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Transferrin Polymorphism versus Growth Rate in Lambs, Polish Long-wool Sheep

I. Frequency of genes and genotypes of transferrin in flock of Polish Long-wool Sheep

Summary

The subject of this study was to identify the transferrin polymorphism and analyse changes in the frequency of alleles and genotypes of the transferrin in a flock of Polish long-wool sheep on the grounds of lambs from the four subsequent years. The flock comprised 3419 lambs , either sex, from the four subsequent lambings, (i - 920 off, ii - 849 off, iii - 914 and iv - 736 off accordingly). The separation of transferrin variants was done using starch gel electrophoresis. The significant increase in the frequency of BD transferrin phenotype was observed , CC and CE phenotypes, however, decreased and the frequency of Tf BD phenotype gradually dropped. The flock selected for quality traits exhibited a significant growth in the frequency of Tf^D allele in subsequent years of the study, whereas the frequency of Tf^C allele decreased. The frequency of remaining alleles varied in certain years of the study and no distinguished changes were found. The homozygosity of the polymorphic transferrin system increased in the third year of the study but then dropped its value in the fourth year below the value noted in the first year. Regularities of changes in the frequency of phenotypes and alleles of transferrin in the flock concerned could mark changes in the breeding - selecting scheme.

Key words: Polish long - wool sheep, transferrin polymorphism

Zusammenfassung

Titel der Arbeit: **Transferrinpolymorphismus und Wachstum von Lämmern der Rasse Polnisches Langwollschaf. 1. Mitt.: Transferrinvarianten beim Polnischen Langwollschaf**

Der Transferrinpolymorphismus wurde untersucht und die Analyse der Frequenzveränderung der Transferrinallele und -genotypen in einer Schafherde der Rasse Polnisches Langwollschaf in vier aufeinanderfolgenden Jahrgängen (I bis IV) durchgeführt. Das Untersuchungsmaterial bestand aus 3419 Lämmern beiderlei Geschlechts und aus 4 Ablammungen (I – 920, II - 849, III - 914, IV - 736 Stück). Das zu untersuchende Blut wurde von den Lämmern im Alter von 5-6 Monaten entnommen. Eine deutliche Zunahme der Frequenz der Transferrin BD bei der gleichzeitig kontinuierlichen Abnahme der Frequenz der Phänotypen CC und CE sowie bei einer langsameren ständigen Abnahme der Frequenz des Phänotypus Tf BC wurde nachgewiesen. In der nach Nutzeigenschaften selektierten Herde stieg in den folgenden Jahren die Frequenz des Allels Tf^D signifikant. Die Frequenz des Allels Tf^C nahm dagegen ab. Die Frequenz der übrigen Allele schwankte in den einzelnen Jahren, ohne deutliche Veränderungen. Die Homozygotie des polymorphen Transferrinsystems stieg im dritten Untersuchungsjahr an, und sank dagegen im vierten Untersuchungsjahr auf einen Wert, der niedriger als im ersten Untersuchungsjahr war. Die festgestellten Regelmäßigkeiten in der Frequenzveränderung der Transferrinphänotypen und -allele in der untersuchten Population Polnischer Langwollschafe können ein Anzeiger der Veränderungen bei der Durchführung des Zucht- und Selektionsprogramms sein.

