In order to review the use of breeds as dam lines, consideration is given to the definition of breeds and the ways in which breed comparisons are carried out. Comparisons of breeds as purebreds in respect of their reproduction characteristics are reviewed, concentrating on a few major breeds of worldwide distribution. Corresponding information on the performance of breeds as crossbreds is examined and the ways in which this basic information can be used in the choice of dam breeds is considered with discussion of some of the complications arising. Future developments that need to be the subject of further enquiry are the potentialities of the prolific Chinese breeds and the likely arrival of transgenic animals with altered performance characteristics. The international distribution of deep-frozen boar semen is seen as a major opportunity for making comparisons both among breeds and among strains with improved performance characteristics.

INTRODUCTION

A specialised dam line contributes to the economy of production through the reproductive performance of females, maintenance costs of the breeding herd and the genetic potential transmitted to progeny for meat production. Therefore to specify breeds for use as dam lines needs a characterisation for both reproduction and production factors (growth rate, efficiency of food conversion and carcass characteristics). A recent bibliography of breed comparisons in pigs by Sutherland et al (1984) shows the size of that task. Some 208 breed groups were located, of which 147 had been involved in at least one comparison with another breed. The more limited purpose of the present review is to pick out some salient features of major breeds and to discuss ways in which appropriate choices of breeds and breed combinations might be made. Some of the many complications which arise will be discussed and suggestions made about future ways in which present resources can be maintained, and new populations created for the future.

DEFINITION AND DESCRIPTION OF BREEDS

The populations commonly denoted as 'breeds' are frequently ill-defined and become differentiated in ways which may or may not be recognised. Although some major breeds maintain pedigrees with herdbook associations, the oldest of these is only about 100 years old and most much more recent. Within the usual disciplines of such an association, immigration of animals from other populations considered to be related are often permitted with effects that are usually not documented. When animals are chosen for export purposes, rarely is any form of random or stratified sampling used which would ensure some reliable connection between the parent and exported population. Instead, chosen animals are frequently selected on the basis of health considerations, price and the opinions of the purchasers. Because of expense, imports are often made on a small scale so that the new emerging population may well pass through a bottle-neck. Once in the new country, selection methods may well differ so that although two breeds may share the same name, their genetic characteristics may gradually diverge.
Despite all the difficulties in defining and describing breeds, it is necessary to accept a common usage and to discuss the results which accrue under these labels, but some of the more discordant results will be noted in passing. Most of the discussion will centre on the Large White/Yorkshire, Landrace, Duroc and Hampshire breeds in view of their worldwide distribution and importance in numbers and will be referred to as the major breeds.

**COMPARISONS OF BREEDS AS PUREBREDS**

**A. Reproduction**

Experimental comparisons of the traits commonly recorded under the heading of reproduction, such as numbers born and weaned, stretch most experimental resources to their limit because of the great variability of these characteristics. Some of the experimental summaries, such as those assembled by Quintana and Robison (1983) and Johnson (1981), are particularly valuable, although the small overlap of breeds between experiments means that there is little realistic opportunity of detecting real interactions in performance in different locations.

For conception rate, Johnson (1981) reported significant breed effects with the Chester White, Hampshire and Berkshire breeds being above average, and the Yorkshire, Landrace and Large Black below average. However, some inconsistency between experiments were pointed out. Observations on the litter sizes of sows have been a common ingredient of many experiments, usually combining both the purebred matings and those where purebred sows produce crossbred litters. The Chester White, the Lacombe and Yorkshire breeds ranked highly for litter size at both birth and weaning, while the Berkshire, Hampshire and Large Black and Spot were below average.

Outside North America most figures for the comparison for productivity come from field records with inherent doubts about the possibility of bias due to some breeds being kept under particular environmental conditions. Nevertheless, the comparisons emerging from Europe also suggest similar ranking for litter size in the major breeds with the Yorkshire and Landrace being consistently high and the Duroc and Hampshire that have been imported from North America being lower, for example, Svineavl og-Produktion i Danmark (1983). The substantial numbers now available show that the difference between breeds are preserved over three parities as shown in Table 1.

**Table 1: Productivity Records of Major Breeds**

<table>
<thead>
<tr>
<th></th>
<th>Landrace</th>
<th>Yorkshire</th>
<th>Duroc</th>
<th>Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DENMARK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gilts</td>
<td>9.4 (8.2)</td>
<td>9.5 (7.8)</td>
<td>8.6 (7.0)</td>
<td>7.8 (6.1)</td>
</tr>
<tr>
<td>Sows</td>
<td>10.0 (8.5)</td>
<td>10.6 (8.7)</td>
<td>9.8 (7.8)</td>
<td>8.8 (7.1)</td>
</tr>
<tr>
<td><strong>SWEDEN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gilts</td>
<td>9.6 (8.0)</td>
<td>10.0 (8.3)</td>
<td>9.1 (7.3)</td>
<td>-</td>
</tr>
<tr>
<td>Sows</td>
<td>11.7 (9.1)</td>
<td>11.5 (8.9)</td>
<td>10.7 (7.7)</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources: 1 Svineavl og-Produktion i Danmark, 1984  
2 J. Sigvardsson, private communication
The inventory of pig breeds in Europe, carried out by the EAAP Working Party (1984), shows that there are many other minority breeds kept in different production systems where litter records are clearly not comparable and indeed in many circumstances are not recorded. As far as is known, these breeds do not appear to have productivity traits in excess of the Yorkshire or Landrace but may have alternative merits and adaptation to less sophisticated environments. A few breeds such as the Welsh in Britain have been subject to the introgression of genes from other breeds so that they now come to resemble the donor breed closely (in this case the Landrace). Such alternative populations may find favour for crossing but unless they find support from sufficient breeders, they usually find it difficult to compete with the major breeds.

