AN OVERVIEW OF TWENTY YEARS OF SELECTION FOR LITTER SIZE IN PIGS USING "HYPERPROLIFIC" SCHEMES

J.P. Bidanel[1], J. Gruand[2] and C. Legault[1]

[1]INRA, Station de Génétique quantitative et appliquée, 78352 Jouy-en-Josas, France
[2]INRA, Station expérimentale de Sélection porcine, 86480 Rouillé, France

SUMMARY

"Hyperprolific" selection schemes have been shown to be an effective way to improve litter size in pigs. This paper presents the main results of 20 years of selection for prolificacy in the INRA "hyperprolific" Large White strain and discusses possible ways to increase the efficiency of these selection schemes.

INTRODUCTION

Until recently, pig breeding programmes have been essentially devoted to the improvement of production traits, i.e. growth efficiency and carcass quality. Some production traits such as leanness now approach optimum levels, so that genetic improvement of other economically important traits, such as sow reproductive efficiency, are assuming increasing importance in breeding goals. Over the last 20 years, important gains in annual sow productivity have been obtained in several countries, mainly through improved herd management. Genetics has so far played a minor role in the improvements achieved, essentially through the implementation of crossbreeding. Increasing sow productivity or its major component, litter size, through selection was considered as a difficult task with little prospect of success. Indeed, the two first selection experiments aimed at improving sow prolificacy were both unsuccessful (Cunningham et al., 1979; Ollivier and Bolet, 1981). The latter authors partly explained the failure of their selection experiment on litter size at birth by lack of the possibility of reaching the expected selection intensity in a closed herd. Legault and Gruand (1976) proposed to overcome this problem by screening large populations so as to identify exceptionally prolific sows, so-called "hyperprolific" sows. By repeated backcrosses to hyperprolific sows, the genetic merit of their boar progeny is progressively raised to the level of the dams. This selection scheme has been successfully applied to the French Large White (LW) population (Le Roy et al., 1987; Petit et al., 1988), as well as to other pig populations throughout the world (Tomes and Nielsen, 1984; Bichard et al., 1985; Sorensen and Vernesen, 1991). The purpose of this article is to review the main results obtained in France on hyperprolific lines of pigs.

THEORETICAL ASPECTS

As indicated above, Legault and Gruand (1976) proposed to use large-scale computerized recording systems in order to identify sows, from large populations, with extremely high performance for litter size, so-called "hyperprolific" sows. The high selection differential so generated is then used to initiate a prolific population. A strain of "hyperprolific" boars can be developed by simply selecting males from the progeny of dams with extreme prolificacy and then backcrossing them to other sows with a similar extreme prolificacy. By repeating this type of backcross, the genetic merit for prolificacy of boars is progressively raised towards that of the hyperprolific sows. A second possibility is to keep both male and female offspring and develop hyperprolific nucleus herds. An important difficulty of this second approach is the health risk encountered when gathering breeding animals from different herds.

The counterpart of the high selection pressure on litter size is the genetic lag for production traits automatically generated in the hyperprolific population for at least three reasons: 1) hyperprolific dams partly come from multiplication herds; 2) they are on average older than normal nucleus sows; 3) it is difficult to apply the usual selection pressure for production traits to the progeny of a limited number of highly selected hyperprolific dams. As a consequence, the interest of hyperprolific lines will depend on the economic balance between the gain for prolificacy and the loss for production traits.

The genetic superiority of an hyperprolific strain can then be exploited in different ways. When hyperprolific boars are mated (generally through artificial insemination) to dams from the base population, only half of their genetic superiority is exploited. This procedure can be improved in nucleus herds by systematically inseminating sows with hyperprolific boars, which allows the average genetic merit of the herd to reach progressively the level of the hyperprolific strain. Half of the genetic superiority of hyperprolific strains can also be exploited in crossbreeding, provided that the this advantage can be cumulated with heterosis effects. This advantage can be doubled when two hyperprolific strains are crossed.

RESULTS FROM THE INRA HYPERPROLIFIC LARGE WHITE STRAIN

A strain of hyperprolific Large White boars has been developed at the INRA experimental station in Rouillé (Vienne) since 1973. Each year, one to six boar progeny from hyper-prolific sires and dams were selected at the end of an individual test for growth rate and backfat thickness and placed into the INRA artificial insemination center of Rouillé. As shown in figure 1, the mean of cumulated selection differentials exceeded 10 piglets/litter after 6 generations of selection and now exceeds 16 piglets/litter.