Schlüsselwörter: Polnisches Langwollschaf, Polymorphismus, Transferrin

Introduction

The structural variability of the proteins which exhibit polymorphism due to genetic conditions is determined by a pair or series of multiple alleles. Transferrin (Tf) is one of such proteins. The locus of transferrin is found on the first chromosome in sheep and cattle (ECHARD et al., 1994) whereas on the thirteenth in pigs (CHOWDHARY et al., 1993; GUERIN et al., 1993; EDFORS-LILJA et al., 1995). The first to study transferrin polymorphism of the sheep blood serum was ASHTON, (1958; 1958a) who found 14 phenotypes controlled by five alleles (Tf^A, Tf^B, Tf^C, Tf^D, Tf^E) in sheep of English breeds. Today twelve transferrin alleles are identified according to decreasing electrophoretic mobility in the starch gel: Tf^I, Tf^A, Tf^G, Tf^H, Tf^B, Tf^K, Tf^C, Tf^M, Tf^D, Tf^Q, Tf^E and Tf^P, (ARCHIBALD and WEBSTER, 1986; ERHARDT, 1986; KURYŁ, 1992; RYCHLIK et al., 1996). The transferrin polymorphism was used to identify inter-breed differences and made it possible to establish genetic differentiation within breeds, kinds and generations of animals due to a great variety of frequencies of certain genes and genotypes of transferrin, (BOJCZUK et al., 1988; BALOV and ALEKSEJEVA, 1989; GLAZKO, 1990; KENJI TSUNODA et al., 1990; RODERO et al., 1990; SHIQAN WANG and FOOTE, 1990; UKBAJEV et al., 1990; NGUYEN et al., 1992; TATE et al., 1992; BOJCZUK and BOJCZUK, 1994; KMIEĆ, 1995).
The aim of this study was to analyse changes in the frequency of genes and genotypes of transferrin in a flock of the Polish long-wool sheep on the grounds of four subsequent lambings.

Materials and Methods

This study was carried out for four subsequent years in a pedigree flock of the Polish long-wool sheep kept at The State Animal Breeding Station at Bobrowniki. The study flock comprised 3419 lambs, either sex, from the four subsequent lambings – 61,5% twins - (i - 920 out of 1160 born, ii - 849 out of 1128 born, iii – 914 out of 1181 born, iv – 736 out of 1061 born accordingly). There were 34 rams responsible for the first and second lambings, 35 for the third and 36 for the fourth respectively. The lambs concerned formed half-sibling groups of comparable size. The serum was separated from the blood taken to a dry test-tube from the zygomatic vein of lambs at the age of 5-6 months. Transferrin phenotypes were determined by horizontal electrophoresis in starch gel, (SMITHIES, 1955), with the use of combined buffers, (KRISTJANSSON, 1962; KHATTAB et al., 1963). Genotypes of the animals in study were identified on the grounds of the direct interpretation of phenotypes, i.e. results of electroforetic determination, and the codomining of alleles affecting the transferrin polymorphism was taken into consideration. The frequency and number of expected transferrin phenotypes were calculated according to the mathematical formula of Hardy-Weinberg law, the significance verified by χ^2 test, (ŻUK, 1989).

Results and Disussion

Fifteen transferrin phenotypes controlled by the following alleles Tf^A, Tf^B, Tf^C, Tf^D

and Tf^E (out of 12 to be possibly found using the method applied) were found in the flock of long-wool sheep. The most frequent phenotypes throughout the whole population in the entire study period were Tf BC (19,43-24,24%), Tf BD (14,78-24,59%), Tf CD (12,69-17,80%) and Tf BB (12,25-14,13%). The least frequent, however, were the following transferrin phenotypes: AA, AE and EE (frequency below 1%), see Table 1. The flock exhibited numerous significant differences ($P \leq 0,05$ and $P \leq 0,01$) of phenotype frequencies between certain years of the study as far as AD, AE, BC, BD, BE, CC, CD, CE, DD and DE phenotypes were concerned. The statistically significant decrease ($P \leq 0,01$) of the frequency of BC transferrin phenotypes (from 24,24 down to 19,43%), of Tf CC (from 11,52 down to 7,61%) and of Tf CE (from 2,61 down to 0,54 %) was observed along with the steady increase of the frequency of Tf BD (from 14,78 up to 24,59%) - see Table 1. The analysis of the transferrin phenotype frequency in lamb rams showed the statistically significant differences ($P \leq 0,05$ and $P \leq 0,01$) between certain years of the study as far as BC, BD, BE, CE and DD phenotypes were concerned. In that group of animals the steady decrease of the frequency of Tf AD, Tf BC and Tf CE phenotypes was observed along with the steady increase of the frequency of Tf BD - see Table 1. The statistically significant differences ($P \leq 0,05$ and $P \leq 0,01$) were also found in the frequency of transferrin phenotypes in lamb ewes in the subsequent years of the study. The differences were observed for AB, AD, BD, BE, CC, CD, CE, DD and DE phenotypes - see Table 1. In that group of animals the steady increase of the Tf BD frequency (from 14,90 up to 25,98%) was observed along with the decrease of Tf CC frequency (from 12,42 down to 5,39%), the differences being statistically confirmed, ($P \leq 0,01$).

