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FREQUENCIES OF ALLELES OF THE B-BLOOD GROUP SYSTEM IN RED DANISH DAIRY CATTLE

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Among the bovine blood group systems known today the B-system is the most complex in serological as well as genetical aspects. It comprises a large number of multiple alleles or so-called B-phenogroups identified by more than 30 antigenic specificities. Because of its complexity, the B-system is useful in many aspects of modern cattle breeding, such as studies of the genetical effect of breeding methods and also of breed structure. Extensive analyses of allele frequencies in the B-system have been performed in many cattle breeds (1, 2, 3, 4, 5, 8, 9, 13), and the B-system of Danish cattle was described by *Neimann-Sørensen* in 1958 (10). Since then the number of known antigenic specificities at the B-locus has been extended, and from typing a large number of animals the more infrequent B-alleles segregating in Danish cattle breeds were established (7).

In the present report the frequencies of B-alleles in samples of Red Danish Dairy Cattle (RDM) are given and the variations in allele frequencies and the degree of homozygosity at the B-locus are discussed.

MATERIALS AND METHODS

The analysis were made on 637 bulls born in 1963—64—65, 794 bulls born in 1960—61—62 and 1226 cows typed in 1963—

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Table 1. Frequencies of B-alleles in samples of bulls and cows of the Red Danish Dairy Cattle.

Allele	Bulls born 1963-64-65	Bulls born*) 1960-61-62	Cows typed 1963-64-65	Allele	Bulls born 1963-64-65	Bulls born*) 1960-61-62	Cows typed 1963-64-65
$BGKO_xY_2A_1'O'D_2$	.0000	.0000	.0024	O_1Y_1	.0038	.0094	.0037
$BGKO_xA_1'O'$	.0000	.0000	.0024	$O_2QJ'K'O'$	.0146	.0214	.0330
BGO_1	.0008	.0038	.0057	$O_2J'K'O'$	.0056	.0013	.0013
BI_1Q	.0000	.0000	.0008	$O_2Y_1A_2'E_3'J'K'O'D_{12}$	.0008	.0000	.0008
BO_1	.1876	.2087	.1462	$O_xY_2O'Y'D_2$	.0008	.0050	.0033
BO_1D_{16}	.0008		.0020	$O_xA_2'E_3'O'D_{12}$	.0000	.0000	.0029
BO_1Y_1D'	.2166	.1950	.1764	P	.0000	.0000	.0008
BO_1D'	.0000	.0006	.0028	PY_2D_2	.0008	.0006	.0024
$BO_3Y_1A_1'E_3'P'D_{12}D_{16}$	.0090	.0113	.0217	Q	.0000	.0000	.0017
$BO_3QA_1'P'D_{16}$	.0008	.0006	.0012	$QA_2'(D')E_3'D_{12}$	.0023	.0006	.0078
$BO_3A_1'E_3'P'D_{12}D_{16}$	.0000	.0006	.0016	$Y_1A_2'E_3'D_{12}$	.0000	.0000	.0024
$BO_3A_1'P'D_{16}$	.0000	.0000	.0008	$Y_1A_2'E_3'Y'D_{12}$	.0008	.0000	.0020
BPY_1A_2'	.0071	.0088	.0087	$Y_2A_2'D'D_2D_{16}$	.0000	.0000	.0012
$BA_2'E_3'P'D_{12}$	.0000	.0000	.0012	$Y_2A_2'E_3'D_2D_{12}$	.0000	.0000	.0008
$BA_2'E_3'D_{12}$	.0000	.0006	.0020	$Y_2Y'D_2$	.1236	.1460	.1865
BP'	.0913	.0982	.0863	A_1'	.0000	.0000	.0029
$GI_2Y_2E_1'D_2D_{16}$	.0000	.0000	.0012	$A_2'E_3'D_{12}$	.0008	.0013	.0034
I_1	.0000	.0000	.0008	$E_3'D_{12}$	.0008	.0013	.0013
I_1D_{16}	.0016		.0017	I'	.0000	.0000	.0012
$I_1O_2QA_1'E_1'K'D_{16}$	.0859	.0573	.0490	I_2	.0000		.0024
$I_1O_2J'K'O'$	.0041	.0038	.0106	D_{16}	.0365	.1659	.0429
$I_1A_2'E_1'D_{12}$	.0212	.0444	.0243	b	.1770		.1291
O_1	.0000	.0116	.0035	others	.0055	.0025	.0097
O_1D_{16}	.0000		.0024	Total	1.0005	1.0006	.9992

*) not typed for I_2 and D_{16}

64—65. The bulls were blood typed because of registration or purchase by artificial insemination centers. Consequently they comprise practically all RDM bulls initially selected for breeding purposes during the last six years. The cows were dams to heifers at the bull progeny testing stations in 1963—64—65. They, therefore, represent cows from common herds.

