ANALYSIS OF INBREEDING OF OLD-KLADRUB HORSES

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The Old-Kladrub horse, the oldest lines of which were founded by the end of the 18th and at the beginning of the 19th centuries, is an important genetic resource of horses not only on the scale of the Czech Republic and Europe but also worldwide. From the very beginning it has been a population of limited number and because of this, over centuries and especially in the past decades, inbreeding took place. Regarding the fact that inbreeding could have a negative impact on properties related to fitness, due to inbred depression, an analysis was made in the framework of a long-term genetic programme. Analyzed was the intensity of inbreeding in the contemporary population of Old-Kladrub horses, in the two colour variants of white and black, as well as in the lines, groups of offspring from sires and offspring from dams (families). An analysis was carried out on 210 mares, out of which 91 were white and 119 black. The male population was divided into 5 white lines (GENERALE, GENERALISSIMUS, SACRAMOSO, FAVORY, RUDOLFO) and 4 black lines (SACRAMOSO, SOLO, SIGLAVI PAKRA, ROMKE), in which 16 stallions belonged to the white and 17 stallions to the black lines. There was a total of 25 families (groups of mares from founder dams) out of which 11 were white and 13 were black families and 1 was mixed (white and black mares). Occasionally there were individuals found in white and black lines and families of opposite coat colour. Coefficients of inbreeding were calculated from eight generations of ancestors according to Wright (1922) for all the stallions and all the mares, including female founders of families. In stallions (white and black), inbreeding coefficients ranged between $F_x = 0$ and 14.5%. Average inbreeding coefficients of sire daughter groups ranged from $F_{\bar{x}} = 0\%$ (stallions Rudolfo and Romke – without mark) up to $F_{\bar{x}} = 15.29\%$ (stallion Romke I-7). Average inbreeding coefficients of daughters of stallions within various lines were within the range of $F_{\bar{x}} = 1.97\%$ in the RUDOLFO line up to $F_{\bar{x}} = 11.31\%$ in the black SACRAMOSO line. The lowest values of $F_{\bar{x}}$ were found in the lines that were founded in the second half of this century (RUDOLFO, FAVORY,

ROMKE). Higher values of $F_{\bar{x}}$ were usually found in lines that were founded by the end of the 18th century and at the beginning of the 19th century (GENERALE, GENERALISSIMUS, SACRAMOSO, SOLO). Daughters of stallions of white lines showed $F_{\bar{x}} = 7.29\%$ and of stallions of black lines $F_{\bar{x}} = 8.4\%$. The average inbreeding coefficient of $F_{\bar{x}} = 7.75\%$ was estimated for the total number of 209 mares from the whole breed. The inbreeding coefficients of mares, within the breed, were within the range 0% up to 23.83%. The inbreeding coefficient of family founders was between 0% and 18.3% for white families and 0% and 18.2% for black, families in which the value of $F_{\bar{x}}$ 7.53% for white mares was slightly lower than the value $F_{\bar{x}} = 7.91\%$ for families of black mares.

Old-Kladrub horse; genetic analysis; genetic resource; inbreeding coefficient; sire lines; dam lines

INTRODUCTION

The Old-Kladrub horse is the only original Czech horse breed which has been bred in Bohemia continuously for a number of centuries. The massive and noble "galacarrossier" (massive carriage horse used for ceremonies and prestige occasions) is now one of the oldest cultural breeds of horses preserved in the world and is part of the national as well as international wealth. For this reason, the demand is justified to declare the breed, as well as the location of its origin, i.e. Národní hřebčín Kladruby nad Labem, a national cultural monument.

According to Bílek (1955) breeds close to the Old-Kladrub horses died out in the first half of the 19th century, even in Spain and Italy, and that was why in the second half of the 19th century inbreeding within the numerically limited breed of Old-Kladrub horses took place.

Bílek (1955) noted that after World War I, hatred for anything bearing the mark of the Habsburg family, brought about bias against the Old-Kladrub horse considering it as a relic of that time, as it was understood to be a horse used only for festive occasions and also to be a horse completely degenerated due to inbreeding. The same author believed that proof testifying against this "degeneration" of Old-Kladrub horses is their toughness, persistence at work, and excellent fertility and milk production in mares. Dušek (1992), too, stated that when evaluating the impact of inbreeding on the manifestation of some physiological functions (such as fertility, character, temperament, development and intensity of growth) in black horses, not even a sign of negative impact of inbreeding was found.

The Old-Kladrub horse is a significant genetic resource, limited in its number, and it is not possible to avoid inbreeding which in its consequences could lead, especially in properties related to fitness, to inbred depression. This is why it is necessary, in the framework of repeated genetic analyses, to pay attention to the level of inbreeding.

The objective of the paper is the analysis of the intensity of inbreeding in the Old-Kladrub horse, in its two variants – the white and the black, lines and groups of progenies from sires and dams (families).

