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MATING AND SELECTION IN NATIONAL ARABIAN HORSE BREEDING: INBREEDING COEFFICIENTS ANALYSIS

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ABSTRACT

The matings and selection of horses for the breeding stock in national Arabian horse studs from the 1947-1948 to 1996-1997 seasons were analysed. The data were examined taking into account the average values of the inbreeding coefficient (*F*). It was stated that breeders constantly avoided mating highly-related horses. Matings which concluded in abortion exhibited a higher level of inbreeding, while those which were either barren or ended in the death of the foal were characterised by lower average values of the inbreeding coefficient. In the selection of horses for the breeding stock, breeders preferred stallions with lower inbreeding coefficients. Moreover, among the stallions of the same father those with *F* values below the average were selected (statistically significant regularity). This tendency, however, was not observed in the selection of mares. These results indicate that matings of highly-related horses are not suitable from the point of view of the future selection of stallions for the breeding stock because the quality of horses born of these matings are not good enough to make them sires in the stud.

Key words: Arabian horse, inbreeding coefficient, mating, selection

INTRODUCTION

Post-war Polish Arabian horses are a small, almost closed population. The level of their genetic diversity was decisively affected by losses of breeding stock during War World II. In 1947 the initial breeding stock consisted of the small number of surviving horses and a group of Hungarian mares reclaimed from Germany. Importing horses from Tersk Stud (former USSR) began in the 1950s, and from 1975 horses were either imported or leased

from other countries as well. The horses from Tersk Stud are mostly descendants of the Polish horses plundered from Janów Podlaski Stud in 1939. Most of the horses imported from the other countries were also of Polish origin.

Due to the small number of breeding horses and the high level of relationship, the major problem for breeders for years has been the necessity of choosing parental pairs which would permit avoiding mating close relatives and prevent the level of inbreeding from increasing excessively to the point where inbreeding depression becomes visible. According to breeder declarations, the avoidance of mating close relatives is one of the criteria of choosing parental pairs. However, in the next stages of breeding work, mainly when new horses are included in the stock, the values of inbreeding coefficients of the horses are not taken into consideration in the breeders' decisions.

The subject of this work is to analyse breeders' decisions related to matings and selection with regard to the average values of the inbreeding coefficient.

MATERIALS AND METHODS

Stallions and brood mares from state-owned studs used in breeding during the 1947-1948 to 1996-1997 seasons and their offspring born from 1948 to 1997 were analysed. The data were divided into six separate periods, which were designated according to the dates when mares foaled.

To check the breeders' decisions concerning the choice of parental pairs the level of inbreeding of potential matings, i.e. matings possible in a given year and in a given stud, and that of realised matings, i.e. matings chosen by the breeders, were computed. Moreover, the values of the inbreeding coefficient were calculated for unsuccessful matings (barren mares, abortions and a group referred to in this work as "dead foals", i.e. still-born, dead or eliminated foals).

To check breeder preferences in selecting breeding horses, the values of inbreeding coefficients were calculated for offspring assembled according to the general criterion of using a horse in a national stud or not. On the basis of criterion thus defined, the offspring were sorted into one of the following groups:

- breeding mares - mares which produced at least one weaned foal and mares which were used in breeding for at least two seasons in spite of barrenness, abortion or the death of a foal before weaning;
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- non-breeding mares - mares which do not meet the preceding requirements;
- breeding stallions - stallions used in national studs;
- non-breeding stallions - stallions not used in national studs.

The results for the 1993-1997 period are not yet conclusive because the process of incorporating horses born in 1993-1997 into the breeding stock is incomplete. This period was analysed without data for horses born in the Kurozwęki Stud because it was closed down.

The pedigree data file was completed based on the Polish Arabian Stud Book (PASB), genealogical charts by Skorkowski [9] and Rozwadowski [8] and the publication by Kwiatkowski [5]. The inbreeding coefficients (F) were computed based on whole pedigrees, i.e. those which included all generations until the founders, using GENES version 11.8 software [6]. To complete the information included in the written sources the breeders Ignacy Jaworowski (Michałów Stud) and Marek Trela (Janów Podlaski Stud) were interviewed [4] and the information from this source are referred to in the article as breeder statements.

RESULTS AND DISCUSSION

The evaluation of matings

Table 1 shows data concerning the number of breeding horses and their potential and the realised matings in the particular periods analysed. The periods differ from each other with respect to the proportion of potential and realised matings. The highest proportion (44.41%) was found for the 1948-1951 period and was caused by the lack of a sufficient number of sires (the highest ratio of mares to stallions from all the periods analysed). This shortage caused a reduction in the possibility of the free choice of pairs to mate. In the subsequent periods the proportion of realised matings decreased to a level of approximately 17%. Except in the first untypical period, in the remaining periods the average value of inbreeding coefficient of realised matings was always significantly lower than the average value for potential matings.

