Potential use of prolific chinese breeds in maternal lines of pigs

Jean Pierre Bidanel

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POTENTIAL USE OF PROLIFIC CHINESE BREEDS IN MATERNAL LINES OF PIGS

J.P. Bidanel
Institut National de la Recherche Agronomique
Station de Génétique quantitative et appliquée
78350 Jouy-en-Josas, France.

SUMMARY

This paper discusses several possible routes for taking advantage of prolific Chinese breeds in various market conditions in the light of the results obtained in France on Meishan and Jiaxing breeds. Possible routes include the use of pure Chinese breeds, the creation of composite lines, the manipulation of the environment and of the genome.

INTRODUCTION

The use of specialized sire and dam lines has become a common practice in pig production in many countries. In sire lines, desirable characteristics mainly concern production traits, i.e. growth, body composition and meat quality, whereas good productive and reproductive performance are required in dam lines. A limited number of Chinese native breeds exhibit exceptional reproductive ability with respect to currently used maternal genotypes and could then be of great interest for improving sow productivity in maternal lines. However, these Chinese breeds are also characterized by very poor production performance, so that their interest and their use are not straightforward in many production systems. This paper intends to discuss different possible ways for taking advantage of these extreme genotypes in a variety of situations in the light of the results obtained in France and in some other countries on two Chinese breeds, i.e. Meishan and Jiaxing, over the last ten years.

BREED EVALUATION

Average performance and between breeds genetic variability. Several reviews of research conducted in China have provided comparative data on native pig breeds over the last 10 years. Though accurate comparisons in a single environment are often missing, they all confirm the exceptional reproductive ability and the poor growth and carcass performance of both MS and JX compared to "foreign" breeds such as Yorkshire, Landrace or Russian White. Important non additive effects on reproduction and growth traits are also obtained in crossbreeding with foreign breeds, but heterosis values are seldom estimated precisely.

In France, the performance of MS and JX has been extensively studied both in pure - and crossbreeding under a more intensive production system. Dickerson's genetic parameters of the cross between the MS and the French Large White (LW) breeds have been estimated for different traits of economic interest. The main results of this evaluation work are summarized in table 1. The main comments about this evaluation work are as follows :

* the excellent reproductive ability and the poor growth and carcass performance of MS have been confirmed under an intensive management system. MS is also characterized by a small adult weight and a low feed consumption of sows.
* the performance of the JX line is inferior to that of MS, except for number of teats and killing out percentage.
* breed differences are, at least in MS, mainly of maternal origin for prolificacy and of direct origin for growth traits. Grand maternal effects are of little importance.
* both MS and JX lines exhibit extremely high heterosis effects for reproductive and growth traits in crosses with European breeds.
* the experiments were not designed to estimate direct heterosis effects for feed efficiency and carcass traits, for this parameter is not necessary for predicting the performance of crossbred terminal products, which can be expressed as a function of the percentage of MS genes and of the difference in crossbreeding between breeds (Bidanel, 1988). However, results from purebred performance suggest that they are low, except for feed efficiency.
* direct and maternal epistatic recombination losses seem to be low.

Within-breed variability. No important differences in within breed or within genetic type phenotypic variability have been evidenced for the various traits analysed. Within-breed genetic parameters have not yet been estimated in French MS and JX lines because of the limited number of data. Few estimates are also available from China. However, results of Wu and Zhang (1982) suggest that they should not be very different from standard values.

PROSPECTS AND PROBLEMS FOR EXPLOITING CHINESE BREEDS

Modelling the economic efficiency of production systems. A central step for an accurate comparison of various strategies involving Chinese breeds lies in a correct prediction of their relative economic merit. Different models have been proposed to compare the economic value of swine production systems. However, due to the peculiarities of Chinese breeds, none of them appears entirely satisfactory in the present case. Indeed, if standard models remain proper to predict and compare profits from finishing slaughter pigs, several components of the cost of young pigs, which usually do not exhibit important breed differences and are hence ignored, may become non negligeable and have to be taken into account, namely :

- the cost of the postweaning period, which varies due to breed differences in growth rate (Bidanel *et al.*, 1989b) and possibly in feed efficiency.
- some components of the cost of producing weaned piglets. It concerns both components of the numerical productivity of sows, i.e. age at first mating and possibly longevity, and of their production and maintenance costs, i.e. feed consumption, culling price and costs of selection and multiplication herds (number of animals required, costs of non-breeding pigs).