HISTORICAL DEVELOPMENT

According to Bílek (1955), the founder of the present herd of Old-Kladrub white (gray) horses was the stallion Generale, of Italian-Spanish white origin, born in Kopčany in 1787, which became the predecessor to what is now called the GENERALE line of Old-Kladrub white horses. The founder of the GENERALISSIMUS line was its son Generalissimus I (white), born in Kopčany in 1797. The herd of Old-Kladrub black horses included the SACRAMOSO and the NAPOLEONE lines. The SACRAMOSO line was founded by the stallion Sacramoso, born in 1800 in the stud of the Olomouc Archbishopric in Kroměříž. The other line of the Old-Kladrub black horse came from the stallion Napoleone, born in 1845. The NAPOLEONE line ceased in 1922 since the stallion Napoleone Sola VI had no more sons.

Bílek (1955) also claimed that white horses are nobler than black ones due to a higher proportion of genes of the Old-Spanish horse, while black horses share, next to some amount of genes of the Old-Spanish horse, a certain proportion of genes of the Occidental (Noric) horse.

The SOLO line is also important. Its founder was the stallion SOLO (Sacramoso XXXI), born in 1927, descendant of the stallion Sacramoso XXIX (1920) and the dam 271 Sacramoso XXVII. In the second half of the 19th century and at the beginning of the 20th century unsuccessful attempts were made to cross Old-Kladrub horses with English thoroughbred and halfbred horses. Products of this crossbreeding lost typical characteristics and properties of Old-Kladrub horses and thus were not used for further breeding. More successful was the mating of Old-Kladrub white mares with the half-blooded Arabian stallion of the Radovec origin, Shagya X after World War I. The stallion had numerous progenies but did not establish a new line.

The stallion Nonius XXXV, born in 1950, imported from Yugoslavia in 1957, was also used for mating with Old-Kladrub mares. The mentioned stallion and the Old-Kladrub mare Majmona produced a son Nonius Majmon XLV, born in 1965, which produced progenies in Slatiňany from 1969 to

1973. His nine daughters were taken into breeding while all his sons were withdrawn from breeding for being non-typical.

More successful was the crossbreeding of Old-Kladrub mares with the Lippizza stallion Favory, born in 1938 in the Bábolna stud (founder of the FAVORY line). The stallion was used in the Kladruby nad Labem stud in the 1951 to 1959 period producing 5 sons and 9 daughters. The line of this stallion still continues in the population of Old-Kladrub white horses. Another horse used in the population of Old-Kladrub white horses was the Lusitanian stallion Rudolfo, born in 1968 in Portugal (founder of the RUDOLFO line). He was used in the Kladruby nad Labem stud between 1977 and 1985 and had one son and 11 daughters. This line, too, has its continuation in the population of the Old-Kladrub white horses.

The black Lippizza stallion Siglavi Pakra, born in 1946 in Yugoslavia (founder of the SIGLAVI PAKRA line) was used in the Slatiňany stud from 1957 to 1967 and had 2 sons and 2 daughters. The line continues in the population of Old-Kladrub black horses.

In the population of black horses, the Friesian stallion Romke, born in 1966 in the Netherlands (founder of the ROMKE line), was also used in the Slatiňany stud from 1974 to 1985 and had 3 sons and 22 daughters. The line has its continuation in the population of black horses.

Quite negligible was the use for mating of stallions of the Orlov trotters, Bàrzoy and Legion.

The herd of Old-Kladrub black horses experienced dramatic development when it was sold out in the 1930's. It was thanks to Bílek that in 1940 remaining black horses were found and gathered in the Průhonice stud and transferred to the Slatiňany stud in 1945. A very important role in the regeneration of the Old-Kladrub black horse was played by Richter and Dušek, who was able to state (Dušek, 1992) that after 40 years of work the regeneration process had been brought to an end and the Old-Kladrub black horse was saved.

MATERIALS AND METHODS

The present population of Old-Kladrub horses in the Czech Republic amounts to some 650 (stallions, mares, young and commercial horses). Of this total, only about 400, including 29 breeding stallions (16 white and 13 black) and 65 white and 65 black mares, are kept in the National stud at Kladruby nad Labem and the Slatiňany stud. Another 30 white and 60 black mares are in the keeping of private owners who do not belong to the two studs. In the whole population 95 white and 125 black mares are kept, i. e. altogether 220. The stallions and their daughters can be classified into 5 white

and 4 black lines. Similarly, the population can be divided into daughters of excellent dams in 25 families, of which 11 are white, 14 black and 1 mixed.

In the 1993 to 1994 period a genetic analysis of 9 lines was carried out – 5 of these were white (GENERALE, GENERALISSIMUS, SACRAMOSO, FAVORY, RUDOLFO) and 4 black (SACRAMOSO, SOLO, SIGLAVI PAKRA, ROMKE). Black horses within the white variant were the result of mating between two white heterozygous individuals (*Gg*). White horses within the black variant came from the mating of black horses (*aaB-gg*) with white heterozygous or homozygous individuals (*aaB-Gg*, *aaB-GG*). For all individuals (stallions as well as mares), coefficients of inbreeding were calculated from eight generations of ancestors according to Wright (1922):

$$F_x = \sum_{i=1}^{m} (1/2)^{n_1 + n_2 + 1} \cdot (1 + F_{A_i})$$

where: F_x – coefficient of inbreeding of individual X
F_A – coefficient of inbreeding of a common ancestor A
i – 1, 2 ..., m – number of common ancestors
n_1 – number of generations from the sire to the common ancestor A
n_2 – number of generations from the dam to the common ancestor A

