

## **Analysis of the inbreeding level in the active population of pigs of different breeds in Poland**

GRZEGORZ ŻAK, MAGDALENA SZYNDLER-NĘDZA, ROBERT ECKERT  
Department of Animal Genetics and Breeding, National Research Institute of Animal Production

**Abstract:** *Analysis of the inbreeding level in the active population of pigs of different breeds in Poland.* Pig breeders in Poland have made extensive use of the BLUP-AM method since 1999. The application of this method for evaluating the breeding value of pigs improves their breeding value in nucleus herds and in the general population. On the other hand, the use of many sources of information (including pedigree information) in the calculations considerably increases the risk of inbreeding. The objective of the study is to estimate the level of inbreeding in sows and boars from the domestic pig population, which have been selected for more than 10 years based on the BLUP-AM estimated breeding value. The study involved Polish Large White, Polish Landrace, Hampshire, Duroc, Pietrain and Puławska sows and boars born between 2007 and 2011. Data on a total of 16,842 sows and 977 boars representing the 6 breeds raised in Poland were collected for the pedigree analyses. During the analyzed period, the coefficient of inbreeding in sows ( $F$ ) ranged from 0 to 0.25 (14 animals). Most of the animals were non-inbred (70% in the PLW and Puławska, over 80% in the PL, Duroc and Pietrain and 100% in the Hampshire). For the boars, the coefficient of inbreeding varied from 0 to 0.1875 (1 animal). The proportion of non-inbred boars was 77% in the PLW, 91% in the PL, 63% in the Puławska, and about 80% in the Duroc and Pietrain breeds. The results point to the appropriate structure of the pig population in terms of inbreeding, which shows that the selection of animals for mating has been correct and there have been no negative consequences of using the BLUP method.

*Key words:* pigs, inbreeding, BLUP

## INTRODUCTION

In addition to the decreasingly popular selection index method, the breeding value of pigs in Poland is estimated by the BLUP-AM (Best Linear Unbiased Prediction-Animal Model). In Polish pig breeding, this method has been widely used since 1999. The application of the BLUP method for evaluating breeding value improves the breeding value of pigs in the nucleus population, as reflected in the results obtained in the general population. Long-term selection of pigs for lean meat production and daily weight gain has increased this parameter in the boars and gilts of all breeds (Eckert and Szyndler-Nędza 2015, Eckert et al. 2015). Using BLUP with information on relatives increases genetic progress but, on the other hand, though the use of many sources of information in the calculations when breeding material is intensively selected, it carries a significantly greater risk of inbreeding (Bijma and Woolliams 2000, Muir 2000, Żak and Różycki 2002, Żak and Różycki 2004, Colleau and Tribout 2008, Filistowicz 2015). Given that an excessive increase in inbreeding may lead to inbreeding depression, especially

with regard to low heritable traits associated with reproductive performance, it is essential that the level of inbreeding must be monitored for every breed raised in Poland (Mroczko and Różycki 2001, Szyndler-Nędza et al. 2014).

The inbreeding analysis performed in sows and boars born during 1989–1993 showed that average inbreeding in Poland was 0.0054 for sows and 0.0050 for boars, ranging from 0.0030 in Puławska pigs to 0.0176 in the Pietrain breed (Mroczko 1999). In the analyzed population, the inbreeding level of inbred sows and boars was similar – at 0.0344 and 0.0324, respectively. For sows and boars born in subsequent years, the inbreeding level increased as was found. Pedigree analysis performed by Szyndler-Nędza et al. (2013) for animals born between 2004 and 2010 showed an increase of inbreeding coefficient in the population of pigs of maternal breeds. Annual average changes in the coefficient of inbreeding in both populations (sows and boars) were 0.06% in the Polish Large White and 0.01% in the Polish Landrace pigs. Considering the negative effects of excessive inbreeding of animals in the active population, it is necessary and practically justified to perform periodic analyses of changes in the inbreeding coefficient separately in the sows and boars raised in Poland.

The studies involved analysis of inbreeding for the active population of the most frequent pig breeds in Poland. Currently, only information of single individuals has been utilized for mating. This kind of study was not considered earlier in Polish literature and in aspect of whole active boars and sows population.

