https://doi.org/10.17221/8/2025-CJAS

Analysis of the mare breeding population of Haflinger breed in the Czech Republic

*Michaela Kulišťáková, Eva Sobotková, Radek Filipčík**

Department of Animal Breeding, Faculty of AgriSciences, Mendel University in Brno, Brno, Czech Republic

**Corresponding author: radek.filipcik@mendelu.cz*

Citation: Kulišťáková M., Sobotková E., Filipčík R. (2025): Analysis of the breeding mare population of Haflinger breed in the Czech Republic. Czech J. Anim. Sci., 70: 83–92.

Abstract: The aim of this study was to analyse the conformation traits and body dimensions of Haflinger mares registered in the Czech Republic studbook. The study focused on the effects of age at studbook entry, year of birth, proportion of Arabian genes, and country of origin on various parameters. Data were collected from 825 mares, including scores obtained during the studbook entry evaluation and body measurements such as withers height measured with a stick (WHS), withers height measured with a tape (WHT), chest girth (CG), and cannon bone circumference (CBC). Based on these data, the bone index (BI) and body massiveness index (MI) were calculated. Statistical analysis was performed using multifactor analysis of variance (ANOVA) and Scheffe's post-hoc testing method. The results showed that the age at studbook entry significantly affected conformation scores, chest girth, cannon bone circumference, and both indices (MI, BI). Mares aged 3–4 years had significantly higher conformation scores compared to mares aged 5–6 years (P = 0.001) and mares aged 7 years and older (P = 0.000). Mares aged 5–6 years and those aged 7 years and older showed higher CG values (P = 0.002, P = 0.000) and CBC values (P = 0.010, P = 0.001). Furthermore, the year of birth had a highly significant impact on all variables studied. The withers height of mares born between 2011 and 2020 was, on average, 3.49 cm higher (144.84 cm) than that of mares born between 1987 and 2000 (141.35 cm) (P < 0.000). Regarding CG, a statistically significant increase was observed in mares born in 1987–2000 and 2001–2010, with chest girth increasing from 180.45 cm to 183.76 cm (P = 0.016). However, a subsequent decrease to 179.91 cm was noted in mares born between 2011 and 2020 (P = 0.002). The influence of the proportion of Arabian genes was significant for WHS, where mares with a higher proportion of Arabian genes (>1.56%) showed lower WHS (141.74 cm) compared to mares with a lower proportion (143.86 cm) or no Arabian genes (143.01 cm). While ANOVA demonstrated a significant effect of Arabian genes on CBC, Scheffe's post-hoc test did not confirm this finding. No statistically significant differences were observed in other body dimensions based on the proportion of Arabian genes. The influence of the country of origin was statistically significant for all variables except WHS and WHT. Regarding the conformation scores, mares from the Czech Republic scored lower (6.98) than Austrian mares (7.22, P = 0.000). Additionally, CG was significantly lower in Austrian mares (178.58 cm) compared to Czech mares (182.54 cm, P = 0.000). Austrian mares also had significantly lower MI (P = 0.000) and BI (P = 0.040), with Austrian indices at 124.71/13.31 and Czech indices at 127.77/13.41. Based on this empirical evaluation of the current and original population of Haflingers in the Czech Republic, the connections and influence of individual factors during breeding are revealed. The results of our analysis have built an objective scientific basis and they allow the breeding organisation to determine the further breeding process.

Keywords: Arabian genes; body dimensions; body indices; bone circumference; chest girth; withers height

https://doi.org/10.17221/8/2025-CJAS

The Haflinger breed originates from South Tyrol, and its ancestry is closely linked to Arabian horses. The founder of the Haflinger breed was a stallion of Arabian origin named "Folie 249", born in 1874 in the Val Venosta valley in Italy. Folie 249 was the offspring of a local mare of Galician origin and an Oriental stallion, "El Bedavi XXII". Folie 249 left behind seven sons who laid the foundation for today's bloodlines of the breed (Gandini et al. 1997; ANACRHAI 2021).

Tocci et al. (2017) and Messner (2017) agree that the first studbook was established in Mölten, Italy. However, the Austrian Haflinger Breeding Association also played a significant role in the worldwide expansion of the breed, mainly through the breeding association in Zams, Austria (Gruber 2020).

Today, the Haflinger is renowned for its compact body structure and adaptability to high-altitude environments. Bred initially as a draught and pack animal within the Austro-Hungarian Empire, using South Tyrolean mares crossed with Norikers, Shagya Arabians, and Arabians, the breed gradually evolved into a riding horse, mainly due to shifts in breeding objectives (Gandini et al. 1997; Druml et al. 2016). Currently, the Haflinger is bred as a versatile horse suitable for all equestrian disciplines as well as for driving. Due to their versatility and friendly disposition, Haflingers are bred worldwide and are utilised in various areas of equestrian sport. In recent years, there has also been an increase in demand for horses ideal for recreational riding (Gille and Spiller 2010; Haflinger World 2021).