The input data were taken from a computer file (the stud book) of Old-Kladrub horses, which was gradually created over the past 8 years and completed in 1993 at the Research Department of the Slatiňany Stud. The stud book of Old-Kladrub horses in the computer contains the pedigrees of Old-Kladrub horses for about 250 past years providing the specification (line and family) of each horse. When making the analysis of the inbreeding coefficient, special software program was made that can be used for other breeds (lines) of horses as well as for other species of livestock. Relevant data files from the stud book of Old-Kladrub horses were classified by specific methods.

On the basis of individual coefficients of inbreeding, average coefficients of inbreeding were calculated for dam groups derived from different stallions and outstanding mares, from lines, from the two variants of white and black horses and for the whole breed with the corresponding standard error of the average inbreeding coefficient (s_{F_x}).

RESULTS AND DISCUSSION

Tabs. I and II show inbreeding coefficients of stallions, average inbreeding coefficients of stallions within lines, white and black variants within the breed, average inbreeding coefficients of daughters within sires, daughters of sires in lines, daughters of sires within the white and black variant and daugh-

I. Coefficients of inbreeding of stallions and average coefficients of inbreeding of stallion groups and groups of stallion daughters, classified according to lines and the variant of white stallions

Colour variant	No.	Line Name	No.	Stallion	Number of stallions	F_x, $F_{\bar{x}}^{(1)}$, $F_{\bar{x}}^{(2)}$ %	$s_{F_{\bar{x}}}^{(1)}$, $s_{F_{\bar{x}}}^{(2)}$	Number of daughters	$F_{\bar{x}}^{(5)}$, $F_{\bar{x}}^{(6)}$, $F_{\bar{x}}^{(7)}$ %	$s_{F_{\bar{x}}}^{(5)}$, $s_{F_{\bar{x}}}^{(6)}$, $s_{F_{\bar{x}}}^{(7)}$
White stallions	1	Generale	1	XLIV	–	11.9	–	7	$9.16^{(5)}$	$0.92^{(5)}$
			2	XLV	–	10.6	–	3	$7.27^{(5)}$	$0.77^{(5)}$
		total			2	$11.3^{(1)}$	$0.65^{(1)}$	10	$8.59^{(6)}$	$0.88^{(6)}$
	2	Generalissimus	1	XXVII	–	3.9	–	2	$10.23^{(5)}$	$4.77^{(5)}$
			2	XXIX	–	7.7	–	22	$9.53^{(5)}$	$0.81^{(5)}$
			3	XXX	–	13.1	–	4	$11.35^{(5)}$	$0.44^{(5)}$
		total			3	$8.2^{(1)}$	$2.67^{(1)}$	28	$9.84^{(6)}$	$1.04^{(6)}$
	3	Sacramoso (W)	1	Aboca XL	–	11.3	–	9	$10.23^{(5)}$	$1.61^{(5)}$
			2	XLI	–	6.1	–	1	$1.70^{(5)}$	$-^{(5)}$
			3	XXXVII	–	3.4	–	9	$10.61^{(5)}$	$0.77^{(5)}$
		total			3	$6.9^{(1)}$	$2.32^{(1)}$	19	$9.96^{(6)}$	$1.13^{(6)}$
	4	Favory	1	IV-K	–	0.0	–	1	$1.09^{(5)}$	$-^{(5)}$
			2	IV-50	–	5.6	–	10	$2.65^{(5)}$	$0.43^{(5)}$
			3	VI-K	–	0.0	–	2	$4.86^{(5)}$	$0.12^{(5)}$
			4	VII-K	–	3.1	–	1	$0.86^{(5)}$	$-^{(5)}$
			5	IX	–	4.6	–	6	$1.54^{(5)}$	$0.38^{(5)}$
			6	XI-K	–	1.2	–	10	$7.83^{(5)}$	$1.42^{(5)}$
		total			6	$2.4^{(1)}$	$0.98^{(1)}$	30	$4.19^{(6)}$	$0.70^{(6)}$

Continuation of Tab. I

Colour variant	No.	Line Name	No.	Stallion	Number of stallions	F_x, $F_{\bar{x}}^{(1)}$, $F_{\bar{x}}^{(2)}$ %	$s_{F_{\bar{x}}}^{(1)}$, $s_{F_{\bar{x}}}^{(2)}$	Number of daughters	$F_{\bar{x}}^{(5)}$, $F_{\bar{x}}^{(6)}$, $F_{\bar{x}}^{(7)}$ %	$s_{F_{\bar{x}}}^{(5)}$, $s_{F_{\bar{x}}}^{(6)}$, $s_{F_{\bar{x}}}^{(7)}$
White stallions	5	Rudolfo	1	without mark	–	14.5	–	6	$0.00^{(5)}$	$-^{(5)}$
			2	I	–	0.0	–	2	$7.86^{(5)}$	$2.91^{(5)}$
		total			2	$7.3^{(1)}$	$7.25^{(1)}$	8	$1.97^{(6)}$	$0.73^{(6)}$
	total 5 lines				16	$6.1^{(2)}$	$2.29^{(2)}$	95	$7.29^{(7)}$	$0.91^{(7)}$