The high genetic merit of the INRA hyperprolific strain has been confirmed several times over the last 10 years. In two contemporary field trials (Le Roy et al., 1987; Petit et al., 1988), daughters from hyperprolific boars exhibited a superiority of 0.8 piglet born and 0.6 piglet born alive per litter over contemporary sows. In a hyperprolific LW experimental herd developed as indicated above by systematically inseminating LW sows with semen from INRA hyperprolific boars, the average litter size of hyperprolific sows exceeded that of normal LW contemporaries by, respectively, 2.6 and 1.5 piglet/litter for total number born and number born alive.

In a recent study aimed at estimating the genetic trend for prolificacy in the main French breeds using a BLUP-animal model, Bidanel and Ducos (1994) compared the average breeding value of daughters from INRA hyperprolific LW boars with that of contemporary LW sows. The advantage of these sows, which represents half of their genetic superiority, exceeded 0.7 piglet/litter over the last four years considered (Figure 2).

Figure 1 - Mean of cumulated selection differentials of hyperprolific boars by year (between brackets: number of boars)

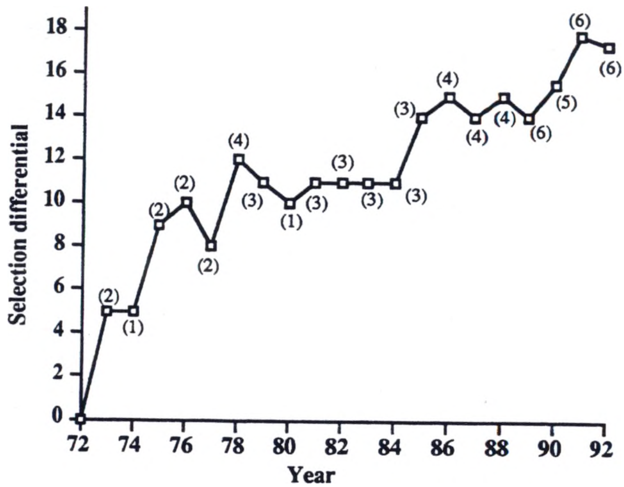
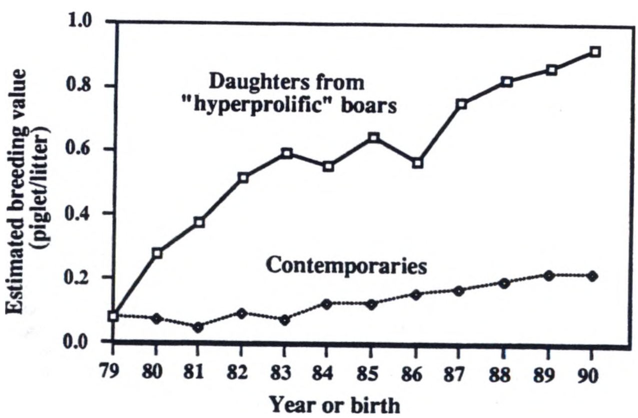


Figure 2 - Average breeding value for prolificacy of daughters from INRA hyperprolific boars and of contemporary Large White sows by year of birth (from Bidanel and Ducos, 1994)



A comparable advantage is obtained when hyperprolific boars are used in crossbreeding. In a first trial, Legault et al. (1981) presented a significant superiority of 0.8 embryo at 30 days of gestation when comparing F1 Large White x Landrace progeny from hyperprolific boars with F1 contemporaries. A significant, but slightly lower difference was obtained for litter size at birth (respectively, 0.6 and 0.5 piglet/litter for total number and number born alive) in the field trial reported by Petit et al. (1988). An important advantage was also obtained when crossing hyperprolific boars with sows from the prolific Meishan breed (table 1).