The aim of the study is to estimate the degree of inbreeding in sows and boars from the domestic pig population, which have been selected for more than ten years based on BLUP-AM estimated breeding value.

## MATERIAL AND METHODS

The study was performed at the National Research Institute of Animal Production and at the Institute's Experimental Station in Grodziec Śląski Ltd. The study involved Polish Large White (PLW), Polish Landrace (PL), Hampshire, Duroc, Pietrain and Puławska sows and boars born between 2007 and 2011. Pedigree data for a total of 33,569 sows and 2,926 boars were obtained for the study from available data sets.

Prior to determining the level of inbreeding, the completeness of data was analyzed in terms of the number of known ancestors of the sows and boars in different generations; this analysis was performed to calculate the pedigree completeness. Only animals with at least three complete generations of ancestors were included in the calculations. Following verification of the pedigree data, data for 16,842 sows and 977 boars representing 6 breeds in Poland were further used. The inbreeding coefficients were estimated based on the methods of Quass (1976) and Hendersson (1976) using the program Optimate 2000.

## RESULTS AND DISCUSSION

In Polish pig breeding the use of BLUP together with information on relatives

significantly accelerates genetic progress in productive traits but, on the other hand, it may increase the degree of relationship in animals selected for parents of the next generation. As a result, inbreeding level in the population subjected to BLUP evaluation may increase and cause negative effects in breeding. We analyzed the level of inbreeding in the current pig population. Sows and boars born between 2007 and 2011 were investigated. Data were collected for a total of 16,842 sows and 977 boars of 6 breeds raised in Poland. The number of sows and boars in different breeds is presented in Table 1. Most of the animals originated from herds of 21–50 and 51–100 sows of the foundation stock. The number of sows and boars of all the studied breeds in herds with a different number of sows is shown in Table 2.

TABLE 1. The number of sows and boars of different breeds, born in the years 2007–2011, included in the study

Breed	The number of sows	The number of boars
PLW	6 244	319
PL	7 930	448
Puławska	1 462	144
Hampshire	16	–
Duroc	822	29
Pietrain	368	37
Total		
	16 842	977

The coefficient of inbreeding was estimated for the sows and boars. During the analyzed period, approximately 70% of the sows in maternal PLW and Puławska breeds were not inbred. Non-inbred sows accounted for over 80% in

TABLE 2. The number of sows and boars of all breeds, born in the years 2007–2011 in herds of different size of sows

Herd size (sows)	The number of sows	The number of boars
<5	2 209	167
6–10	99	10
11–20	1 442	66
21–50	8 097	492
51–100	3 003	193
>100	1 992	49
Total		
	16 842	977

the PL breed and the Duroc and Pietrain sire breeds, and 100% in the Hampshire breed (Table 3). The maximum value of the inbreeding coefficient in the sows was 0.25. Such a high degree of inbreeding was observed in 4 PLW sows, 2 PL sows, 5 Duroc sows and 3 Pietrain sows.

TABLE 3. Percentage of animals with inbreeding coefficient  $F = 0$  in different breeds

Breed	Sows	Boars
PLW	74.98	77.14
PL	87.87	91.29
Puławska	71.89	63.89
Hampshire	100	–
Duroc	86.13	82.76
Pietrain	83.15	83.78

In maternal breeds (PLW, PL, Puławska) and in the Duroc breed, most of the sows had an inbreeding coefficient of 0.0156–0.0314 (13, 7.9, 18 and 7.9%, respectively), followed by 0.0625–0.125 (9, 3.6, 7.3 and 4.8%, respectively). The proportions for the Pietrain breed were the opposite, because in most sows the inbreeding ranged from 0.0625 to 0.125

(9.2%) – Figures 1–5. Compared to the inbreeding coefficients estimated by Mroczo (1999) for sows of different breeds raised in 1989–1993, it can be stated that over the last twenty years the number of non-inbred sows of the PLW, Puławska, Duroc and Pietrain breeds has diminished; whereas in the PL breed, the

number of animals with zero inbreeding is similar. The generally lower inbreeding coefficient in the breeds that were raised during the above period was influenced by the large number of sows whose inbreeding coefficient was up to 0.0313. In the active population, there were 77% and 73% of such sows in the PLW and