The population of the first three years of lambs did not exhibit any upset of the genetic equilibrium between observed and calculated sizes of phenotype groups. In the fourth year, however, the statistically significant differences ($P \leq 0,01$) were found between the observed and expected quantities of transferrin phenotypes - see Table 2. The similar upset of the genetic equilibrium was also observed in flocks of Sudanese (OSMAN, 1967) and Macedonian (EFREMOV and VASKOV, 1968) sheep respectively which was explained by selecting the flock for quality traits (OSMAN, 1967) or crossing to result in the increase of the number of phenotype groups, (EFREMOV and VASKOV, 1968).

The flock in study exhibited statistically significant differences ($P \leq 0,05$ and ($P \leq 0,01$) in the frequency of Tf^A, Tf^C, Tf^D and Tf^E alleles between certain years of the study - see Table 3. The Tf^A was more frequent ($P \leq 0,01$) in the first, second and third years of the study than in the fourth year. The Tf^C was less and less frequent over subsequent years and the statistically significant differences ($P \leq 0,05$ and $P \leq 0,01$) were observed between the first year and the third and fourth years and between the second year and the third and fourth years of the study. The significant increase of the frequency was observed for the Tf^D (20,27 up to 27,79%) and statistically significant differences ($P \leq 0,01$) were found between the first year and the third and fourth years and between the second year and the third and fourth years of the study - see Table 3.

The analysis of the frequency of transferrin alleles in lamb rams showed statistically

Table 1
Frequency of transferrin phenotypes in animal groups in years of study (Frequenz der Transferrinphänotypen nach Tiergruppen und Jahren)

Phenotype	Lamb rams				Lamb ewes				Total			
Tf	I	II	III	IV	I	II	III	IV	I	II	III	IV
	n = 437	n = 404	n = 447	n = 328	n = 483	n = 445	n = 467	n = 408	n = 920	n =849	n = 914	n = 736
AA	0,23	0,00	0,67	0,00	0,00	0,22	0,64	0,00	0,11	0,12	0,66	0,00
AB	2,97	4,95	3,13	4,57	4,55^{a}	3,60	4,50^{b}	1,96^{ab}	3,80	4,24	3,83	3,13
AC	3,20	4,20	2,46	2,44	4,14	3,37	4,50	2,70	3,70	3,77	3,50	2,58
AD	2,75	2,48	2,01	0,92	3,11^{c}	2,70	3,21^{d}	1,22^{cd}	2,93^{A}	2,59^{a}	2,62^{b}	1,09^{abA}
AE	0,23	0,25	0,67	0,00	0,21	0,22	0,43	0,00	0,22	0,24	0,55^{a}	0,00^{a}
BB	13,27	12,62	12,53	14,63	13,87	11,91	14,56	13,73	13,59	12,25	13,57	14,13
BC	25,86^{bB}	22,52	20,36^{b}	18,29^{B}	22,77	24,94	24,63	20,34	24,24^{A}	23,79^{a}	22,53	19,43^{aA}
BD	14,64^{DE}	17,82	20,81^{D}	22,87^{E}	14,90^{F}	16,41^{G}	19,49^{b}	25,98^{bFG}	14,78^{AB}	17,08^{AC}	20,13^{a}	24,59^{aBC}
BE	3,20^{a}	2,72	1,12^{a}	2,13	3,11^{D}	2,70^{E}	0,00^{DEF}	2,45^{F}	3,15^{A}	2,71^{B}	0,55^{ABC}	2,31^{C}
CC	10,53	11,14	12,30	10,37	12,42^{Bb}	11,24^{C}	7,49^{b}	5,39^{BC}	11,52^{A}	11,19^{a}	9,85	7,61^{aA}
CD	12,59	14,36	13,42	16,46	14,08	13,26^{b}	11,99^{C}	18,87^{bC}	13,37^{A}	13,78^{a}	12,69^{B}	17,80^{aAB}
CE	4,12^{cC}	2,48^{d}	1,79^{c}	0,61^{Cd}	1,24	2,47^{eD}	0,64^{e}	0,49^{D}	2,61^{aA}	2,47^{bB}	1,20^{aAb}	0,54^{B}
DD	4,35^{C}	3,22^{D}	8,28^{CD}	5,49	3,11^{bE}	5,62^{b}	7,28^{E}	5,15	3,70^{A}	4,47^{B}	7,77^{aAB}	5,30^{a}
DE	1,83	1,24	0,45	1,22	2,28^{b}	1,12	0,64^{b}	1,72	2,06^{A}	1,18	0,55^{aA}	1,49^{a}
EE	0,23	0,00	0,00	0,00	0,21	0,22	0,00	0,00	0,22	0,12	0,00	0,00