Explanatory notes for Tabs. I and II:

F_x – inbreeding coefficient of a stallion
$F_{\bar{x}}^{(1)}$ – average inbreeding coefficient of stallions for line
$F_{\bar{x}}^{(2)}$ – average inbreeding coefficient of stallions for whites
$F_{\bar{x}}^{(3)}$ – average inbreeding coefficient of stallions for blacks
$F_{\bar{x}}^{(4)}$ – average inbreeding coefficient of stallions for the breed
$F_{\bar{x}}^{(5)}$ – average inbreeding coefficient of a group of daughters of a stallion
$F_{\bar{x}}^{(6)}$ – average inbreeding coefficient of daughters of stallions within a line
$F_{\bar{x}}^{(7)}$ – average inbreeding coefficient of daughters of stallions within whites
$F_{\bar{x}}^{(8)}$ – average inbreeding coefficient of daughters of stallions within blacks
$F_{\bar{x}}^{(9)}$ – average inbreeding coefficient of daughters of stallions within the breed
$s_{F_{\bar{x}}}$ – standard error of the corresponding average coefficients of inbreeding

II. Coefficients of inbreeding of stallions and average coefficients of inbreeding of stallion groups and groups of stallion daughters, classified according to lines the variant of black stallions and the whole breed

Colour variant	No.	Line Name	No.	Stallion	Number of stallions	F_x, $F_{\bar{x}}^{(1)}$, $F_{\bar{x}}^{(3)}$, $F_{\bar{x}}^{(4)}$ %	$s_{F_{\bar{x}}}^{(1)}$, $s_{F_{\bar{x}}}^{(3)}$, $s_{F_{\bar{x}}}^{(4)}$	Number of daughters	$F_{\bar{x}}^{(5)}$, $F_{\bar{x}}^{(6)}$, $F_{\bar{x}}^{(8)}$, $F_{\bar{x}}^{(9)}$ %	$s_{F_{\bar{x}}}^{(5)}$, $s_{F_{\bar{x}}}^{(6)}$, $s_{F_{\bar{x}}}^{(8)}$, $s_{F_{\bar{x}}}^{(9)}$
Black stallions	1	Sacramoso (B)	1	Roma XXXVI	–	8.5	–	3	$8.80^{(5)}$	$1.28^{(5)}$
			2	Eleonora XXXVIII	–	12.9	–	11	$13.57^{(5)}$	$0.81^{(5)}$
			3	XXXVIII-Candelia-22	–	8.2	–	3	$8.76^{(5)}$	$1.58^{(5)}$
			4	XXXVIII-48	–	14.2	–	1	$2.67^{(5)}$	$-^{(5)}$
			5	Xerxes XXXIX	–	11.5	–	6	$11.16^{(5)}$	$1.67^{(5)}$
		total			5	$11.1^{(1)}$	$1.19^{(1)}$	24	$11.31^{(6)}$	$1.15^{(6)}$
	2	Solo	1	Narcis IV	–	9.6	–	6	$13.53^{(5)}$	$3.33^{(5)}$
			2	Majka VI	–	8.5	–	6	$9.08^{(5)}$	$2.51^{(5)}$
			3	Magnifica VII	–	5.1	–	20	$6.53^{(5)}$	$3.03^{(5)}$
			4	Elveta XIII	–	4.6	–	2	$8.27^{(5)}$	$1.58^{(5)}$
			5	Isoleta VIII	–	11.5	–	11	$8.58^{(5)}$	$3.81^{(5)}$
			6	Seclana IX	–	7.7	–	3	$8.52^{(5)}$	$4.33^{(5)}$
		total			6	$7.8^{(1)}$	$1.08^{(1)}$	48	$8.38^{(6)}$	$3.20^{(6)}$
	3	Siglavi Pakra	1	Favorina I	–	0.4	–	10	$8.71^{(5)}$	$1.01^{(5)}$
			2	I-22	–	6.2	–	2	$11.52^{(5)}$	$1.91^{(5)}$
			3	Barbara III	–	6.9	–	2	$9.39^{(5)}$	$3.53^{(5)}$
		total			3	$4.5^{(1)}$	$2.06^{(1)}$	14	9.21	$1.50^{(6)}$

