Productivity Analysis of the Botosani Karakul Sheep Depending on the Genetic Types of Serum Transferrin

Gheorghe Hrincă[1], Gabriel Vicovan[2], Ioan Pădeanu[3], Sorin Voia[3]

[1]*Research and Development Station for Sheep and Goat Breeding, 717310, Popauti-Botoşani, Romania*
[2]*Research and Development Institute for Sheep and Goat Breeding, 900316, I.C.Brătianu, 248, Palas-Constanţa, Romania*
[3]*Faculty of Animal Sciences and Biotechnologies, 300645, Calea Aradului, 119, Timişoara, Romania*

Abstract

The paper analyzes the sheep productivity of the Botosani Karakul breed in relation to their belonging in different transferrin genotypes. Thirteen electrophoretic phenotypes of transferrin have been identified in this breed. Experimental results show that it is possible to establish correlations between genetic types of serum transferrin and quantitative characteristics of production (meat, wool, milk) in this breed depending on age and sex of animals. In lambs, the values of the productive parameters are more grouped in most transferrin genotypes, while in adult animals, more important differentiations of productivity occur among different transferrin genotypes. In adult animals, the productive differentiation among the genotypes Tf is more obvious in rams than in ewes. Irrespective of age and sex, the differences of productivity among transferrin genotypes, in their reciprocity, seldom present significant statistical assurance, a relatively frequent part of them is situated near the first critical threshold of significance, and most of them are unsignificant. Thus, a certain production metabolism is characteristic to each genotype transferrin. But the transferrin genotypes which enhance the sheep productivity, those that differ significantly from the rest of transferrin genotypes, deserve to be taken into account, in the selection works of this breed for its productive improvement.

Keywords: sheep production, transferrin genotype, transferrin polymorphism

1. Introduction

So far, among all serum proteins, the serum transferrins represent the most researched fraction protein in all species of domestic animals due to both of their very accentuated genetic polymorphism [1, 2] and of correlation of their genetic variants with some economic, production, reproduction and health traits of animal body [3, 4, 1, 2, 5]. In ovine species, the transferrins can and must occupy an important place in the research of biochemical genetics, because the sheep have the most pronounced polymorphism among all species at this locus [1, 2]; and the more polymorph is a system, the greater is its theoretical and applicative importance [4, 1, 5].

In the pointed context, the transferrin serotyping of the Botosani Karakul sheep aimed, among other things, investigation of some relations of the genetic variants of serum trensferrin with the quantitative traits of production (meat, wool, milk), in order to improve the productivity of this breed.

2. Materials and methods

The experiment was carried out on sheep belonging to the Botosani Karakul breed as follows: 194 lambs (0-3 months), 169 adult females and 177 adult males. The genetic transferrin types were identified by electrophoresis method. The production traits taken into account were: body weights at birth and weaning, daily average gain and lamb pelt surface in lambs, body weight at mating and wool quantity in adult ewes and adult rams and milk quantity in adult females. The experimental results were statistically interpreted: the comparison of production

* Corresponding author: Gheorghe Hrinca, Tel/ Fax 0040231512968, ghrinca@yahoo.com

differences among the transferrin genotypes has been achieved by means of the Student test (t).

3. Results and discussion

Thirteen genetic types of serum transferrin were identified in the electrophoretic field (table 1, 7, 13). The analysis of sheep production has been carried out taking into account the transferrin genotype, age and sex of animals.

a) Correlations between transferrin genotypes and production traits in lambs (table 1)

The lambs with the highest weight at birth belong to genotype $Tf^{A}Tf^{B}$, and those belonging to genotype $Tf^{C}Tf^{D}$ are slightest. In many transferrin genotypes, lamb weight at birth is similar to that of the average of whole population ($Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{M}$). In lambs with the other genotypes, body weights register values situated below the population average of lambs ($Tf^{B}Tf^{E}$, $Tf^{D}Tf^{E}$ and especially $Tf^{M}Tf^{M}$).
Because the body weight of the genotypes Tf oscillates around the populational average, differences between the genotypes Tf, in terms of this production parameter, are generally small and unsignificant. The only differences that have statistical assurance are those between genotype $Tf^{M}Tf^{M}$ with genotypes $Tf^{C}Tf^{C}$ (significant) and $Tf^{B}Tf^{C}$ (distinctly significant). Differences between the genotype $Tf^{M}Tf^{M}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$ and $Tf^{B}Tf^{M}$, between genotype $Tf^{A}Tf^{C}$ and genotypes $Tf^{C}Tf^{C}$ and $Tf^{A}Tf^{B}$, between genotype $Tf^{B}Tf^{C}$ and genotypes $Tf^{A}Tf^{C}$ and $Tf^{B}Tf^{D}$ and between genotype $Tf^{C}Tf^{D}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{B}$ $Tf^{B}Tf^{C}$ and $Tf^{B}Tf^{M}$ are important by the "t" test values, but they do not have statistical assurance (table 2).
Both homozygotes Tf and heterozygotes Tf register the same body weight at birth, so that the value of test "t" is null (table 2).
Sheep of Karakul type are specialized for lamb pelt production. Besides the qualitative features, the size of lamb pelts has a great importance for clothing industry. According to Brody's equation, concerning the relationship between body weight and body surface, correlations of transferrin genotype with lamb pelt surface are identical to those established with body weight at the lamb birth. Also, the differences among transferrin genotypes are identical, under this aspect (table 1, 3).

The most weighting lambs at weaning age were those with genotype $Tf^{A}Tf^{M}$, and the lightest ones belonged to genotype $Tf^{M}Tf^{M}$. If, at birth, most genotypes recorded body weights around the population average or were identical with this average, at weaning only the weight of genotype $Tf^{C}Tf^{D}$ was close to that of total population. The lambs $Tf^{B}Tf^{B}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{E}$, and especially $Tf^{A}Tf^{M}$ were much heavier at this age than the whole population. Some lambs recorded body weights a little above ($Tf^{A}Tf^{B}$, $Tf^{B}Tf^{M}$ and $Tf^{D}Tf^{E}$) or a little below ($Tf^{B}Tf^{D}$) the population average. The lambs $Tf^{C}Tf^{C}$, $Tf^{C}Tf^{M}$, $Tf^{A}Tf^{C}$ and especially those $Tf^{M}Tf^{M}$ achieved the lowest body weights at weaning age.
Differences of body weight at weaning with statistical assurance are when the genotype $Tf^{M}Tf^{M}$ is compared with genotypes $Tf^{A}Tf^{M}$ and $Tf^{D}Tf^{E}$ (significant), $Tf^{A}Tf^{B}$ (distinctly significant), $Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{C}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{M}$ and $Tf^{B}Tf^{D}$ (very significant). Also, the difference between the genotypes $Tf^{B}Tf^{C}$ and $Tf^{A}Tf^{C}$ is significant. Important differences, but without statistical asssurance, occurred between genotype $Tf^{A}Tf^{C}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{M}$, $Tf^{B}Tf^{D}$ and $Tf^{D}Tf^{E}$, between genotype $Tf^{A}Tf^{M}$ and genotypes $Tf^{C}Tf^{C}$ and $Tf^{B}Tf^{D}$, and between genotypes $Tf^{M}Tf^{M}$ and $Tf^{C}Tf^{M}$ (table 4).
Relatively important differences occur between homozygotes and heterozygotes; heterozygotes are more weighting than homozygotes, but statistical differences between them are unsignificant (table 4).
Registration of weight gain achieved at 90 days and of daily average gain shows that the lambs belonging to different genotypes Tf have not the same growth rate. At the same time, it also points out that there is not a linear relationship between the weight at birth and gains achieved at weaning. Thus, the lambs $Tf^{C}Tf^{D}$ have one of the highest growth rates although are the slightest at birth, and the lambs $Tf^{A}Tf^{B}$, which are the heaviest at birth, have not the highest growth rate, being only at the populational average level. At the same time, the genotypes Tf, that had the same body at birth, accumulated various daily average and total gains at weaning. The gains achieved by lambs $Tf^{A}Tf^{B}$ and $Tf^{B}Tf^{D}$ are at populational average level. More obvious gains are achieved by the lambs $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{M}$, $Tf^{B}Tf^{E}$, $Tf^{C}Tf^{D}$ and $Tf^{D}Tf^{E}$, and the lambs $Tf^{C}Tf^{C}$, $Tf^{M}Tf^{M}$, $Tf^{A}Tf^{C}$ and $Tf^{C}Tf^{M}$ achieve lower gains than the averages obtained on the total population. The highest

growth rate is achieved by the lambs Tf^ATf^M, and the lowest by the lambs Tf^MTf^M.

