Pedigree Analysis Of Finnish Landrace and Yorkshire Pig Populations

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Introduction

Inbreeding is one of the main concerns in breeding populations. It causes reduction in genetic variation and also increases risk to recessively inherited defects and diseases. It has also been shown that inbreeding creates depression particularly in fertility and reproduction traits. Commercial pig breeds are particularly vulnerable to inbreeding because of their short generation interval and high reproduction capacity allowing strong selection of breeding animals.

Finnish Landrace and Finnish Yorkshire are the main domestic pig breeds in Finland. The active purebred breeding population currently is about 2000 sows in both breeds. A strong selection against halothane sensitivity has limited the availability of boars and sows for breeding in the 1980's and the beginning of 1990's. In addition, strong marker assisted selection against immotile short tail sperm defect (Sironen *et al*. 2006) has been applied in Finnish Yorkshire population after 2001 restricting the pool of the breeding animals to those that do not carry the defect. The objective of this paper is to study level and rate of inbreeding in these two Finnish pig breeds. Population gene pool is investigated using the number of ancestors and the proportion of genes inherited from the top breeding animals as indicative measurements.

Material and methods

Data sets. Pedigree information files for Finnish Landrace and Finnish Yorkshire breeds were obtained from the national pig breeding organization Faba Pig. For both breeds the oldest information came from the 1970's but the majority of the animals in the files were born after 1980.

Inbreeding coefficients. Inbreeding coefficients were calculated using all animals in the data but inbreeding coefficients were reported only for animals that had pedigree completeness value (*PEC*) (MacCluer *et al.* 1983) of 0.6 or higher. Five ancestral generations were used in calculation of PEC. Number of animals in the pedigree file was 608 138 for Finnish Landrace and 554 237 for Finnish Yorkshire. *PEC* > 0.6 was obtained for 493 933 Finnish Landrace animals (including 86 527 breeding animals) and for 439 255 Finnish Yorkshire animals (including 72 957 breeding animals).

Population statistics. Rate of inbreeding (ΔF) and effective population size were estimated using the method presented by Gutiérrez *et al.* (2008) and Gutiérrez *et al.* (2009). Rate of

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Table 1: Annual average inbreeding coefficient (F) for the Finnish Yorkshire and Finnish Landrace populations. Only animals with PEC ≥ 0.6 were considered.

	Yorkshire		Landrace			Yorkshire		Landrace	
Year	N	F (%)	N	F (%)	Year	N	F (%)	N	F (%)
1983	74	0.4	57	0.6	1997	23390	4.7	27414	3.6
1984	1677	0.5	1391	0.5	1998	24072	5.5	26509	3.9
1985	6431	0.5	5374	0.6	1999	22128	6.3	25482	4.4
1986	12436	0.7	11024	0.7	2000	20489	6.8	23822	4.6
1987	17108	0.9	16149	0.9	2001	20825	7.3	23141	5.0
1988	20563	1.1	21075	1.3	2002	19712	7.9	21069	5.2
1989	21661	1.5	23459	1.4	2003	15508	8.6	17191	5.6
1990	22613	1.7	25326	1.5	2004	13443	9.2	15090	6.1
1991	22657	2.0	26251	1.8	2005	12134	9.8	13953	6.2
1992	22267	2.4	25713	2.1	2006	11362	10.3	12694	6.6
1993	22198	2.8	27733	2.3	2007	9558	10.6	10271	7.1
1994	23486	3.2	28164	2.6	2008	5998	11.1	7871	7.5
1995	22969	3.7	28047	2.9	2009	2010	11.5	2632	7.7
1996	22486	4.2	27031	3.2	Total	439255		493933	

inbreeding was calculated from individual increase of inbreeding $\Delta F_i = 1 - \sqrt[t_i-1]{1 - F_i}$ where t_i is the number of equivalent complete generations (Maignel *et al.* 1996) for individual *i*. Effective population size was estimated as $N_e = 1/(2\overline{\Delta F_i})$, where $\overline{\Delta F_i}$ is the average over individual increase of inbreeding of the reference population (Gutiérrez *et al.* 2009). Effective number of ancestors (f_a) for the reference population was calculated using the algorithm presented by Boichard *et al.* (1997). The algorithm also gives the proportion of genes each ancestor has contributed to reference population. Inbreeding coefficients and all population statistics were calculated using RelaX2 program (Strandén and Vuori 2006).

Results and discussion

Average number of equivalent complete generations reached 15 for both breeds in this data set by the end of 2009 and was over five in 1990 (Figure 1a). The depth of the pedigree and the number of observations (Table 1) makes the estimates of inbreeding coefficients, effective population sizes, and other population measures presented in the paper reliable. The average inbreeding coefficients are given in Table 1 and in Figure 1b. The difference in inbreeding coefficients between all animals and breeding animals was negligible (not presented). Average inbreeding coefficient has increased in faster rate in Finnish Yorkshire population compared to Finnish Landrace population in animals born after 1990 (Figure 1b). Currently the average inbreeding is 12% and 8% in Finnish Yorkshire and Landrace populations, respectively.