Frequency in lines designated with the same letter differ significantly. Small letters denote significance at $P \leq 0,05$; capitals at $P \leq 0,01$.

Table 2

Observed (obs.) and expected (exp.) number of transferrin phenotypes of differences in animal groups in study (Beobachteter und erwarteter Bestand der Transferrinphänotypen nach Tiergruppen und Jahren)

Phenotype	Lamb rams				Lamb ewes				Total			
Tf	I	II	III	IV	I	II	III	IV	I	II	III	IV
	Obs. / exp.	obs./ exp.	obs./ exp.	obs./ exp.	Obs./ exp.	obs./ exp.	obs./ exp.	obs./ exp.	Obs./ exp.	obs./ exp.	obs./ exp.	obs./exp.
AA	1/ 1,0	0/ 1,4	3/ 1,0	0/ 0,5	0/ 1,7	1/ 1,2	3/ 2,3	0/ 0,4	1/ 2,7	1/ 2,6	6/ 3,2	0/ 0,8
AB	13/ 15,4	20/17,6	14/15,2	15/10,0	22/ 21,2	16/ 16,4	21/ 25,3	8/ 9,4	35/ 36,6	36/ 34,0	35/ 40,1	23/ 19,4
AC	14/ 14,0	17/15,8	11/13,5	8/ 7,6	20/ 19,5	15/ 15,3	21/ 18,4	11/ 6,4	34/ 33,5	32/ 31,1	32/ 32,0	19/ 13,9
AD	12/ 8,5	10/10,2	9/11,4	3/ 6,8	15/ 11,8	12/ 10,3	15/ 16,2	5/ 7,0	27/ 20,3	22/ 20,5	24/ 27,8	8/ 13,9
AE	1/ 2,1	1/ 1,6	3/ 0,9	0/ 0,5	1/ 2,1	1/ 1,6	2/ 0,6	0/ 0,6	2/ 4,2	2/ 3,2	5/ 1,5	0/ 1,1
BB	58/ 58,6	51/54,2	56/55,5	48/48,8	67/ 64,5	53/ 56,8	68/ 70,5	56/62,4	125/123,1	104/111,0	124/125,7	104/111,1
BC	113/106,9	91/97,4	91/98,7	60/74,0	110/118,4	111/105,8	115/103,0	83/84,8	223/225,3	202/203,2	206/202,1	143/158,9
BD	64/ 64,8	72/62,6	93/83,9	75/66,3	72/ 71,6	73/ 71,1	91/ 90,6	106/92,7	136/136,4	145/133,8	184/174,7	181/158,9
BE	14/ 15,7	11/ 9,9	5/ 6,3	7/ 5,0	15/ 12,8	12/ 11,1	0/ 3,1	10/ 7,4	29/ 28,5	23/ 21,0	5/ 9,6	17/ 12,4
CC	46/ 48,8	45/43,8	55/43,8	34/28,1	60/ 54,3	50/ 49,2	35/ 37,6	22/28,9	106/103,1	95/ 93,0	90/ 81,2	56/ 56,8
CD	55/ 59,1	58/56,3	60/74,5	54/50,3	68/ 65,7	59/ 66,2	56/ 66,1	77/63,0	123/124,9	117/122,5	116/140,4	131/113,6
CE	18/ 14,4	10/ 8,9	8/ 5,6	2/ 3,8	6/ 11,7	11/ 10,3	3/ 2,3	2/ 5,1	24/ 26,1	21/ 19,2	11/ 7,8	4/ 8,9
DD	19/ 17,9	13/18,1	37/31,7	18/22,5	15/ 19,9	25/ 22,2	34/ 29,1	21/34,4	34/ 37,8	38/ 40,3	71/ 60,7	39/ 56,8
DE	8/ 8,7	5/ 5,7	2/ 4,8	4/ 3,4	11/ 7,1	5/ 6,9	3/ 2,0	7/ 5,5	19/ 15,5	10/ 12,6	5/ 6,7	11/ 8,9
EE	1/ 1,1	0/ 0,5	0/ 0,2	0/ 0,1	1/ 0,6	1/ 0,5	0/ 0,0	0/ 0,2	2/ 1,7	1/ 1,0	0/ 0,2	0/ 0,3
F_0	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	**