The history of Haflinger breeding in the Czech Republic dates back to the 19th century when horses were primarily imported from Austria and Germany. These horses often had suboptimal conformation, poor movement, and a high proportion of Arabian genes. Breeding was interrupted after World War II and resumed after 1989. Significant improvements in breeding quality occurred in the 21st century when the Czech Republic joined the European and World Haflinger Breeders' Associations, leading to standardisation of breeding criteria (CSCHH 2017).

Bihuncova et al. (2015) reported that by 2013, Haflingers in the Czech Republic were frequently used in the breeding of horses of unknown pedigree, both sires and dams. Over the past 15 years, substantial improvements in breeding quality have been achieved through revised breeding documentation, organisational restructuring, and especially the importation of high-quality horses from countries of their origin.

Many authors studied the genetic diversity of the Haflinger breed, including Gandini et al. (1997), Vostry et al. (2019), Druml et al. (2016), Grilz-Seger et al. (2019) and Kulistakova et al. (2024). Some studies were also focused on the heritability of temperament, such as Gandini et al. (1997) and Zanon et al. (2023). However, studies specifically addressing the body dimensions of the breed are less common. An exception is the work by Falaschini et al. (2003), which analyses basic Haflinger measurements, such as withers height and chest girth, in selected groups of horses from Italy. For other breeds, conformation analyses were conducted by e.g. Matousova-Malbohanova et al. (2004), Sobotkova et al. (2006), Kralova et al. (2012), Sabbioni et al. (2005) and Popova (2020).

The objective of this study is to analyse the body proportions and breeding direction of Haflingers in the Czech Republic and compare their differences based on the country of origin and development over individual years. The study results should contribute to monitoring and improving breeding quality and optimising selection criteria for including individuals in breeding programs.

MATERIAL AND METHODS

The analysis of Haflinger mares was based on a database provided by the Central Horse Register in Slatinany. The dataset included 825 mares registered in the Czech studbook, for which all necessary data were available. The mares originated from the Czech Republic, Austria, and Germany. Despite the small number of mares from Germany (n = 40), they were included in the analysis due to their influence on the early development of the population. Mares from Italy, France, and Slovakia (a total of 19 mares) were excluded from the evaluation due to minimal numbers.

Analysed factors and grouping

Country of origin:
- Czech Republic (n = 562);
- Austria (n = 223);
- Germany (n = 40).

https://doi.org/10.17221/8/2025-CJAS

Age at studbook entry:
– 3–4 years (n = 614);
– 5–6 years (n = 109);
– 7 years and older (n = 102).
Year of birth:
– 1987–2000 (n = 234);
– 2001–2010 (n = 356);
– 2011–2020 (n = 235).
Proportion of Arabian genes (AG):
– 0% AG (n = 541);
– Proportion not exceeding 1.56% AG (n = 144);
– Proportion exceeding 1.56% AG (n = 140).

The evaluated parameters included scores awarded during studbook entry, withers height measured with a stick (WHS), withers height measured with a tape (WHT), chest girth (CG), cannon bone circumference (CBC), and body indices: massiveness index (MI) and bone index (BI).

Calculation of body indices

The body indices were calculated using the methodology described by Bilek et al. (1955):

$$MI = (\text{chest girth}/WHS) \times 100 \quad (1)$$

$$BI = (\text{cannon bone circumference}/WHS) \times 100 \quad (2)$$

where:
BI – index of bone development;
MI – massiveness index;
WHS – withers height measured with a stick.

Statistical analysis

The data were statistically analysed using the STATISTICA v14 software (TIBCO Software Inc., USA). The statistical model was based on a multifactor analysis of variance (ANOVA) to assess the effects of age at studbook entry, year of birth, country of origin, and the proportion of Arabian genes on conformation scores, individual body dimensions, and body indices.

The ANOVA equation was as follows:

$$y_{ijklm} = \mu + s_i + l_j + a_k + c_l + e_{ijklm} \quad (3)$$

where:
y_{ijklm} – observed body dimension or index;
μ – overall mean;
s_i – fixed effect of age at studbook entry (i = 1, 2, 3);
l_j – fixed effect of the year of birth (j = 1, 2, 3);
a_k – fixed effect of the country of origin (k = 1, 2, 3);
c_l – fixed effect of the proportion of Arabian genes (l = 1, 2, 3);
e_{ijklm} – random residual error.

Statistically significant results were further verified using Scheffe's post-hoc test, which allowed for detailed comparisons between groups and identified differences caused by individual factors.

RESULTS AND DISCUSSION

The statistical analysis results demonstrate the influence of various factors on conformation scores, body dimensions, and indices of Haflinger mares. The year of birth had a highly significant effect on all body dimensions and indices. Age at studbook entry and country of origin statistically significantly influenced most variables, except for WHS and WHT. Conversely, the slightest effect was observed for the proportion of Arabian genes. Table 1 provides an overview of the F-values for individual factors.