Another important feature concerns the genetic consequences of the high prolificacy and the early puberty of Chinese breeds. An important increase (up to 50% - Bidanel, 1988) in the rate of response to selection can be expected by shortening the generation interval and/or increasing selection intensities. On the other hand, the high sexual activity of Chinese breeds strongly disturbs their growth and might lower the efficiency of standard performance tests.

Present perspectives - use of MS and JX breeds in terminal crossing plans. Due to the important heterosis effects on prolificacy, the use of Chinese breeds as grand-maternal breeds (i.e. as one of the components of the maternal genotype) is always superior to its use as a single maternal genotype (Bidanel, 1988). The short-term interest of Chinese breeds greatly depends on the relative economic weights of production and reproduction traits, and particularly on the part played by the pork payment system in the global profit. For instance, the EEC market, which puts a strong emphasis on lean weight, is much less favourable to Chinese breeds than the U.S. market, which essentially prices pork by live weight. In the U.S., simulation studies of Mc Laren (1988) suggest that the incorporation of Meishan genes into commercial herds might rapidly improve cost-return ratios. Similar conclusions can presumably be drawn for other markets having such payment systems. On the other hand, it has been demonstrated (Legault *et al.*, 1985 ; Gueblez *et al.*, 1987 ; Bidanel, 1988, 1989) that, in France and probably in many EEC countries, there is no conclusive short-term strategy for using MS or JX breeds, at least under the predominant intensive production system.

Future prospects. In most markets, future perspective for using Chinese breeds as grand-maternal lines will greatly depend on the possibilities of improving their growth and carcass performance without impairing their reproductive merit. Indeed, breed differences tend to enlarge with time due to selection in conventional maternal breeds, thus reducing the interest of Chinese breeds. When Chinese breeds presently have some interest (i.e. in markets with low emphasis on lean content), a sufficient condition is to achieve a gain similar to that obtained in the other breeds. This should be easily realized through selection, unless genetic parameters, particularly the relationship between production and reproduction traits, are unfavourable. In the EEC market (and in other markets with a strong emphasis on lean content), an important improvement has to be carried out before planning to use Chinese genes. Several different strategies can be proposed to achieve this goal.

Selecting pure breeds for production traits. As stated above, a 50% higher genetic progress could be expected in pure Chinese breeds compared to conventional breeds, provided that the genetic parameters are similar and that the sexual activity does not cause any loss in the

efficiency of performance tests. Under these hypotheses, the French MS line could become economically interesting after 6 or 7 years of intense selection for production traits (Bidanel, 1988 ; 1989). However, this interval is quite sensitive to variations in the hypotheses and can be much lengthened under less optimistic conditions (Bidanel, unpublished results). Moreover, the costs are very high and outside the financial facilities of most breeding organisations, so that it still remains a rather unrealistic strategy in the EEC market context.

Creating a composite line and selecting it for production traits. The creation of a 50% Chinese x 50% European composite line reduces by half the initial gap for production traits. Further reductions can be expected through selection, which could also be more efficient than in a European-type line, because of an earlier puberty, a higher prolificacy and a possible increase of the additive genetic variance. On the other hand, 50% of the favourable genetic effects on reproduction and growth are lost (in the absence of recombination loss). From simulation studies, the time necessary to overtake conventional grand-maternal lines should not exceed 3 or 4 years of intense selection for production traits. One should add, however, the time necessary to break down linkage desequilibria involving production and reproduction genes, so that 6 or 7 years are necessary to reach the economic equilibrium (Bidanel, 1989). These theoretical studies have been recently confirmed by results obtained in 2 French companies which have undertaken to constitute such lines. A very high improvement of production traits has been achieved without any perceptible reduction of litter size (Ducos, 1988).

