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BLOOD GENETIC POLYMORPHISM OF THOROUGHBREDS BRED IN POLAND AND IN FRANCE[1]

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Summary. Genetic polymorphism of six blood protein loci in 5692 Polish and French thoroughbreds was studied by the method of starch gel electrophoresis. In serum: albumin, transferrin, esterase; in hemolysate: 6-phosphogluconate dehydrogenase, phosphoglucomutase, and phosphohexose isomerase. The horses studied were arranged in formal male lines to compare the lines of horses bred under somewhat different conditions in Poland and in France. Studies of blood genetic polymorphism reveal differences between Polish and French thoroughbreds. Differences in the frequency of alleles and phenotypes discovered at the blood protein loci studied in different populations of horses of the same breed are probably a result of different breeding conditions in these two countries, and first of all different criteria of selection as well as different criteria of choice of stallions for reproduction.

Thoroughbreds (racing breed in existence for more than 200 years) came into being as a result of mating various horse breeds in England. The genealogical tree takes its beginning from the three basic progenitors, Byerley Turk (born inabout 1679), Darley Arabian (born in1702), and Goldophin Arabian (born in 1724), as well as from about a hundred mares probably heavy breeds cross-bred with local ponies (Prawocheński 1948).

A good acquaintance with the genealogy is indispensable for breeding full blood thoroughbreds. Breeding practice dealing with racing trials revealed that

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the ability to transfer required features is more pronounced in some sires which produce outstanding offspring (sons, greatsons, etc.), and hence the concept of sire lines (Prawocheński 1948).

All the advantages of thoroughbreds werearesult of strict selection aimed at preparing horses for racing conditions. It can be said that for many years this breed has been selected for a complex of features determining racing sucesses, and that, in the first place, the ability to run at high speed. The quality of horses of this breed as observed in many countries is relatively uniform and in respect of speed approaches the upper limit. This is a result of breeding which, irrespective of geographic and economic conditions, is based on a similar approach to organizing horse racing. It is also determined, to a certain extent, by environmental conditions and the genetic basis (Sasimowski 1973).

However, it should be taken into account that each country has its own aims to achieve by organizing horse races and by planning a specified number of horses to be bred. This determines the selection of a certain type of horse to be evolved as suitable for the given breeding and economic conditions. In this respect it seems still possible to determine the distinctness of almost each thoroughbred population in spite of a considerable homogenity of this breed additionally enhanced by intensive exchange of sires successful in reproductive activities and by frequent sending of mares to be covered in other countries.

One of the ways permitting the establishment of this distinctness may be the genealogical structure and the comparison of the genetic polymorphism of blood proteins between thoroughbreds in Polish and French studs.

The aim of the present paper was to compare the genealogical structure of the formal sire lines in the two populations studied as well as to compare genetic polymorphism of blood proteins between horses of those populations.

MATERIAL AND METHODS

5692 thoroughbreds were covered by the present study:

	French	Polish
total population	4500	1192
sires	740	69
dams	2024	361
progeny (1974 - 1980)	1736	762

Genetic systems of six blood proteins in serum (albumin, transferrin, esterase), and in hemolysate (phosphogluconate dehydrogenase, phosphoglucomutase, and phosphohexose isomerase) were determined by the method of starch electrophoresis.

Chi^2 and *t*-Student's or its modification were used for the statistical analysis of the obtained results.

RESULTS AND DISCUSSION

An analysis of formal sire lines which directly determine the descent on father origin made possible a comparison between thoroughbred populations in Poland and in France. All the horses studied for blood genetic polymorphism were put in the male lines (Table 1). Table 1 presents the blood lines of the sires Byrley Turk and Godolphin Arabian together with the number of studied horses of these lines bred in Poland and in France. The line of Darley Arabian, the third progenitor of the blood line, was studied similarly in respect of the occurrence of the horses studied. This enabled us to detect similarities, as well as certain differences, between the methods and results of the breeding practice in Poland and in France.