When evaluating the individual body measurements of Haflingers, it was shown that height at withers was most influenced by the year of birth (F = 47.30). Similarly, the year of birth was a key factor for the bone index, reaching an F-value of 65.70. Conformation scores were most affected by the age at studbook entry (F = 22.50), while the body mass index was predominantly influenced by the year of birth (F = 25.65). Chest girth was most affected by the age at studbook entry (F = 19.20).

Effect of age on stud book entry

The most significant proportion of horses in our database consists of mares aged 3–4 years (75%), followed by mares registered at the age of 5–6 years (13%) and mares registered after the age of 7 years (12%). According to research by Popova (2020), the average age of the first breeding of Haflinger mares in Bulgaria was 3.98 ± 0.78 years, the average age at first fertilisation was 4.02 ± 0.80 years, and the average age at the birth of the first foal was 5.79 ± 1.43 years. Therefore, planned breeding could be one of the

https://doi.org/10.17221/8/2025-CJAS

Table 1. Effects of age at studbook entry, year of birth, country of origin, and share of Arabian genes on different parameters in Haflinger horses

Measurements/indices	Age at studbook entry effect *F*	Age at studbook entry effect *P*	Year of birth effect *F*	Year of birth effect *P*	Country of origin effect *F*	Country of origin effect *P*	Arabian genes share effect *F*	Arabian genes share effect *P*
Body score	22.50	0.00	4.96	0.01	8.23	0.00	1.49	0.23
WHS	0.10	0.93	47.30	0.00	2.00	0.14	3.60	0.03
WHT	0.60	0.54	37.10	0.00	0.20	0.80	2.40	0.10
CG	19.20	0.00	6.43	0.00	13.63	0.00	1.24	0.29
CBC	8.40	0.00	12.40	0.00	3.60	0.03	5.00	0.01
BI	10.10	0.00	65.70	0.00	8.50	0.00	2.90	0.053
MI	20.18	0.00	25.65	0.00	19.59	0.00	0.91	0.40

Statistically highly significant effect $P \leq 0.01$; statistically significant effect $P \leq 0.05$

BI = bone index; CBC = cannon bone circumference; CG = chest girth; MI = body massiveness index; WHS = withers height measured with stick; WHT = withers height measured with tape

reasons for the early registration of mares in the studbook.

The suitability of evaluating horses at the age of 3 years was also confirmed by the study of Coudkova et al. (2022), who demonstrated in warmblood stallions that horses at 36 months of age reach 97% of the development of their body dimensions. Among these, the most advanced growth, reaching 99% of the full potential, occurs at 36 months, particularly in CBC. WHT and CG reach 98% of their final values during this period.

Scheffe's test confirmed statistically highly significant differences in conformation scores between mares aged 3–4 years and older mares (5–6 years, $P = 0.010$; 7 years and older, $P = 0.000$), with younger mares achieving higher scores. Specific values are presented in Table 2.

In addition to age, external factors such as the environment, the way of horse presentation, and the subjectivity of the evaluator may also influence the final assessment of the horse, as shown in a study by Kralova et al. (2012). However, further research would be necessary to demonstrate this effect in Haflingers.

Statistical analysis did not reveal any effect of the age at studbook entry on WHS and WHT, which aligns with the findings of Matfei et al. (2008), who documented that growth intensity was greatest up to 1.5 years of age, followed by a deceleration in growth until the age of 3.5 years when only minimal increases in withers height were observed – the growth of withers height in Hucul horses.

Additionally, statistically significant differences were observed in CG and CBC between the different age groups of mares. For CG, highly significant differences were noted between mares aged 3–4 years and older mares (5–6 years, $P = 0.002$; 7 years and older, $P = 0.000$), with older mares consistently exhibiting higher CG measurements than younger mares. Similarly, Scheffe's test showed statistically significant differences in CBC, although the specific differences were minimal. Highly significant differences were found between mares aged 3–4 years and older mares (5–6 years, $P = 0.010$;

Table 2. The average body score and measurements are based on the effect of the age at studbook entry

Age	Body score	WHS	WHT	CG	CBC	MI	BI
3–4 years old	7.11	142.98	153.59	180.25	19.06	126.11	13.34
5–6 years old	6.93	142.90	153.77	183.80	19.22	128.70	13.45
7 years old and older	6.80	142.74	153.69	184.87	19.38	129.55	13.58

BI = bone index; CBC = cannon bone circumference; CG = chest girth; MI = body massiveness index; WHS = withers height measured with stick; WHT = withers height measured with tape

https://doi.org/10.17221/8/2025-CJAS

7 years and older, $P = 0.001$), with older mares having larger CBC.

Statistically highly significant differences in the BI were observed not only between mares aged 3–4 years and mares older than 7 years ($P = 0.000$) but also between mares aged 3–4 years and 5–6 years ($P = 0.016$), with older mares exhibiting higher BI values. Similar differences were observed in MI, where mares aged 3–4 years showed lower values than older mares (5–6 years, $P = 0.007$; 7 years and older, $P = 0.000$) (Figure 1).

