ORIGINAL PAPER

AN ANALYSIS OF THE INBREEDING LEVEL OF HOLSTEIN STALLIONS PRESENTED FOR CLASSIFICATION IN 2003–2012

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ABSTRACT

The aim of the present study was to analyze and compare the inbreeding level of the Holstein stallions presented for classification for breeding in 2003–2012 in Germany. The data were collected from the Holsteiner Körung und Reitepferde – Auktion catalogues. Based on the analysis of 869 pedigrees (up to the fifth generation inclusive), inbreeding coefficients (F), expressed as a percentage for each stallion, were calculated. The highest F values were recorded in 2003 (2.05%) and 2004 (1.74%). Statistically significant differences in the F values of the stallions from individual years were found. The outcomes of the present study show that the breeding work based on conscious assumptions is carried out in order to increase an inbreeding level in the sport horses' production, regarding at the same time that the value of the inbreeding coefficient cannot be too high.

Key words: inbreeding, Holstein, stallions, classification, breeding

INTRODUCTION

There is always a great demand worldwide for high-quality sport horses. According to the criteria adopted by the Association of Holstein Horse Breeders, horses of this breed should have long lines, athletic conformation, outstanding movement and jumping abilities. Good character, even temperament, "intelligence" and will to cooperate with a rider are also important [Verband der Zuchter 2004]. Breeding on the highest level is guaranteed by the sires of the high sports and breeding value. In the development of the Holstein breed, English Thoroughbred stallions (Cottage Son, Ladykiller and his two Holstein sons: Landgraf I and Lord), Anglo-Norman stallions (Alme Z and Cor de la Bryere) as well as the halfbred Anglo-Arabian (Ramzes) from the Polish breeding turned out to be the most outstanding [Fedorski 2008].

The modern Holstein horse has high sporting predispositions, which result from the well-thought-out breeding work with regard to mating, breeding material selection and increased genetic consolidation [Bruns et al. 1978, Fedorski 2014]. Such work is aimed at the improvement of horses by accumulating the genes of out-standing ancestors and subsequently consolidating desired traits [Pikuła and Werkowska 2009, 2011a, 2011b].

The aim of the present study was to analyze and compare the inbreeding level of the Holstein stallions presented for classification for breeding in 2003–2012.

MATERIAL AND METHODS

The study was performed on 2.5-year-old Holstein stallions, which were presented for classification for breeding in Neumunster (Germany) in 2003–2012. The data were collected from the Holsteiner Körung und Reitepferde – Auktion catalogues (volumes from 2003––2012). Based on the analysis of 869 pedigrees (up to the fifth generation inclusive), inbreeding coefficients (F), expressed as a percentage for each stallion, were calculated by the authors of the present study using the OpiMate program [Tierärztliche Hochschule 2016]. The statistical analysis of the obtained F values was carried out using Statistica 12.5 software [StatSoft Inc. 2017]. The non-parametric Kruskal-Wallis ANOVA was used to determine significant differences in F between years.

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RESULTS

Table 1 shows the mean inbreeding coefficients (F) of Holstein stallions and their corresponding standard deviations. The highest F values were recorded in 2003 (2.05%) and 2004 (1.74%) and the lowest ones (0.78%) in 2005 and 2008. Statistically significant differences in the F values of the stallions from individual years were found (Table 1). The highest standard deviations of F (2.19%) were observed in 2003, 2006 and 2012, whereas the lowest ones in 2010 (1.35%) and 2005 (1.55%).

Table 1. The mean inbreeding coefficient (F) values of the Holstein stallions presented for classification for breeding in Neumunster in 2003–2012

Tabela 1. Średnie wartości współczynnika inbredu (F) ogierów rasy holsztyńskiej przedstawionych do kwalifikacji do hodowli w Neumunster w latach 2003––2012

Year – Rok	n	Mean, % Średnia, %	SD, %
2003	89	2.0517^A	2.1887
2004	82	1.7366^{Ca}	1.9179
2005	88	0.7841^B	1.5538
2006	95	1.3189^{CB}	2.1913
2007	101	0.8069^B	1.6200
2008	99	0.7768^B	1.7473
2009	91	0.8714^B	1.6265
2010	71	0.8296^B	1.3542
2011	74	1.1378^{BCb}	1.8750
2012	79	1.1722^B	2.1933

$^{a,b, A, B, C}$ – different superscript letters denote statistical significance at P $\leq$ 0.05 (small letters) or P $\leq$ 0.01 (capital letters).
$^{a,b, A, B, C}$ – różne litery oznaczają istotność statystyczną na poziomie P $\leq$ 0,05 (małe litery) lub P $\leq$ 0,01 (wielkie litery).