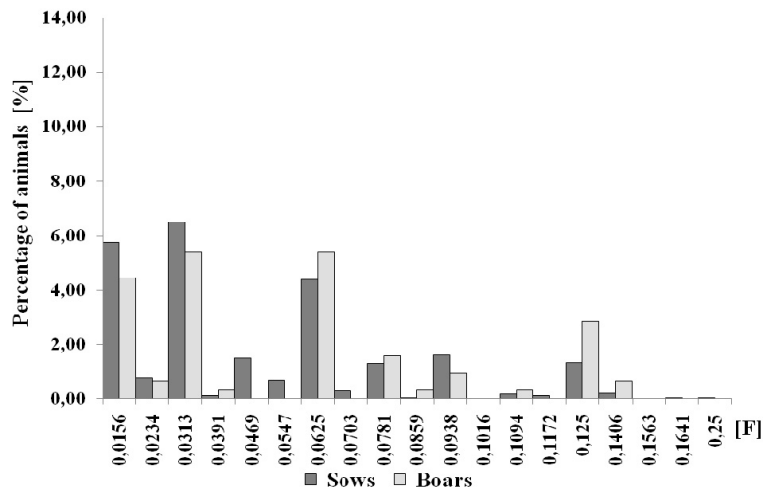


FIGURE 1. Distribution coefficients of inbreeding ( $F$ ) in the population of animals – Polish Large White breed

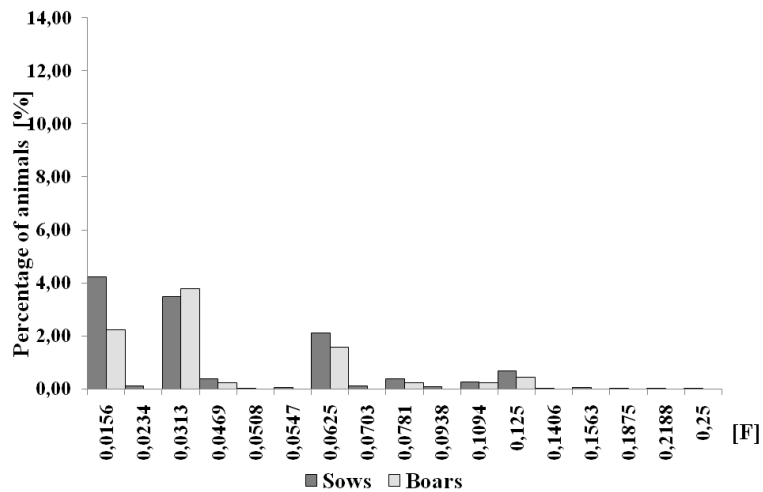


FIGURE 2. Distribution coefficients of inbreeding ( $F$ ) in the population of animals – Polish Landrace breed

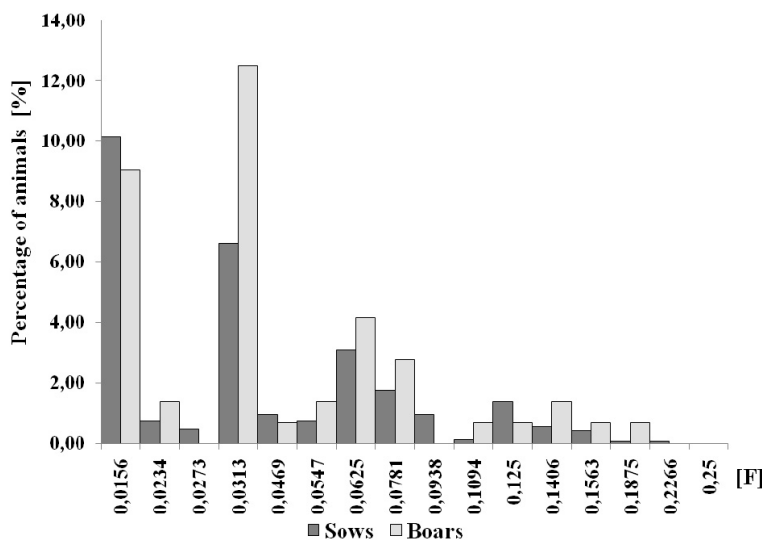


FIGURE 3. Distribution coefficients of inbreeding ( $F$ ) in the population of animals – Puławska breed