* - significance of differences at P ≤ 0,05; ** - significance of differences at P ≤ 0,01; n.s. - non-significant

significant differences for Tf^A, Tf^D, Tf^E alleles between certain years of the study ($P \leq 0{,}05$ and $P \leq 0{,}01$). In that group of animals the steady decrease of the frequency of Tf^C and Tf^E was observed along with the increase of the Tf^D frequency - see Table 3. The statistically significant differences ($P \leq 0{,}05$ and $P \leq 0{,}01$) were also found in the frequency of Tf^A, Tf^C, Tf^D and Tf^E in lamb ewes in the years of the study - see Table 3. That group of animals exhibited the steady increase of the frequency of Tf^D (from 20,29 up to 29,05%) along with the decrease of the frequency of Tf^C (from 33,54 down to 26,59%), the differences being statistically confirmed at $P \leq 0{,}01$. Frequencies of other alleles varied in subsequent years of the study, the significant differences ($P \leq 0{,}05$ and $P \leq 001$) concerned Tf^A and Tf^E alleles.

Table 3
Frequency of transferrine alleles in animal groups in years of study (Frequenz der Transferrinallele nach Tiergruppen und Jahren)

Group	Year	Tf^A	Tf^B	Tf^C	Tf^D	Tf^E
Ram lambs	I	4,81	36,61	33,41	$20{,}25^{EF}$	$4{,}92^{DE}$
	II	5,94	36,63	32,92	$21{,}17^{aG}$	3,34
	III	4,81	35,24	31,32	$26{,}62^{EG}$	$2{,}01^{D}$
	IV	3,96	38,57	29,27	$26{,}22^{aF}$	$1{,}98^{E}$
Ewe lambs	I	$6{,}01^{D}$	36,54	$33{,}54^{DE}$	$20{,}29^{HI}$	$3{,}62^{F}$
	II	$5{,}17^{a}$	35,73	$33{,}26^{bF}$	$22{,}36^{J}$	$3{,}48^{G}$
	III	$6{,}96^{E}$	38,86	$28{,}37^{bD}$	$24{,}95^{bH}$	$0{,}86^{FGH}$
	IV	$2{,}94^{aDE}$	39,09	$26{,}59^{EF}$	$29{,}05^{bIJ}$	$2{,}33^{H}$
Total	I	$5{,}43^{A}$	36,58	$33{,}48^{AB}$	$20{,}27^{AB}$	$4{,}24^{AB}$
	II	$5{,}54^{B}$	36,16	$33{,}10^{aC}$	$21{,}79^{CD}$	$3{,}41^{aC}$
	III	$5{,}91^{C}$	37,09	$29{,}81^{aA}$	$25{,}77^{AC}$	$1{,}42^{AC}$
	IV	$3{,}39^{ABC}$	38,86	$27{,}79^{BC}$	$27{,}79^{BD}$	$2{,}17^{aB}$

Freguency in columns designated with the same letter differ significantly. Small letters denote significance at $P \leq 0{,}05$; capitals at $P \leq 0{,}01$.