Table 1. Average values of inbreeding coefficient (*F*) for potential and realised matings

Period			1948-1951	1957-1961	1966-1970	1975-1979	1984-1988	1993-1997
Sires	N		8	24	29	30	46	48
Brood mares	N		83	130	167	230	341	381
Potential matings	N		590	1362	3447	4283	5970	6813
	F (%)	mean	3.89	4.91	5.94	6.43	6.70	7.33
		min-max values	0-27.22	0-30.35	0.12-29.72	0.23-33.50	0.23-32.62	0-32.53
Realised matings	N		262	408	506	715	1041	1121
	N % *		44.41	29.96	14.68	16.69	17.44	16.45
	F (%)	mean	3.95	2.93	4.89	5.36	5.33	6.11
		min-max values	0-18.49	0-13.81	0.29-19.12	0.33-22.06	0.40-19.73	0-21.31

* Proportion of realised matings to potential matings.

The lower values of inbreeding coefficients were affected by the purposeful avoidance of matings of close relatives like brother-sister or father-daughter by the breeders. This type of mating was very rare. The highest value of inbreeding coefficient stated for realised matings (F=22.06% in the 1975-1979 period) was the result of the mating of Eufrat (Elf by Aquinor-Estebna) x Esencja (Aquinor-Estebna). However, as a rule the level of inbreeding of realised matings did not exceed 12%.

The second important reason for the lower level of inbreeding of realised matings was the intensive use of imported stallions which were less related to the brood mares than the stallions bred in Poland. For the most valuable imported stallions the proportion of realised matings exceeded a level of 40% in particular years (i. e. Monogramm 68.2%; Nabor 54.3%; Tallin 43.0%; Probat 44.1%).

Table 2 shows the results of the analysis of the level of inbreeding for unsuccessful matings. For those which concluded in barrenness, except during the 1975-1979 period, in the remaining periods the average *F* values were lower than the average values for realised matings. It is worth noting that the study on reproduction parameters in Polish Arabian stallions by Chmiel et al. [3] indicated that the highest average number of barren matings was found in the group of brood mares sired by non-inbred stallions. The results of Budzyński et al. [1] showing the significant positive correlation between the level of inbreeding of brood mares and their fertility also should be mentioned here. These results might be interpreted as evidence of outbreeding depression, which might occur while mating unrelated individuals [10].

Table 2. Average values of inbreeding coefficient (*F*) for unsuccessful matings (barren mares, abortions and "dead foals"group: still-born, dead or eliminated foals)

Period			1948-1951	1957-1961	1966-1970	1975-1979	1984-1988	1993-1997
Barrenness	N		38	49	67	118	141	199
	N % *		14.50	12.01	13.24	16.50	13.54	17.75
	F (%)	mean	2.40	2.87	4.78	5.99	5.30	5.72
		min-max values	0-7.33	1.62-7.66	0.34-14.76	0.43-20.19	0.40-16.12	0-17.49
Abortions	N		4	6	32	31	35	45
	N % *		1.53	1.47	6.32	4.34	3.36	4.01
	F (%)	mean	7.91	3.54	5.34	5.72	5.48	5.75
		min-max values	3.41-16.6	0.13-9.35	1.38-11.50	0.43-11.28	2.77-9.37	0-12.74
"Dead foals" group	N		25	24	49	34	82	81
	N % *		9.54	5.88	9.68	4.76	7.88	7.23
	F (%)	mean	4.03	2.81	4.76	4.32	5.06	5.80
		min-max values	0-16.94	0.03-7.82	0.80-14.39	0.39-9.11	0.45-11.84	0-15.18

* Proportion of unsuccessful matings to realised matings.

In the group of matings which concluded in abortion the value of *F* was lower than the value of *F* for realised matings only in the last period. This might indicate a connection between the level of homozygosity of potential offspring, expressed by the value of *F*, and susceptibility to abortion.

In the group of matings designated as the "dead foal group", except in the first period, the average value of *F* was lower than the average value for realised matings. Though this group of matings is very heterogeneous (the cause of death of foals can be highly varied) and the analysis is of an approximate character, nevertheless the results obtained might indicate both the lack of inbreeding depression and the occurrence of possible outbreeding depression in Polish Arabs [10]. The results of Radomska et al. [7], who did not report the statistically significant influence of the level of inbreeding on inborn faults in Arabian foals, should be mentioned.

Based on the results above it might be ascertained that purposeful breeder decisions (the choice of less related pairs for mating) and natural selection, which is independent of the breeders and which caused abortions, favours the suppression of the increase in the homozygosity of the population. However, it was not found that natural selection would eliminate individuals with a higher level of homozygosity through barrenness or the death of foals.