Table 1. Production parameters in lambs of the Botosani Karakul breed depending on the transferrin genotypes

Transferrin genotype	Statistical parameter	Body weight at birth (Kg)	Lamb pelt surface (cm^2)	Body weight at weaning (Kg)	Weight gain at 90 days (Kg)	Daily average gain (g/day)
Tf^BTf^B n=22	$\bar{x} \pm s_{\bar{x}}$	4.20±0.11	2616±50	15.50±0.60	11.30±0.54	126±6
	s	0.53	232.30	2.82	2.52	27.75
	v%	12.69	8.88	18.21	22.27	22.02
Tf^CTf^C n=37	$\bar{x} \pm s_{\bar{x}}$	4.20±0.09	2616±40	14.86±0.54	10.66±0.51	118±5
	s	0.56	243.81	3.24	3.05	32.64
	v%	13.32	9.32	21.82	28.59	27.66
Tf^MTf^M n=1	$\bar{x} \pm s_{\bar{x}}$	4.00±0	2531±0	10.80±0	6.80±0	76±0
	s	0.00	0.00	0.00	0.00	0.00
	v%	0.00	0.00	0.00	0.00	0.00
Tf^ATf^B n=12	$\bar{x} \pm s_{\bar{x}}$	4.30±0.15	2657±67	15.31±1.35	11.01±1.26	122±14
	s	0.53	227.97	4.68	4.35	47.37
	v%	12.26	8.58	30.56	39.50	38.83
Tf^ATf^C n=14	$\bar{x} \pm s_{\bar{x}}$	4.00±0.13	2531±60	13.78±0.64	9.78±0.57	109±7
	s	0.50	223.49	2.41	2.15	25.38
	v%	12.62	8.83	17.47	21.98	23.28
Tf^ATf^M n=5	$\bar{x} \pm s_{\bar{x}}$	4.20±0.27	2616±118	16.96±1.31	12.77±0.96	142±12
	s	0.61	264.74	2.93	2.16	25.99
	v%	14.45	10.12	17.27	16.90	18.30
Tf^BTf^C n=57	$\bar{x} \pm s_{\bar{x}}$	4.20±0.07	2616±32	15.63±0.48	11.43±0.44	127±5
	s	0.55	239.63	3.61	3.33	36.30
	v%	13.09	9.16	23.09	29.17	28.58
Tf^BTf^M n=19	$\bar{x} \pm s_{\bar{x}}$	4.20±0.11	2616±50	15.30±0.70	11.10±0.67	123±7
	s	0.50	217.65	3.05	2.91	31.57
	v%	11.89	8.32	19.92	26.18	25.67
Tf^BTf^D n=13	$\bar{x} \pm s_{\bar{x}}$	4.00±0.16	2431±69	14.99±0.69	10.99±0.57	122±6
	s	0.56	249.56	2.49	2.07	22.39
	v%	14.08	9.86	16.61	18.86	18.35
Tf^BTf^E n=4	$\bar{x} \pm s_{\bar{x}}$	4.10±0.37	2573±162	15.58±3.12	11.48±2.66	128±31
	s	0.74	323.68	6.24	5.33	62.05
	v%	17.97	12.58	40.07	46.41	48.48
Tf^CTf^M n=5	$\bar{x} \pm s_{\bar{x}}$	4.10±0.33	2573±144	14.78±1.75	10.68±1.45	119±16
	s	0.74	323.43	3.91	3.26	35.30
	v%	17.97	12.57	26.48	30.51	29.66
Tf^CTf^D n=2	$\bar{x} \pm s_{\bar{x}}$	3.70±0.25	2403±112	15.20±3.61	11.50±2.86	128±33
	s	0.35	158.60	5.09	4.04	46.13
	v%	9.43	6.60	33.49	35.10	36.04
Tf^DTf^E n=3	$\bar{x} \pm s_{\bar{x}}$	4.10±0.21	2573±91	15.37±0.54	11.27±0.54	125±5
	s	0.36	158.24	0.93	0.93	9.48
	v%	8.79	6.15	6.05	8.27	7.58
Homozy-gotes n=60	$\bar{x} \pm s_{\bar{x}}$	4.20±0.07	2616±30	15.03±0.40	10.83±0.37	120±4
	s	0.54	236.22	3.11	2.88	31.07
	v%	12.90	9.03	20.68	26.61	25.89
Heterozy-gotes n=134	$\bar{x} \pm s_{\bar{x}}$	4.20±0.05	2616±20	15.30±0.30	11.10±0.27	123±3
	s	0.54	237.01	3.44	3.12	34.30
	v%	12.94	9.06	22.54	28.07	27.89
Total population n=194	$\bar{x} \pm s_{\bar{x}}$	4.20±0.04	2616±18	15.22±0.24	11.02±0.23	122±2
	s	0.54	235.44	3.34	3.05	33.28
	v%	12.90	0.00	21.96	27.65	27.28

Table 2. Testing the differences of body weight at birth in lambs of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	$Tf^{B}Tf^{B}$	$Tf^{C}Tf^{C}$	$Tf^{M}Tf^{M}$	$Tf^{A}Tf^{B}$	$Tf^{A}Tf^{C}$	$Tf^{A}Tf^{M}$	$Tf^{B}Tf^{C}$	$Tf^{B}Tf^{M}$	$Tf^{B}Tf^{D}$	$Tf^{B}Tf^{E}$	$Tf^{C}Tf^{M}$	$Tf^{C}Tf^{D}$	$Tf^{D}Tf^{E}$
$Tf^{B}Tf^{B}$		57	21	32	34	25	77	39	33	24	25	22	23
$Tf^{C}Tf^{C}$	0.00		36	47	49	40	92	54	48	39	40	37	38
$Tf^{M}Tf^{M}$	1.74^{+}	2.22*		11	13	4	56	18	12	3	4	1	2
$Tf^{A}Tf^{B}$	0.50	0.56	1.88^{+}		24	15	67	29	23	14	15	12	13
$Tf^{A}Tf^{C}$	1.11	1.25^{+}	0.00	1.43^{+}		17	69	31	25	16	17	14	15
$Tf^{A}Tf^{M}$	0.00	0.00	0.67	0.29	0.61		60	22	16	7	8	5	6
$Tf^{B}Tf^{C}$	0.00	0.00	2.74**	0.59	1.25^{+}	0.00		74	68	59	60	57	58
$Tf^{B}Tf^{M}$	0.00	0.00	1.67^{+}	0.50	1.11	0.00	0.00		30	21	22	19	20
$Tf^{B}Tf^{D}$	1.00	1.05	0.00	1.30^{+}	0.00	0.59	1.43^{+}	1.00		15	16	13	14
$Tf^{B}Tf^{E}$	0.23	0.23	0.24	0.44	0.22	0.19	0.23	0.23	0.22		7	4	5
$Tf^{C}Tf^{M}$	0.26	0.26	0.57	0.50	0.27	0.21	0.27	0.26	0.25	0.00		5	6
$Tf^{C}Tf^{D}$	1.39^{+}	1.39^{+}	0.86	1.58^{+}	0.81	1.09	1.43^{+}	1.35^{+}	0.79	0.73	0.80		3
$Tf^{D}Tf^{E}$	0.36	0.37	0.40	0.67	0.34	0.26	0.38	0.36	0.33	0.00	0.00	0.93	
	Values of the Student test (t)												LD=192
	Difference between homozygotes and heterozygotes											t=0.00	