Table 4 shows frequencies of homozygotes and heterozygotes as far as transferrin genotypes are concerned. Homozygotous genotypes contributed from 27,04 to 31,84% types of transferrin in the study flock. Statistically significant differences ($P \leq 0{,}05$) were noted for homozygotous genotypes of transferrin between the third and fourth years of lambs. Having analysed the ceratin sex within the flock in terms of the frequency of hetero- and homozygotous transferrin genotypes the statistically significant differences ($P \leq 0{,}05$) were found between the second and third years of lamb rams, between the third and fourth years of lamb ewes and between the lamb rams and lamb ewes in the fourth year of the study. - see Table 5. Heterozygotes in the flock of the long - wool sheep amounted to 70%, variations, however, were observed in the certain groups, i.e. from 66,22% (lamb rams, third year) to 75,74% (lamb ewes, fourth year). Domestic flocks exhibited higher share of heterozygotes and the regularity was confirmed by a number of researchers, (LIPECKA, 1984; KMIEĆ, 1986; PORĘBSKA et al., 1990). Discrepancies between quantities of homozygotes and heterozygotes in the population of the study force researchers to keep on studying the

Table 4

Frequency of homo- and heterozygous transferrin phenotypes in animal groups in study (Frequenz der homo- und heterozygoten Transferrinphänotypen nach Tiergruppen und Jahren)

Group	Year	Number of animals	Homozygous		Heterozygous	
			n	Frequency [%]	n	Frequency [%]
Ram lambs	I	437	125	28,60	312	71,40
	II	404	109	26,98^{b}	295	73,02
	III	447	151	33,78^{b}	296	66,22
	IV	328	100	30,49^{e}	228	69,51
Ewe lambs	I	483	143	29,61	340	70,39
	II	445	130	29,21	315	70,79
	III	467	140	29,98^{c}	327	70,02
	IV	408	99	24,26^{ce}	309	75,74
Total	I	920	268	29,13	652	70,87
	II	849	239	28,15	610	71,85
	III	914	291	31,84^{a}	623	68,16
	IV	736	199	27,04^{a}	537	72,96

Frequency in columns designated with the same letter differ significantly. Small lettes denote significance at $P \leq 0,05$; capitals at $P \leq 0,01$.

Table 5

Observed and expected numbers of homozygous/heterozygous ref. to transferrin phenotype in groups and years of study (Beobachteter und erwarteter Bestand der Homo- und Heterozygotie hinsichtlich des Transferrinsphänotypus nach Tiergruppen und Jahren)

Group	Year	Total obs. / exp.	Homozygous obs. / exp.	Heterozygous obs. / exp.	Significance of differences
Ram lambs	I	437 / 437,0	125 / 127,3	312 / 309,7	n.s.
	II	404 / 404,0	109 / 118,0	295 / 286,0	n.s.
	III	447 / 447,0	151 / 132,2	296 / 314,8	*
	IV	328 / 328,0	100 / 100,1	228 / 227,9	n.s.
Ewe lambs	I	483 / 483,0	143 / 141,1	340 / 341,9	n.s.
	II	445 / 445,0	130 / 130,0	315 / 315,0	n.s.
	III	467 / 467,0	140 / 139,5	327 / 327,5	n.s.
	IV	408 / 408,0	99 / 126,2	309 / 281,8	**
Total	I	920 / 920,0	268 / 268,4	652 / 651,6	n.s.
	II	849 / 849,0	239 / 247,9	610 / 601,1	n.s.
	III	914 / 914,0	291 / 271,0	623 / 643,0	n.s.
	IV	736 / 736,0	199 / 226,0	537 / 510,0	*

* - significance of differences at $P \leq 0,05$; ** - significance of differences at $P \leq 0,01$; n.s. - non-significant.

problem. They may be caused by a lower survival rate exhibited by homozygotous embryos, (ASHTON, 1959), selection in the flock (COOPER, 1966; EFREMOV and VASKOV, 1968) or prevailance of a certain type in accordance with breeding conditions, (RASMUSEN and TUCKER, 1973). The analysis of the population for quantities of homo- and heterozygous genotypes of transferrin showed differences between theoretical and observed values in the forth year of the study ($P \leq 0,05$) as well as in lamb rams ($P \leq 0,05$), third year of the study and in lamb ewes ($P \leq 0,01$), fourth year of the study. It seems that the upset of the genetic equilibrium in the flock is caused by breding - selecting activities in the parent flock.