Blood typing test was made for the following antigenic factors belonging to the B-system: B G K I_1 I_2 O_1 O_2 O_3 O_x P Q T_1 Y_1 Y_2 A_1' A_2' B' D' E_1' E_2' E_3' I' J' K' O' Y' P' D_2 D_{12} and D_{16}. (P' was

previously designated D_4 (7) and D_{16} is a new factor discovered in this laboratory in 1963).

The frequencies of the various alleles were calculated by the allocation method (9, 10).

RESULTS

The different B-alleles and their frequencies in each of the three subpopulations under study are given in Table 1. The table comprises 46 alleles and a group termed "others". The latter group includes phenogroups of uncertain composition and for the cow material also alleles observed once only.

In a previous investigation (10) only the frequencies of 26 alleles were recorded. The increase in number of alleles is not only due to rare alleles being represented because of the larger number of animals studied, but also to the fact that some phenogroups have been divided into two or more groups by the new reagents. Thus, when I_2 and D_{16} are not in use, groups as BO_1 and BO_1D_{16} or I_2, D_{16} and b are recorded respectively as BO_1 or b only.

From Table 1 it can be seen that only about 10 of the alleles have frequencies above 1 %. A comparison of the frequencies of these phenogroups to the distribution observed by *Neimann-Sørensen* (10) is presented in Fig. 1. In the few cases where subdivisions of alleles by means of new factors made it necessary, the frequencies are added together. Fig. 1 shows that differencies in allele frequencies are present within the seven subpopulations and that the variations are consistant for some alleles when the bulls and cows are compared separately. This is particularly the case for $Y_2Y'D_2$ which has continuously decreased in frequency during the past 10—15 years. On the other hand the frequency of $I_2+D_{16}+b$ is consistently increased in that period. The frequency of this group seems to be even higher for the cows in column 5 than might be expected from the frequencies among bulls and the cows in column 7. Also for some other groups a less pronounced continuous increase or decrease takes place. In the case of BO_1Y_1D' and $BO_1+BO_1D_{16}$ more irregular fluctuations are seen.

Under the assumption that the alleles of the B-system are independent of viability and production capacity, the degree of homozygosity at the B-locus may serve as an expression of the degree of inbreeding (9, 10, 16). On the basis of the allele frequencies in Table 1, the homozygosity of the three subpopulations studied here was calculated. The results are given in Table 2

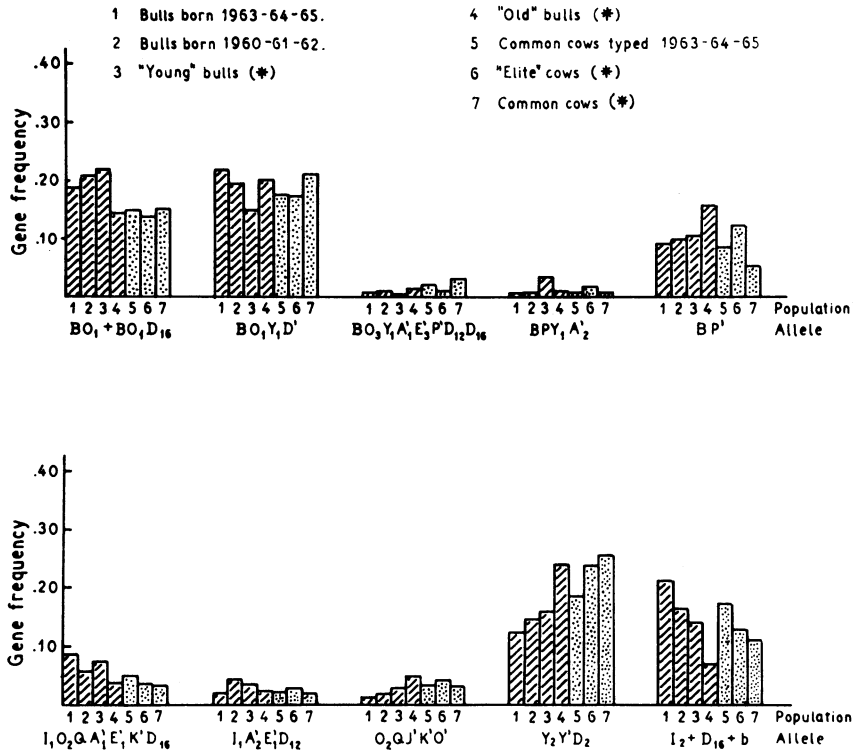

Figure 1. Changes in allele frequencies at the B-locus of RDM cattle during the last 10—15 years. (*) indicates populations studied by *Neimann-Sørensen* (10).

together with similar values for the four subpopulations investigated by *Neimann-Sørensen* (10). The values of Ca in Table 2 are the probabilities of randomly selected animals being homozygotic at the B-locus; Na is the reciprocal of Ca and is an estimate of the effective number of alleles in the populations. The figures show that the degree of homozygosity within the four subpopulations of bulls has remained on almost the same level in the past 10—15 years. Among cows from common herds the homozygosity tends to decrease. These findings are in agreement with the results obtained by *Rottensten* (17) from examination of pedigrees. He found that the inbreeding coefficient among bulls tended to decrease from 1947 to 1957 and concluded from this and previous investigations (18) that extensive use of artificial insemination as practiced in Denmark, tends to decrease the intensity of inbreeding, particularly in the cow population.

