ISSN 1644-0714
ISSN 2300-6145 (online)
DOI:10.21005/asp.2016.15.3.09
www.asp.zut.edu.pl

ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 15(3) 2016, 111–118

COMPARISON OF INBREEDING COEFFICIENTS IN POLISH HALFBRED AND HOLSTEIN STALLIONS

Ryszard Pikuła[1], Daniel Zaborski[2]✉, Wilhelm Grzesiak[2], Wioletta Werkowska[1]

[1]Laboratory of Horse Breeding and Animal Assisted Therapy, West Pomeranian University of Technology, Szczecin, Doktora Judyma 14, 71-466 Szczecin, Poland
[2]Laboratory of Biostatistics, West Pomeranian University of Technology, Szczecin, Doktora Judyma 10, 71-466 Szczecin, Poland

Abstract. The aim of this study was to compare the inbreeding coefficients (F) in Polish Halfbred (PH) and Holstein (H) stallions in the area of their Associations' activity in 2004 and 2012. A total of 184 PH and 209 H stallions covering in 2012 in Poland and the area of Holstein Horse Breeders Association were investigated. The calculated F values were compared depending on the stallion's breed. In addition, all the stallions were assigned to one of the four groups depending on the F value. The mean F value for the PH stallions (0.22%) was significantly lower than that for the H stallions (0.89%). Most animals of both breeds (88.59% and 69.38%, respectively) were not inbred. The F values in 2004 and 2012 for the H stallions did not differ significantly, whereas those for the PH stallions were significantly higher in 2012 compared with 2004. It can be concluded that using a greater kinship level in order to increase horses' performance value becomes popular.

Key words: Holstein, Polish Halfbred Horse, inbreeding coefficient

INTRODUCTION

The concept of inbreeding and its consequences was unknown until the beginning of the 20th century. The breeders of many animal species observing the rule that "like begets like" applied mating in close kinship in order to obtain excellent animals accumulating the most valuable traits of their ancestors [Filistowicz

✉daniel.zaborski@zut.edu.pl

2015]. In the case of horses, it is especially popular to use inbreeding in the breeding for the lines of excellent ancestors, i.e. foundation stallions of the so-called strains or lines. The globalization of horse breeding through the use of artificial insemination results in the utilization of the same gene pool across many countries and breeding associations. This way, horses improved in terms of their performance traits are obtained, but, at the same time, the possibility of inbreeding depression occurrence must be taken into account. This danger also concerns indigenous horse breeds, present in small populations [Budzyński et al. 2001, van Eldik et al. 2006, Avdi and Banos 2008, Gómez et al. 2009, Vostrỳ et al. 2011, Barcaccia et al. 2013].

In recent years, well-thought-out inbreeding has increasingly been applied in sport horse production. The aim of such actions is the improvement of horses through the accumulation of the genes of excellent ancestors, and then the consolidation of desired traits, due to which the lines of a high performance level can be obtained [Fedorski 2014, Pikuła and Werkowska 2009, 2011a].

The observation of the changes and trends in the European breeding of sport horses caused that also in Poland, valuable stallions registered by the World Breeding Federation for Sport Horses and representing the best commercial lines, have been appreciated. The introduction of the genes of these excellent ancestors and their conscious accumulation through inbreeding is aimed at the improvement of traits determining the sports performance of Polish Halfbred horses.

The aim of the present study was to compare the inbreeding level of Polish Halfbred and Holstein stallions in the area of their Associations' activity in the years 2004 and 2012.

MATERIAL AND METHODS

A total of 184 Polish Halfbred stallions (excluding those from foreign breeding registered in the Polish Halfbred Horse Stud-Book) covering in 2012 in Poland (Stallion Register 2012) and 209 Holstein stallions covering at the same time in the Holstein Horse Breeders Association (Hengstsationierung 2012) were investigated. Due to the long process of data collection and processing, no newer information was available for the study. Based on pedigree analysis (up to the fifth generation inclusive) the coefficients of inbreeding (F) were calculated using the OptiMate computer program (Tierärztliche Hochschule, Hannover, Germany). The coefficient value was expressed as a percentage for each stallion. The F values were compared with each other depending on the stallion's breed. In addition, all the stallions were assigned to one of the four groups depending on the F value: 0%, 0.1–3.0%, 3.1–6.0% and more than 6.0%. The results were compared with

the outcomes of the studies on the inbreeding of stallions covering in 2004 [Pikuła and Werkowska 2011b].