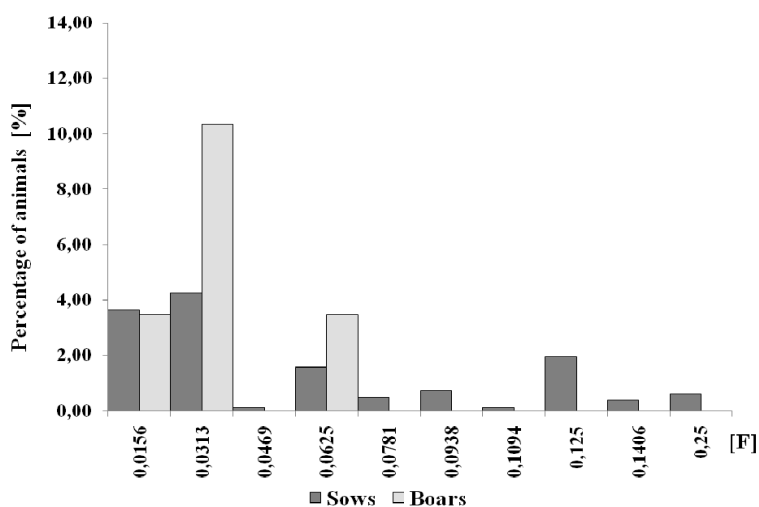


FIGURE 4. Distribution coefficients of inbreeding ( $F$ ) in the population of animals – Duroc breed

PL breeds, 86% in the Puławska breed, and 69% and 73% in the Duroc and Pietrain breeds, respectively.

In the boars, the coefficient of inbreeding varied between 0 and 0.1875. Non-inbred boars accounted for 77% in the PLW breed, 91% in the PL breed, 63% in the Puławska and approximately

80% in the Duroc and Pietrain breeds (Table 3). The maximum coefficient of inbreeding was characteristic of one Puławska boar. When analyzing the distribution of males with specific inbreeding values in Figures 1–5, it was found that in the PLW breed most of the animals have inbreeding levels ranging from

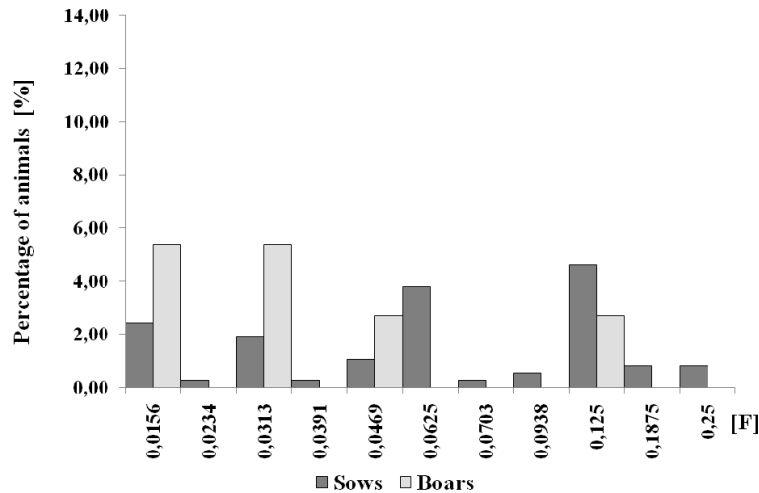


FIGURE 5. Distribution coefficients of inbreeding ( $F$ ) in the population of animals – Pietrain breed

0.0625 to 0.1406. In the other breeds the situation was the opposite because most of the boars had an inbreeding value of 0.0156–0.0313. Such a distribution of the inbreeding coefficient may be due to the size of the population and the number of imported boars introduced into Polish farms. A low inbreeding is to be expected for large populations such as the PL, whereas in small populations, such as the Duroc and Pietrain, to which imported animals are often introduced, each imported boar contributes to a considerable decrease in the inbreeding coefficient within a given breed.