DISCUSSION

Inbreeding is one of the tools of increasing the homozygosity of a population. Our results show that the F value in 2003–2012 remained on a relatively stable level of 0.78–2.05% (with a slightly decreasing tendency) which means that breeders are conscious of the advantages and dangers resulting from inbreeding. A similar study on the level of inbreeding in Holstein stallions presented for classification in 1978–2006 [Pikuła and Werkowska 2009] showed an upward trend in F with some fluctuations from one year to another. The highest F value was recorded in 2003 (2.05%) and a decreasing tendency was observed since then, which has been confirmed by the results of the present work.

The estimated F values for the Holstein stallions obtained in the present study are also comparable to those reported by Roos et al. [2015], who have recently investigated inbreeding coefficients in 129,923 German Holstein horses. An average F value for the reference population (including all horses) in their study was 2.27% and that for the population comprising only inbred individuals amounted to 2.47%. The respective values for the whole population were 1.57% and 2.17%. Moreover, an analysis of the temporal changes in F revealed that its value increased almost three times over a decade (from 1.1% in 1990 to 2.9% in 2010). An opposite tendency was observed in the present study, in which F generally decreased over a similar time period (between 2003 and 2012). Finally, the mean value of Kalinowski's new inbreeding coefficient reported by Roos et al. [2015] was 1.38% (compared with 0.08% for the ancestral inbreeding coefficient) which indicates that more than 90% of the classical inbreeding occurred in the last five generations.

The inbreeding level in the Slovak population of 831 show jumping horses, including 144 Holsteiners among other breeds, was investigated by Schubertová et al. [2016], who found that an average F value for the inbred horses taking part in the competitions between 2004 and 2013 (74.5% of the whole investigated population) was 0.68%, which was lower than the estimates obtained in the present study.

The mean F value in approx. 12,632 individuals belonging to six Spanish riding-horse breeds (purebreds: Arab Purebred, Menorca Purebred, Spanish Purebred, and crossbreds: Anglo-Arab, Spanish Sport horse and Spanish Trotter horse) divided into two cohorts based on their birth date (from 1989 through 2000 and from 2001 through 2012) has also been recently estimated by Negro et al. [2016]. The global values of Wright's F_{IS} (measuring the level of heterozygosity within subpopulations) in the cited study ranged from –1.0% for Menorca Purebred to 19.0% for Arab Purebred and decreased in the second cohort for all the investigated breeds, apart from Menorca Purebred breed. The values of F_{ST} (measuring genetic differentiation between breeds) ranged from 0.9% (between Anglo-Arab horse and Spanish Sport horse) to 8.6% (between Menorca Purebred horse and Spanish Trotter horse).

In the study by Barcaccia et al. [2013] on the inbreeding level in 140 and 49 Italian Lipizzan horses (depending on the molecular marker type), the values of F_{IS} and F_{IT} were –13.3% and –6.7% on average, respectively, indicating an excessive level of heterozygosity within the subpopulations on the one hand, and a small excess of heterozygous loci in the whole Lipizzan horse genome on the other hand. In addition, an estimated value of F_{ST} (5.8%), measuring the genetic effect of the total population subdivision, revealed a very low genetic differentiation of Italian Lipizzan horse.

The temporal trends in the inbreeding level of another horse breed (467 Thoroughbred horses born in 1961–2006) were investigated by Binns et al. [2012], who found

a marked increase in F during this time period confirmed by the weak but statistically significant correlation (r = 0.24) between the year of birth and the F value. Moreover, a more detailed analysis of the F changes in time showed that the greatest part of this increase occurred in the last 10 years. A similar analysis on inbreeding in 16,472 Andalusian horses and its effect on selected body measurements carried out by Gómez et al. [2009] revealed that an average F value for the total stallion population and the measured subpopulation was 8.3% in both cases and that an approx. 1.0% increase in F for both groups occurred in 1900–2004.