Continuation of Tab. II

Colour variant	No.	Line Name	No.	Stallion	Number of stallions	F_x, $F_{\bar{x}}^{(1)}$, $F_{\bar{x}}^{(3)}$, $F_{\bar{x}}^{(4)}$ %	$s_{F_{\bar{x}}}^{(1)}$, $s_{F_{\bar{x}}}^{(3)}$, $s_{F_{\bar{x}}}^{(4)}$	Number of daughters	$F_{\bar{x}}^{(5)}$, $F_{\bar{x}}^{(6)}$, $F_{\bar{x}}^{(8)}$, $F_{\bar{x}}^{(9)}$ %	$s_{F_{\bar{x}}}^{(5)}$, $s_{F_{\bar{x}}}^{(6)}$, $s_{F_{\bar{x}}}^{(8)}$, $s_{F_{\bar{x}}}^{(9)}$
	4	Romke	1	without mark	–	9.8	–	16	$0.00^{(5)}$	$-^{(5)}$
			2	I-7	–	13.9	–	1	$15.29^{(5)}$	$-^{(5)}$
			3	Eleona II	–	0.0	–	11	$10.01^{(5)}$	$0.75^{(5)}$
		total			3	$7.9^{(1)}$	$4.12^{(1)}$	28	$4.48^{(6)}$	$0.29^{(6)}$
	total 4 lines				17	$8.2^{(3)}$	$1.82^{(3)}$	114	$8.40^{(8)}$	$1.84^{(8)}$
Breed total (9 lines)					33	$7.2^{(4)}$	$2.05^{(4)}$	209	$7.75^{(9)}$	$1.42^{(9)}$

ters of sires within the breed. When making the analysis, the breed was divided into 5 lines of white and 4 lines of black horses. It must mentioned that there is a Sacramoso line – white, and a Sacramoso line – black. The following lines have the highest numbers of stallions: FAVORY (6), SOLO (6) and SACRAMOSO - black (5). Other lines have fewer stallions (from 2 to 3).

Values of the inbreeding coefficients of white stallions range from $F_x = 0\%$ to $F_x = 14.5\%$. The highest inbreeding coefficients were found in stallions Rudolfo (without mark) ($F_x = 14{,}5\%$), Generalissimus XXX ($F_x = 13.1\%$), Sacramoso Aboca L ($F_x = 11.3\%$), Generale XLIV ($F_x = 11.9\%$) and Generale XLV ($F_x = 10.6\%$).

The inbreeding coefficients in black stallions reach values ranging from $F_x = 0\%$ to $F_x = 14.2\%$. The highest values of inbreeding coefficient were found in stallions Sacramoso XXXVIII-48 ($F_x = 14.2\%$), Romke I-7 ($F_x = 13.9\%$), Sacramoso Eleonora XXXVIII ($F_x = 12.9\%$) Sacramoso Xerxes XXXIX ($F_x = 11.5\%$) and Solo Isoleta VIII ($F_x = 11.5\%$).

The Lusitanian stallion Rudolfo ($F_x = 14{,}5\%$) and the Friesian stallion Romke ($F_x = 9{,}8\%$), imported in the 1980's to immigrate genes into the Old-Kladrub horses, have a high inbreeding coefficient as compared to the original Old-Kladrub stallions.

The lowest average coefficient of inbreeding $F_{\bar{x}}$ was found in the FAVORY line of stallions ($F_x^{(1)} = 2.4\%$), which was founded in the second half of this century. Higher values of $F_{\bar{x}}$ were in lines which were founded at the end of the 18th and the beginning of the 19th centuries (GENERALE – $F_x^{(1)} = 11.3\%$, GENERALISSIMUS – $F_x^{(1)} = 8.2\%$, SACRAMOSO – black – $F_x^{(1)} = 11.1\%$, SACRAMOSO – white – $F_x^{(1)} = 6.9\%$, SOLO – $F_x^{(1)} = 7.8\%$).

Inbreeding coefficients of mares range from $F_x = 0\%$ to $F_x = 23.83\%$. The highest values F_x were found in the mares 327 Elka (23.82%) and 310 Romana (23.31%) from the sire Solo Narcis IV.

Average inbreeding coefficients of groups of stallion daughters range from $F_x^{(5)}$ 0% in daughters of the stallions Rudolfo and Romke (without mark) up to $F_x^{(5)} = 15.29\%$ in daughters of the stallion Romke I-7, $F_x^{(5)} = 13.53\%$ in daughters of the stallion Solo Narcis IV, and $F_x^{(5)} = 13.57\%$ in daughters of the stallion Sacramoso Eleonora XXXVIII.

Average inbreeding coefficients of mares within lines differed within the range of $F_x^{(6)} = 1.97\%$ in the Rudolfo line and $F_x^{(6)} = 11.31\%$ in the Sacramoso – black line. The lowest values of $F_x^{(6)}$ were found in lines founded in the second half of this century (RUDOLFO, FAVORY, ROMKE). Higher $F_x^{(6)}$ values were in lines founded by the end of the 18th century and at the beginning of the 19th century (SACRAMOSO – black – $F_x^{(6)} = 11.31\%$, SACRAMOSO – white – $F_x^{(6)} = 9.96\%$, GENERALISSIMUS – $F_x^{(6)} = 9.84\%$

and GENERALE – $F_x^{(6)} = 8.59\%$), including the SOLO line – $F_x^{(6)} = 8.38\%$. A higher average inbreeding coefficient was noted in the Siglavi Pakra line (black line) – $F_x^{(6)} = 9.21\%$.