Table 3. Testing the differences of lamb pelts surface at birth in lambs of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	$Tf^{B}Tf^{B}$	$Tf^{C}Tf^{C}$	$Tf^{M}Tf^{M}$	$Tf^{A}Tf^{B}$	$Tf^{A}Tf^{C}$	$Tf^{A}Tf^{M}$	$Tf^{B}Tf^{C}$	$Tf^{B}Tf^{M}$	$Tf^{B}Tf^{D}$	$Tf^{B}Tf^{E}$	$Tf^{C}Tf^{M}$	$Tf^{C}Tf^{D}$	$Tf^{D}Tf^{E}$
$Tf^{B}Tf^{B}$		57	21	32	34	25	77	39	33	24	25	22	23
$Tf^{C}Tf^{C}$	0.00		36	47	49	40	92	54	48	39	40	37	38
$Tf^{M}Tf^{M}$	1.68^{+}	2.18*		11	13	4	56	18	12	3	4	1	2
$Tf^{A}Tf^{B}$	0.48	0.55	1.81^{+}		24	15	67	29	23	14	15	12	13
$Tf^{A}Tf^{C}$	1.06	1.21^{+}	0.00	1.36^{+}		17	69	31	25	16	17	14	15
$Tf^{A}Tf^{M}$	0.00	0.00	0.63	0.28	0.57		60	22	16	7	8	5	6
$Tf^{B}Tf^{C}$	0.00	0.00	2.70**	0.58	1.21^{+}	0.00		74	68	59	60	57	58
$Tf^{B}Tf^{M}$	0.00	0.00	1.63^{+}	0.49	1.09	0.00	0.00		30	21	22	19	20
$Tf^{B}Tf^{D}$	0.97	1.01	0.00	1.23^{+}	0.00	0.55	1.39^{+}	0.96		15	16	13	14
$Tf^{B}Tf^{E}$	0.22	0.22	0.23	0.40	0.02	0.18	0.22	0.22	0.20		7	4	5
$Tf^{C}Tf^{M}$	0.25	0.25	0.26	0.46	0.24	0.20	0.25	0.25	0.24	0.00		5	6
$Tf^{C}Tf^{D}$	1.28^{+}	1.28^{+}	0.78	1.47^{+}	0.75	0.98	1.32^{+}	1.32^{+}	0.72	0.64	0.71		3
$Tf^{D}Tf^{E}$	0.35	0.36	0.39	0.63	0.33	0.25	0.36	0.36	0.31	0.00	0.00	0.84	
	Values of the Student test (t)												LD=192
	Difference between homozygotes and heterozygotes											t=0.00	

Table 4. Testing the differences of body weight at weaning in lambs of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	$Tf^{B}Tf^{B}$	$Tf^{C}Tf^{C}$	$Tf^{M}Tf^{M}$	$Tf^{A}Tf^{B}$	$Tf^{A}Tf^{C}$	$Tf^{A}Tf^{M}$	$Tf^{B}Tf^{C}$	$Tf^{B}Tf^{M}$	$Tf^{B}Tf^{D}$	$Tf^{B}Tf^{E}$	$Tf^{C}Tf^{M}$	$Tf^{C}Tf^{D}$	$Tf^{D}Tf^{E}$
$Tf^{B}Tf^{B}$		57	21	32	34	25	77	39	33	24	25	22	23
$Tf^{C}Tf^{C}$	0.78		36	47	49	40	92	54	48	39	40	37	38
$Tf^{M}Tf^{M}$	7.58***	7.52*		11	13	4	56	18	12	3	4	1	2
$Tf^{A}Tf^{B}$	0.29	0.30	3.20**		24	15	67	29	23	14	15	12	13
$Tf^{A}Tf^{C}$	1.89^{+}	1.23^{+}	4.45***	0.98		17	69	31	25	16	17	14	15
$Tf^{A}Tf^{M}$	0.92	1.35^{+}	4.22*	0.81	1.98^{+}		60	22	16	7	8	5	6
$Tf^{B}Tf^{C}$	0.17	1.07	10.06***	0.22	2.23*	0.87		74	68	59	60	57	58
$Tf^{B}Tf^{M}$	0.21	0.49	6.25***	0.01	1.55^{+}	1.02	0.38		30	21	22	19	20
$Tf^{B}Tf^{D}$	0.54	0.14	5.82***	0.20	1.23^{+}	1.21^{+}	0.74	0.30		15	16	13	14
$Tf^{B}Tf^{E}$	0.02	0.20	1.33	0.07	0.49	0.88	0.01	0.08	0.16		7	4	5
$Tf^{C}Tf^{M}$	0.35	0.04	2.03^{+}	0.22	0.48	0.89	0.42	0.25	0.10	0.20		5	6
$Tf^{C}Tf^{D}$	0.06	0.07	0.86	0.02	0.28	0.33	0.08	0.02	0.04	0.06	0.08		3
$Tf^{D}Tf^{E}$	0.14	0.60	4.91*	0.04	1.69^{+}	0.99	0.32	0.07	0.39	0.06	0.29	0.03	
	Values of the Student test (t)												LD=192
	Difference between homozygotes and heterozygotes											t=0.54	

The statistically assured differences occur when the genotype Tf^MTf^M is related to genotypes Tf^DTf^E (significant), Tf^ATf^B and Tf^ATf^M (distinctly significant), Tf^BTf^B, Tf^CTf^C, Tf^ATf^C, Tf^BTf^C, Tf^BTf^M and Tf^BTf^D (very significant), as well as when the genotype Tf^ATf^C is compared with genotypes Tf^ATf^M and Tf^BTf^C (significant). Without to be significant, the values of the Student test are appreciable when they refer to differences between genotype Tf^ATf^C and genotypes Tf^BTf^B, Tf^BTf^M, Tf^BTf^D and Tf^DTf^E, between genotype Tf^CTf^C and genotypes Tf^ATf^M and Tf^BTf^C, between genotype Tf^MTf^M and genotypes Tf^BTf^E and Tf^CTf^M, as well as between genotype Tf^ATf^M and genotypes Tf^BTf^C, Tf^BTf^M and Tf^BTf^D (tab. 5, 6).

On the whole, the heterozygotes Tf achieved bigger daily and total body weight gains than homozygotes Tf, but differences are relatively unsignificant (tab. 5, 6). So, in lambs the most productive genotypes Tf are the genotype Tf^ATfB for lamb pelt production (their surface size) and genotypes Tf^ATf^M, Tf^BTf^C, Tf^BTf^E, Tf^CTf^D when aiming the meat production.

Table 5. Testing the differences of weight gain at 90 days in lambs of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		57	21	32	34	25	77	39	33	24	25	22	23
Tf^CTf^C	0.85		36	47	49	40	92	54	48	39	40	37	38
Tf^MTf^M	8.33***	7.57***		11	13	4	56	18	12	3	4	1	2
Tf^ATf^B	0.20	0.25	3.21**		24	15	67	29	23	14	15	12	13
Tf^ATf^C	1.88$^+$	1.11	4.97***	0.85		17	69	31	25	16	17	14	15
Tf^ATf^M	1.21$^+$	1.77$^+$	5.52**	1.03	2.42*		60	22	16	7	8	5	6
Tf^BTf^C	0.18	1.13$^+$	10.29***	0.30	2.20*	1.14$^+$		74	68	59	60	57	58
Tf^BTf^M	0.23	0.52	6.23***	0.06	1.45$^+$	1.30$^+$	0.40		30	21	22	19	20
Tf^BTf^D	0.38	0.42	6.98***	0.01	1.42$^+$	1.44$^+$	0.59	0.12		15	16	13	14
Tf^BTf^E	0.06	0.26	1.52$^+$	0.14	0.54	0.39	0.02	0.12	0.16		7	4	5
Tf^CTf^M	0.36	0.01	2.38$^+$	0.16	0.52	1.07	0.44	0.24	0.18	0.23		5	6
Tf^CTf^D	0.05	0.21	1.16	0.12	0.42	0.30	0.02	0.10	0.13	0.00	0.19		3
Tf^DTf^E	0.03	0.73	6.77*	0.18	1.67$^+$	1.18	0.20	0.18	0.31	0.07	0.34	0.06	
	Values of the Student test (t)												LD=192
	Difference between homozygotes and heterozygotes											t=0.59	