Table 2. The degree of homozygosity (Ca) and the number of effective alleles (Na) in the B-system of RDM cattle.

	No. of animals	Ca	Na
Bulls born 1963—64—65	637	15 %	7
Bulls born 1960—61—62	794	15 %	7
Young bulls*	280	14 %	7
Old bulls*	779	16 %	6
Cows typed 1963—64—65	1226	12 %	9
Élite cows*	227	14 %	7
Common cows*	224	15 %	7

*) From *Neimann-Sørensen 1958* (10).

DISCUSSION

The majority of the alleles known in the B-system of RDM are rare. Only about 10 phenogroups have frequencies above 1 % and may be of some importance in characterizing the breed and for other applications of blood groups in cattle breeding. This seems to border on what has been observed so far in other cattle breeds.

The blood groups have been found to have only a slight effect on production characters of dairy cattle (6, 11, 14). Further, the two groups $Y_2Y'D_2$ and $I_2+D_{16}+b$, which show the most pronounced changes, are not known to influence characters of economical value. The changes observed, therefore, are more likely to be due to selection and breeding methods than to an effect of a certain blood group composition on the animals. Similar changes in frequencies of blood group genes caused by breeding policy have been observed in other cattle breeds (1, 15); *Neimann-Sørensen* (10) explained the decrease in frequency of the A-factor in RDM as being due to extensive use of some bulls which happened to be A-negative. The changes observed here in allele frequencies seem to have a similar explanation. Of more than 800 bulls progeny tested in the period 1945—1960 approximately ⅓ were sons from 12 bulls only (12). Since the majority of RDM bulls are bred by progeny tested sires (18) these 12 bulls are expected to have influenced the breed to some extent and in fact the frequencies of $Y_2Y'D_2$, $I_2+D_{16}+b$ and BP′ among these bulls were very close to those found among bulls born in the last three years.

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SUMMARY

The frequencies of B-alleles in RDM were analysed in samples of 637 bulls born in 1963—64—65, 794 bulls born in 1960—61—62 and 1226 cows from common herds.

Among the 46 distinct alleles for which frequencies were estimated only about 10 alleles have frequencies above 1 %. The frequency of some alleles shows consistent variations during the last 10—15 years.

The degree of homozygosity at the B-locus has remained almost constant among bulls during the last 10—15 years, while the homozygosity among cows from common herds shows a decreasing tendency.

ZUSAMMENFASSUNG

Allele Frequenzen im B-System der Roten dänischen Milchrasse.

Die Häufigkeit der Allele im B-System beim Roten dänischen Milchvieh ist anhand einer Analyse von 637 Stieren geboren in den Jahren 1963—64—65, 794 Stieren geboren in den Jahren 1960—61—62 und 1226 Kühen, die in den Jahren 1963—64—65 typenbestimmt worden sind, untersucht worden. Nur etwa 10 von den insgesamt etwa 46 Allelen besitzen eine Häufigkeit von mehr als 1 %. Einzelne von diesen zeigen systematische Verschiebungen in der Häufigkeit im Laufe der letzten 10 bis 15 Jahren. Eine Untersuchung über den Homozygotiegrad im B-System zeigt, dass dieser in den vergangenen 10 bis 15 Jahren bei den Stieren recht konstant gewesen ist. Dagegen zeigt die Homozygotie bei Kühen in gewöhnlichen Viehbeständen eine fallende Tendenz.

SAMMENDRAG

Allele frekvenser i B-systemet hos RDM.

Hyppigheden af allelerne i B-systemet hos RDM er belyst ved en analyse af 637 tyre født i årene 1963—64—65, 794 tyre født 1960—61—62 og 1226 køer typebestemt i 1963—64—65. Kun en halv snes af de ialt ca. 46 alleler har hyppigheder over 1 %. Enkelte af disse viser systematiske forskydninger i hyppighed gennem de sidste 10—15 år. En undersøgelse over graden af homozygoti i B-systemet viser, at denne har været ret konstant hos tyrene i de sidste 10—15 år, medens homozygotien hos køer fra almindelige brugsbesætninger viser en nedadgående tendens.

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