The reason for higher average inbreeding coefficients of black lines lies in the fact that more intensive inbreeding was used to regenerate black horses after World War II and this brought about the generally higher $F_x^{(6)}$ values in black lines than in white lines.

Daughters of stallions of the white lines ($n = 95$) show $F_x^{(7)} = 7.29\%$ and 133 daughters of stallions of black lines show $F_x^{(7)} = 8.40\%$. The fact that the number of mares derived from the lines of black horses is at present almost one-third higher than the number of mares in the white lines, is also worth mentioning.

Tabs. III, IV and V show the frequency distribution of white, black, and white and black stallions in three classes according to their own inbreeding coefficient (F_x).

Tab. III demonstrates that in most white stallions (69%) the F_x is below 10% and in half (50%) stallions the F_x is below 5%. In 71% black stallions their own inbreeding coefficient is below 10% and in 53% black stallions the inbreeding coefficient is between 5% and 10% (Tab. IV). This means that black stallions with higher inbreeding coefficients than white stallions are being selected for breeding.

Tab. V shows that the absolute and relative frequencies of F_x of white and black stallions are equably distributed into the three classes.

Tabs. VI and VII demonstrate the frequency distribution of white and black stallions with the average inbreeding coefficient of daughter groups in classes within the range of $F_{\bar{x}}$ = 0–4.99%, 5–9.99%, 10–14.99%. In white horses there were more stallions in the range of $F_{\bar{x}}$ = 0–4.99% and, on the other hand, fewer stallions in the range of $F_{\bar{x}}$ = 10–14.99% than in black horses while the frequency distribution in the class $F_{\bar{x}}$ = 5–9.99% was more or less the same. In the whole breed (white and black) the highest number of stallions was in the class with $F_{\bar{x}}$ = 5–9.99% (Tab. VIII).

Tabs. IX, X and XI show the frequency distribution of mares in classes in the range of F_x = 0–4.99%, 5–9.99%, 10–14.99%, 15–19.99% and 20–24.99% separately for the white and black lines and for the whole breed.

In the 5 classes the absolute and relative frequency distributions of F_x of mares for the white and black lines and for the whole breed are relatively identical.

In the past 50 years more intensive inbreeding was used in the regeneration process in the population of black horses than in that of white horses (Tabs. III–XI).

III. Frequency distribution of white stallions into classes according to their own coefficient of inbreeding (F_x)

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	8	50.00
5–9.99	3	19.00
10–14.99	5	31.00
Total	16	100.00

IV. Frequency distribution of black stallions into classes according to their own coefficient of inbreeding (F_x)

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	3	18.00
5–9.99	9	53.00
10–14.99	5	29.00
Total	17	100.00

V. Frequency distribution of white and black stallions into classes according to their own coefficient of inbreeding (F_x)

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	11	34.00
5–9.99	12	36.00
10–14.99	10	30.00
Total	33	100.00

VI. Frequency distribution of white stallions into classes according to the average inbreeding coefficient of daughter groups ($F_{\bar{x}}$)

Classes with limits of $F_{\bar{x}}$ in %	Absolute frequency n	Relative frequency %
0–4.99	7	43.75
5–9.99	5	31.25
10–14.99	4	25.00
Total	16	100.00

VII. Frequency distribution of black stallions into classes according to the average inbreeding coefficient of daughter groups ($F_{\bar{x}}$)

Classes with limits of $F_{\bar{x}}$ in %	Absolute frequency n	Relative frequency %
0–4.99	2	11.76
5–9.99	9	52.94
10–14.99	5	29.41
15–19.99	1	5.89
Total	17	100.00

VIII. Frequency distribution of stallions for the breed into classes according to the average inbreeding coefficient of daughter groups ($F_{\bar{x}}$)

Classes with limits of $F_{\bar{x}}$ in %	Absolute frequency n	Relative frequency %
0–4.99	9	27.27
5–9.99	14	42.43
10–14.99	9	27.27
15–19.99	1	3.03
Total	33	100.00

IX. Frequency distribution of mares (daughters of white stallions) into classes according to F_x

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	36	37.89
5–9.99	23	24.21
10–14.99	30	31.58
15–19.99	6	6.32
20–24.99	0	0.00
Total	95	100.00

The average coefficient of inbreeding of mares (209) in the breed was $F_x^{(9)} = 7.75\%$.

Tabs. XII and XIII show inbreeding coefficients of female founders of families and average inbreeding coefficients of groups of female offspring of

X. Frequency distribution of mares (daughters of black stallions) into classes according to F_x

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	26	22.81
5–9.99	50	43.86
10–14.99	28	24.56
15–19.99	8	7.02
20–24.99	2	1.75
Total	114	100.00

XI. Frequency distribution of mares (daughters of white and black stallions) into classes according to F_x

Classes with limits of F_x in %	Absolute frequency n	Relative frequency %
0–4.99	62	29.67
5–9.99	73	34.93
10–14.99	58	27.75
15–19.99	14	6.70
20–24.99	2	0.95
Total	209	100.00

family founders classified according to the white, resp. black variant and the breed as a whole.