Table 1 - Prolificacy of Large White, Meishan and F1 Large White x Meishan sows sired by hyperprolific or normal Large White boars (from Mandonnet, 1991)

Genotype	Number of litters	Number of piglets/litter		
		Total born	Born alive	Weaned
Large White	446	12.5	11.3	10.0
Meishan	627	15.2	14.1	12.6
F1 - Normal LW sires	170	16.2	15.2	13.1
F1 - Hyperprolific LW sires	72	17.7	16.8	14.1

The physiological basis of the high prolificacy of Hyperprolific sows has been investigated by Bolet et al. (1986), Després et al. (1992), Driancourt et al. (1992) and Martinat-Botté et al. (1992). Sows from the INRA hyperprolific LW strain are characterized by a high ovarian sensitivity, which results in very high normal (22.9 ova shed by hyperprolific LW sows vs 17.6 for normal LW sows; Bolet et al., 1986) or induced (Martinat-Botté et al., 1992) ovulation rate and an increased prenatal mortality. Hyperprolific LW sows also exhibit a lower age at puberty (185±1 in hyperprolific gilts vs 197±1 in normal LW gilts - Després et al., 1992) and lower FSH concentrations at 150 days of age (Driancourt et al., 1992) than normal LW sows.

Table 2 - Within-batch comparison of on-farm performance of contemporary pigs sired by hyperprolific or normal Large White boars (from Petit et al., 1988).

Trait	Sex	Hyperprolific LW sires	Normal LW sires
Number of pigs	Females	406	712
	Males	182	217
Age at 100 kg (d)	Females	157.2 a	157.3 a
	Males	148.4 b	150.0 b
Average backfat thickness at 100 kg(mm)	Females	16.4 a	15.9 b
	Males	14.8 c	14.6 c

Least-squares means with the same letter do not differ significantly (P<0.05)

The genetic lag for production traits has been evaluated by comparing the on-farm performance of the progeny of hyperprolific LW and of contemporary LW boars (Petit et al., 1988). As shown in table 2, animals sired by hyperprolific boars have a similar growth rate, but a higher backfat thickness (+0.4 mm on average) than pigs sired by normal LW boars.

RESULTS FROM OTHER HYPERPROLIFIC STRAINS

Hyperprolific LW and French Landrace (LF) strains have been developed by several French breeding organizations over the last few years. Offspring from hyperprolific boars and sows were introduced into 6 LW and 4 LF selection herds using SPF techniques. Boars used in the LW breed were partly boars from the INRA hyperprolific LW strain and partly boars with a high pedigree index for litter size. These 10 selection herds then supplied 59 multiplication herds with hyperprolific animals. The average superiority of daughters from hyperprolific parents over normal sows in selection and multiplication herds is shown in table 3. These results are in agreement with those presented here above, even if the average genetic merit of these hyperprolific strains is, as could be expected, still lower than the genetic merit of the INRA hyperprolific LW strain, particularly in the LF breed. A new evaluation of the genetic lag for production traits indicates that the progeny of hyperprolific animals do not show any disadvantage in growth rate, but have a slightly higher feed conversion ratio (+0.02±0.01 and +0.04±0.01, respectively, in LW and LF breeds) and a higher backfat thickness (+0.5±0.1 mm and +0.3±0.1 mm, respectively, in LW and LF breeds).

Table 3 - Average superiority of daughters from hyperprolific parents over herd contemporaries (from Herment et al., 1994).

		Large White		French Landrace	
		Selection	Multiplication	Selection	Multiplication
Number of litters[1]		2953 (541)	10660 (427)	1623 (305)	7569 (363)
Number of piglets /litter	Total born	1.27 ***[2]	1.02 ***	0.61 **	0.45
	Born alive	1.03 ***	1.01 ***	0.61 **	0.33
	Weaned	0.93 ***	_[3]	0.49 **	

[1]Number of litters from sows with hyperprolific parents into brackets; [2]***P<0.001; **P<0.01; [3]crossfosterings were not recorded in multiplication herds

PROSPECTS

The interest of hyperprolific selection schemes for the improvement of litter size in pigs is now clearly established. Their effiency is directly related to the size of the populations screened, to the use of artificial insemination and to the existence of a large-scale computerised recording system. This efficiency should be favoured by the existence of a collective spirit enabling the pooling of genetic potentials of as many breeding stocks as possible. The improvement of litter size is accompanied by some deterioration of production traits However, this deterioration is rather limited and is likely to be less important in the future because of the decreasing economic value of some production traits. Most breeding organizations in France are currently developing hyperprolific selection schemes. Future improvements can be expected through the use of more sophisticated genetic evaluation methods such as the BLUP-animal model, which should allow a more accurate screening of hyperprolific animals.

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