RESULTS

It was found that the mean value of the inbreeding coefficient (F) for Polish Halfbred stallions was 0.22% and it was statistically significantly lower ($P \leq 0.05$) than that for Holstein stallions (0.89%) (Table 1). Comparing the values of the inbreeding coefficients of the stallions obtained in two research periods, no statistically significant differences were found between the F values for Holstein stallions in 2004 and 2012 (Table 1). However, Polish Halfbred stallions covering in 2012 were characterized by the coefficient of inbreeding (0.22%) which differed statistically significantly ($P \leq 0.05$) from that (0.16%) in 2004 (Table 1).

Table 1. Percentage values of inbreeding coefficient depending on the breed in 2004 and 2012

Tabela 1. Wartości procentowe współczynnika inbredu w zależności od rasy w roku 2004 i 2012

Breed Rasa	2004			2012		
	n	$\bar{x}$	SD	n	$\bar{x}$	SD
Holstein – holsztyńska	199	1.1432	0.4735	209	0.8936*	1.5046
Polish Halfbred Horse Polski koń szlachetny półkrwi	280	0.1568^{a}	0.3507	184	0.2217^{b}*	0.7604

a, b – different superscript letters within rows denote statistical significance at $P \leq 0.05$, * – asterisks within columns denote statistical significance at $P \leq 0.05$.
a, b – różne litery w wierszach oznaczają istotność statystyczną przy $P \leq 0,05$, * – gwiazdki w kolumnach oznaczają istotność statystyczną przy $P \leq 0,05$.

Considering the F value, it was observed that for both breeds, the most numerous group was that of the non-inbred animals, including 88.59% of Polish Halfbred stallions and 69.38% of Holstein stallions (Table 2). Similar values were found for the percentage of stallions in the 0.1 to 3.0% group (9.24% and 10.53% for Polish Halfbred and Holstein breed, respectively). In subsequent classes (3.1 to 6.0%) the differences were considerable, i.e. 1.63% and 18.18% for Polish Halfbred and Holstein stallions, respectively. In the range of the F value above 6.0%, only one stallion covered in the Polish breeding (0.54%) and four Holstein stallions (1.91%) in the Holstein Association.

DISCUSSION

In the present work, the mean values of inbreeding coefficient in Polish Halfbred and Holstein stallions amounted to 0.16% and 1.14% in 2004 and 0.22% and

Table 2. Percentage of stallions depending on breed and the range of inbreeding coefficient in 2004 and 2012

Tabela 2. Odsetek ogierów w zależności od rasy i zakresu współczynnika inbredu w roku 2004 i 2012

Inbreeding coefficient range, % Zakres współczynnika inbredu, %	2004		2012	
	Holstein - holsztyńska	Polish Halfbred Horse polski koń szlachetny półkrwi	Holstein - holsztyńska	Polish Halfbred Horse polski koń szlachetny półkrwi
0	68.34	94.33	69.38	88.59
0.1–3.0	6.03	2.48	10.53	9.24
3.1–6.0	20.10	2.48	18.18	1.63
6.1–9.0	5.53	0.71	1.91	0.54

0.89% in 2012, respectively. The lack of a significant difference in the F values for Holstein stallions in 2004 and 2012 observed in the present study results from the consistent breeding work on the use of a greater kinship level in order to increase the performance value of the bred horses carried out by the Holstein Association. At the same time, the possibility of an excessive increase in inbreeding is limited by the informed selection of stallions for covering. Polish breeders are still learning this breeding method but the first effects are already present, which is reflected in a higher F value for Polish Halfbred stallions in 2012 compared with 2004.

In the production of sport horses, the crossbreeding of animals of a high performance value is performed. The concept of a breed is frequently substituted with the term Stud-Book, for which stallions and mares representing the horses belonging to a given Breeding Association are registered. These are the horses characterized by the traits essential for the realization of a breeding goal, i.e. the production of horses intended for high sport performance, with a clear determination of the usefulness for a given riding discipline. For horse breeds with a high and uniform sport performance value, only the use of well-thought-out and controlled inbreeding guarantees the breeding progress based on increased homozygosis. And Holstein stallions are an example of such well-thought-out breeding work.

In the relatively new populations, such as those of Polish Halfbred Horse, an increase in a performance value in the initial period is obtained using the so-called heterosis effect. The breed improvement is attained by crossing native mares with foreign stallions, belonging to the so-called sport lines. Due to these stallions, often with inbred pedigrees, and the purchase of mares, which also have ancestors proved in terms of performance utility, the coefficient of inbreeding rises slowly but systematically in the breeds of sport horses bred in Poland. The possibility of applying on a greater scale the method of inbreeding in the Polish Halfbred

Horse results from certain limitations, e.g. an unknown or low performance value of mares, the use in breeding of stallions with the so-called sport pedigrees, but frequently with a low own sports performance, the small population of Polish Halfbred Horse and the lack of a common breeding program based on a well-thought-out and consistent mating. All the above-mentioned factors result in a relatively small role of inbreeding in the Polish production of sport horses, in contrast to the horse breeding in the German, Dutch or Belgian Associations.