The similarities observed in the two horse populations are related to the basic breeding practice, and namely;

Tabela 1. An example of how Polish and French thoroughbreds were arranged in the male line

Progenitor of a male line	Number of horses studied	
	France	Poland
Byerley Turk 1689		
BUZZARD 1787		
CASTREL 1801		
Pantaloon 1824		
Windhound 1847		
Thormancy 1857 (or ofter Melbourne)		
Atlantic 1872		
Le Sancy 1884		
Le Samaritain 1895		
Roi Herode 1904		
THE TETRACH 1911	113	–
Selim 1802		
Sultan 1816		
Bay Middleton 1833		
The Flying Dutchmann 1846		
Dollar 1860		
Androcles 1870		
Gardefeu 1895		
Chouberski 1902		
Bruleur 1910	4	–
Ksar 1918		
TOURBILION 1928	454	47
6 17 Total	571	47
Godolphin Arabian 1724		
West Australian 1850		
Australian 1858		
Spendthrift 1876		
Hastings 1893		
Fair Play 1905		
MAN O'WAR 1917	197	98
Solon 1861		
Baroaldine 1878		
Marco 1892		
Marcovil 1903		
HURRY ON 1913	63	7
9 14 Total	260	105

— maintenance of a high variety of formal male lines to provide the necessary genetic potential,

— selection of individuals for reproduction carried out mainly within the lines tested under racing conditions.

The differences recorded permit to infer that:

— there are more male lines in France with considerable racing successes (the number of thoroughbred in France is seven-fold larger than that in Poland),

— there are significant differences in the order of male lines determined on the basis of the total number of wins recorded by thoroughbreds in these two countries, but the totals are in proportion to the number of descendants of the given line in the two countries (Table 2).

As it follows from Table 2, the line of Rabelais is the best represented male line in Poland. This line has collected the highest number of wins. It consists mainly of descendants of the stallion Turysta, and from 1974, of the descendants of the stallion Juggernault, a grandson of the famous stallion Ribot. On the other hand, about fifteen per cent of the French population are the descendants of the stallions Persimmon, Pricequillo, Prince Bio (sire of the stallion Sicambre), and of the stallion Prince Chevalier.

The parallel studies for blood genetic polymorphism in separate male lines revealed that the formal male lines differ significantly in the frequency of certain phenotypes in the following systems: albumins, transferrins, esterases, and 6-phosphogluconate dehydrogenase (*6-PGD*) (Table 3).

It was assumed that:

— each male line has a different blood genetic polymorphism,

— the selection of horses for breeding purposes in Poland and in France is

Table 2. Most numerous formal male lines in Poland (minimum 3%) compared with male lines in France

Male lines	Poland		France	
	percentage participation of the:		percentage participation of the:	
	horses studied	total wins by all the horses	horses studied	total wins by all the horses
1. Rabelais	13.17	11.98	8.37	10.14
2. Pharos	9.65	11.18	10.79	13.26
3. Galopin-Galliard	9.56	5.89	0.94	—
4. Asterus	9.31	10.28	3.04	1.50
5. Man O'War	8.22	4.56	4.43	1.74
6. Solario-Hyperion	7.72	6.93	7.67	7.54
7. Persimhon	6.88	3.31	14.84	15.65
8. Aethelstan	6.63	2.98	3.13	6.81
9. Fairway	4.87	8.17	4.43	3.83
10. Tourbillon	3.94	8.15	10.21	10.87
11. Blandford	3.61	0.62	11.20	11.83
12. Bend or:				
Kendal + Orby	3.19	5.51	—	—
Ormonde	—	—	1.33	0.52
Total	86.75	79.56	80.38	83.69

Table 3. Significant differences in the expected and observed distribution of blood protein phenotypes in the representatives of six male lines in France

Male lines		*n*	Albumin	Transferrin	Esterase	*6-PGD*
Blanford	1*	498	0.001	0.001	0.05	0.001
	2**		0.02	0.05	0.01	0.001
Tourbillion	1	454	0.01	0.001	0.05	–
	2		0.001	0.001	–	0.02
Pharos	1	480	0.05	0.05	–	–
	2		–	0.01	–	–
Rabelais	1	372	0.001	0.001	0.001	0.05
	2		0.001	0.001	0.001	–
Persimmon	1	660	0.001	0.01	0.001	–
	2		0.001	0.001	0.001	–
Hyperion	1	341	–	0.001	0.001	0.01
	2		–	0.001	0.001	0.05

* 1-Chi^2 on the basis of the frequency of blood phenotype occurrence in the total population

** 2-Chi^2 on the basis of the frequency of blood phenotype occurrence in the population of stallions

frequently concentrated on lines with better racing results which automatically increases the number of descendants of a given line. These factors can affect the specific blood genetic polymorphism in these two thoroughbred populations.