The study of Matousova-Malbohanova et al. (2004) on Hucul horses confirmed that both MI and BI increase with age. In that study, many examined factors, including MI, increased with age, reaching their highest values in the 7–9-year age group, after which these values slightly decreased with age (above 10 years). In contrast, the BI showed a growth trend that continued throughout the observation period, indicating different developmental dynamics of these indices during the ageing process of horses.

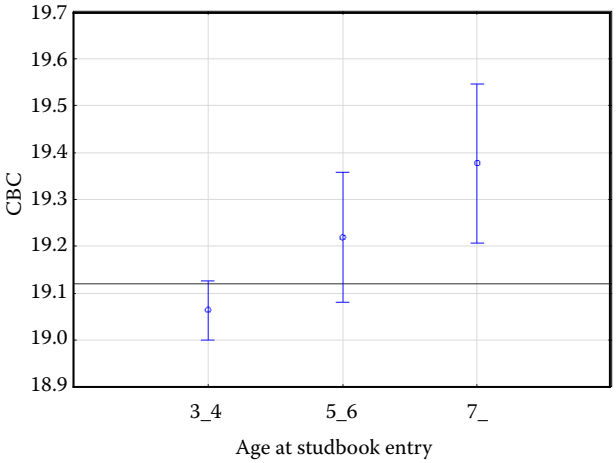

Figure 1. The effect of the age at studbook entry on cannon bone circumference (CBC)

The horizontal line denotes the mean value of the monitored population; The vertical bars represent the standard errors of the differences

3_4 = mares 3–4 years old; 5_6 = mares 5–6 years old; 7_ = mares 7+ years old

Effect of the year of birth

The year of birth may reflect trends in breeding and the development of body parameters, particularly in response to evolving breeding goals and advancements in the refinement of the breed. This study divided mares into three groups based on their year of birth: 1987–2000, 2001–2010, and 2011–2020. The results showed that the year of birth had a statistically significant effect on all selected variables, as confirmed by subsequent Scheffe's post-hoc tests. Conformation scores for mares in the respective groups are presented in Table 3. Scheffe's test revealed statistically highly significant differences between mares born in 1987–2000 and those born in 2001–2010 ($P = 0.001$).

Statistically significant differences were found between all three groups of mares for both WHS and WHT ($P = 0.000$). As shown in Figure 2, the average withers height of mares increased progressively across decades, suggesting long-term trends in breeding and selection for taller withers height. Falaschini et al. (2003) reported a significant increase in withers height in Haflingers between 1984 and 1999, with a rise of +6.06 cm ($P = 0.001$). This development reflects a shift in breeding objectives toward a lighter, riding-oriented type of horse.

A similar trend was observed in draught horse breeds, where the average withers height of stallions gradually increased until the 1970s and 1990s, reaching an average of 160.83 cm. However, after 2000, a decline to 159.26 cm was recorded (Navratil et al. 2016). Sobotkova et al. (2006) also observed an increase in WHS among Old Kladruber horses, from the oldest to the youngest individuals.

For the CG variable, Scheffe's test revealed statistically significant differences between mares born in 1987–2000 and those born in 2001–2010 ($P = 0.016$) as well as between mares born in 2001–2010 and those born in 2011–2020 ($P = 0.002$). The trend in mares' CG initially shows a slight increase, followed by a decrease. A similar pattern

Table 3. The average body score and basic body measurements are based on the effect of the year of birth

Year of birth	Body score	WHS	WHT	CG	CBC	MI	BI
1987–2000	7.16	141.35	152.06	180.45	19.19	127.67	13.58
2001–2010	6.98	142.73	153.45	183.76	19.20	128.08	13.46
2011–2020	7.06	144.84	155.47	179.91	18.93	124.27	13.08

BI = bone index; CBC = cannon bone circumference; CG = chest girth; MI = body massiveness index; WHS = withers height measured with stick; WHT = withers height measured with tape

https://doi.org/10.17221/8/2025-CJAS

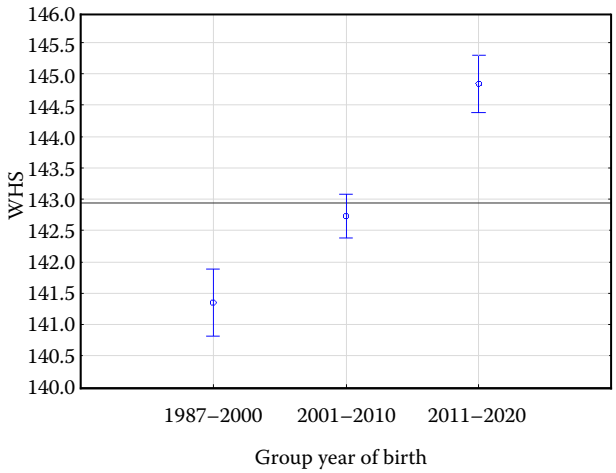

Figure 2. The effect of the year of the birth group on withers height (WHS) measured with a stick

The horizontal line denotes the mean value of the monitored population; The vertical bars represent the standard errors of the differences

was observed in CG of stallions from draught horse breeds, where the average CG reached its highest level of 207.81 cm between 1970 and 1980, followed by a decline to 198.20 cm after 2000 (Navratil et al. 2016).