In the recent years, several articles on the inbreeding level in different horse breeds across Europe have been published. In the study by Walkowicz [2009] on the inbreeding coefficients in 849 Silesian horses, the mean F value in the present population was 1.26% and it was two times higher than the value (0.54%) for the population in the post-war Poland. Hence, the reported figure was higher than that in the present study. Moreover, according to this author, the number of inbred horses doubled during this period (23.3% vs. 54.3%) and stallions were characterized by a higher F value than mares (1.41% vs. 1.14% in the whole population and 2.55% vs. 2.13% in the group of inbred horses). A similar estimation of the inbreeding coefficient was obtained in the population of 5180 Hucul horses [Nogaj et al. 2001], where the mean F value calculated from the allele frequencies of seven selected protein loci amounted to 1.18%. In another study on the Hucul horses kept in Bieszczady National Park in Poland [Jackowska et al. 2013], it was observed that the average F value among leading stallions was 5.2% (range 0.59–13.92%) and the respective value for breeding stallions was 3.76% (range 0.05–7.72%). In the groups of three-year-old, two-year-old and one-year-old stallions, the mean F values were 5.0% (4.79–5.23%), 5.37% (2.00–9.18%) and 4.8% (2.00–6.54%), respectively, so they were much higher than those obtained in our study. In a different work on the inbreeding depression for body measurements in Andalusian horses, Gómez et al. [2009] recorded the mean F value for the whole population of stallions equal to 8.3% (range 0.0–54.0%) and that for the measured subpopulation also amounting to 8.3% (range 0.9%–37.1%). They also observed a similar increase (approx. 1.0%) in the F value for the whole and measured populations between the years 1900 and 2004. In another breed of horses (the endangered purebred Skyros horses in Greece), Avdi and Banos [2008] noted the F value of 11.0% for the 21 inbred individuals (accounting for 32% of the 66 non-founding animals) and 3.0% for the whole analyzed population of the above-mentioned 66 non-founding horses. The estimated F-value ranged between 2.34% and 25.0%. Moreover, the cited authors observed a 0.9% annual increase in the proportion of inbred animals in the period 1998–2008 and the mean annual inbreeding change of 0.002. On the other hand, the analysis of the effect of inbreeding coefficient on reproduction traits in 285 Shetland pony stallions [van Eldik et al. 2006], revealed that that the mean value of F was 3.0% (ranging from less than 1.0% to almost

25.0%) and the number of stallions in the individual classes of inbreeding coefficient (below 1.0%, 1.0–2.0%, 2.0–5.0%, 5.0–8.0%, 8.0–12.0% and above 12.0%) was 132, 40, 42, 27, 25 and 19, respectively. The ranges of inbreeding coefficient were also investigated by Vostrỳ et al. [2011] in the three breeds of Czech cold-blooded horses (Silesian Noriker, Noriker and Czech-Moravian Belgian). These authors found that the mean F values in 1990 were 2.01, 1.16 and 2.54%, respectively, and they increased to 3.23, 1.51 and 3.55%, respectively, in 2007. Moreover, the F value was 0 for 23.68% of horses and it ranged from more than 0 to less than 6.25 for 70.01% of horses. A total of 5.79% of horses belonged to the group whose F value ranged from more than 6.25% to less than 12.5 and 0.52% to the group whose F value was above 12.5%. The first two groups (F < 6.25%) comprised 93.69% of all investigated horses. This finding was similar to our results, which showed that 98.09% of Holstein horses and 99.46% of Polish Halfbred horses had F lower than or equal to 6.0%. Finally, in the work on the inbreeding level of Italian Lipizzan horses based on the analysis of amplified fragment length polymorphism (AFLP) and simple sequence repeat (SSR) markers [Barcaccia et al. 2013], Wright's inbreeding coefficient F_{is} (measuring the level of heterozygosity within subpopulations) was –0.133 on average suggesting its excessive extent. In addition, the mean value of Wright's inbreeding coefficient F_{it} (measuring the level of heterozygosity between subpopulations) (–0.067) showed a small excess of heterozygous loci in the genome of the Lipizzan horse and the value of F_{st} (0.058) (which measured the genetic effect of total population subdivision as the proportional reduction in the overall heterozygosity due to variation in SSR allele frequencies among different subpopulations) indicated a very low degree of genetic differentiation in this horse breed.