Table 6. Testing the differences of daily average gain in lambs of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		57	21	32	34	25	77	39	33	24	25	22	23
Tf^CTf^C	0.98		36	47	49	40	92	54	48	39	40	37	38
Tf^MTf^M	8.26***	7.72***		11	13	4	56	18	12	3	4	1	2
Tf^ATf^B	0.26	0.26	3.22**		24	15	67	29	23	14	15	12	13
Tf^ATf^C	1.83$^+$	1.01	4.69***	0.82		17	69	31	25	16	17	14	15
Tf^ATf^M	1.12$^+$	1.70$^+$	5.08**	1.04	2.23*		60	22	16	7	8	5	6
Tf^BTf^C	0.13	1.23$^+$	10.52***	0.33	2.11*	1.08$^+$		74	68	59	60	57	58
Tf^BTf^M	0.31	0.54	6.32***	0.06	1.37$^+$	1.27$^+$	0.45		30	21	22	19	20
Tf^BTf^D	0.45	0.47	7.12***	0.00	1.36$^+$	1.38$^+$	0.62	0.10		15	16	13	14
Tf^BTf^E	0.06	0.28	1.45$^+$	0.16	0.52	0.36	0.03	0.14	0.17		7	4	5
Tf^CTf^M	0.38	0.05	2.44$^+$	0.13	0.53	1.05	0.44	0.21	0.16	0.23		5	6
Tf^CTf^D	0.04	0.22	1.13	0.12	0.41	0.29	0.02	0.11	0.13	0.00	0.18		3
Tf^DTf^E	0.11	0.81	7.31*	0.19	1.65$^+$	1.16	0.24	0.20	0.32	0.08	0.32	0.06	
	Values of the Student test (t)												LD=192
	Difference between homozygotes and heterozygotes											t=0.60	

b) Correlations between transferrin genotypes and production traits in adult ewes (table 7)

Among the adult females possessing the genotypes Tf^CTf^C, Tf^BTf^C, Tf^BTf^M and Tf^BTf^D, the differences of body weight are very small, the values of this production parameter oscillating around the populational average. The females Tf^DTf^E and Tf^CTf^D are much more weighting than these ewes, but the biggest body weight is found in ewes with genotype $Tf^{A}Tf^{M}$. Also, the females $Tf^{B}Tf^{B}$ presented a little higher body weight at mating than the population average. The females $Tf^{M}Tf^{M}$, $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{C}$ and $Tf^{C}Tf^{M}$ have body weights situated below the population average. But the ewes $Tf^{B}Tf^{E}$ have the smallest body weight among all genotypes Tf.

Nevertheless, significant differences are recorded only between genotype $Tf^{A}Tf^{M}$ and genotypes $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{E}$ and $Tf^{C}Tf^{M}$. Some differences of body weight are important, even if they are not significant, such as those between genotypes $Tf^{A}Tf^{B}$ and $Tf^{B}Tf^{B}$, or between genotypes $Tf^{B}Tf^{E}$ and $Tf^{B}Tf^{B}$, or between genotypes $Tf^{D}Tf^{E}$ and $Tf^{A}Tf^{B}$, as well as those found between genotype $Tf^{A}Tf^{M}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{C}$, $Tf^{B}Tf^{M}$ and $Tf^{B}Tf^{D}$, or those achieved by the genotype $Tf^{C}Tf^{D}$ with genotypes $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{C}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{E}$ and $Tf^{C}Tf^{M}$ (table 8).

The most substantial quantity of wool is obtained from females $Tf^{B}Tf^{M}$. Higher wool productions than population average give the ewes $Tf^{C}Tf^{M}$ and $Tf^{B}Tf^{D}$ too. Around the populational average there are the genotypes $Tf^{B}Tf^{B}$, $Tf^{M}Tf^{M}$ and $Tf^{B}Tf^{C}$ with slightly higher productions and genotypes $Tf^{C}Tf^{C}$ and $Tf^{C}Tf^{D}$ with slightly lower productions. Lower productions than the populational average are obtained from females $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{E}$ and $Tf^{A}Tf^{C}$, and ewes with genotype $Tf^{D}Tf^{E}$ register the smallest quantity of wool.

In terms of statistics, the genotype $Tf^{A}Tf^{C}$ differs significantly of genotypes $Tf^{B}Tf^{B}$ and $Tf^{C}Tf^{C}$ and distinctly significantly of genotypes $Tf^{B}Tf^{C}$ and $Tf^{B}Tf^{M}$. Also, the genotype $Tf^{D}Tf^{E}$ differs significantly of genotypes $Tf^{B}Tf^{B}$ and $Tf^{C}Tf^{C}$ and distinctly significantly of genotypes $Tf^{B}Tf^{C}$ and $Tf^{B}Tf^{M}$. A significant difference is achieved between genotypes $Tf^{B}Tf^{M}$ and $Tf^{B}Tf^{E}$. The differences of wool quantities between the genotype $Tf^{A}Tf^{C}$ and genotypes $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{D}$, $Tf^{C}Tf^{M}$ and $Tf^{C}Tf^{D}$, between genotype $Tf^{B}Tf^{M}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{M}$ and $Tf^{B}Tf^{C}$, between genotype $Tf^{B}Tf^{E}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{B}Tf^{C}$ and $Tf^{B}Tf^{D}$, between genotype $Tf^{D}Tf^{E}$ and genotypes $Tf^{D}Tf^{E}$ $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{D}$, $Tf^{C}Tf^{M}$ and $Tf^{C}Tf^{D}$ as well as those between genotypes $Tf^{C}Tf^{M}$ and $Tf^{B}Tf^{E}$ or between genotypes $Tf^{C}Tf^{D}$ and $Tf^{B}Tf^{M}$ are appreciable by their values, but they do not present statistical assurance (table 9).

The most productive ewes for milk production are those which belong to genotype $Tf^{C}Tf^{D}$. Considerable quantities of milk are also obtained from females $Tf^{D}Tf^{E}$ and $Tf^{C}Tf^{C}$ and even from those $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{M}$ and $Tf^{C}Tf^{M}$, whose productions are over average production of population. In female $Tf^{A}Tf^{C}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{D}$ and $Tf^{B}Tf^{E}$, the milk productions are below the populational average, and individuals $Tf^{M}Tf^{M}$ give the lowest quantity of milk, incomparably less than ewes of the other genotypes Tf.

Although there is a great variability of this production trait among all transferrin genotypes, significant differences are recorded only between genotype $Tf^{B}Tf^{C}$ and genotypes $Tf^{C}Tf^{C}$ and $Tf^{C}Tf^{D}$, as well as between genotype $Tf^{M}Tf^{M}$ and genotypes $Tf^{C}Tf^{C}$ and $Tf^{C}Tf^{D}$; also, the production difference between the genotypes TfBTfC and TfCTfM is distinctly significant. Differences registered between genotype $Tf^{M}Tf^{M}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{M}$ and $Tf^{C}Tf^{M}$, between genotype $Tf^{A}Tf^{C}$ and genotypes $Tf^{C}Tf^{C}$, $Tf^{C}Tf^{M}$ and $Tf^{C}Tf^{D}$, between genotype $Tf^{B}Tf^{C}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$ and $Tf^{B}Tf^{M}$, between genotype $Tf^{B}Tf^{D}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$ and $Tf^{C}Tf^{M}$ and between genotype $Tf^{C}Tf^{D}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{D}$, $Tf^{B}Tf^{E}$ and $Tf^{C}Tf^{M}$ can be taken into account, even if they do not have significant statistical assurance (table 10).

The total milk production of ewes is dependent on the quantity of milk obtained in each day and on the number of days necessary for their milking. Therefore, the two lactogen parameters (milking period and daily average milk production) present the same production aspects and the same statistical characteristics like the total milk production (table 11, 12).