Families similar as lines were divided according to the coat colour of family founders into families of white mares as well as black mares. Therefore, in the families of white mares, black mares can occasionally be found and vice versa. This is why the number of mares within families of white and black mares is not identical with the number of mares within the white and black sire lines. The number of mares within families of black mares (n = 119) is higher than within the families of white mares (n = 91). The total number of mares in the breed (white and black) when classifying into families was 210. The total number of mares in the breed (white and black), when classifying according to sires, was 209. One mare does not belong to any of the 9 analyzed lines. Her sire was the stallion Nonius XLV who was not included into the classification according to lines. The inbreeding coefficients of white family founders were in the range of F_x = 0–18.3% and black family

XII. Coefficients of inbreeding of family founders and average coefficients of inbreeding of groups of female offspring of family founders for the white variant

Colour variant	No.	Family (family founder)	F_x, $\bar{F}_x^{(1)}$ %	$s_{\bar{F}_x}^{(1)}$	Number of female progenies	$\bar{F}_x^{(4)}$, $\bar{F}_x^{(5)}$ %	$s_{\bar{F}_x}^{(4)}$, $s_{\bar{F}_x}^{(5)}$
White mares	1	Albona (89 Generalissimus XVI)	17.4	–	19	$5.67^{(4)}$	$0.90^{(4)}$
	2	Cariera	0.0	–	13	$8.67^{(4)}$	$1.16^{(4)}$
	3	Č 3934 Dana	2.9	–	2	$3.04^{(4)}$	$1.89^{(4)}$
	4	Egloga (116 Generale XXIX)	18.3	–	22	$8.92^{(4)}$	$0.80^{(4)}$
	5	Č 3912 Favora	0.0	–	6	$4.50^{(4)}$	$1.16^{(4)}$
	6	630 Generalissimus XXIII (Raduga III)	3.7	–	10	$9.81^{(4)}$	$1.66^{(4)}$
	7	Č 399 Gita	0.0	–	4	$2.98^{(4)}$	$0.68^{(4)}$
	8	Peripherie (93 Generalissimus)	10.0	–	2	$7.49^{(4)}$	$2.77^{(4)}$
	9	566 Pluto XXIII	0.0	–	1	$0.91^{(4)}$	$-^{(4)}$
	10	615 Rava	2.1	–	1	$1.18^{(4)}$	$-^{(4)}$
	11	532 Shagya VI	0.0	–	7	$12.80^{(4)}$	$0.98^{(4)}$
	12	121 Septimia	0.0	–	4	$4.80^{(4)}$	$3.65^{(4)}$
	families total (12)		$4.5^{(1)}$	$1.98^{(1)}$	91	$7.53^{(5)}$	$1.17^{(5)}$

Explanatory notes for tab. XII and XIII:

F_x – inbreeding coefficients of family founders

$\bar{F}_x^{(1)}$ – average inbreeding coefficient of white family founders

$\bar{F}_x^{(2)}$ – average inbreeding coefficient of black family founders

$\bar{F}_x^{(3)}$ – average inbreeding coefficient of family founders for the breed

$\bar{F}_x^{(4)}$ – average inbreeding coefficient of a group of female progenies of a family founder

$\bar{F}_x^{(5)}$ – average inbreeding coefficient of groups of female progenies of family founders within white mares

$\bar{F}_x^{(6)}$ – average inbreeding coefficient of groups of female progenies of family founders within black mares

$\bar{F}_x^{(7)}$ – average inbreeding coefficient of groups of female progenies of family founders for the breed

$s_{\bar{F}_x}$ – standard errors of the corresponding average coefficients of inbreeding

XIII. Coefficients of inbreeding of family founders and average coefficients of inbreeding of groups of female offspring of family founders for the black variant and the whole breed

Colour variant	No.	Family (family founder)	F_x, $F_x^{(2)}$, $F_x^{(3)}$ %	$s_{F_x}^{(2)}$, $s_{F_x}^{(3)}$	Number of female progenies	$F_x^{(4)}$, $F_x^{(6)}$, $F_x^{(7)}$ %	$s_{F_x}^{(4)}$, $s_{F_x}^{(4)}$, $s_{F_x}^{(6)}$, $s_{F_x}^{(7)}$
Black mares	1	154 Bárta	0.0	–	17	$7.17^{(4)}$	$1.26^{(4)}$
	2	43 Campanella	0.4	–	4	$7.52^{(4)}$	$2.87^{(4)}$
	3	114 Capra (9 Neapolitana)	4.7	–	4	$7.76^{(4)}$	$3.24^{(4)}$
	4	143 Elektra (18 Maestoso)	12.9	–	22	$8.64^{(4)}$	$1.18^{(4)}$
	5	35 Formosa (475 Furioso VII)	0.0	–	6	$9.10^{(4)}$	$2.27^{(4)}$
	6	7 Maga	1.9	–	5	$3.59^{(4)}$	$1.48^{(4)}$
	7	3 Magura	1.4	–	8	$5.50^{(4)}$	$1.51^{(4)}$
	8	1 Maja	0.0	–	5	$8.86^{(4)}$	$0.71^{(4)}$
	9	15 Narcis	18.2	–	4	$8.32^{(4)}$	$4.25^{(4)}$
	10	60 Plutona (Pluto I)	1.9	–	2	$10.71^{(4)}$	$-^{(4)}$
	11	32 Raguza	0.2	–	12	$8.93^{(4)}$	$2.12^{(4)}$
	12	272 Ritorna	0.0	–	1	$7.97^{(4)}$	–
	13	121 Septima	0.0	–	17	$7.35^{(4)}$	$0.86^{(4)}$
	14	67 Xandra	0.0	–	12	$9.36^{(4)}$	$1.25^{(4)}$
		families total (14)	$3.0^{(2)}$	$1.49^{(2)}$	119	$7.91^{(6)}$	$1.52^{(6)}$
Breed total (25 families)			$3.7^{(3)}$	$1.72^{(3)}$	210	$7.75^{(7)}$	$1.37^{(7)}$

