PRODUCING MORE PIGS PER SOW PER YEAR—GENETIC CONTRIBUTIONS

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ABSTRACT

This review paper summarizes available knowledge on the genetic manipulation of litter size in pigs. Selection among breeds permits the exploitation of existing variation and this has already proceeded much further in Europe than in the United States. Crossbreeding strategies are available to enable the commercial herd to maximize sow productivity while ensuring carcasses acceptable to each particular market demand. These involve either the regular purchase of both replacement gilts and boars, or a high standard of management of the herd breeding program. Selection within purebred lines to increase further prolificacy seems possible, in spite of some contrary results from initial experiments. Success will only be achieved in well-designed and carefully executed programs with adequate population size that are continued for many generations. It is likely that breeders can continue to improve the potential of their stock at the commercial level, and this will be achieved by a degree of specialization between sire and dam lines.

(Key Words: Pigs, Litter Size, Productivity, Genetics, Selection.)

Introduction

Against a background of normal United States production of around seven to eight pigs weaned per litter, and 12 to 14 weaned per sow per year, huge increases in sow productivity, at least 50%, are already quite possible. Proof of this comes from over 700 United Kingdom herds recorded by the Meat and Livestock Commission, involving more than 300,000 litters per year (MLC, 1985). During the year ended September 1984 these sows weaned 9.2 pigs per litter and 20.8 pig per sow per year. Furthermore these results have already been achieved in the United States. During 1984, 32 herds of Camborough sows recorded by Pig Improvement Company in modern confinement units with good management produced over 35,000 litters. They averaged 9.2 pigs weaned per litter and 20.8 pig per sow per year. The very best herds are achieving as many as 23.7.

Of course, individual sows do much better even than this. Quite a number of our white crossbred sows average over 12 weaned in each of their first four litters. What is more, with 3-wk weaning and rapid rebreeding they attain a farrowing interval close to 140, equivalent to 2.6 litters per sow per year. Hence the very best current figures are at least 31 pigs per sow per year—though, admittedly, very few sows achieve such output.

Such prolific swine are freely available in many countries today. Will they be even more prolific in the future? This review summarizes the methods available to the breeder and tries to forecast what further advances are possible.

Genetic Contributions

Papers in this symposium focus attention on three separate areas: 1) number born per litter, 2) farrowing interval and 3) mortality. Genetic manipulation can influence areas 2 and 3, mainly through crossbreeding, but it would be expected that major advances will only come by non-genetic means. By contrast a great deal more is known about the genetic control of litter size. Existing breeds and lines differ widely in this trait, as a result of past generations of selection. These have not all yet been


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exploited. Crossbreeding between unrelated strains may offer further gains of 8 to 15% immediately (Johnson, 1980). In addition recent results have suggested that careful selection programs can further improve some already prolific lines.

It is notoriously difficult to disentangle completely the effects of improved genetics and changing environment. Here the word environment is used in its widest sense, embracing nutrition, disease, buildings, equipment and system and level of management. But obviously the genotype of the animals sets the potential for all the other disciplines to exploit. The mean genotype is controlled by three separate processes: the choice of breeds and lines, the way these are put together into a crossbreeding system, and the amount of within-line improvement arising from selection.

Between-Line Differences

In recent years large numbers of local breeds have been rejected by commercial pig producers for all sorts of reasons: growth/efficiency, carcass and sow productivity. As a result of this process many of the less productive lines have been replaced (Epstein and Bichard, 1984). In countries where bacon types have been preferred, the most prolific lines have survived, e.g., Large White and Landrace in the United Kingdom, Yorkshire in Canada and Landrace in Scandinavia. In other countries where shorter, blockier carcasses are preferred (e.g., United States) the change has been slower—but there has still been a strong move in the direction of white sows.

Further between-breed selection seems less likely in the future as we exhaust the available range produced for us by previous generations of breeders. Perhaps only the Chinese breeds appear to offer significant advantages in the reproductive traits. Of the 100 or more indigenous "breeds" in China, only a handful seem to excel in prolificacy, though many more have very early sexual maturity. The best-documented are those originating around Lake Taihu in the South East (Meishan, Fengjing, Jiaxing Black and Erhualian; Cheng, 1983), but others (Min from the North East, Dahuabai in the South) are also worthy of study. There are now good data from small samples of some of these breeds sent to France (Legault and Caritez, 1983), as well as a growing amount of information coming out of China itself. Sexual maturity around 3 mo of age, litter sizes of 15 born and up to 13 weaned, and 16 to 20 teats on which to rear the piglets are common in these breeds.