Conclusions

Results obtained may show that there were significant changes in the frequency of transferrin phenotypes in the flock of the Polish long - wool sheep, high wool yield flock. The significant increase in the frequency of BD transferrin phenotype was observed along with the steady drop of frequencies of CC and CE accordingly and the slighlty slower steady decrease in the frequency of the Tf BC. The significant increase in the frequency of Tf^D allele was observed in the subsequent four years of the study in the flock selected for quality traits whereas the Tf^C frequency dropped in the same time. The frequency of other alleles varied in certian years of the study and significant changes were not found. The homozygosity of the polymorphic system of transferrin increased in the third year of the study, and then dropped in the fourth year to reach the lower level than in the first year.

Regularities found in changes in the frequencies of phenotypes nad transferrin alleles in the study flock of the long-wool sheep may be markers of changes that associate the breeding - selecting schedule. The regular growth in the frequency of BD transferrin phenotype along with the drop in the Tf CC and rather slow but steady decrease in the frequency of Tf BC and Tf CE were found.

References

ARCHIBALD,A.L.; WEBSTER, J.:
A new transferrin allele in sheep. Anim. Genet., **17** (1986) 2, 191-194

ASHTON, G.C.:
Polymorphism in the beta-globulins of sheep. Nature, London **181** (1958), 849-850

ASHTON, G.C.:
Further beta-globulin phenotypes in sheep. Nature, London **182** (1958a), 1101-1102

ASHTON, G.C.:
Beta-globulin polymorphism and early mortality in cattle, Nature, London **183** (1959), 404

BALOV, M.; ALEKSEJEVA, S.:
Geneticna struktura na stada ot karakacanskich ovec po geni, kontrolirašci polimorfizma na njakoi biochimicni prinaci v krvta, Genetika i Selekcija, **22** (1989) 3, 210-218

BOJCZUK, H.; BOJCZUK B.:
Sheep polymorphic proteins as genetic markers. (Polish Language). Zoot. 3, (Zesz. specjalny), 49-50, 1994

BOJCZUK, H.; BOJCZUK, B.; ŻURKOWSKI, M.:
Estimate of the genetic distance in sheep on the basis of polymorphism of transferrins, haemoglobin and carbonic anhydrase. (Polish Language). Zesz. Probl. Post. Nauk Rol. **352** (1988), 11-15

CHOWDHARY, B..P.; JOHANSSON, M.; CHAUDHARY, R.; ELLEGREN, H.; GU, F.; ANDERSSON, L.; GUSTAVSSON, I.:
In situ hybridization mapping and restriction fragment length polymorphism analysis of porcine albumin (ALB) and transferrin (Tf) genes. Anim. Genet. **24** (1993) 2, 85-90

COOPER, D.W.:
Some results of genetical studies on the transferrin variants of the Australian Merino, In: Proc. 10[th] Eur. Anim. Blood Grps Conf. Paris July 1966, Paris 1966, s. 301-305.

ECHARD, G; BROAD T.E.; HILL D.; PEARCE P.:
Present status of the ovine gene map (Ovis aries); comparison with the bovine map (*Bos taurus*). Mamm. Genome **5** (1994), 324-332

EDFORS-LILJA, I.; GEUSTAVSSON, U.; DUVAL-IFLAH, D.; ELLEGREN, H.; JOHANSSON, M.; JUNEJA, R.K.; MARKLUND, L.; ANDERSSON, L.:
The porcine intestinal receptor for Escherichia coli K88ab, K88ac: regional localisation on chromosome 13 and influence of IgG response to K88 antigen. Anim. Genet. **26** (1995), 237-242

EFREMOV, G.; VASKOV, B.:
Serumtransferrin polymorphism in Macedonian sheep breeds. Physiol. Pharmacol. Acta 4 (1968), 227-282

ERHARDT, G.:
Transferrins variants in sheep: separation and characterization by polyacrylamide gel electrophoresis and isoelectric focusing. Anim. Genet. **17** (1986), 343-352

GLAZKO, V.I.:
Primienienie metoda geneticzeskich rasstojanija dlja ocenki differencicji porod i linij, Westn. S-H. Nauki, 12, 411, 34-42, 1990