Falaschini et al. (2003) documented a 12.57 cm reduction in the CG of Italian Haflingers between 1984 and 1999, indicating a shift towards a less robust horse type better suited for riding purposes. The differences in CG are illustrated in Figure 3.

In contrast, Sobotkova et al. (2006) reported that in Old Kladruber horses, the gradual increase in WHS was accompanied by a corresponding decrease in CG, which contradicts our findings.

Statistically highly significant differences were also found for CBC between mares born in 2011–2020 and those born in 2001–2010 (P = 0.000) and 1987–2000 (P = 0.002). The trend in CBC follows a similar pattern to that observed for CG. While there were no significant changes in CBC between mares born in 1987–2000 and 2001–2010, its values decreased in mares born after 2011, suggesting an overall reduction in the limb skeletal robustness. The decline in CBC observed in the study by Falaschini et al. (2003) corresponds with our findings, which also indicate a trend towards lighter limb skeletons in Haflingers.

A similar trend was noted in stallions of draught horse breeds, with average CBC values ranging from 24.11 cm to 24.87 cm across different decades. Stallions born between 1970 and 1980 had an average CBC of 24.71 cm, whereas a decline to 24.18 cm was recorded after 2000 (Navratil et al. 2016).

For the BI, statistically significant differences were found between all three groups of mares: 1987–2000 vs 2001–2010 (P = 0.016), 1987–2000 vs 2011–2020 (P = 0.000), and 2001–2010 vs 2011–2020 (P = 0.000). The development of the BI shows a consistent decline, which is the opposite trend compared to WHS, which increased across generations. BI of 12.1 is typical for riding horses, while for working horses, it can reach 16.2 (Bilek et al. 1955). The mares in our population, with average BI of 13.08 in the last decade, are closer to the riding horse type.

The MI decreased in mares born later. Scheffe's test revealed statistically highly significant differences between mares born in 1987–2000 vs 2011–2020 and 2001–2010 vs 2011–2020 (P = 0.000). The MI follows a similar trend to CG, showing an initial slight increase followed by a significant decline, as shown in Table 3. Bilek et al. (1955) reported MI of 113.5 for respiratory (riding) horse types and 129.5 for lymphatic (working) types. The study by Falaschini et al. (2003) documented the gradual development of Haflingers towards a mesodolichomorphic type, consistent with their shift in the breeding focus from draught work to riding.

Breeding modifications in Haflingers have evolved in response to historical events and economic conditions. According to CSCHH (2017), some of the earliest recorded measurements for Haflingers are found in Dr. Leo Pretz's book from

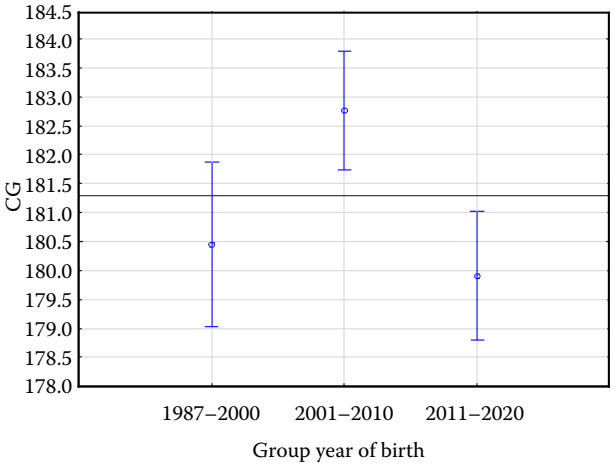

Figure 3. The effect of the year of birth group on chest girth (CG)

The horizontal line denotes the mean value of the monitored population; The vertical bars represent the standard errors of the differences

https://doi.org/10.17221/8/2025-CJAS

1925: WHS – approximately 140 cm, CG – 175 cm, CBC – 18.6 cm for mares and 19.8 cm for stallions. Haflingers were described as elegant horses with slightly disharmonious trunks and often downhill conformation, where the withers were not the highest point. Neumayr (2015) noted significant changes in Haflinger breeding goals in Austria over the years. Since the 1960s, breeding has focused on producing versatile horses with good temperament, quality of movement, and harmonious proportions. The transition from robust mountain draught horses led to the modern refined type with a lighter frame, aligning with recreational and hobby riding demands.

Breeding criteria have prioritised height, movement quality, and uniform coat colour, contributing to the breed's increased attractiveness for contemporary sport and family use.

Withers height and body dimensions are partially influenced by heritability. The findings of Molina et al. (1999) indicate moderate to high heritability for body dimensions in Andalusian horses, particularly for the skeletal system and limb development, with heritability estimates ranging from 0.35 to 0.95. Miserani et al. (2002) obtained even higher values, with 0.61 for WHS and 0.51 for CG in Pantaneiro horses. These high heritability coefficients suggest a significant potential for genetic improvement of these physical traits through selective breeding.