Manipulating the environment. The administration of molecules such as porcine somatotropin (PST) or beta-agonists to growing pigs steadily improves their production traits. The production of large quantities of PST has recently become possible with the help of recombinant bacteria. It has been shown (Bidanel *et al.*, 1990) that the effects of PST are much more important in fat genotypes such as MS, thus reducing their handicap for production traits. It is not yet known whether this handicap would entirely disappear but, in any case, a combined use of PST and selection looks very appealing. However, much uncertainty presently remains about the autorization of using PST, particularly in the EEC market.

Introducing a gene with favourable effects on production traits into Chinese pigs. Introducing a new gene with large favourable effects on growth and carcass traits through successive backcrossings or gene transfer is conceptually attractive. However, the "candidate" genes are seldom. The halothane gene has such favourable effects, but also many drawbacks, so that its introduction in maternal lines of pigs is not recommended. Another possibility could be to transfer the growth hormone gene into Chinese pigs. Such a transfer has already been successfully realized in pigs, with large favourable effects on growth and feed efficiency. Unfortunately, the efficiency of this technique is still very low and has many deleterious effects on the health and the reproductive performance of the animals (Pursel *et al.*, 1989), so that its use in pig production cannot presently be envisaged. Technical improvements will certainly occur within next years but, in any case, several years and many animals are necessary in order to test the transmission, stability, expression and economic merit of the transgene (Smith *et al.*, 1987). The transgenic way thus competes with other improvement techniques and its efficiency should be compared to that of these other techniques.

Searching for "prolificacy" genes in Chinese breeds and introducing them into conventional breeds. This strategy would be quite easy to achieve if the high prolificacy of Chinese breeds is due to a single major gene. There is unfortunately no present answer to this hypothesis. It is not so surprising, as the effect of the gene should not exceed much one standard deviation of the trait, and is therefore very difficult to evidence. It would probably be easier to find it by looking at physiological components of litter size. Another strategy could be to find markers associated with QTL. Marker loci could then be used to delimit the interesting portions of the genome (those carrying the QTL of interest) that are required to be transferred from Chinese to European breeds. Another possible use is marker assisted selection. Such developments are still long-term prospects, because they require a dense gene map of the pig, which has become possible with the new generation of DNA polymorphisms recently discovered, but is yet far from being achieved. An EEC project on this topic should start this year (Haley *et al.*, 1990).

CONCLUSION

Chinese breeds should play an active part in the improvement of the efficiency of pig production over the next decade, as evidenced by the recent development of research and application projects in an increasing number of countries. Moreover, Chinese breeds offer a valuable resource to conduct basic research in a number of fields of biology including naturally reproduction and growth, but also resistance to diseases, behaviour,...

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Table 1 : Breed differences between Meishan (MS), Jiaxing (JX) and Large White (LW) breeds and heterosis effects of MS x LW and JX x LW crosses (Synthesis of French results).

Item	Breed difference		Heterosis effects			
			direct		maternal	
	MS-LW	JX-LW	MSxLW	JX-LW	MSxLW	JXxLW
Age at puberty(d)	-101	(-91)[b]	(-50)	(-49)	-[c]	-
Number of teats	+3.4	+5.9	(0)	(0)	0	-
Piglets born alive	+3.1	+0.6	+0.9	-	+2.3	+3.8
Piglets weaned	+2.6	+0.8	+1.2	-	+2.3	+3.5
Adult weight (kg)	-98	-127	+27	-	0	-
Feed consumption during lactation (kg)	-21	-51	+16	-	0	-
Average daily gain(g/d)	-230	-280	+187	-	+29	-
Food conversion ratio[a]	+0.9	+1.4	(0)	-	0	-
Killing out %[a]	-3.8	+0.4	(0)	-	0	-
Backfat thickness[a](mm)	+11.8	+6.7	(0)	-	0	-
Lean content[a](%)	-16.0	-18.0	(0)	-	0	-
Ultimate pH[a]	+0.12	-	(0)	-	0	-
Reflectance (0-1000)[a]	-36	-	(0)	-	0	-
Imbibition time(sec.)(a)	+10	-	(0)	-	0	-

a-Extrapolated from the performance of crossbred pigs. b-Approximate value.
c-Not estimated.