In other recent studies on inbreeding in various horse populations (Spanish Arab Horse, Hanoverian Warmblood horse and Trakehner Horse), the mean F value differed depending on the time period and calculation method. Cervantes et al. [2008] reported an average F value of 7.0% (9.8% for the animals born in 1995–2004) in the population of the Spanish Arab Horse. The F value obtained using the total pedigree increased steadily from the decade 1895–1904 (F = 0%) to the decade 1995–2004 (F = 9.8%), while the temporal change in F calculated based on only the last five generations was more diverse (an initial increase to 6.1% in the decade 1985–1994 followed by a decrease to 5.2% in the decade 1995–2004). In the cited study, 17.7% horses in the whole population had a very high inbreeding level (F $\geq$ 12.5%), whereas the percentage of highly-inbred individuals born in 1995–2004 amounted to 26.7%. In the Hanoverian breed [Hamann and Distl 2008], the average values of F for the whole reference population (animals born from 1980 to 2000), stallions and breeding mares (both born from 1980 to 1995) were 1.33%, 1.19% and 1.29%, respectively. In this study, no clear trend in the mean F value was observed during the 20-year period. Finally, the study by Teegen et al. [2009] on the Trakehner Horse breed revealed a strong increase in the rate of inbreeding from the early 1990s onwards (the whole study period being from 1950 to 2002).

In general, the reported F values showed an upward tendency in most of the above-mentioned breeds, except for the studies by Negro et al. [2016], Hamann and Distl [2008] and (partially) Pikuła and Werkowska [2009]. The results of the present study prove the conscious assumptions of breeders on the use of increased inbreeding in the sport horses' production, but at the same time, it is also desirable that the F values in the population of Holstein stallions are not too high.

CONCLUSIONS

Based on the results obtained in the present study, it can be concluded that the highest values of inbreeding coefficient in the analyzed population of Holstein stallions were recorded at the beginning of the study period (2003–2004) and that a general downward tendency in its values was observed over a decade. Moreover, these outcomes also confirm that the breeding work based on the conscious assumptions is carried out in order to increase the inbreeding level in the sport horses' production, regarding at the same time that the value of the inbreeding coefficient in the population of Holstein stallions cannot be too high. Finally, it should be stated that the consistent and conscious use of modern breeding methods, including the application of controlled inbreeding by the members of the Association of Holstein Horse Breeders, has noticeable effects in the breeding and production of outstanding sport horses. It is certain that the unquestionable achievements of the German breeders should be an example for other Associations, including the Polish breeders of sports horses.

REFERENCES

Barcaccia, G., Felicetti, M., Galla, G., Capomaccio, S., Cappelli, K., Albertini, E., Buttazzoni, L., Pieramati, C., Silvestrelli, M., Supplizi, A.V. (2013). Molecular analysis of genetic diversity, population structure and inbreeding level of the Italian Lipizzan horse. Livest. Sci., 151(2), 124–133.

Binns, M.M., Boehler, D.A., Bailey, E., Lear, T.L., Cardwell, J.M., Lambert, D.H. (2012). Inbreeding in the Thoroughbred horse. Anim. Genet., 43(3), 340–342.

Bruns, E., Bierbaum M., Frese D., Haring H.J. (1978). Die Entwicklung von Selektionskriterien für die Reitpferdezucht. Zuchtungskunde, 50, 93–100.

Cervantes, I., Molina, A., Goyache, F., Gutiérrez, J.P., Valera, M. (2008). Population history and genetic variability in the Spanish Arab Horse assessed via pedigree analysis. Livest. Sci., 113(1), 24–33.

Fedorski, J. (2014). Nowoczesny koń sportowy we współczesnej Europie. Naukowe i praktyczne aspekty hodowli koni w Europie. Materiały konferencyjne [A modern sports horse in contemporary Europe. Proc. of the International Scientific Conference on the Scientific and Practical Aspects of Horse Breeding in Europe]. 6 June 2014, Kraków, Poland, 13 [in Polish].

