Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2003
Volume 6
Issue 1
Series ANIMAL HUSBANDRY

 ISSN 1505-0297
STACHURSKA A., BRODACKI A. 2003. SELECTION OF POLISH KONIK HORSES FOR COAT COLOUR AND THE WAYS TO IMPROVE ITS EFFECTIVENESS **Electronic Journal of Polish Agricultural Universities**, Animal Husbandry, Volume 6, Issue 1.
Available Online http://www.ejpau.media.pl

SELECTION OF POLISH KONIK HORSES FOR COAT COLOUR AND THE WAYS TO IMPROVE ITS EFFECTIVENESS

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ABSTRACT

Blue dun colour with no white markings represents a trait of the Polish Konik horse breed. However, in spite of long-term selection, non-blue-dun individuals, and those with the markings have still been appearing. The aim of this study was to analyse the genetic structure of the Polish Konik population with respect to coat colour and, on this basis, to propose improved methods of selection. The material comprised Polish Konik horses registered in all eight volumes of the studbook published so far.

Among the horses currently used in the Polish Konik breeding, 10.7% were found to be *Ee* heterozygotes and 4.9% *Dd* heterozygotes, which can produce progeny of recessive colours, red dun and black. The dominant *A* allele does not occur in the population any more. The frequency of the undesired recessive *e* and *d* alleles, estimated on the basis of recessive phenotype frequency, is 0.1536 and 0.1024, respectively. In order to improve the efficiency of the selection, it is proposed to not only eliminate non-blue-dun individuals from the breeding, but also heterozygous *Ee* and *Dd* horses. Further consistent selection should lead to reduction of the white marking occurrence, the heritability of which is high.

Key words: Polish Konik horses, blue dun colour, white markings, selection.

INTRODUCTION

The Polish Konik horses are descendants of the Tarpans that lived in Eastern Europe until the beginning of the 19th century [9]. As it is known, the Tarpans were blue dun and, as wild horses, did not have any white markings. The blue dun colour was probably a protective trait [6]. It was not until breeding of cultural breeds had started, when markings became common [8, 18]. The Polish Konik horses survived the invasion of such breeds, mainly in the refuge of country farms, also due to their characteristic coat colour. To some extent, however, they had been crossbred with other local horses and, consequently, different colours appeared. Before the World War II, Professor T. Vetulani, willing to preserve these precious horses, began their breeding. From the very beginning, the selection aimed at the best possible resembling the Polish Konik to its wild ascendant [15]. Thus, both non-blue-dun animals and those showing markings were eliminated. After World War II, basing on scarce genetic material that had survived, the reconstruction of the Konik horse breeding was begun, with continuation of similar rules of selection. The studbook has been published since 1962. At present, according to the breed-preserving genetic programme for the Polish Konik [5], the criteria allow to breed only blue dun horses with a stripe, without white markings; however, tiny facial markings have been temporarily allowed in local breeding. According to the studies by Stachurska [12], all Polish Koniks bred currently are blue dun; however, still black, red dun, or exceptionally chestnut animals can be found among their progeny. Horses without markings approximate 82% of the population recorded in the studbook.

Blue dun horses are characteristic of their grey-brownish coat colour on the trunk and darker lower parts of legs. Their generally dark hair of mane and tail is composed of dark strands, including black, as well as light strands, i.e. grey-white and cream. A dorsal stripe is present and, possibly, tiny stripes in other areas. Red dun horses are light red with whitish clearings. The hairs of mane and tail are of various colours from red to cream, the striping being red. In the dun colour, the coat is yellow-brown, lower parts of legs are dark, black hairs prevail in the mixed hair of mane and tail, black striping occurs. Bay, black, and chestnut represent the basic colours, found in the majority of horse breeds.

The aim of the study was to establish the genetic structure of the population of the Polish Konik horses recorded in the studbook in respect to their coat colour and, on such basis, to propose improved methods of their selection.

MATERIALS AND METHODS

The studies was conducted Polish Konik horses recorded in eight volumes of the studbook published so far (n =1148) and their progeny recorded in the most recent volume derived from pure breeding (n = 1145). In the determination of heterozygosity of the presently living stud animals, the entire stud records of the horses were taken into account, including those on interbreed crosses.

