Differences	Chi²
	AA	41	11	AA versus AB and BB	3.39κ
κ – Cn	BB	10	6	AB and BB	0.05 NS
N = 219	AB	99	52		
No. of animals		150	69		

NS: Not significant
κ: Significant at 0.10 level.

groups were very similar (Table 2). Analysing the frequency of particular B alleles in the groups a statistically significant difference ($P < 0.05$) was found for $Y_2D'G'I'$ allele, which occurred in I group with the frequency of 3.60 % and in group II of cows with the frequency of 6.42 % (Table 2). In the other blood groups systems there were no statistical differences stated ($P < 0.05$).

In the population studied, five phenotypes of Tf (AA, DD, AD, AE, DE), three phenotypes of Poa (FF, FS, SS), three phenotypes of Am I (BB, BC, CC), two phenotypes of α_s.—Cn and β-Cn (BB, BC and AA, AB, respectively) and three phenotypes of $\varkappa$-Cn and β-Lg (AA, AB and BB) were found. A significant difference between groups of cows was only found for $\varkappa$-Cn phenotypes (Table 3). The animals possesing $\varkappa$-Cn AA types a significantly lower ($P < 0.10$) incidence of leukaemic infection than in cows producing $\varkappa$-Cn BB or AB types.

The effect of allele combination in the two groups of cows has only shown a significant difference in the frequency of Am BB × Poa FF combinations of loci. In the group of cows with negative results the frequencies of Am BB + Poa FF phenotypes was higher in comparison with frequencies of this combinations of loci in group of cows with positive results of leukaemic test.

Discussion

Bulls transmitted different levels of resistance or susceptibility to leukaemia to their daughters (Table 1). The same has been observed in other diseases of domestic animals (Hutt, 1958, 1974, 1975; Cole, 1968; Yamada 1974; Skolasiński et al., 1977; Lindström and Syväjärvi 1978).

Generally speaking resistance to infectious disease is more likely to be polygenic than monogenic. It is greatly influenced by the severity of exposure to the pathogen (virulence, dosage) and environmental stress (Hutt 1958, 1974, 1975; Payne 1973; Bradley and Spooner 1977). In this study determining the type of inheritance of leukaemia resistance was very difficult. On the other hand, the h^2 of leukaemia resistance in bulls was very low (0.13). However, Ernst et al. (1973a, 1974) found that the h^2 of predisposition to bovine leukaemia was very small (0.1622). On the other hand, Hutt (1975) suggests that from a population of animals, resistant animals can be obtained even though the value of the heritability coefficient is very small.

On the basis of this work, the bulls transmitted different levels of resistance or susceptibility to leukaemia to their daughters. This preliminary investigation also indicates the extremely important role which genetic typing of bulls could play as a supplementary measure in the control of leukaemia. It can be in practice used for early elimination of bulls which are predisposed to leukaemic infection.

In the population studied some genetic markers of resistance to leukaemia in cows were found. However, the differences reported are no greater than would be expected by chance. These results are also not entirely in agreement with those of Ernst et al. (1973 b), Joomkov et al. (1978), Klimov et al. (1974).

On the basis of these results there were no significant differences in the Tf phenotypes between groups of cows. It was assumed hypothetically that significant difference of Tf DD type could occur in the cows of I and II groups if the statement reported below were taken into consideration. Wiesner (1963) stated that cows which are characterized by the highest milk production are afflicted with leukaemia more than cows having lower milk production. In the author's opinion it was caused by higher metabolic rate in cows with high milk

production and thus the greater deficiency of mineral and vitamins, occurring in such animals. On the other hand, Ashton et al. (1964), Kliment (1974), Siracky and Golota (1971), Przytulski (1979) reported that Tf DD cows produced more milk in comparison with cows with other Tf types.

Also, this idea is not borne out by the finding that $\varkappa$-Cn AA cows a significant lower incidence to leukaemia than in cows producing $\varkappa$-Cn BB or AB types. Hovewer, Mácha and Müllerová (1979) found that $\varkappa$-Cn AB cows had higher milk yield in comparison to $\varkappa$-Cn BB and AA cows. On the other hand, Klemke (1978), Przytulski et al. (1979) reported that $\varkappa$-Cn AA cows had higher milk yield than $\varkappa$-Cn AB cows.

It seems likely that the mechanism of the connection of the pathological changes of leukaemia in animals with higher milk production has different character than the relationship between transferrin and $\varkappa$-Cn types and milk yield.