In terms of the zygosity status, the homozygous ewes are more weighting and have a much better production of milk than the heterozygous ewes; instead, the heterozygotes produce more wool than the homozygotes. Nevertheless, although sometimes some production differences between the two subpopulations are considerable, they do not reach the first critical threshold of significance (table 8, 9, 10, 11, 12.

So, in the adult female, the most productive transferrin genotypes are genotypes $Tf^{A}Tf^{M}$, $Tf^{D}Tf^{E}$ and $Tf^{C}Tf^{D}$ for meat production, genotypes $Tf^{B}Tf^{M}$, $Tf^{C}Tf^{M}$ and $Tf^{B}Tf^{D}$ for wool production and genotypes $Tf^{C}Tf^{D}$, $Tf^{D}Tf^{E}$ and $Tf^{C}Tf^{C}$ for milk production.

Table 7. Production parameters in adult ewes of the Botosani Karakul breed depending on the transferrin genotypes

Transferrin genotype	Statistical parameter	Body weight at mating (Kg)	Wool production (Kg)	Milk production (l)	Milking period (days)	Daily average milk production (ml/day)
Tf^BTf^B n=20	$\bar{x}\pm s\bar{x}$	45.25±1.08	2.72±0.16	59.16±3.68	166±5	356±22
	s	4.81	0.71	16.46	24.55	99.79
	v%	10.62	25.89.88	27.82	14.76	28.00
Tf^CTf^C n=31	$\bar{x}\pm s\bar{x}$	44.42±2.81	2.60±0.16	61.24±3.96	166±5	370±17
	s	3.33	0.78	22.05	28.52	95.50
	v%	7.51	30.01	36.01	17.22	25.81
Tf^MTf^M n=4	$\bar{x}\pm s\bar{x}$	43.75±2.81	2.78±0.47	44.43±6.37	134±13	334±5
	s	5.62	0.94	12.73	26.11	97.86
	v%	12.85	33.85	28.66	19.56	29.30
Tf^ATf^B n=17	$\bar{x}\pm s\bar{x}$	43.06±1.12	2.52±0.23	58.28±5.62	163±6	357±25
	s	4.62	0.93	23.17	23.77	102.51
	v%	10.72	37.08	39.76	14.60	28.67
Tf^ATf^C n=9	$\bar{x}\pm s\bar{x}$	43.56±1.74	2.10±0.18	50.03±7.42	160±8	313±40
	s	5.22	0.55	22.27	25.02	120.63
	v%	11.99	26.41	44.51	15.66	38.54
Tf^ATf^M n=6	$\bar{x}\pm s\bar{x}$	48.33±1.43	2.57±0.37	53.00±9.61	152±14	349±67
	s	3.50	0.90	23.55	34.73	163.85
	v%	7.25	34.91	44.43	22.77	46.95
Tf^BTf^C n=39	$\bar{x}\pm s\bar{x}$	44.28±0.63	2.77±0.13	50.26±2.59	151±4	333±16
	s	3.95	0.82	16.20	27.26	102.80
	v%	8.93	29.64	32.23	18.00	30.87
Tf^BTf^M n=14	$\bar{x}\pm s\bar{x}$	44.21±1.53	3.19±0.24	59.57±5.25	171±7	348±21
	s	5.73	0.88	19.65	28.07	79.58
	v%	12.95	27.67	32.98	16.45	22.87
Tf^BTf^D n=9	$\bar{x}\pm s\bar{x}$	44.67±1.57	2.87±0.29	51.40±5.01	148±12	347±30
	s	4.72	0.88	15.02	35.06	91.26
	v%	10.56	30.56	29.23	23.72	26.30
Tf^BTf^E n=7	$\bar{x}\pm s\bar{x}$	42.86±1.58	2.34±0.18	53.74±8.09	161±9	334±46
	s	4.18	0.49	21.40	24.86	122.34
	v%	9.75	20.89	39.81	15.42	36.63
Tf^CTf^M n=5	$\bar{x}\pm s\bar{x}$	43.80±0.80	2.92±0.36	59.16±1.59	170±7	348±10
	s	1.79	0.81	3.56	16.65	23.28
	v%	4.08	27.76	6.01	9.81	6.69
Tf^CTf^D n=6	$\bar{x}\pm s\bar{x}$	46.17±1.19	2.62±0.25	68.83±6.60	170±11	405±22
	s	2.93	0.60	16.17	27.32	54.27
	v%	6.34	23.11	23.49	16.06	13.40
Tf^DTf^E n=2	$\bar{x}\pm s\bar{x}$	47.00±2.00	2.05±0.15	64.35±18.95	165±26	390±57
	s	2.83	0.21	26.80	37.48	80.89
	v%	6.02	10.35	41.65	22.64	20.74
Homozygotes n=55	$\bar{x}\pm s\bar{x}$	44.67±0.54	2.66±0.10	59.26±2.67	164±4	361±13
	s	4.04	0.75	19.82	27.83	95.34
	v%	9.04	28.32	33.45	17.01	26.41
Heterozygotes n=114	$\bar{x}\pm s\bar{x}$	44.32±0.41	2.71±0.08	54.65±1.76	159±3	344±9
	s	4.38	0.83	18.83	27.51	99.62
	v%	9.89	30.60	34.46	17.35	28.96
Total population n=169	$\bar{x}\pm s\bar{x}$	44.43±0.33	2.69±0.06	56.15±1.48	160±2	351±8
	s	4.26	0.80	19.22	27.63	98.74
	v%	9.60	29.82	34.24	17.25	28.13

Table 8. Testing the differences of body weight at mating in adult ewes of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		49	22	35	27	24	57	32	27	25	23	24	20
Tf^CTf^C	0.66		33	46	38	35	68	43	38	36	34	35	31
Tf^MTf^M	0.44	0.20		19	11	8	41	16	11	9	7	8	4
Tf^ATf^B	1.37^+	1.05	0.20		24	21	54	29	24	22	20	21	13
Tf^ATf^C	0.79	0.44	0.05	0.23		13	46	21	16	14	12	13	17
Tf^ATf^M	1.60^+	2.33*	1.27	2.72*	1.97^+		43	18	13	11	9	10	9
Tf^BTf^C	0.76	0.16	0.16	0.92	0.37	2.40*		51	46	44	42	43	6
Tf^BTf^M	0.54	0.12	0.13	0.59	0.27	1.79^+	0.04		21	19	17	18	39
Tf^BTf^D	0.29	0.14	0.25	0.79	0.45	1.60^+	0.22	0.20		14	12	13	14
Tf^BTf^E	1.18^+	0.86	0.24	0.10	0.28	2.37*	0.78	0.58	0.76		10	11	7
Tf^CTf^M	1.02	0.57	0.01	0.51	0.12	2.52*	0.44	0.22	0.46	0.49		9	5
Tf^CTf^D	0.54	1.21^+	0.69	1.79^+	1.15^+	1.06	1.29^+	0.95	0.71	1.54^+	1.50		6
Tf^DTf^E	0.58	0.89	0.76	1.29^+	1.02	0.41	0.94	0.86	0.71	1.25	1.08	0.27	
	Values of the Student test (t)												LD=167
	Difference between homozygotes and heterozygotes											t=0.51	