CONCLUSIONS

Based on the performed analysis, it can be stated that the mean value of the inbreeding coefficient for Polish Halfbred stallions was significantly lower than that for Holstein stallions. In addition, most stallions of both breeds were not inbred. Finally, the values of inbreeding coefficient in 2004 and 2012 for Holstein stallions did not differ significantly, whereas those for Polish Halfbred stallions were significantly higher in 2012 compared with 2004, which shows that using a greater kinship level in order to increase horses' performance value becomes popular.

REFERENCES

Avdi, M., Banos, G. (2008). Genetic diversity and inbreeding in the Greek Skyros horse. Livest. Sci., 114(2–3), 362–365.

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.

Budzyński, M., Kamieniak, J., Sapuła, M., Sołtys, L., Budzyńska, M., Krupa, W., Stefaniuk, A. (2001). Zależności przyczynowe między poziomem cech rozrodu a inbredem klaczy arabskich [Causation relations between the level of reproductive indexes and the inbreeding of Arabian mares]. Ann. Univ. Mariae Curie-Sklodowska Sect. EE Zootech., 19, 153–159 [in Polish].

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].

Filistowicz, A. (2015). Inbred w doskonalonych i chronionych populacjach zwierząt gospodarskich [Inbreeding in improved and protected livestock populations]. Prz. Hod., 83(2), 3–6 [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.

Jackowska, A., Jackowski, M., Holovach, M. (2013). Konie huculskie hodowli Bieszczadzkiego Parku Narodowego w Wołosatem [Hucul horses breeding in the Bieszczady National Park at Wolosate]. Rocz. Bieszczadzkie, 21, 259–286 [in Polish].

Nogaj, A., Nogaj, J., Kozubska-Sobocińska, A., Rychlik, T. (2001). Evaluation of changes in the genetic structure of Hucul horses based on the analysis of I type of genetic markers. Ann. Univ. Mariae Curie-Skłodowska Lub. – Pol. Sect. EE, 31(2), 39–48.

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].

van Eldik, P., van der Waaij, E.H., Ducro, B., Kooper, A.W., Stout, T.A.E., Colenbrander, B. (2006). Possible negative effects of inbreeding on semen quality in Shetland pony stallions. Theriogenology, 65(6), 1159–1170.

Vostrỳ, L., Čapková, Z., Pribyl, J., Mach, K. (2011). Analysis of Czech cold-blooded horses: genetic parameters, breeding value and the influence of inbreeding depression on linear description of conformation and type characters. Czech J. Anim. Sci., 56(5), 217–230.

Walkowicz, E. (2009). Ocena zinbredowania współczesnej populacji koni śląskich [Inbreeding in the modern population of Silesian horses]. Zesz. Nauk. Uniw. Przyr. we Wrocławiu Biol. Hod. Zwierz., 58(572) 159–170 [in Polish].

PORÓWNANIE WARTOŚCI WSPÓŁCZYNNIKÓW INBREDU OGIERÓW RASY POLSKI KOŃ SZLACHETNY PÓŁKRWI I HOLSZTYŃSKIEJ

Streszczenie. Celem badań było porównanie wartości współczynników inbredu (F) ogierów rasy polski koń szlachetny półkrwi (sp) i holsztyńskiej (h) kryjących na terenie działalności swoich Związków, w latach 2004 i 2012. W badaniach uwzględniono łącznie 184 ogiery sp i 209 ogierów h kryjących w roku 2012 odpowiednio w Polsce oraz w Holsztyńskim Związku Hodowców Koni. Wyliczone wartości F porównano w zależności od rasy ogierów. Dodatkowo, każdy ogier został przypisany do jednej z czterech grup wyodrębnionych na podstawie zakresu wartości F. Średnia wartość F dla ogierów sp (0,22%) była istotnie niższa od wartości dla ogierów h (0,89%). W obu rasach najliczniejszą grupę (88,59 i 69,38%, odpowiednio dla rasy sp i h) stanowiły ogiery niezinbredowane. Średnie wartości F ogierów h w roku 2004 i 2012 nie różniły się istotnie, natomiast wartości F ogierów sp były istotnie wyższe w roku 2012 niż w 2004. Można wnioskować, że wykorzystanie zwiększonego pokrewieństwa w celu podwyższenia wartości użytkowej hodowanych koni staje się popularne.

Słowa kluczowe: rasa holsztyńska, polski koń szlachetny półkrwi, współczynnik inbredu

Accepted for print: 14.11.2016

For citation: Pikuła, R., Zaborski, D., Grzesiak, W., Werkowska, W. (2016). Comparison of inbreeding coefficients in Polish Halfbred and Holstein stallions. Acta Sci. Pol. Zootechnica, 15(3), 111–118. DOI: 10.21005/asp.2016.15.3.09