But unless it can be shown that these traits are controlled by only one or two gene pairs, and that these genes can be simply transferred by some of the new techniques of biotechnology, their utilization in Western countries remains doubtful. This is because their reproductive advantages are balanced by almost equal disadvantages in growth rate, killing-out percent, carcass lean and conformation (Legault et al., 1985). Using conventional crossbreeding techniques, by the time the percentage of Chinese genes has been reduced to 25 or 12.5 in the slaughtered pig, then most of their reproductive advantages have been diluted too far.

Crossbreeding Systems

Crossing unrelated lines of breeds cashes in on heterosis—the increased fitness of the cross by comparison with the mean of the parental lines. An F1 piglet exhibits individual heterosis in its ability to survive the hazards of foetal conditions, birth, and early postnatal conditions. An F1 sow shows maternal heterosis in her rebreeding interval, strength and duration of heat, number of piglets born per litter and in her milk production (Johnson, 1981).

While many commercial herds contained purebred hogs 50 yr ago, crossing became popular in the United States as a result of early experimental work (Winters et al., 1935). Two-, three- or four-breed rotation crossing systems were recommended, and adopted by the majority of the industry. Unfortunately the reproductive ability of the pure breeds utilized has limited reproductive performance of the commercial sow, and the systems are best suited to twice-a-year farrowing where breed of boar can be easily changed. The degree of management skill required to operate a rotation efficiently with continuous farrowing has been underestimated by many advisers (Ahlschwede, 1982). Europe came to crossbreeding a little late—but had more fertile breeds to work with, and soon appreciated the value of F1 sows. In 1970 every sow and every slaughter pig in Denmark was a purebred Landrace. Today, only 15 yr later, almost all commercial herds contain F1 (Large White × Landrace) sows, with backcross or three-breed cross litters—so
achieving nearly the maximum benefits of heterosis in a very short time. Full exploitation of these genetic benefits in the United States today, plus the husbandry and management systems already worked out, could give a rapid increase in prolificacy of up to 50%.

Genetic Variation Within Lines

Can Progress be Made? There has been a mistaken view for many years that the amount of useful genetic variation in prolificacy in pigs is very small. The truth is that the proportion of the total variation that isheritable is small—around 10% (Bichard and David, 1986). But the genetic variation relative to the mean, is in fact higher than for most economic traits—around 8%. The genetic coefficient of variation for growth and carcass traits is typically 4 to 6%. The problems of selecting for increased litter size have to do with the nature of the trait: it can only be measured long after puberty, when the animal farrows; and then, of course, in one sex only. Hence, if selection decisions have to be taken among all available candidates at around market weight, then the only available information on their breeding values has to come from their female relatives—dam, aunts and perhaps paternal half-sisters.

A better explanation for why within-line genetic variation in prolificacy has not been exploited for many years must be sought outside genetics. First, other methods of achieving the same objective were being used—better management, earlier weaning, etc. Second, within-line selection has frequently not been well organized, or not very scientifically based—small herds forced to purchase herd sires, and of limited duration, lack of recording, importance of showing in setting objectives, etc. Third, where scientific selection programs were pursued, other traits were being selected for—the available selection pressure was devoted to growth, efficiency and carcass traits.

It is true that a few scientific experiments have been conducted in recent years, and have not been very successful in increasing litter size. Direct selection for 11 generations in France produced no response (Ollivier and Bolet, 1981; Ollivier 1982). Selection for ovulation rate in Nebraska, though highly effective, produced a rather small response in number born, because embryo mortality increased to compensate (Johnson et al., 1984). Other small-scale attempts in Norway and Wisconsin have been similarly ineffective.

While many reasons have been invoked to explain general failure to raise litter sizes by selection, the most likely seems to be that adequate controlled experiments of sufficient size and duration have not been attempted. There are nevertheless some more encouraging signs. French workers have pioneered a technique that they have called the hyper-prolific approach. With it they have tried to overcome the two main problems of selection for litter size referred to previously. First, the inaccuracy of the information about a candidate's breeding value when the only data came from the dam's record can be overcome when repeated records are averaged. For example, the mean of four successive litter records may have a heritability close to three times that of a single record. The second problem is the small number of available candidates that can be retained in a herd to the point of first or subsequent farrowing. If animals outside the nucleus unit are also recorded and considered during selection, as is possible when many purebred gilts are moved at 6 mo to multiplication herds to spend their lives producing crossbred offspring, then high selection intensities become possible. Legault and Gruand (1976) outlined the theory of such a system, and some early results are given by Legault (1986). F1 gilts produced from crosses between two such prolific lines have averaged 11.43 piglets born alive per litter during their first four parities in a trial involving over 300 females on 14 different farms, compared with 10.73 from controls (Bichard and David, 1986). These data lend support to the argument that selection for litter size in the nucleus herd should improve performance at the commercial level similar to selection for growth and carcass traits—at a small but significant annual rate (Smith, 1984)—somewhere around 1 to 3% of the mean.