A comparison of the genetic polymorphism of the blood protein systems studied in two populations, as well as in the subgroups (Table 4), confirmed the assumptions presented above as these thoroughbred populations differ significantly in the frequency of certain protein phenotypes.

Differences in the phenotype frequency in six genetic systems are presented in Table 5. It follows from this Table that the population of Polish thoroughbreds displays the following characteristics:

— a higher frequency of heterozygotic *FS* phenotypes in the genetic systems of albumin and 6-phosphogluconate dehydrogenase,

— a higher frequency of I phenotype of esterase.

Considerable differences have been recorded in the transferrin system in the Polish population. It should be pointed out that phenotypes with variant *Tf H* have occurred very frequently, while phenotypes *Tf O* and *Tf R* have been much rarer. It also follows from Table 5 that the presently studied population of Polish thoroughbreds has no homozygotic phenotype *Tf R*.

Table 4. Comparison of two thoroughbred populations

Groups of horses*	Albumin			Transferrin			*6-PGD*		
	t	st sw	*p*	*t*	st sw	*p*	*t*	st sw	*p*
a	2.25	10	0.05	3.42	58	0.001	3.06	10	0.02
d	2.73	10	0.02	3.69	58	0.001	3.95	10	0.01
c	2.02	10	–	3.28	58	0.001	2.78	10	0.02
b	1.75	10	–	2.87	54	0.01	2.08	10	–

* a – total population, b – stallions, c – mares, d – progeny (born between 1974 and 1980)

Table 5. Comparison of the frequency of blood protein phenotype occurrence in thoroughbreds in Poland and in France

Genetic systems	Phenotypes	Population	
		French	Polish
Albumin	F	0.046	0.049
	FS	0.337	0.412
	S	0.617	0.539
	B	0.099	0.099
	DF	0.303	0.344
	DH	0.026	0.064
	DO	0.069	0.039
	DR	0.046	0.018
Transferrin	F	0.219	0.217
	FH	0.040	0.094
	FO	0.091	0.059
	FR	0.067	0.034
	H	0.002	0.005
	HO	0.009	0.010
	HR	0.004	0.008
	O	0.009	0.004
	OR	0.012	0.005
	R	0.004	—
	F	0.004	—
	FI	0.110	0.076
Esterase	FS	0.004	0.002
	I	0.818	0.902
	IS	0.064	0.021
	F	0.322	0.304
6-PGD	FS	0.492	0.526
	S	0.186	0.170
	FS	0.008	0.003
PGM	S	0.992	0.997
	FI	0.0007	
PHI	I	0.009	1.0
	IS	0.0003	
Number of individuals		4500	1192

Table 6. Frequency of alleles at six loci of blood proteins in thoroughbreds in Poland and in France

Genetic system	Alleles	Population		Stallions		Mares		Progeny	
		French	Polish	France	Poland	France	Poland	France	Poland
	n	4500	1192	740	69	2024	361	1736	762
Albumin F	*Al F*	0.214	0.255	0.197	0.290	0.213	0.241	0.222	0.258
	Al S	0.786	0.745	0.803	0.710	0.787	0.759	0.778	0.742
	Tf D	0.321	0.331	0.331	0.326	0.307	0.316	0.332	0.339
	Tf F	0.460	0.483	0.472	0.551	0.468	0.472	0.469	0.482
Transferrin	*Tf H*	0.041	0.093	0.040	0.051	0.043	0.108	0.038	0.090
	Tf O	0.100	0.060	0.080	0.058	0.109	0.064	0.098	0.059
	TF R	0.069	0.033	0.077	0.014	0.072	0.040	0.063	0.031
Esterase	*Es F*	0.061	0.039	0.066	0.036	0.057	0.038	0.063	0.039
	Es I	0.905	0.950	0.897	0.942	0.912	0.956	0.900	0.948
	Es S	0.034	0.011	0.036	0.022	0.031	0.006	0.037	0.013
	PGD F	0.568	0.567	0.591	0.536	0.555	0.560	0.573	0.573
6-PGD	*PGD-S*	0.432	0.433	0.409	0.464	0.445	0.440	0.427	0.427
PGM	*PGM F*	0.004	0.002	0.002		0.006	0.001	0.002	0.002
	PGM S	0.996	0.998	0.998	1.0	0.994	0.999	0.998	0.998
	PHI F	0.0002		0.001					
PHI	*PHI I*	0.999	1.0	0.999	1.0	0.999	1.0	1.0	1.0
	PHI S	0.0001				0.0002			