GUERIN, G.; DUVAL-IFLAH, Y.; BONNEAU, M.; BERTAUD, M.; GUILLAUME, P.; OLIVIER, L.:
Evidence for linkage between K88ab, K88ac intestinal receptors to Escherichia coli and transferrin Loci in pigs. Anim. Genet. **24** (1993), 393-396

KENJI TSUNODA; TAKASHI AMANO; KEN NOZAWA; HASNATH, M.A.:
Genetic characteristics of Bangladeshi Sheep as based on biochemical variations, Jpn. J. Zoot. Sci. **61** (1990) 1, 54-66

KHATTAB, A.G.H.; WATSON, J.H.; AXFORD, R.F.E.:
Transferrin polymorphism in Welsh Mountain sheep. Anim. Prod., Edinburgh **5** (1963), 218

KMIEĆ, M.:
Possibilities of utilization of transferrin polymorphism, haemoglobin and K^+ gene in breeding work in the flock of sheep at the Bobrowniki Breeding Station (POHZ). (Polish Language). Praca doktorska, AR, Szczecin, 1986

KMIEĆ, M.:
The genetic distance of some sheep breeds kept in Pomerania. (Polish Language). Wrocław 18-19 wrzeœnia 1995, AR Wrocław, 1995, s. 217-220

KRISTJANSSON, F.K.:
Recent research in serum protein polymorphisms of livestock. In: VIII[th] Europ. Conf. on Blood Grps, Ljubljana, 1962

KURYŁ, J.:
Genetic markers. (Polish Language). Zesz. Nauk. PTZ 6, 48-76, 1992

LIPECKA, CZ.:
Changes in the frequency of transferrin phenotypes in a selected sheep population. (Polish Language). Pr. Mater. Zoot. **29** (1984), 11-19

NGUYEN, T.C.; MORERA, L.; LLANES, D.; LEGER P.:
Sheep blood polymorphism and genetic divergence between French Rambouillet and Spanish Merino: role of genetic drift. Anim. Genet. **23** (1992), 325-332

OSMAN, H.E.S.:
Serum transferrin polymorphism in the Desert sheep of the Sudan. Nature, London **215** (1967), 162-163

PORĘBSKA, W.; PIESTRAK, T.; GRABOŃ, A.; ŻARNECKA, A.:
Changes in frequencies of genes of some blood proteins and enzymes in merino sheep. (Polish Language). In: LIII Zjazd Naukowy Polskiego Towarzystwa Naukowego, Olsztyn, 14-16 wrzecœnia 1988, Prz. Nauk. Lit. Zoot. (zesz. specjalny), PWN Warszawa-£ódŸ 1990, s. 50-53
RASMUSEN, B.; TUCKER, E.M.:
Transferrin type and reproduction in sheep. Anim. Blood Grps Biochem. Genet. 4 (1973), 207-220
RODERO, A.; HABA, M.R.; DE LA, LLANES, D.; MORENO, A.:
Evolucion de una poblacion de Merino Espanol con marcadores geneticos. Arch. Zootec. **39** (1990), 187-196
RYCHLIK, T.; JANIK, A.; DUNIEC, M.:
Application of sheep blood groups and polymporphic proteins testing in breeding practice. (Polish Language). Biul. Inf. IZ **34** (1996) 4, 51-60
SHIQUAN, W.; FOOTE, W.C.:
Protein polymorphism in sheep pedigree testing. Theriogenology **34** (1990) 6, 1079-1085
SMITHIES, O.:
Zone electrophoresis in strach gels, group variations in serum proteins of normal human adults. Biochem. J. **61** (1955), 629
TATE, M.L.; MANLY, H.C.; SCHMACK, A.:
Genetic polymorphism in sheep plasma detected using antibodies to human plasminogen. Anim. Genet. **23** (1992), 385-389
UKBAJEV, H.I.; NAJSABIEKOV, N.N.; PAK, T.A.:
Ocenka geneticeskoj struktury ovec edylbajevskoj i karakulskoj porod i ich gibridov, Selskochazjajst. Biolog. **6** (1990), 58-61
ŻUK, B.:
Practical biometrics. (Polish Language). PWN, Warszawa, 1989

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