founders were in the range of F_x = 0–18.2%. The $F_x^{(5)}$ = 7.53% for white families is slightly lower than the $F_x^{(6)}$ = 7.91% in black families.

The range from the minimum value up to the maximum value $F_x^{(4)}$ is broader in families of white mares ($F_x^{(4)}$ = 0.91–12.80%) than in families of black mares ($F_x^{(4)}$ = 3.59–10.71%).

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Analýza inbrídingu u starokladrubských koní.

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Starokladrubský kůň, jehož nejstarší linie byly založeny koncem 18. a začátkem 19. století, je významnou genetickou rezervou koní jak v měřítku České republiky a Evropy, tak i v měřítku celosvětovém. Od jejího vzniku se jedná o početně omezenou populaci, a proto v průběhu staletí a zejména v posledních desetiletích tohoto století docházelo k příbuzenské plemenitbě. Vzhledem k tomu, že příbuzenská plemenitba by mohla mít z důvodu vznikající inbrední deprese negativní vliv na vlastnosti spojené s fitnes, byla v rámci dlouhodobého genetického programu provedena analýza intenzity příbuzenské plemenitby u současné populace starokladrubských koní, jejích dvou barevných variet běloušů a vraníků, jakož i linií, skupin potomků po otcích a potomků po matkách (rodin). Analyzováno bylo 210 klisen, z toho 91 bělek a 119 vranek. Samčí populace se člení na pět bílých linií (GENERALE, GENERALISSIMUS, SACRAMOSO, FAVORY, RUDOLFO) a čtyři vrané linie (SACRAMOSO, SOLO, SIGLAVI PAKRA, ROMKE), přičemž k bílým liniím náleželo 16 hřebců a k černým liniím 17 hřebců. Z 25 rodin (skupin klisen po matkách) bylo 11 rodin bělek, 13 rodin vranek a 1 rodina smíšená.

V liniích a rodinách běloušů a vraníků se vyskytli ojediněle jedinci opačného zbarvení. Pro všechny plemeníky i pro všechny klisny, včetně zakladatelek rodin, byly vypočteny koeficienty inbrídingu podle Wrighta (1922). U plemeníků (běloušů a vraníků) se pohybují jejich vlastní koeficienty inbrídingu od F_x = 0 až po F_x = 14,5 %. U jednotlivých klisen se pohybují koeficienty inbrídingu v rozpětí 0 až 23,83 %. Průměrné koeficienty inbrídingu skupin klisen po jednotlivých plemenících se pohybují od $F_{\bar{x}}$ = 0 % u hřebců Rudolfo a Romke (bez označení) až po $F_{\bar{x}}$ = 15,29 % u hřebce Romke I-7, u jednotlivých linií jsou v rozpětí od 1,97 % u bílé linie RUDOLFO až po 11,31 % u vrané linie SACRAMOSO. Nejnižší hodnoty $F_{\bar{x}}$ jsou u linií, které byly založeny v druhé polovině tohoto století (RUDOLFO, FA-

VORY, ROMKE). Vyšší hodnoty $F_{\bar{x}}$ se zpravidla vyskytují u linií, které byly založeny koncem 18. a začátkem 19. století (GENERALE, GENERALISSIMUS, SACRAMOSO, SOLO). Dcery po hřebcích linií běloušů vykazovaly $F_{\bar{x}}$ = 7,29 % a po hřebcích vraníků $F_{\bar{x}}$ = 8,4 %. U celkového počtu 209 klisen (za celé plemeno) byl odhadnut průměrný koeficient inbrídingu $F_{\bar{x}}$ = 7,75 %.

U jednotlivých klisen v celé populaci se pohybují koeficienty inbrídingu od 0 % až po 23,83 %, u zakladatelek rodin bělek od 0 do 18,33 % a u vranek od 0 do 18,2 %, přičemž hodnota $F_{\bar{x}}$ = 7,53 % pro rodiny bělek je nepatrně nižší než hodnota $F_{\bar{x}}$ = 7,91 % pro rodiny vranek, což koresponduje s tendencí $F_{\bar{x}}$ u linií běloušů a vraníků.

starokladrubský kůň; genetická analýza; genová rezerva; koeficient inbrídingu; otcovské linie; mateřské rodiny

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