The relatively high number of sows with an inbreeding coefficient of up to 12.5%, boars with inbreeding of 6.25–14.06% (PLW), individuals with inbreeding of 12.5% (PL, Pietrain) and 12.5–18.75% (Puławska), found in the populations studied by other authors, increased the mean level of inbreeding in these breeds, which is particularly noticeable in the PLW (0.5%), Puławska

(2.5%) and Pietrain breeds (0.9%) (Szyndler-Nędzka et al. 2013). Apart from the domestic populations, the inbreeding level of pigs of various breeds in different periods was also reported to increase in other countries. Welsh et al. (2010) found the inbreeding coefficient increased in pig populations raised in the United States in 2006–2009. These authors showed that 99% of the population was inbred, but most of the animals had inbreeding levels below 10%.

In large animal populations, the main reasons for losses in genetic variation and an accelerated increase in inbreeding are increased selection pressure, artificial insemination, which drastically reduces the number of sires, and the use of modern methods of breeding value evaluation, including the BLUP Animal Model (Rathje 2000, Colleau and Tributout 2008). Colleau and Tributout (2008), who considered the effect of different inbreeding reduction strategies on the preservation of genetic merit (breeding

value) in the French Landrace population, showed that only a proper choice of boars with a low coancestry coefficient for mating can reduce the value of the inbreeding coefficient in the population by an average of 21%, while introduction a proper choice of sows for mating will further contribute to decreasing the mean inbreeding coefficient in the population by another 11%. Therefore, efficient herd reproductive management is of the utmost importance in maintaining different herds, and thus whole populations of pigs within the permitted inbreeding levels.

## CONCLUSIONS

The present findings show that the level of inbreeding in the domestic population of pigs is appropriate. This is evidenced by the estimated inbreeding coefficients, most of which are considerably lower than 10%, the value which is considered the limit of relationship that should not be exceeded to avoid the negative effects in breeding. The absence, or the low level, of inbreeding coefficients among pigs in the active population is indicative of the appropriate selection of both domestic and imported animals for mating, as well as the lack of negative consequences of using BLUP for estimating the breeding value of pigs.

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- cji, w tym informacji rodowodowej, zwiększa się zagrożenie istotnego wzrostu stopnia inbredowania zwierząt. Celem pracy jest oszacowanie stopnia zimbredowania loch i knurów krajowej populacji świń, po kilkunastu latach stosowania selekcji bazującej na wartości hodowlanej szacowanej metodą BLUP-AM. Do badań zostały wybrane lochy i knury ras wielkiej białej polskiej, polskiej białej zwisłouchej, hampshire, duroc, pietrain oraz puławskiej, urodzone w latach 2007–2011. Do analiz rodowodowych pozyskano ogółem dane dla 16 842 loch oraz 977 knurów 6 ras hodowanych w Polsce. W analizowanym okresie czasu stwierdzono, że u loch wartość współczynnika inbrodu ( $F$ ) mieściła się w zakresie od 0 do 0,25 (14 szt.), przy czym najczęściej osobników było niezimbredowanych (70% w rasach wbp i puławskiej, ponad 80% w rasach pbz, duroc i pietrain i 100% w rasie hampshire). W przypadku knurów rozpiętość wartości współczynnika inbrodu wynosiła od 0 do 0,1875 (1 szt.). Knurów niezimbredowanych było 77% w rasie wbp, 91% w rasie pbz, 63% w rasie puławskiej oraz około 80% w rasach duroc i pietrain. Uzyskane wyniki wskazują na właściwą strukturę pogłowia świń w zakresie zimbredowania, co wskazuje na poprawnie prowadzony dobór zwierząt do kojarzeń i brak negatywnych skutków stosowania metody BLUP.

*Słowa kluczowe:* świnie, inbred, metoda BLUP

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**Streszczenie:** Analiza poziomu inbrodu populacji aktywnej różnych ras świń w Polsce. W hodowli trzody chlewnej w Polsce metoda BLUP-AM jest wykorzystywana na szeroką skalę od 1999 roku. Zastosowanie tej metody do oceny wartości hodowlanej świń wpływa na poprawę wartości hodowlanej świń w populacji zarodowej oraz w populacji masowej. Równocześnie poprzez wykorzystanie w obliczeniach wielu źródeł informa-

**Authors' address:**

Grzegorz Żak  
Katedra Genetyki i Hodowli Zwierząt  
Państwowy Instytut Badawczy  
ul. Sarego 2, 31-047 Kraków  
Poland  
e-mail: grzegorz.zak@izoo.krakow.pl