The evaluation of selection

Not only does the mating system influence the level of homozygosity of the population, the criteria for choosing young horses for the breeding stock does as well. The stallions and the brood mares differ from each other due to selection intensity. Nearly one of every two mares is included in the stock, while only one in ten stallions is used in breeding. This difference suggests that stallion selection is made according to stricter criteria than that of mares. According to breeder statements [4], the value of the inbreeding coefficient is not taken into account when choosing young horses for the breeding stock. Therefore it should be assumed that low or high average values of *F* in the breeding horse groups do not result from wilful breeder decisions but rather independently of breeder will and knowledge of processes of selection.

Table 3 shows the results of analysis of breeding and non-breeding mares and stallions. There was no clear tendency found for the choice of mares, although the breeding mares were characterised by the higher average value of inbreeding coefficient in comparison with the non-breeding mares in four of the six periods. Inconsiderable, positive or negative differences between breeding and non-breeding groups lead to the conclusion that there is no univocal preference for individuals with higher or lower values of *F* in the choice of the brood mares.

Another tendency was found for the stallions. In the five periods breeding stallions were characterised by a lower average value of the inbreeding coefficient than that for the non-breeding stallions (Table 3). Differences in the *F* values between both groups are distinct for the 1948-1951, 1984-1988 and 1993-1997 periods. The choice of the less inbred stallions could have resulted from the preference for sons of imported sires, which are less related to the brood mares than Polish sires are. To verify this hypothesis, the *F* values of the breeding stallions sired by particular fathers were compared to that of non-breeding stallions sired by the same fathers in a given period. The value of the inbreeding coefficient was lower than the average computed for all the sons for 72 out of 101 breeding stallions sired by 58 fathers (test of sign - statistically significant result; $p<0.01$). What is more, of the 101 breeding stallions considered in the analysis, the *F* values for only two stallions exceed 10% (Engano - 10.73% and Hazard - 12.80%), and for another 11 stallions it ranged from 7 to 10%. Based on the results above, it can be stated that the preference for less inbred stallions is independent of their origin from Polish or imported fathers. Thus the stallions with the lower *F* values, i.e. those which are more heterozygous, are chosen for the breeding stock and this preference happens without the will or knowledge of the breeders.

Table 3. Average values of inbreeding coefficient (*F*) for different selection groups

Period			1948-1951	1957-1961	1966-1970	1975-1979	1984-1988	1993-1997
Breeding mares	N		49	67	93	146	197	136
	F (%)	mean	4.54	3.26	4.96	5.31	5.15	6.25
		min-max values	0-16.94	0.01-8.95	0.29-15.56	0.43-20.19	0.40-14.03	0-21.31
Non-breeding mares	N		54	88	87	138	205	171
	F (%)	mean	3.58	3.01	5.35	5.25	5.32	6.11
		min-max values	0-18.49	0-13.81	0.30-19.12	0.33-22.06	0.43-16.12	0-16.47
Total mares	F (%)		4.04	3.12	5.15	5.29	5.24	6.17
Percentage of breeding mares	(%)		47.57	43.23	51.67	51.41	49.00	44.30
Breeding stallions	N		9	19	15	24	16	18
	F (%)	mean	1.49	2.90	4.26	5.14	4.15	4.66
		min-max values	0.02-5.11	0.02-9.20	1.15-10.73	0.51-12.80	0.41-7.70	0-7.08
Non-breeding stallions	N		80	148	151	221	361	296
	F (%)	mean	4.50	2.78	4.75	5.29	5.50	6.30
		min-max values	0.01-18.49	0-9.46	0.56-16.85	0.39-15.99	0.43-19.72	0-16.70
Total stallions	F (%)		4.20	2.80	4.71	5.28	5.44	6.20
Percentage of breeding stallions	(%)		10.11	11.38	9.04	9.80	4.24	5.73

Based on the data by Chmiel et al. [2] it appears that the Arabian horses with higher values of inbreeding coefficients achieve considerably better marks at horse shows that those with the lower values of *F*; this regularity is statistically significant. However, according to the results of the current study, there is an emphatic and statistically important preference for stallions with a lower level of inbreeding during qualifications for the breeding stock. According to breeder statements [4], one of the criteria for choosing sires is their perceptibly higher vitality, and this feature is commonly recognised as a sign of the higher heterozygosity of an individual. Thus, taking into account the future selection of breeding stallions, the mating of highly related parental pairs is futile because the foals produced are not of high enough quality to ensure that they become a sire in the stud.

In the results shown in Table 3, the significant decrease of the proportion of breeding stallions in the 1984-1988 and 1993-1997 periods is conspicuous. It might have been caused by changes in breeding policy, which lie, among other things, in the wider use of foreign breeding material (import of sires or frozen semen).

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