The blue dun colour is the diluted black colour of the genotype *aa E_ D_* [1, 2, 3, 4, 16]. The genotypes *aa E_ dd*, *_ _ ee D_*, *_ _ ee dd*, *A_ E_ D_,* and *A_ E_ dd* are responsible for emerging of, respectively, black, red dun, chestnut, and, once happening in the population of the Koniks, dun and bay colours. The Polish Konik horses that have been so far identified as chestnut are most probably almost all red dun, as the probability is low that two recessive alleles meet in the population [11, 12]. On the other hand, the foals referred to as dun are most probably yellow shaded blue dun of a blue dun horse genotype, as they could not inherit the dominant *A* allele from either of the blue dun parents [12].

In order to determine which of the horses currently used for breeding and registered in the studbook posses the recessive *e* and *d* genes, the pedigree of the horses was examined, as well as their stud records. It is known that a horse that descends from a recessive parent at one of the studied loci, or has produced at least one recessive foal at this locus, has the recessive allele in its genotype. Basing on that, the frequency of the observed heterozygotes was determined and the resultant frequency of the alleles in the herd was estimated. On the other hand, the allele frequency was estimated basing on the frequency of recessive phenotypes, which emerged in the herd progeny. Here, the colour of the progeny obtained from pure breeding before selection was taken into account.
Considering the marking inheritance, these matings were analysed which resulted in horses later registered in the 8^{th} volume of the studbook. Only those horses were included in the analysis whose both parents had been registered in the printed version of the studbook. Both the parents and their progeny were divided into four groups: without markings, with white hairs on forehead, with a snip or star, and with other markings.

For the comparison of the distributions, if the sample size allowed, the chi-squared test was applied.

RESULTS

Today's population of the Polish Konik horses registered in the studbook is entirely blue dun, whereas 75% of those registered in volume I were blue dun, and 18.5% were dun horses (Fig 1). However, in the progeny of the breeding herd, still non-blue-dun foals appear. Table 1 presents the sires used in Polish Konik breeding in 2002, which revealed heterozygosity at least at one of the loci that determine the blue dun colour. The frequency of the *Ee* heterozygotes observed among the Polish Koniks presently used in breeding is more than 10%, while that of the *Dd* heterozygotes is nearly 5% (Table 2). The differences in the frequencies between sires and dams are non-significant.

Fig. 1. Colour percentage of non-blue-dun Polish Konik horses registered in subsequent volumes of the studbook (the difference to 100% includes blue dun horses)

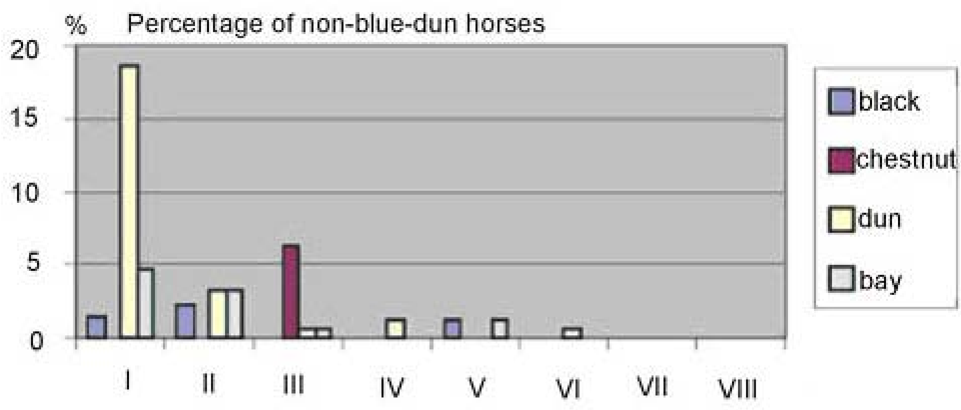

Table 1. Sires heterozygous at *E* or *D* locus used in Polish Konik breeding in 2002