Genetická rezistence vůči leukémii u černobílého skotu

Data získaná na 1312 dcerách 75 býků černobílého skotu z různých farem ukazují, že býci předávají svým dcerám různý stupeň odolnosti či vnímavosti vůči leukémii. Tento poznatek lze využít pro brzkou eliminaci býků geneticky predisponovaných k nemoci. Koeficient dědivosti h^2 zvýšené odolnosti vůči leukémii byl 0,13. Vztah mezi krevními skupinami, transferriny, postalbuminy, amylázou, $\varkappa$-Cn, α_{s1}-Cn, β-Cn (kaseiny) a β-Lg fenotypy a leukémií byl rovněž analyzován. U krav s $\varkappa$-Cn AA typy byl výskyt leukémie signifikantně nižší než u krav s $\varkappa$-Cn BB anebo AB. Frekvence alel $Y_2D'G'I'$ u krav s leukémií byla velmi vysoká. Rozdíly v jiných fenotypech významné nebyly.

Генетическая резистентность к лейкемии черно-белого крупного рогатого скота

Полученные у 1312 дочерей 75 быков черно-белого крупного рогатого скота разных ферм данные свидетельствуют о том, что быки передают своим дочерям разную степень резистентности или восприимчивости к лейкемии. Данный вывод можно использовать для выделения быков, генетически предрасположенных к заболеванию. Коэффициент наследственности г 2 повышенной устойчивости к лейкемии достигал 0,13. Отношение между группами крови, трансферринами, постальбуминами, амилазой, $\varkappa$-Cn, α_{s1}—Cn, (казеины) и β — Lg фенотипами и лейкемией подвергалось также анализу. У коров с $\varkappa$-Cn AA типа наличие лейкемии был явно ниже по сравнению с коровами с $\varkappa$-Cn BB или AB. Частота аллелей $Y_2D'G'I'$ у коров с лейкемией была очень большой. Разность в остальных фенотипах не отличалась значимостью.

References

ASHTON, G. C. — FALLON, G. R. — SUTHERLAND, D. N.: Transferrin type and milk butterfat production in dairy cows. J. Agric. Sci., **62,** 1964: 27—34.

BÖTTGER, T.: Zschr. Tierzüt. Zücht. Biol., **62,** 1954: 223 in Ernst et al. 1974.

BRADLEY, J. D. — SPOONER, R. L.: Genetic disease in domestic animals. ABRO Report, 1977: 31—35.

BUSSOL, V. A. — MESHCHERYAKOV, V. Y.: Blood groups and genetic protein systems and their relationship with cattle resistance to leucosis. XVIth Inter Conf. Anim. Blood Grps Biochem. Polymorph., Leningrad, 1978.