It should be added that the frequency of the occurrence of allele *Tf H* (0.093) determined for the Polish population (0.041 for the French population — Table 6) has turned out to be the highest as compared with data for fifteen populations of this breed in different countries. An exceptionally high frequency of the occurrence of the allele of transferrin *Tf H* seems to indicate that this allele is a favourable acquirement in the present breeding conditions prevailing in Poland and for the present requirements of the Polish horse racing policy.

The results of the present studies concerning various aspects of breeding activities and the blood genetic polymorphism enable us to conclude that the differences recorded in the frequency of the occurrence of certain phenotypes of albumin, transferrin, esterase and *6-PGD* in the two thoroughbred populations are the result of different selection criteria applied in respect of thoroughbreds in Poland and in France.

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POLIMORFIZM GENETYCZNY BIAŁEK KRWI KONI PEŁNEJ KRWI ANGIELSKIEJ HODOWANYCH W POLSCE I WE FRANCJI

Streszczenie

U 5692 koni pełnej krwi angielskiej hodowli polskiej i francuskiej określono metodą elektroforezy w żelu skrobiowym polimorfizm genetyczny 6 układów białek krwi. W surowicy: albuminę, transferynę, esterazę, natomiast w krwinkach: dehydrogenazę fosfoglukonową, fosfoglukomutazę i izomerazę fosfoheksozonową. W celu porównania tych linii u koni hodowanych w odmiennych nieco warunkach w Polsce i we Francji, uszeregowano badane konie w formalne linie męskie. Na podstawie badań polimorfizmu genetycznego układów białek krwi można było stwierdzić odrębność genealogii koni pełnej krwi angielskiej z hodowli polskiej i francuskiej. Zaobserwowane różnice w częstościach allelicznych i fenotypowych badanych układów białek krwi w populacjach konii należących do tej samej rasy wynikają przypuszczalnie z odmiennego celu hodowlanego w obu krajach, a mianowicie różnych kryteriów selekcji koni i doboru osobników do rozpłodu.

ГЕНЕТИЧЕСКИЙ ПОЛИМОРФИЗМ БЕЛКОВ КРОВИ ЧИСТОКРОВНЫХ АНГЛИЙСКИХ КОНЕЙ, ВЫРАЩЕННЫХ В ПОЛЬШЕ И ВО ФРАНЦИИ

Резюме

У 5692 чистокровных английских коней, выращенных в Польше и во Франции, был определен генетический полиморфизм 6 систем белков крови с помощью метода электрофореза в крахмальном геле. В сыворотке: альбумин, трансферин, эстераза, а в кровяных тельцах: фосфоргюконовая

дегидрогеназа, фосфорглюкомутаза и фосфогексозоновая изомераза. Для того, чтобы сравнить эти линии у коней, выращенных в несколько различных условиях в Польше и во Франции, исследуемые кони были помещены в формальные мужские линии. На основании исследований генетического полиморфизма систем белков крови можна считать, что генеалогия чистокровных английских коней, выращенных в Польше и во Франции, отличается своеобразием. Отмеенные различия в частоте аллелей и фенотипов исследуемых систем белков крови в популяциях коней той же самой породы, возникают, как предполагается, из разных целей разведения коней в обеих странах, т.е. из разных критериев селекции и выбора коней для расплода.