Other findings were reported in additional studies. For example, in Polish Konik horses, heritability was estimated at 0.65 (±0.13) for WHS, 0.22 (±0.14) for CG, and 0.65 (±0.13) for CBC (Wolc and Balinska 2010).

Effect of the proportion of arabian genes

In this study, mares were divided into three groups based on the proportion of Arabian genes, following the rules of the Czech Haflinger studbook and the global breeding objectives. The maximum permissible proportion of Arabian genes is set at 1.56% (ASCHK CZ 2019; Haflinger World 2021). These rules are based on international breeding guidelines, where the proportion of Arabian genes is considered an important indicator of breed purity (Table 4).

In the Czech breeding program, mares with an Arabian gene proportion exceeding 1.56% can remain registered in the studbook under previous regulations. However, after the end of the transitional period (December 31, 2018), their offspring are no longer eligible for studbook registration (ASCHK CZ 2019). Gandini (1997) noted that the proportion of Arabian genes in Italian Haflingers was higher during the early breeding stages but it stabilised over time. This genetic contribution was transmitted through several Arabian ancestors, some of whom significantly impacted subsequent generations.

The Czech Haflinger Association (CSCHH 2017) reported that while Austria preferred purebred Haflingers with no Arabian genes, Germany bred Haflingers with more than 30% of Arabian genes for sporting purposes. Among 26 mares of German origin in our database, the proportion of Arabian genes ranged from 2.34% to 23.63%. This suggests that Arabian genes may have been introduced into Czech breeding programs more by importing horses from Germany. Further extensive research would be necessary to confirm this hypothesis.

Subsequent testing revealed statistically significant differences only in WHS. The difference between mares with no Arabian genes and those with a higher proportion of Arabian genes was statistically significant (0 AG vs AG ≤1.56%, $P = 0.001$; 0 AG vs AG >1.56%, $P = 0.042$). Similarly, statistically significant differences were observed between mares with varying proportions of Arabian genes (AG ≤1.56% vs AG >1.56%, $P = 0.000$).

No comparable studies on the effects of the proportion of Arabian genes in Haflingers were

Table 4. The average body score and basic body measurements are based on the effect of Arabian genes

Arabian genes	Body score	WHS	WHT	CG	CBC	MI	BI
No AG	7.11	143.01	153.64	180.98	19.14	126.62	13.39
AG ≤1.56%	6.92	143.86	154.57	182.87	19.20	127.14	13.35
AG >1.56%	6.98	141.74	152.61	180.87	18.98	127.60	13.39

AG = Arabian genes; BI = bone index; CBC = cannon bone circumference; CG = chest girth; MI = body massiveness index; WHS = withers height measured with stick; WHT = withers height measured with tape

https://doi.org/10.17221/8/2025-CJAS

Table 5. The average body score and basic body measurements are based on the country of origin

Country	Body score	WHS	WHT	CG	CBC	MI	BI
CZE	6.98	142.91	153.73	182.54	19.16	127.77	13.41
AUT	7.22	143.27	153.56	178.58	19.05	124.71	13.31
DEU	7.16	141.50	152.62	178.85	18.98	126.40	13.41

AUT = Austria; BI = bone index; CBC = cannon bone circumference; CG = chest girth; CZE = Czech Republic; DEU = Germany; MI = body massiveness index; WHS = withers height measured with stick; WHT = withers height measured with tape

found, highlighting the need for further evaluations of the influence of crossbreeding with other breeds to compare results.

Effect of the country of origin

The analysis of Haflinger mares' body dimensions included an examination of the effect of the country of origin, considering three countries: the Czech Republic (CZE), Austria (AUT), and Germany (DEU). It is important to note that the number of mares from Germany is relatively low compared to those from the Czech Republic and Austria. This small sample size may affect the accuracy of the results and potentially skew some conclusions (Table 5).

Except for one mare, the mares of German origin were born before 2010. These mares have not been imported into the Czech breeding program for over a decade and primarily influenced Haflinger breeding in the Czech Republic during its early stages.

Subsequent testing revealed statistically significant differences only between Czech and Austrian mares. Czech mares were characterised by greater massiveness, reflected in more considerable CG (P = 0.000), MI (P = 0.000), and BI (P = 0.040). On the other hand, Austrian mares exhibited better conformation scores (P = 0.000).

The breeding objective in the Czech Republic includes the following requirements for mares' body dimensions: WHS between 138 and 150 cm and minimum CBC of 17.5 cm (ASCHK CZ 2019). These requirements closely align with the original Italian breeding program, which also specifies minimum CG of 155 cm, minimum WHS of 137 cm, and CBC between 17 and 21 cm (ANACRHAI 2021).

The breeding objectives of most Haflinger-breeding countries have undergone significant changes in recent decades, aiming at unification on an international level. The original Austrian model remains the foundation of all breeding programs. However, Austria, Italy, and Germany have committed to adhering to unified standards outlined in the Basic Principles of Haflinger Breeding (Haflinger World 2021). These guidelines establish standard measurements such as WHS of 147–150 cm (up to a maximum of 155 cm) and CBC of 18–19 cm, ensuring the typical body conformation of Haflingers (Haflinger World 2021).