There will undoubtedly be more attempts to achieve such responses in the future. The Nebraska group is already exploring interesting new approaches. One of these is an alternative way to achieve higher selection pressures by keeping all candidates until their own litter size can be determined (half-way through first pregnancy), and then only farrowing the selected group. They are also attempting to give different weight to the components of litter size, in order that gains in ovulation rate should not all be negated by losses in embryo survival (Johnson et al., 1984). There is also renewed
interest in making better use of information from several types of relatives (Avalos, 1985).

Selection Schemes Within Commercial Herds. The implications of these results are that it may, after all, be possible to achieve reasonable gains in sow productivity by within-population selection. Such gains may in the future be built into commercial sows through the same sort of breeding pyramid structure that has already been successful in improving the performance of slaughter pigs. It is perhaps useful at this stage to point out that improvement schemes to achieve the same objectives but carried out in normal commercial herds are doomed, if not to complete failure, at least to very limited success. The point is that most commercial herds purchase all their herd boars from outside—both as a method of bringing in improvement, and as a simple way of avoiding inbreeding. In this situation they must realize that the genes in their herds are virtually all derived from the source herds. If the source herds are not pursuing a successful policy of genetic improvement in sow productivity then careful recording in the commercial herds, with selection of replacement gilts from the best sows, will not have the cumulative effect which is desired. The most that can be achieved over several generations is an improvement in commercial herd output equal to the genetic superiority of the selected sows. Once that is achieved no more gain is possible, since the unimproved boars brought in each generation constantly cancel out further change. Nevertheless the recording and selection must be continued, or even that gain will disappear.

But, of course, if the source herds are improving, then the commercial herd will receive the benefit automatically, through purchased boars (or gilts), and the cumulative gain will soon be much greater than can be brought about by their choosing replacement gilts from their best sows. A proper appreciation of this by herd managers and their advisers could save the unnecessary introduction of time-consuming selection schemes at the commercial level, whose only effect may be to divert attention from areas of management, that would lead to real improvements in profitability.

Culling Within Commercial Herds. There is a widespread feeling among herd managers that they can increase their herd mean performance, even in the short term, by culling those sows that have produced at well below average performance in their first one, two or three litters. Now the improvement in mean litter size obtained at the next parity, as a result of culling depends heavily upon the repeatability of the trait. Many analyses confirm the repeatability of a single record to be around 15%, though this can increase if the mean of two or three records is used as the culling criterion. Calculations of the overall effectiveness of culling schemes in raising herd mean productivity show extremely small predicted increases (around 1% of the mean). There are two main reasons. First, repeatability is low; second, the increased proportion of gilts and young sows in the herd, which is an inevitable consequence of any voluntary culling scheme. Consequently culling on the basis of litter size is not to be recommended (Strang and King, 1970).

Nevertheless, the important question may still turn out to be not, can we improve prolificacy by selection, but should we? The problem concerns the inevitable trade-off if selection pressure on growth, efficiency and carcass traits is relaxed in favor of selection for reproduction. The breeder will have to make an assessment of the monetary values of progress foregone in the traditional traits vs the progress made in prolificacy. The solution is bound to vary in different lines, in different markets and at different times. Some further discussion of this area is in Bichard and David (1986).

Effect of Boar on Productivity of His Mates. Finally, mention must be made of the possibility of improving sow productivity through the boar contributions. Naturally, high performance can be achieved where the individual boars are willing and able to detect heat, to serve efficiently and to achieve a high fertilization rate and, hence, high litter size. Once again, there are breed differences in these traits, and since they are clearly fitness traits then crossbred boars are as good as, or are slightly better than, purebreds. Furthermore, boars from lines unrelated to the sow lines may produce slightly more viable progeny. But only a small proportion of the total variation in litter size is controlled by individual boar differences. This is a fact that appears unacceptable to many producers and advisers. Boars are occasionally sterile, and a few have chromosome defects, that drastically reduce litter size among their mates. Apart from these, the normal range that appears when boars are ranked on farrowing rate or litter size is much more a function of sampling error, arising from the
relatively small number of sows served by any one boar in a year, than of any inherent differences among boars which would be repeatable. Hence genetic selection, or even culling among boars in the stud, does not hold any great promise of helping to achieve higher sow output. It is boar management that is the key in this area.

**Literature Cited**