Fedorski, J. (2008). Najważniejsze rody holsztyńskie [The most important Holstein strains]. Koń Pol., 1, 44–46 [in Polish].

Gómez, M.D., Valera, M., Molina, A., Gutiérrez, J.P., Goyache, F. (2009). Assessment of inbreeding depression for body measurements in Spanish Purebred (Andalusian) horses. Livest. Sci., 122(2–3), 149–155.

Hamann, H., Distl, O. (2008). Genetic variability in Hanoverian warmblood horses using pedigree analysis. J. Anim. Sci., 86(7), 1503–1513.

Negro, S., Solé, M., Pelayo, R., Gómez, M.D., Azor, P.J., Valera, M. (2016). Molecular diversity between two cohorts of six Spanish riding-horse breeds: Impact of selection in Crossbred vs Purebred populations. Livest. Sci., 193, 88–91.

Pikuła, R., Werkowska, W. (2009). Analysis of the degree of inbreeding in Holstein stallions. Book of Abstracts of the 60th Annual Meeting of the EAAP. 24–27 August 2009, Barcelona, Spain, 225.

Pikuła, R., Werkowska, W. (2011). Charakterystyka modeli inbredu na wybitnych męskich przodków ogierów rasy holsztyńskiej. Konie trakeńskie i wielkopolskie w realiach XXI wieku Materiały konferencyjne [Characteristics of the models of inbreeding to excellent male ancestors in Holstein stallions. Proc. of the Scientific Conference on Trakehner and Wielkopolski Horses in the Reality of the 21st Century], 14–16 June 2011, Olsztyn, Poland, 60 [in Polish].

Pikuła, R., Werkowska, W. (2011). Porównanie wartości współczynników inbredu ogierów rasy holsztyńskiej i polski koń szlachetny półkrwi. Konie trakeńskie i wielkopolskie w realiach XXI wieku. Materiały konferencyjne [Comparison of the values of inbreeding coefficient in Holstein and Polish Noble Half-bred stallions. Proc. of the Scientific Conference on Trakehner and Wielkopolski Horses in the Reality of the 21st Century]. 14–16 June 2011, Olsztyn, Poland, 59 [in Polish].

Roos, L., Hinrichs, D., Nissen, T., Krieter, J. (2015). Investigations into genetic variability in Holstein horse breed using pedigree data. Livest. Sci., 177, 25–32.

Schubertová, Z., Candrák, J., Rolinec, M. (2016). Genetic evaluation of show jumping horses in the Slovak Republic. Ann. Anim. Sci., 16(2), 387–398.

StatSoft (2017). Statistica 12.5. StatSoft Inc., Tulsa, OK, USA.

Teegen, R., Edel, C., Thaller, G. (2009). Population structure of the Trakehner Horse breed. Animal, 3, 6–15.

Tierärztliche Hochschule (2016). OptiMate. Tierärztliche Hochschule, Hannover, Germany.

Verband der Zuchter (2004). Bericht, 2004.

ANALIZA STOPNIA INBREDU OGIERÓW RASY HOLSZTYŃSKIEJ PRZEDSTAWIONYCH DO KWALIFIKACJI W LATACH 2003–2012

STRESZCZENIE

Celem pracy była analiza i porównanie stopnia inbredu ogierów rasy holsztyńskiej przedstawionych do kwalifikacji do hodowli w Niemczech w latach 2003–2012. Dane zostały zebrane na podstawie katalogów Holsteiner Körung und Reitepferde – Auktion. Na podstawie analizy 869 rodowodów (do 5 pokolenia włącznie) zostały wyliczone (w % dla każdego ogiera) współczynniki inbredu (F). Najwyższą wartość współczynniki uzyskały w roku 2003 (2,05%) oraz 2004 (1,74%). Stwierdzono różnice statystycznie istotne między wartościami F ogierów z poszczególnych lat. Uzyskane wyniki świadczą o świadomych założeniach pracy hodowlanej nad wykorzystaniem zwiększonego inbredu w produkcji koni sportowych, ale z drugiej strony o dążeniach do tego, żeby wartości współczynników inbredu nie przekraczały w populacji ogierów holsztyńskich zbyt wysokich wartości.

Słowa kluczowe: inbred, rasa holsztyńska, ogiery, kwalifikacja, hodowla