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Variation of gene frequencies in ASIP, MC1R and GREY loci in Thoroughbred horses

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Abstract

The objective of the study has been to verify the hypothesis that the coat colour is regarded in the selection of Polish Thoroughbred horse population. Formally, the colour is not a selection criterion in this breed selected mainly for speed. The material consisted of twelve groups of foals registered in successive volumes of the Stud Book (11,688 foals, in total) and their parents selected to the breeding stud. The frequency of alleles in ASIP, MC1R and GREY loci controlling the coat colours was estimated from the recessive phenotype frequency square in the groups of foals. The inflow of foreign genes was limited and the population great, hence the migration effect was very low. The drift and Wahlund effect hardly influenced the genetic structure in the groups which enabled to analyze the population not divided. The total offspring frequency of recessive *a*, *e* and *g* alleles amounted to 0.1552, 0.4877 and 0.9773, respectively. Accuracy of the assessment of the *a* and *e* frequency was confirmed on the basis of test matings. The *a*, *e* and *g* alleles were more frequent in dams than in sires and the *a* alleles occurred more often in fillies than in colts. The frequency of *a* and *e* alleles was higher in the offspring than in the parents. The genotype distribution in the offspring differed from the expected one, assessed from the gamete frequency in sires and in dams. Fewer bay foals were born than anticipated. All the results show that the coat colour is not entirely disregarded in the breeding of Thoroughbred horses. The dominant *A* and *E* alleles producing the colour are preferred in the selection, particularly in the sires. This leads to some alterations in the phenotypic structure of the population. On the other hand, the horses are mated randomly, irrespective of the coat colour.

Keywords: Horse; Thoroughbred; Genetic structure; Coat colour; Selection

1. Introduction

The issue on how a selection affects a population has been analyzed by many authors (e.g. Balloux et al., 2004; Głażewska and Gralak, 2006). In view of breeding, it is also interesting to find out whether a population is selected for a given trait (according or against a breeding program) and what is the effect of such selection, i.e. if there are any changes in the genetic structure of the population. Formally, the coat colour is not regarded in the breeding of Thoroughbreds that have been selected almost exclusively for speed since centuries. However, breeders often have preferences for particular colours believing that this trait may be related to better or worse performance (Henner et al., 2002a). Recent investigations (Stachurska and Pięta, 2006;

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Stachurska et al., 2007) conducted according to the genotype in *E* and *G* loci controlling the colour and with regard to the age of the horse, are consistent with the results of earlier studies which showed that the racing scores from variously coloured Thoroughbreds were similar (Dušek, 1980; Galizzi Vecchiotti, 1986). These findings indicate that the *E* and *G* loci are neither linked with possible QTLs and other genes responsible for racing performance, nor are pleiotropic in this regard (Stachurska et al., 2007).

Among Polish warmblooded horses, solely in Silesian breeding, chestnuts are officially eliminated. However, they are so few that the selection does not alter considerably the allele frequency in the population (Stachurska et al., 2005). The colour criterion is not included in the breeding programs of all other halfbred horses (Wielkopolski, Małopolski, Polish Warmblood) and Purebred Arabians (Brodacki and Stachurska, 2000; Stachurska and Brodacki, 2000a,b; Stachurska and Bruśniak, 2003).

Thoroughbreds in the Polish Stud Book (PSB) are recorded as light bay, bay, dark bay, seal brown (numbered among bay shades), light chestnut, chestnut, dark chestnut, flaxen dark chestnut, black or grey. The bay, chestnut and black colours are controlled by ASIP (*A*) and MC1R (*E*) loci which have been assigned to ECA22 and ECA3, respectively (Marklund et al., 1996, Rieder et al., 2001). The genotype of bay horses is *A_E_*, that of blacks is *aaE_* and that of chestnuts *_ _ee* (Adalsteinsson, 1974). The bays and blacks are called eumelanic horses for the *E* allele producing eumelanin in the coat (though in bays, phaeomelanin is also produced). The chestnuts are phaeomelanic since they have only phaeomelanin in hairs. The hypotheses on bay and chestnut shades, as well as on genetic variants of the black colours are not all consistent or fully documented (Henner et al., 2002a; Stachurska et al., 2002). The GREY locus (*G*) has been assigned to ECA25 (Henner et al., 2002b; Locke et al., 2002; Swinburne et al., 2002). The completely dominant *G* allele produces grey phenotype (Salisbury, 1941), whereas *gg* horses are nongrey.

The aim of the study has been to verify the hypothesis that coat colour is regarded in the selection of Polish Thoroughbred horse population.

2. Materials and methods

The material consisted of 11,688 Thoroughbred foals and their parents. The foals were born in a fifty-year period (1953–2002) and registered in all eleven Polish Stud Book (PSB) volumes (and a supplement) published after the Second World War when the breeding was reconstructed. An inflow of foreign genes to the population was very small. In Thoroughbreds, all newborn foals are registered in the Stud Book and the selection performed according to assumed criteria concerns only the parents. The foals belong to consecutive generations. The offspring coat colour distribution was determined in the foals registered in the successive volumes considering bay, chestnut, black and grey colours.

The frequency of *a*, *e* and *g* alleles was estimated from the frequency square of recessive phenotypes: blacks with *aaee* chestnuts, chestnuts and nongreys, respectively (Jorde and Ryman, 1990). To calculate the *aaee* chestnut number it was assumed that the ratio of blacks to bays and blacks in total agrees with the proportion of *aaee* chestnuts to all chestnuts (Stachurska and Brodacki, 2000a). In this way, the allele frequencies were determined in groups of foals registered in the consecutive PSB volumes. The standard error (SE) of the allele frequencies and Wahlund effect were calculated (Elseth and Baumgardner, 1981; Gillespie, 2004; Jorde and Ryman, 1990). The allele frequencies and SE were also defined totally in the offspring and its parents, regardless of the division into PSB volumes. In order to confirm the accuracy of the calculations, the allele frequency in *E* and *G* loci in the total parental generation was estimated on the basis of test matings (eumelanic horses × phaeomelanic horses, grey horses × nongrey horses). The total actual offspring genotype distribution was compared with the genotype distribution anticipated from the gamete frequency in sires and in dams. To analyze whether matings were random with respect to the coat colour, the total distributions of differently coloured dams mated to differently coloured sires were compared. In this case, black sires were not included in the significance test since they were few. The statistical analysis was performed with the GENETICS procedure in SAS software for the allele and genotype frequency, as well as for χ^2 test.

3. Results

There were 71.0% bay, 22.7% chestnut, 4.5% grey and 1.8% black foals in the whole Thoroughbred offspring. The frequency alterations in foals registered in the successive volumes of the Stud Book concerned mainly bays and chestnuts: an increase of bay foal number went hand in hand with a decrease of chestnut foal number and vice versa (Fig. 1). The changes have not been significant since 1983 (14th volume).

The frequency of recessive alleles estimated from the recessive phenotype frequency square in groups of foals