Table 9. Testing the differences of wool production at mating in adult ewes of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		49	22	35	27	24	57	32	27	25	23	24	20
Tf^CTf^C	0.57		33	46	38	35	68	43	38	36	34	35	31
Tf^MTf^M	0.11	0.32		19	11	8	41	16	11	9	7	8	4
Tf^ATf^B	0.71	0.30	0.44		24	21	54	29	24	22	20	21	17
Tf^ATf^C	2.48*	2.08*	1.17	1.40^+		13	46	21	16	14	12	13	9
Tf^ATf^M	0.35	0.07	0.31	0.11	1.04		43	18	13	11	9	10	6
Tf^BTf^C	0.24	0.89	0.02	0.93	2.79**	0.48		51	46	44	42	43	39
Tf^BTf^M	1.62^+	2.11*	0.69	1.97^+	3.52**	1.32^+	1.50^+		14	12	13	18	14
Tf^BTf^D	0.43	0.79	0.14	0.90	2.08^+	0.59	0.29	0.82		14	12	13	9
Tf^BTf^E	1.46^+	1.08	0.76	0.58	0.86	0.51	1.79^+	2.74*	1.43^+		10	11	7
Tf^CTf^M	0.45	0.74	0.21	0.85	1.82^+	0.61	0.35	0.57	0.10	1.29		9	5
Tf^CTf^D	0.31	0.64	0.26	0.28	1.53^+	0.10	0.50	1.58^+	0.61	0.82	0.61		6
Tf^DTf^E	2.39*	2.11*	1.24	1.47^+	0.17	1.13	2.77**	3.45**	2.16^+	0.97	1.89^+	1.63^+	
	Values of the Student test (t)												LD=167
	Difference between homozygotes and heterozygotes											t=0.38	

Table 10. Testing the differences of milk production in adult ewes of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		49	22	35	27	24	57	32	27	25	23	24	20
Tf^CTf^C	0.38		33	46	38	35	68	43	38	36	34	35	31
Tf^MTf^M	1.78^+	2.01*		19	11	8	41	16	11	9	7	8	4
Tf^ATf^B	0.13	0.42	1.48^+		24	21	54	29	24	22	20	21	17
Tf^ATf^C	1.05	1.27^+	0.52	0.84		13	46	21	16	14	12	13	9
Tf^ATf^M	0.55	0.73	0.67	0.44	0.23		43	18	13	11	9	10	6
Tf^BTf^C	1.93^+	2.28*	0.75	1.26^+	0.03	0.25		51	46	44	42	43	39
Tf^BTf^M	0.06	0.25	1.65^+	0.16	1.00	0.55	1.54^+		14	12	13	18	14
Tf^BTf^D	1.19^+	1.48^+	0.77	0.87	0.14	0.14	0.19	1.07		14	12	13	9
Tf^BTf^E	0.57	0.78	0.81	0.43	0.31	0.05	0.38	0.57	0.23		10	11	7
Tf^CTf^M	0.00	0.47	1.95^+	0.14	1.13^+	0.58	2.81**	0.07	1.39^+	0.61		8	5
Tf^CTf^D	1.18^+	0.92	2.37*	1.14^+	1.76^+	1.24^+	2.41*	1.02	1.94^+	1.43^+	1.30^+		6
Tf^DTf^E	0.19	0.11	0.72	0.22	0.51	0.39	0.52	0.52	0.47	0.38	0.19	0.16	
	Values of the Student test (t)												LD=167
	Difference between homozygotes and heterozygotes											t=1.43	

Table 11. Testing the differences of milking period in adult ewes of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		49	22	35	27	24	57	32	27	25	23	24	20
Tf^CTf^C	0.00		33	46	38	35	68	43	38	36	34	35	31
Tf^MTf^M	1.99^+	2.01*		19	11	8	41	16	11	9	7	8	4
Tf^ATf^B	0.37	0.38	1.79^+		24	21	54	29	24	22	20	21	17
Tf^ATf^C	0.57	0.58	1.49^+	0.28		13	46	21	16	14	12	13	9
Tf^ATf^M	0.85	0.85	0.83	0.66	0.45		43	18	13	11	9	10	6
Tf^BTf^C	2.09*	2.20*	1.08	1.62^+	0.91	0.06		51	46	44	42	43	39
Tf^BTf^M	0.52	0.53	2.18*	0.82	0.93	1.09	2.23*		14	12	13	18	14
Tf^BTf^D	1.32^+	1.34^+	0.72	1.09	0.79	0.20	0.23	1.57*		14	12	13	9
Tf^BTf^E	0.43	0.44	1.49^+	0.17	0.07	0.48	0.90	0.78	0.81		10	11	7
Tf^CTf^M	0.40	0.41	2.09^+	0.68	0.82	1.02	2.01*	0.09	1.47^+	0.69		9	5
Tf^CTf^D	0.30	0.30	1.86^+	0.51	0.66	0.91	1.46*	0.07	1.26^+	0.57	0.00		6
Tf^DTf^E	0.03	0.03	1.53^+	0.05	0.13	0.32	0.37	0.16	0.43	0.10	0.13	0.13	
	Values of the Student test (t)												LD=167
	Difference between homozygotes and heterozygotes											t=1.01	

Table 12. Testing the differences of daily average milk production in adult ewes of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	Tf^BTf^B	Tf^CTf^C	Tf^MTf^M	Tf^ATf^B	Tf^ATf^C	Tf^ATf^M	Tf^BTf^C	Tf^BTf^M	Tf^BTf^D	Tf^BTf^E	Tf^CTf^M	Tf^CTf^D	Tf^DTf^E
Tf^BTf^B		49	22	35	27	24	57	32	27	25	23	24	20
Tf^CTf^C	0.49		33	46	38	35	68	43	38	36	34	35	31
Tf^MTf^M	0.36	0.61		19	11	8	41	16	11	9	7	8	4
Tf^ATf^B	0.03	0.42	0.37		24	21	54	29	24	22	20	21	17
Tf^ATf^C	0.89	1.24^+	0.30	0.46		13	46	21	16	14	12	13	9
Tf^ATf^M	0.09	0.28	0.16	0.10	0.42		43	18	13	11	9	10	6
Tf^BTf^C	0.82	1.54^+	0.02	0.79	0.44	0.21		51	46	44	42	43	39
Tf^BTf^M	0.25	0.69	0.23	0.27	0.73	0.01	0.54		14	12	13	18	14
Tf^BTf^D	0.23	0.63	0.20	0.24	0.64	0.02	0.39	0.03		14	12	13	9
Tf^BTf^E	0.40	0.68	0.00	0.41	0.32	0.17	0.02	0.26	0.22		10	11	7
Tf^CTf^M	0.31	1.05	0.24	0.32	0.79	0.01	0.74	0.00	0.03	0.27		9	5
Tf^CTf^D	1.47^+	1.17^+	1.15	1.36^+	1.87^+	0.72	2.48*	1.74^+	1.44^+	1.28^+	2.12^+		6
Tf^DTf^E	0.40	0.24	0.57	0.67	0.84	0.38	0.69	0.50	0.49	0.59	0.51	0.18	
	Values of the Student test (t)												LD=167
	Difference between homozygotes and heterozygotes											t=1.06	

c) Correlations between transferrin genotypes and production traits in adult rams (table 13)

The adult males with the greatest body weight at mating are those which possess the genotype Tf^MTf^M, clearly distinguishing from the rams with the other genotypes Tf. Significant body weights, over population average, are recorded in the rams Tf^ATf^B, Tf^BTf^E and Tf^CTf^D. Also, the rams Tf^BTf^C and Tf^BTf^B too are more weighting than the average of populational ensemble, but the differences are not so obvious like in previous genotypes. The males with genotypes Tf^ATf^M, Tf^BTf^M and Tf^BTf^D are a little lighter than the average of whole population. The rams of type Tf^CTf^C and Tf^CTf^M record even lower body weights, and the rams Tf^DTf^E and especially those Tf^ATf^C have the lowest body weight, much below the average of total population or of the other genotypes Tf.

Because of these aspects, the genotype Tf^MTf^M differs significantly of the genotypes Tf^ATf^M and Tf^DTf^E, distinctly significantly of the genotype Tf^ATf^B and very significantly of the genotypes Tf^BTf^B, Tf^CTf^C, Tf^ATf^C, Tf^BTf^C, Tf^BTf^M and Tf^BTf^D. Also, the genotype Tf^ATf^C differs significantly of genotype Tf^BTf^D, distinctly significantly of genotypes Tf^BTf^B and Tf^ATf^B and very significantly of the genotype Tf^BTf^C. Significant differences are recorded between genotype Tf^DTf^E and genotypes Tf^BTf^B, Tf^ATf^B and Tf^BTf^C, too. The differences between genotype Tf^CTf^C and genotypes Tf^BTf^B, Tf^ATf^B, Tf^ATf^C and Tf^BTf^C, between genotype Tf^ATf^C and genotypes Tf^ATf^M, Tf^BTf^M and Tf^CTf^M, between genotype Tf^BTf^D and genotypes Tf^ATf^B and Tf^BTf^C, between genotype

Tf^CTf^M and genotypes Tf^BTf^B, Tf^CTf^M, Tf^ATf^B and Tf^BTf^C or those between genotype Tf^DTf^E and genotypes Tf^BTf^M and Tf^BTf^D are relevant by their values, but without to be significant (table 14).