Matousova-Malbohanova et al. (2004) also found differences between Hucul horses bred in the Czech Republic and Poland. They recorded variations in withers height, with Czech horses taller than their Polish counterparts (140.84 cm vs 137.99 cm). This suggests that breeding practices may vary globally, even within a single breed. Kulistakova et al. (2024) analysed the genetic diversity of Haflingers in the Czech Republic using microsatellite markers. They concluded that horses born in the Czech Republic and Austria exhibit high genetic similarity and low genetic differentiation (Fst = 0.012). This indicates the significant gene flow between these populations, primarily due to the importation of breeding stock from Austria to the Czech Republic.

CONCLUSION

The analysis of Haflinger mares provided valuable insights into the development of conformation traits of this breed in the Czech Republic. This study confirmed the influence of most examined factors on fundamental body parameters and conformation scores. The year of birth significantly affected all studied variables, with a clear trend of increasing withers height and simultaneously decreasing BI throughout breeding. CBC and body mass index increased between 1987–2001 and 2001–2010 but they subsequently declined, which may indicate changes in Haflinger breeding practices in the Czech Republic over the years.

The age at studbook entry was a statistically significant factor for several traits. Younger mares

https://doi.org/10.17221/8/2025-CJAS

achieved higher conformation scores, whereas older mares exhibited greater CG and CBC, likely reflecting the influence of physical development. The study also observed variations in withers height among mares with different proportions of Arabian genes, though no clear trend was identified. Further research would be necessary to validate and refine the understanding of the impact of Arabian genes on the conformation traits of Haflingers.

The country of origin also emerged as a significant factor; Austrian mares received higher conformation scores than Czech mares, while Czech mares exhibited greater CG, MI, and BI. These differences may reflect divergent breeding strategies.

This study is the first to compare imported Haflinger horses with those bred in the Czech Republic. Future research should evaluate Czech Haflinger breeding in relation to other breeding countries, such as Austria, Italy, and Germany.

The findings of this study underscore the importance of targeted population management for Haflinger mares in the Czech Republic. The results can serve as an important basis for optimising breeding practices and improving the population quality based on breeding objectives. Furthermore, systematic population monitoring and expanding available databases are essential to ensure continued objective evaluation of the breeding population.

Given the trend of declining BI, it is also crucial to focus on maintaining optimal conformation traits that ensure the functionality and resilience of this breed.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

ANACRHAI. Technical norms of the breeding programme of Haflinger breed horses [Internet]. 2021 [cited 2024 Oct 11]. Available from: https://www.haflinger.it/wp-content/uploads/2021/02/Allegato-2-EN_rev.pdf.

ASCHK CR. Chovny cil plemene Haflinger [The breeding objective of the Haflinger breed] [Internet]. 2019 [cited 2024 Oct 11]. Available from: https://www.aschk.cz/wp-content/uploads/2019/07/Chovn%C3%BD-c%C3%ADl-haflinga.pdf. Czech.

Bihuncova I, Jiskrova I, Kostukova M, Cernohorska H, Oravcova I, Sobotkova E. The effect of increasing numbers of horses of undefined breed on horse breeding in the Czech Republic. Acta Univ Agric Silvic Mendel Brun. 2015;63(1):23-8.

Bilek F, Ambroz L, Blazek K, Hartman K, Hanus K, Kral E, et al. Specialni zootechnika – Chov koni [Special animal husbandry – Horse breeding]. Praha: Statni zemedelske nakladatelstvi; 1955. 849 p. Czech.

Coudkova K, Sarova J, Sebek R, Chybicki J. The growth curves for some biometric traits in Czech Warmblood stallions. Acta Univ Agric Silvic Mendel Brun. 2022;70(2): 307-15.

CSCHH. Rocenka chovu Haflinga 2017 [Haflinger breeding yearbook 2017]. Pisek: Cesky svaz chovatelu haflingu, z.s.; 2017. p. 86. Czech.

Druml T, Sauer K, Elsbacher J, Grilz-Sager G, Brem G. Analyse des Genpools, der genetischen Diversitat und der Inzuchtverhaltnisse der osterreichischen Haflinger-population [Analysis of the gene pool, genetic diversity, and inbreeding ratios of the Austrian Haflinger population]. Zuchtungskunde. 2016;88:379-94. German.

Falaschini A, Rizzi S, Pasquini M. Morphological evaluation of the Haflinger horse. Ital J Anim Sci. 2003;2(Suppl 1): 595-7.

Gandini GC, Samore A, Pagnacco G. Genetic contribution of the Arabian to the Italian Haflinger horse. J Anim Breed Genet. 1997;114(5):457-64.

Gille C, Spiller A. Kundenorientierte Zuchtung in der deutschen Reitpferdezucht. Zielgruppensegmentierung im Reitsport: eine empirische Analyse [Customer-oriented breeding in German riding horse breeding. Target group segmentation in equestrian sports: An empirical analysis]. Zuchtungskunde. 2010;82(3):229-40. German.