Sire	Red dun foals	Black foals	Recessive parent
Double *Ee Dd* heterozygotes			
1. Gong	3	1	-
2. Mruk	3	1	-
3. Syriusz	2	1	-
Ee heterozygotes			
4. Druk	2	0	-
5. Hebel	2	0	-
6. Kirs	1	0	-
7. Kordiał	1	0	-
8. Malibu	0	0	+
9. Mohacz	2	0	-
10. Mustang	0	0	+
11. Nero	0	0	+
12. Nordo	1	0	-
13. Orlik	1	0	-
14. Topaz	7	0	-
Dd heterozygotes			
15. Kliper	0	1	-
16. Lansjer	0	2	-
17. Pałasz	0	1	-
18. Trawers	0	1	-
19. Tasznik	0	1	-

Table 2. Frequency of *Ee* and *Dd* heterozygotes in Polish Konik breeding in 2002

	N	*Ee*	*Dd*
Sires	135	0.1037	0.0593
Dams	379	0.1082	0.0449
Total	514	0.1070	0.0486

The phenomenon of non-blue-dun colours, which appear among the progeny of Polish Konik horses results from the fact that the recessive *e* or *d* alleles meet each other. The alleles occur in the heterozygous blue dun parents, which do not differ from homozygotes in the phenotype. The accepted system of identifying heterozygotes in the present-living population allowed detection of only a part of them, i.e. all descending from a recessive parent and those which produced a recessive foal with another heterozygote. In the case of older sires and dams, which had produced more progeny, the probability was higher that the carriers of one of the recessive genes had been mated with each other and that a non-blue-dun foal had been born. The probability that a parent is a dominant homozygote does not amount to approx. 97% unless 12 foals from test matings, e.g. *E_ x ee*, are obtained of which none is a recessive homozygote [14]. In the mating of a heterozygote with a recessive homozygote, the probability of the recessive genes meeting in the progeny is 0.5, whereas in the mating of heterozygotes with each other, the probability is twice lower. The inference about the parent's homozygosity should therefore be based on a very large number of progeny. Hence, it is obvious that the frequency of the *Ee* and *Dd* heterozygotes in the Polish Konik population is actually higher than that observed in the study. The frequency of recessive alleles estimated basing on the frequency of heterozygotes Table 3(A) should also be considered as lower than the actual one. After the long-term selection, the frequency does not seem sufficiently low.

Table 3. Frequency of alleles at *E* and *D* loci in the Polish Konik population in 2002
A – estimated basing on the frequency of observed heterozygotes
B – estimated basing on the frequency of recessive phenotypes

	A					B				
	N	E	e	D	d	N	E	e	D	d
Sires	135	0.9482	0.0518	0.9704	0.0296	561	0.8537	0.1463	0.9339	0.0661
Dams	379	0.9459	0.0541	0.9776	0.0224	584	0.8397	0.1603	0.8905	0.1095
Total	514	0.9465	0.0535	0.9757	0.0243	1145	0.8464	0.1536	0.8976	0.1024

Differences in the distribution of alleles at *D* locus between sires and dams obtained with B method and at *E* and *D* loci in sires and dams in total obtained with two (A and B) methods are significant at $p \leq 0.01$.

The frequency of recessive alleles estimated basing on the frequency of recessive phenotypes in the progeny considerably exceeded the frequency of alleles estimated basing on the frequencies of the observed heterozygotes - Table 3(B). According to the frequency of recessive phenotypes, the *d* allele occurred in more than 10% of the herd, whereas the *e* allele was carried by more than 15% of the population. The differences between the allele distributions obtained with the two methods are highly significant for both loci. On the other hand, the allele distributions in sires and dams are similar, except for those estimated basing on the recessive phenotype frequency at the *D* locus. In this case, the frequency of the recessive allele in sires was lower than in dams, which can be considered as a positive effect.

The relatively high frequency of the recessive alleles estimated with two methods, particularly on the basis of recessive phenotype frequency, means that the applied model of selection, which consists in excluding recessive homozygotes only, is not fully efficient. This method brought desired effects only initially, when there were many such horses in the population. As it is known, it is impossible to eliminate completely recessive genes from a population. A satisfactory situation would be, both from the breeding and economical point of view, if the frequency of undesired genes was close to 0.01. With the selection model applied at present, a reduction of a recessive gene frequency from 10 to 1% would require as many as 90 generations [7].