Table 13. Production parameters in adult rams of the Botosani Karakul breed depending on the transferrin genotypes

Transferrin genotype	Statistical parameter	Body weight at mating (Kg)	Wool production (Kg)
Tf^BTf^B n=18	$\bar{x} \pm s\bar{x}$	72.89±1.79	4.60±0.23
	s	7.59	0.98
	v%	10.42	21.33
Tf^CTf^C n=30	$\bar{x} \pm s\bar{x}$	68.73±1.91	4.89±0.20
	s	10.48	0.98
	v%	15.25	22.73
Tf^MTf^M n=1	$\bar{x} \pm s\bar{x}$	85.0±0	7.84±0.00
	s	0.00	0.00
	v%	0.00	0.00
Tf^ATf^B n=12	$\bar{x} \pm s\bar{x}$	74.17±2.58	4.04±0.31
	s	8.92	1.08
	v%	12.03	26.73
Tf^ATf^C n=11	$\bar{x} \pm s\bar{x}$	63.82±2.02	5.07±0.43
	s	6.89	1.43
	v%	10.48	28.15
Tf^ATf^M n=5	$\bar{x} \pm s\bar{x}$	70.00±3.33	4.81±0.33
	s	7.45	0.74
	v%	10.64	15.34
Tf^BTf^C n=58	$\bar{x} \pm s\bar{x}$	73.00±1.19	4.59±0.16
	s	9.09	1.25
	v%	12.45	27.79
Tf^BTf^M n=16	$\bar{x} \pm s\bar{x}$	70.31±2.40	4.41±0.32
	s	9.58	1.27
	v%	13.63	28.76
Tf^BTf^D n=16	$\bar{x} \pm s\bar{x}$	70.13±1.75	4.74±0.26
	s	6.99	1.04
	v%	9.97	21.85
Tf^BTf^E n=2	$\bar{x} \pm s\bar{x}$	74.00±9.00	4.42±0.17
	s	12.73	0.24
	v%	17.20	5.44
Tf^CTf^M n=2	$\bar{x} \pm s\bar{x}$	68.50±2.50	5.99±0.39
	s	3.54	0.55
	v%	5.16	9.21
Tf^CTf^D n=2	$\bar{x} \pm s\bar{x}$	74.33±9.29	3.95±0.26
	s	15.95	0.45
	v%	21.45	11.38
Tf^DTf^E n=3	$\bar{x} \pm s\bar{x}$	66.00±2.65	6.23±0.69
	s	4.58	1.20
	v%	6.94	19.28
Homozygotes n=49	$\bar{x} \pm s\bar{x}$	70.59±1.39	4.84±0.16
	s	9.76	1.14
	v%	13.83	23.33
Heterozygotes n=128	$\bar{x} \pm s\bar{x}$	71.33±0.79	4.63±0.11
	s	8.95	1.22
	v%	12.54	26.37
Total population n=177	$\bar{x} \pm s\bar{x}$	71.12±0.69	4.69±0.09
	s	9.16	1.20
	v%	12.88	25.58

The rams $Tf^{M}Tf^{M}$ are the most productive in the case of wool production too. Also, significant quantities of wool are obtained from the males $Tf^{A}Tf^{C}$ and in particular from those $Tf^{C}Tf^{M}$ and $Tf^{D}Tf^{E}$. The genotypes $Tf^{C}Tf^{C}$ and $Tf^{A}Tf^{M}$ record smaller quantities of wool than of previous genotypes too, but over the average of total population. In some genotypes, wool quantities fluctuate around the populational average, either slightly higher ($Tf^{B}Tf^{D}$) or slightly lower ($Tf^{B}Tf^{B}$, $Tf^{B}Tf^{C}$) of this value. The males $Tf^{B}Tf^{M}$ and $Tf^{B}Tf^{E}$ register much lower wool productions than the average for whole population, and rams $Tf^{A}Tf^{B}$ and $Tf^{C}Tf^{D}$ produce the lowest quantities of wool.

From the statistical viewpoint, the genotype $Tf^{M}Tf^{M}$ differs fundamentally from almost all genotypes Tf, as follows: significantly compared to genotype $Tf^{B}Tf^{E}$, distinctly significantly in comparison with genotypes $Tf^{A}Tf^{M}$ and $Tf^{C}Tf^{D}$ or very significantly against the genotypes $Tf^{B}Tf^{B}$, $Tf^{C}Tf^{C}$, $Tf^{A}Tf^{B}$, $Tf^{A}Tf^{C}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{M}$ and $Tf^{B}Tf^{D}$. Significant differences can be observed when there are compared the genotype $Tf^{C}Tf^{C}$ and genotypes $Tf^{A}Tf^{B}$ and $Tf^{C}Tf^{D}$, the genotype $Tf^{C}Tf^{M}$ and genotypes $Tf^{B}Tf^{B}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{C}$ and $Tf^{B}Tf^{M}$, the genotypes $Tf^{C}Tf^{D}$ and $Tf^{C}Tf^{M}$ or the genotypes $Tf^{D}Tf^{E}$ and $Tf^{A}Tf^{B}$. It should also be noted that most differences of wool production among the transferrin genotypes are enough relevant, but they do not reach the first critical threshold of significance. Thus, the wool production of adult rams seems to be the most variable production trait of this breed with reference to the transferrin genotypes (tab. 15).

Table 14. Testing the differences of body weight at mating in adult rams of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	$Tf^{B}Tf^{B}$	$Tf^{C}Tf^{C}$	$Tf^{M}Tf^{M}$	$Tf^{A}Tf^{B}$	$Tf^{A}Tf^{C}$	$Tf^{A}Tf^{M}$	$Tf^{B}Tf^{C}$	$Tf^{B}Tf^{M}$	$Tf^{B}Tf^{D}$	$Tf^{B}Tf^{E}$	$Tf^{C}Tf^{M}$	$Tf^{C}Tf^{D}$	$Tf^{D}Tf^{E}$
$Tf^{B}Tf^{B}$		46	17	28	27	21	74	32	32	18	18	19	19
$Tf^{C}Tf^{C}$	1.55^{+}		29	40	39	33	86	44	44	30	30	31	31
$Tf^{M}Tf^{M}$	6.58***	8.34***		11	10	4	57	15	15	1	1	2	2
$Tf^{A}Tf^{B}$	0.39	1.64^{+}	4.03**		21	15	68	26	26	12	12	13	13
$Tf^{A}Tf^{C}$	3.24**	1.70^{+}	9.99***	3.03**		14	67	25	25	11	11	12	12
$Tf^{A}Tf^{M}$	0.70	0.30	4.03*	0.91	1.44^{+}		61	19	19	5	5	6	6
$Tf^{B}Tf^{C}$	0.06	1.87^{+}	9.98***	0.39	3.79***	0.77		72	72	58	58	59	59
$Tf^{B}Tf^{M}$	0.84	0.50	5.95***	1.06	1.99^{+}	0.07	0.98		30	16	16	17	17
$Tf^{B}Tf^{D}$	1.07	0.53	8.26***	1.25^{+}	2.27*	0.03	1.33^{+}	0.07		16	16	17	17
$Tf^{B}Tf^{E}$	0.09	0.41	0.86	0.01	0.79	0.30	0.08	0.28	0.30		2	3	3
$Tf^{C}Tf^{M}$	1.10^{+}	0.06	4.67^{+}	1.28^{+}	1.14^{+}	0.29	1.21^{+}	0.42	0.41	0.42		3	3
$Tf^{C}Tf^{D}$	0.13	0.49	0.95	0.01	0.92	0.36	0.11	0.35	0.37	0.02	0.45		4
$Tf^{D}Tf^{E}$	2.14*	0.83	7.17*	2.17*	0.64	0.87	2.41*	1.19^{+}	1.29^{+}	0.61	0.57	0.72	
	Values of the Student test (t)												LD=175
	Difference between homozygotes and heterozygotes											t=0.46	