Grilz-Seger G, Neuditschko M, Mesaric M, Cotman M, Brem G, Druml T. Die Auswirkungen des Umzuchtungsprozesses auf das Haflinger Genom [The effects of the breeding process on the Haflinger genome]. Zuchtungskunde. 2019;91(4):296-311. German.

Gruber M. Harmonisierung als globaler Prozess [Harmonization as a global process]. Haflinger Info. 2020;2020(5): 28-9. German.

Haflinger World. Basic principles of Haflinger breeding [Internet]. 2021 [cited 2024 Oct 11]. Available from: https://www.haflinger-world.com/fileadmin/user_upload/Grundsaetze_Principi_Basic_principles-Haflinger_19.02.2021.pdf.

Kralova B, Jiskrova I, Bihuncova I, Kostukova M, Sobotkova E. Evaluation of the linear description of horses registered in the studbook Czech Warmblood. In: Proceedings of MENDELNET 2012; 2012 Nov 21-22;

https://doi.org/10.17221/8/2025-CJAS

Brno, Czech Republic. Brno: Mendel University in Brno; 2012. p. 362-6.

Kulistakova M, Jiskrova I, Vrtkova I, Bartonova P, Urban T. The genetic diversity and structure of the Haflinger horse population in the Czech Republic. Arch Anim Breed. 2024;67(1):323-33.

Matfei M, Popa D, Popa R. Study of withers height average performances in Hucul horse breed – Hroby bloodline. Lucr Stiint Zootehnie Biotehnol. 2008;41(2):573-6.

Matousova-Malbohanova Z, Hajkova M, Jiskrova I. Porovnani exterieru Huculskych koni chovanych v Ceske republice a v Polsku [Comparison of the exteriors of Hucul horses bred in the Czech Republic and Poland]. Acta Univ Agric Silvic Mendel Brun. 2004;52(1):153-8. Czech.

Messner E. Historischer Abriss der Haflinger Rassebeschreibung [Historical outline of the Haflinger breed description]. Haflinger Info. 2017;22(4):6-9. German.

Miserani MG, Pereira JCC, Mourao GB, Costa MD, Andrade PC, Filho JGM. Genetic parameter estimates for biometric traits of the Pantaneiro horse. Rev Bras Zootec. 2002;31(3):1217-22.

Molina A, Valera M, Dos Santos R, Rodero A. Genetic parameters of morphofunctional traits in the Andalusian horse. Livest Prod Sci. 1999;60(3):295-303.

Navratil J, Duchacek J, Ptacek M, Stadnik L, Eichler V. Development of the body size in stallions of selected Bohemian-Moravian Belgian horse, Silesian Noriker and Noriker breeds in the Czech Republic. J Cent Eur Agric. 2016 Jun;17(2):508-21.

Neumayr AM. Die Entwicklung der osterreichischen Haflingerhengstlinien – eine genealogische Betrachtung [The development of the Austrian Haflinger stallion lines – A genealogical view] [diploma thesis]. [Vienna]: Veterinarmedizinische Universitat Wien; 2015. 107 p. German.

Popova M. Breeding age of mares from the Haflinger breed, duration of gestational length and the influence of some paratype factors on it. Sci Pap Ser D Anim Sci. 2020; 63(1):XXX.

Sabbioni A, Beretti V, Zanon A, Pagani GP, Filippini S, Superchi P, Catalano AL. Morphological evolution of Bardigiano horse. Ital J Anim Sci. 2005;4(Suppl 2):412-4.

Sobotkova E, Jiskrova I, Somerlikova K. Analyza exterieru Starokladrubskeho kone chovaneho v Narodnim hrebcine Kladruby nad Labem [Analysis of the exterior of the Old Kladruby horse bred in the National Stud Kladruby nad Labem]. Acta Univ Agric Silvic Mendel Brun. 2006 Jun 15;54(5):117-28. Czech.

Tocci R, Sargentini C, Martini A, Andrenelli L, Pezzati A, Benvenuti D, Giorgetti A. Hoof quality of Anglo-Arabian and Haflinger horses. J Vet Res. 2017 Sep 19;61(3):367-73.

Vostry M, Vostra Vydrova H, Hofmanova B, Vesela Z, Majzlik I. Genetic diversity in Haflinger horse population in the Czech Republic. J Anim Breed Genet. 2019 Feb; 136(1):123-34.

Wolc A, Balinska K. Inbreeding effects on exterior traits in Polish Konik horses. Arch Anim Breed. 2010 Oct;53: 1-8.

Zanon T, Fuerst-Waltl B, Gruber S, Gauly M. Estimation of the genetic parameters for temperament in Haflinger horses based on the results of a character test using a pedigree-based relationship matrix. Ital J Anim Sci. 2023;22(1):798-804.

Received: January 17, 2025
Accepted: March 6, 2025
Published online: March 24, 2025