Since the aims of breeding include the unification of the breed in relation to coat colour, it seems that a more strict model of selection should be considered, which not only would consist in removing recessive homozygotes from the population, but at least some of the heterozygotes as well. Sires, which have a stronger influence on the breeding, should be particularly thoroughly selected in this respect. The sires of a heterozygous genotype which were found in the study, produced relatively few recessive foals, because mating with a dam that is heterozygous at the same locus is rare. Heterozygotes transfer, however, the recessive gene to the half of their progeny, and the gene is passed to the next generations. In the case when elimination of a given heterozygote is impossible due to some justified reasons, avoiding mating of heterozygotes with each other should be proposed as a provisional way out. Such action will not contribute to a reduction of recessive allele frequency, but it will not at least allow non-blue-dun foals to be born. The method applied in this study can be used for detection of heterozygotes among both stallions and mares, as running test matings would be a loss for the breeding of the Polish Konik horses.

Among the Polish Koniks used in breeding in 2002, also four blue dun mares and one blue dun stallion were found that, mated with another blue dun parent, were to produce five dun foals, in total. As it was explained earlier, the foals were probably yellow shaded blue dun [12]. According to present-day knowledge, the dun colour, as well as the bay, is determined by the dominant *A* allele, which is missing in blue dun horses. The *A* allele was the easiest to eliminate from the population, because as dominant, it was expressed in the phenotype of all the animals carrying it.

Table 4 presents the results of matings of the Polish Konik horses, registered in the most recent studbook volume, in relation to the presence of markings. The results should be considered as rough data only, since the population has been selected also for the lack of markings. Among the progeny obtained from the parents with more and more markings, a tendency can be seen decreasing number of animals without markings with parallel increasing number of progeny with larger markings. As many as 19% of the progeny inherited larger markings from its parent with this character.

Table 4. Percentage of white markings in the Polish Konik breeding herd in 2002 (%)

Parents		Offspring					
		N	no markings	white hairs	snip/star	other	total
No markings	no markings	209	88.5	4.3	5.7	1.4	100.0
No markings	white hairs	29	86.2	0.0	10.3	3.4	100.0
No markings	snip/star	42	69.0	0.0	23.8	7.1	100.0
No markings	other	21	71.4	0.0	9.5	19.0	100.0
White hairs	white hairs	6	83.3	0.0	16.7	0.0	100.0
White hairs	snip/star	5	60.0	20.0	20.0	0.0	100.0
Snip/star	snip/star	2	50.0	50.0	0.0	0.0	100.0
Total		314					

The observed tendencies to inherit the number of markings depending on their size in the parents, despite the selection of the studied material, seem to correspond to the polygenic model of inheritance proposed by Woolf [18]. According to the author, the white marking heritability amounts to 0.69 for the head, 0.68 for the legs, and 0.77 for the markings on the head and legs altogether. A certain threshold number of genes that allow the markings to appear must be exceeded in a given individual to trigger the process, together with an effect of environment during the prenatal life. In the breeding practice, this means the probability that a foal without markings would be born is always higher if its parents have no markings either. The heritability of markings is relatively high, so strict selection may bring distinct effects.

According to Woolf [17], the *AA ee* genotype is the one that results in appearing the highest number of markings, while the *aa EE* genotype involves their lowest number. The alleles in *A* and *E* loci behave like major genes in a quantitative trait [10]. Thus, blue dun horses have the genotype that is the least favourable for markings, which should facilitate achievement of the breeding goal. In Fjord horse breeding more than 80% of the population are dun. Despite the prevailing genotype associated with a higher number of markings and due to the consistent selection eliminating the markings, it was possible to introduce criteria that allow only a star of 5 cm diameter in Norwegian mares, and only white hairs on the forehead in Danish mares [13].

CONCLUSIONS

To achieve the desired goal of the Polish Konik breeding in respect to coat colour, a more strict model of selection should be applied, which would not only eliminate non-blue-dun horses, but the *Ee* and *Dd* heterozygotes, as well. If simultaneous exclusion of all heterozygotes from the breeding is impossible, they should be prevented from mating with one another. Heterozygosity of a given individual should be noted in the studbook. The criterion of no markings should be more rigidly obeyed, also in the horses of local breeding.

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