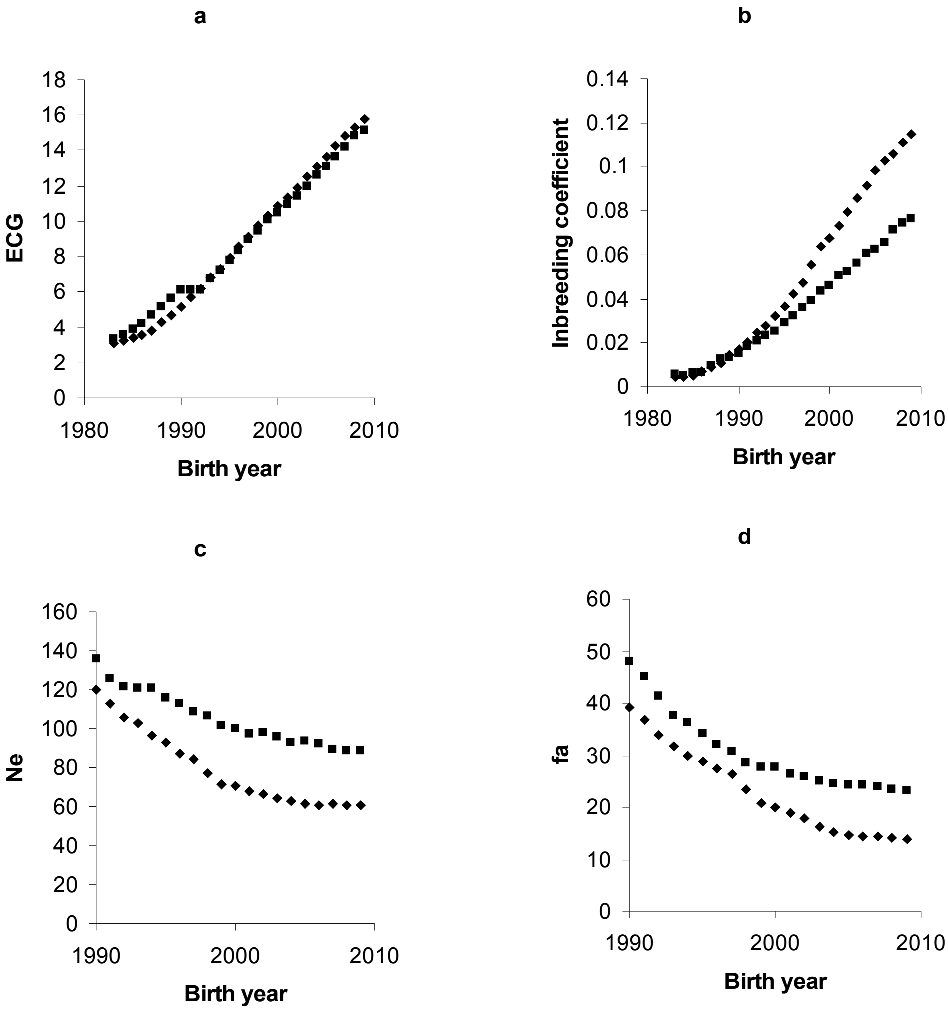

Figure 1: Average equivalent complete generations (a), inbreeding coefficient (b), effective population size (N_e) (c), and effective number of ancestors (f_a) (by birth year) for Finnish Yorkshire (diamond) and Finnish Landrace (square) breeds.

Rate of inbreeding $\overline{\Delta F_i}$ was calculated as an average ΔF_i of animals born in 2008 and 2009. The estimated effective population size N_e for current Finnish Yorkshire is 60 (Figure 1c) corresponding to rate of inbreeding of 0.8% per generation. For Finnish Landrace the corresponding values are 90 (N_e) and 0.55% ($\overline{\Delta F_i}$). Effective number of ancestors (f_a) has decreased from 40 to 14 in Finnish Yorkshire population during the last twenty years, and from 50 to 23 in Finnish Landrace population (Figure 1d). Population sizes, mating policies, selection intensities and breeding value estimation for both breeds have been similar since 1990 so the difference in the level and rate of inbreeding is most likely due to uneven use of breeding animals. In Finnish Yorkshire a few very good boars and their sons have been used extensively in 1990's while in Finnish Landrace more boars have passed their genes to next generation. Evidence for this can be found from the proportion of genes inherited from the top ten breeding animals that has increased from 44% to 70% during the last two decades in the Finnish Yorkshire while in Finnish Landrace the increase has been smaller (from 37% to 56%).

Average inbreeding coefficient in Finnish Yorkshire population has reached a level where deleterious recessive effects can cumulate and cause economical losses. An example of this is the recessive immotile short tail sperm defect found in Finnish Yorkshire population (Sironen *et al*. 2006). Marker assisted selection against short tail sperm defect have not changed the rate of inbreeding most probably because in any particular litter of the carrier sire both carriers and non-carrier full-sibs are available for selection. Thus the proportion of genes passed to next generation have not depended on if the sire has been carrier or not. Inbreeding causes also depression in polygenic quantitative traits especially in fertility and reproduction traits. Luckily this does not apply to commercial sows which are crosses of two breeds. Thus, instead of inbreeding depression, the commercials sows benefit from heterosis.

Conclusion

Average inbreeding coefficient is over 10% and around 8% in Finnish Yorkshire in Finnish Landrace populations, respectively. Rate of inbreeding is around 0.8% and 0.55% per generation in Finnish Yorkshire in Finnish Landrace populations, respectively. These levels are lower than 1%, that is commonly used as a limit for acceptable rate of inbreeding. However, in order to avoid problems related to inbreeding in the future, appropriate selection methods that maximize selection response with a fixed rate of inbreeding should be applied or alternatively minimize the rate of inbreeding with a selected level of genetic gain. A possible strategy for that has been introduced by Colleau and Tribout (2008).

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