COCHRAN, W. G.: J. Amer. Stat. Assn., **38,** 1943: 287.
COLE, R. K.: Studies on genetic resistance to Marek's disease. Avian Dis., **12,** 1968: 9—28.
ENGELBERT-HOLM, J.: Spotaneous and experimental leukaemia in animals. Edinburgh, Oliver and Boyd, 1942.
ERNST, L. K. — KLABUKOV, P. G. — KRALIKOV, D. V. — ZIVOTOVSKY, L. A. — CALITIS, A. A. — GRINBERG, R. O. — PRIEDNIEK, O. K. — AUZINA, A. K.: Bull. Nauch. Robot. VIZ, 1973: 34, 15.
ERNST, L. K. — KLABUKOV, P. G. — GOLDMAN, I. L. — SOROKOVOY, P. F.: Niekotorye rezultaty izuchenya genetycheskoy ustoychivosti krupnovo rogatovo skota k leykozu. Kokl. Vses. Akad. Sel. Nauk, 8, 1973b: 29—30.
ERNST, L. K. — KLABUKOV, P. G. — KRALIKOV, D. V. — GRINBERG, R. O.: A statistical and genetical study of bovine leukaemia. 1st World Gong. Genet. Appl. Livest. Prod., Madrid, 1974: 187—190.
GÖTZE, R. — ZIEGENHAGEN, G.: Dtsch. Tierärztl. Wschr., Suppl. Fortpfl. u. Besam., **3,** 1953: 55-after Ernst et al. 1974.
HUTT, F. B.: Genetic Resistance to Disease in Domestic Animals. Ithaca, New York, Cornell University Press, 1958.
HUTT, F. B.: Genetic indicators of resistance to disease in domestic animals. 1st World Cong. Genet. Appl. Livest. Prod., Madrid, 1974: 179—185.
HUTT, F. B.: Genetyczna oporność zwierzat domowych na choroby. Post. Nauk Rol. **163,** 1975: 149—164.
JOOMKOV, V. A. — PLESHKEVICH, I. S. — ZOTOVA, V. S. — KAMLENOK. P, O.: Polymorphism study of some blood proteins in leukaemic cattle of Black- and White breed. XVIth Inter Conf. Anim. Blood Grps Biochem. Polymorph., Leningrad, 1978.
KLEMKE, A.: Charakterystyka genetyczna bydla rasy czarnobialej hodowanego na Pomorzu Zachodnim w świetle biochemicznego polimorfizmu bialek mleka. Doc. Diss., Szczecin, 1978.
KLIMOV, N. M. — YAREMENKO, I. I. — KOROLOV, R. K.: Typy transferrinov pri leukozie krupnovo rogatovo skota. Biul. Vses. Inst. Bks. Vet., **17,** 1974: 61—62.
KLIMENT, J.: Relation between polymorphic proteins of blood serum of cattle and important traits of performance. 1st World Cong. Genet. Appl. Livest. Prod., Madrid, 1974: 231—233.
KRALIKOV, D. V. — SOROKOVOY, P. F. — JAKUSHENKOV, A. M.: An analysis of association between the blood group marker genes and the incidence of bovine leukosis. XVIth Inter. Conf. Anim. Blood Grps Biochem. Polymorph., Leningrad, 1978.
LINDSTRÖM, U. B. — SYVÄJÄRVI, J.: Use of field records in breeding for mastitis resistance in dairy cattle. Liv. Prod. Sci., **5,** 1978: 29—44.
LUSH, J. L. — LAMOREUX, W. F. — HAZEL, L. N.: Poultry Sci., **27,** 1948: 375.
MACHA, J. — MÜLLEROVÁ, Z.: Analysis of protein polymorphous types of milk in relation to certain utility properties of cows. Acta Univ. Agric. Fac. Agron., Brno, **17,** 1969: 275—281.
MICHALAK, W.: Zastosowanie elektroforezy na zelu skrobiowym do rownoczesnego określenia fenotypów czterech głównych bialek mleka. Cz. I. Biul. IGHZ PAN, **15,** 1969: 75—86.
PAYNE, L. N.: Genetics and control of avian diseases. Avian Pathol. **4,** 1973: 237—250.
PRZYTULSKI, R.: Relationship between phenotypes of blood serum transferrins and post-albumins and production characteristics in Black-and-White cows. Vet. Arhiv **1,** 1979a: 33—43.
PRZYTULSKI, T. — BARTOSZEWICZ, B. — KAMIENIECKI, H. — KAWECKI, A. — KLEMKE, A. — NIEMYSKA, L.: Zwiazek fenotypów i enzymów krwi oraz bialek mleka z cecham produkcyjnymi krów rasy czarno-bialej. VII Zjazd Pol. Tow. Genet., Poznań, 1979b.
SEMENOVA, E. I.: Amylase and ceruloplasmin gene sets selection in cattle and methods of its determination. Cit. Genet., **3,** 1976: 229—232.
SKOLASIŃSKI, W. — TYSZKA, Z. J. — CHARON, K. M.: Róznice w wystepwaniu mastitis powodowanego róznymi drobnoustrojami u córek określonych buhajów. Prace Mat. Zoot., **14,** 1977: 131—140.
SIRACKY, I. Z. — GOLOTA, J. A.: Polimorfizm transferrinov u skota simentalskoy porody i evo svyz z hkozjajstviennopoleznami priznakami. Mart II Conf. Molod. Uch. Genet. Roz. Sách. Zhiv. **2,** 1971: 41—42.
SMITHIES, O.: Zone electrophoresis in starch gel: Group variation in the serum of normal human adults. Biochem. J., **61,** 1955: 629—641.
TOMASZEWSKA — GUSZKIEWICZ, K. — SKŁADANOWSKA, E. — ZURKOWSKI, M.: Badania nad polimorfizmem amylazy w surowicy krwi bydla nizinnego czarno-bialego. Biul. IGHZ PAN, **24,** 1971: 5—10.
WIESNER, E.: Die Leukosen des Rindes. 2nd ed., Gustav Fis., 1967.
YAMADA, Y.: Genetic resistance to Marek's disease (MD) and lymphoid leukosis (LL) in chickens. 1st World Congr. Genet. Appl. Livest. Prod., Madrid, 1974: 191—203.