Table 15. Testing the differences of wool production at mating in adult rams of the Botosani Karakul breed

Genotip Tf	Liberty degrees (LD)												
	$Tf^{B}Tf^{B}$	$Tf^{C}Tf^{C}$	$Tf^{M}Tf^{M}$	$Tf^{A}Tf^{B}$	$Tf^{A}Tf^{C}$	$Tf^{A}Tf^{M}$	$Tf^{B}Tf^{C}$	$Tf^{B}Tf^{M}$	$Tf^{B}Tf^{D}$	$Tf^{B}Tf^{E}$	$Tf^{C}Tf^{M}$	$Tf^{C}Tf^{D}$	$Tf^{D}Tf^{E}$
$Tf^{B}Tf^{B}$		46	17	28	27	21	74	32	32	18	18	19	19
$Tf^{C}Tf^{C}$	0.93		29	40	39	33	86	44	44	30	30	31	31
$Tf^{M}Tf^{M}$	13.50***	14.75***		11	10	4	57	15	15	1	1	2	2
$Tf^{A}Tf^{B}$	1.40^{+}	2.24*	11.51***		21	15	68	26	26	12	12	13	13
$Tf^{A}Tf^{C}$	0.92	0.36	6.16***	1.84^{+}		14	67	25	25	11	11	12	12
$Tf^{A}Tf^{M}$	0.48	0.19	8.19***	1.57^{+}	0.45		61	19	19	5	5	6	6
$Tf^{B}Tf^{C}$	0.03	1.15^{+}	20.31***	1.53^{+}	1.00	0.55		72	72	58	58	59	59
$Tf^{B}Tf^{M}$	0.48	1.23^{+}	10.39***	0.80	1.18^{+}	0.82	0.49		30	16	16	17	17
$Tf^{B}Tf^{D}$	0.39	0.44	11.48***	1.67^{+}	0.63	0.11	0.48	0.79		16	16	17	17
$Tf^{B}Tf^{E}$	0.53	1.47^{+}	14.25*	0.93	1.27^{+}	0.89	0.59	0.02	0.89		2	3	3
$Tf^{C}Tf^{M}$	2.32*	1.90^{+}	3.36^{+}	3.05*	1.30	1.79^{+}	2.46*	2.47*	2.05^{+}	2.62^{+}		3	3
$Tf^{C}Tf^{D}$	1.67^{+}	2.47*	12.16**	0.20	2.04^{+}	1.76^{+}	1.78^{+}	1.02	1.76^{+}	1.18^{+}	3.24*		4
$Tf^{D}Tf^{E}$	1.85^{+}	1.54^{+}	1.89	2.41*	1.21^{+}	1.53^{+}	1.91^{+}	2.00^{+}	1.67^{+}	2.06^{+}	0.24	2.53^{+}	
	Values of the Student test (t)												LD=175
	Difference between homozygotes and heterozygotes											t=1.05	

In terms of the zygosity status of transferrins, the heterozygotes are more weighting than the homozygotes, and the homozygotes produce a greater quantity of wool than the heterozygotes, but the productive superiority of a subpopulation compared to the other one is unsignificant (tab. 14, 15).

So, the most productive transferrin genotypes in adult males are the genotypes $Tf^{M}Tf^{M}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{E}$ and $Tf^{C}Tf^{D}$ for meat production and the genotypes $Tf^{M}Tf^{M}$, $Tf^{D}Tf^{E}$, $Tf^{C}Tf^{M}$ and $Tf^{A}Tf^{C}$ for wool production.

The correlations which can be established between transferrin genotypes and the production traits in the Botosani Karakul sheep, (as well as with the reproduction and health ones), would be due probably just to the biochemical and physiological peculiarities of transferrin to capture the ionic iron and carrying it to the haematopoietic organs. The intensity of haematogen phenomenon with profound implications on the overall metabolism (including the production metabolism too) is determined by the saturation degree of transferrin with *Fe* ions and its capacity to carrying them and to provide the haematopoietic organs with these ions. It is possible that the intensity and sense of the correlations between transferrin genotypes and economic characteristics of sheep be determined by differentiated synthesis rate of serum transferrin for each of transferrin genotypes. As such, it can be said that each transferrin genotype has a specific production metabolism. Thus, the serum transferrin, by the most productive genotypes, can be used as genetic marker for improving the productivity of this sheep breed.

4. Conclusions

In the Botosani Karakul breed, some interelations between sheep productivity and their transferrin genotypes were performed, whose intensity and significance are depending on age and sex of animals.

The most performing transferrin genotypes are the genotype $Tf^{A}Tf^{B}$ for surface lamb pelts and genotypes $Tf^{A}Tf^{M}$, $Tf^{B}Tf^{C}$, $Tf^{B}Tf^{E}$, $Tf^{C}Tf^{D}$ for meat production in lambs, the genotypes $Tf^{A}Tf^{M}$, $Tf^{D}Tf^{E}$ and $Tf^{C}Tf^{D}$ for meat production, the genotypes $Tf^{B}Tf^{M}$, $Tf^{C}Tf^{M}$ and $Tf^{B}Tf^{D}$ for wool production and genotypes $Tf^{C}Tf^{D}$, $Tf^{D}Tf^{E}$ and $Tf^{C}Tf^{C}$ for milk production in adult ewes, the genotypes $Tf^{M}Tf^{M}$, $Tf^{A}Tf^{B}$, $Tf^{B}Tf^{E}$ and $Tf^{C}Tf^{D}$ for meat production and the genotypes $Tf^{M}Tf^{M}$, $Tf^{D}Tf^{E}$, $Tf^{C}Tf^{M}$ and $Tf^{A}Tf^{C}$ for wool production in adult rams.

On the whole, the heterozygotes Tf are more productive than the homozygotes concerning the growth rate in lambs, wool quantity in adult ewes and body weight in adult rams, and higher productivity of the homozygotes Tf in comparison with the heterozygotes Tf is manifested in terms of the body weight and of milk quantity in adult females and of wool quantity in adult males.

The production differences among the transferrin genotypes are more relevant in adult animals than in lambs and more obvious in adult rams than in adult ewes.

Most production differences among all transferrin genotypes do not present statistical assurance, the values of some of them are placed near the first critical threshold of significance and several differences are significant.

The most performing transferrin genotypes can be used for increasing the productivity of the Botosani Karakul sheep.

References

1. Lara, M. A. C., Cuhna, E. A., Varissimo, C. J., Santos, L. E., Bueno, M. S., Genetic characterization of sheep breeds based on protein polymorphisms, Arch. Latinoam. Prod. Anim., 2004, 12(1), 35-41

2. Vicovan, G., Cercetări privind stabilirea corelaţiei dintre tipurile de transferine şi intensitatea de creştere la mieii Spancă, Lucr. şt. ale SCCCO Palas-Constanţa, 1977, III, 45-49

3. Bleta, V. H., Tartari, T., Şteto, T., Disa te dhena per şperndarjen e tipit te transferinave (Tf) ne delet e races "Şkodrane". Bul. i Shken. Zootek. e Vet., 1985, 3(3), 11-14

4. Iovenko, V. N., Polymorphic proteins and performance of Tsigai sheep, Nauci. Tekhn. Biull., Ukr. Nauci. Issledov. Inst. Jivotnovod, 1985, 2, 71-72

5. Yaman, K., Gokcen, H., Camas, H., Baspinar, H., Erdinc, H., Merinos erhek kuzularda baz i kan parametreleri (transferrin, hemoglobin, glutatyon, testosteron) ile besi performans i aras i ndaki ilisk i uzerinde arastirmalar, Vet. Fak. Derg., Uludag Univ., 1986, 5-7(1-3), 29-34