Many indigenous breeds in developing countries have been investigated and found to have comparatively low levels of productivity. Even where controlled comparisons have been made, the differences tend to persist, for example, the Nigerian indigenous pig (Adebambo, 1982) and the Sri Lankan indigenous pig (Goonewardene et al, 1984).

In a quite different category there are a few prolific breeds from China with a long history of domestication and selective breeding. Details of the many Chinese breeds are being collated (Cheng, 1985) and shows an inventory of over 90 distinct breeds. It emerges from these studies that there is a small group of highly prolific breeds from Lake Taihu region west of Shanghai which are indeed exceptional and quite different from the majority of Chinese breeds in their reproductive performance. The review by Xu (1985) on the investigations being carried out on 10 indigenous breeds shows both the extent of the effort which is now being made to characterise these breeds and also their distinctive qualities. Among the 10 breeds studied, only the Taihu breeds have exceptionally high litter performance with the Min breed from Harbin possibly also having litter sizes above those encountered in the West. The Taihu group are outstanding not only in litter size but also in a very low age at puberty (Table 2). The export of a small sample of two of these prolific breeds, the Meishan and Jiaxing, to France has confirmed the unique nature of this resource (Legault and Caritez, 1983) and opens up some of the possibilities envisaged in the survey of Phillips et al (1945).

Table 2: Percent difference in reproductive performance of Chinese breeds compared to Large White and/or Landrace (LWL) controls in France

<table>
<thead>
<tr>
<th>BREEDS*</th>
<th>MS</th>
<th>JX</th>
<th>MS/2</th>
<th>JX/2</th>
<th>MS/4, JX/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total born</td>
<td>+39.3</td>
<td>+ 8.4</td>
<td>+43.0</td>
<td>+42.1</td>
<td>+7.5</td>
</tr>
<tr>
<td>Weaned (28 days)</td>
<td>+42.4</td>
<td>+ 8.7</td>
<td>+39.1</td>
<td>+43.5</td>
<td>+7.6</td>
</tr>
<tr>
<td>Ovulation rate</td>
<td>- 2.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embryo mortality</td>
<td>-38.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Litter weight (birth)</td>
<td>+10.2</td>
<td>-35.4</td>
<td>+31.3</td>
<td>+ 7.5</td>
<td>+6.1</td>
</tr>
<tr>
<td>Litter weight (21 days)</td>
<td>+ 9.0</td>
<td>-32.0</td>
<td>+19.4</td>
<td>+13.6</td>
<td>+1.4</td>
</tr>
<tr>
<td>Food consumed (30 day lactation)</td>
<td>-37.5</td>
<td>-47.2</td>
<td>-19.7</td>
<td>-19.2</td>
<td>-26.6</td>
</tr>
<tr>
<td>Teat number</td>
<td>+16.4</td>
<td>+42.1</td>
<td>+ 5.0</td>
<td>+19.3</td>
<td></td>
</tr>
<tr>
<td>Age at puberty</td>
<td>-60.0</td>
<td>-55.1</td>
<td>-57.0</td>
<td>-54.0</td>
<td></td>
</tr>
</tbody>
</table>

* MS = Meishan; JX = Jiaxing; MS/2 = MSx(LWL); JX/2 = JXx(LWL); MS/4, JX/4 = MX/2x(LWL) and JX/2x(LWL).
Sources: 1 Sellier and Legault (1986)
It is appropriate that attention is now being paid to some other maternal characteristics, for example, the re-breeding interval after the first litter and teat number. In this respect, some of the Chinese breeds are also outstanding. Taking sow weight as a guide to sow maintenance costs, points to the potential of Chinese breeds in other areas of reproductive performance yet to be fully explored.

B. Production

Extensive data exists on the growth and carcass attributes of purebreds not only from experiments but from those countries operating national testing stations.

Although many crossbreeding experiments have included groups of purebred animals, the statistical analyses carried out have frequently used these as part of a complex statistical model and it is not always possible to obtain comparative figures on the performances of purebreds in these experiments. From test station figures in the USA, certain breed characteristics become apparent. For example, Hampshires have the least back fat and the largest area of longissimus dorsi, while Durocs and Yorkshires are characterised by high growth rates. The figures of Buchanan and Luce (1985) show the changes in the Oklahoma station over the years and demonstrate how breed differences may change.

In Europe testing station figures usually show the Landrace and Yorkshire to have very similar growth and feed efficiency characteristics, although there is an exception in the case of the Danish Landrace which is slower growing and less efficient than other national varieties of this breed. When tested, alongside Yorkshire pigs, Durocs and Hampshires have generally been found to be less fast growing and not as efficient in food conversion (Table 3). In carcass characteristics they are shorter in carcass length and on dissection have usually proved to be slightly fatter, although not to the extent that would be predicted from their backfat measurements. These tend to be unreliable in choosing between breeds, and complete dissection is usually recommended. Where they have been tested as purebreds in testing stations, most other European breeds have been found to be slower growing, less efficient and usually fatter than the Yorkshire or the Large White. The one exception to this in regard to leanness would be the Pietrain breed from Belgium.

Table 3: Productive performance of four major breeds in Denmark

<table>
<thead>
<tr>
<th></th>
<th>Landrace</th>
<th>Yorkshire</th>
<th>Duroc</th>
<th>Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers</td>
<td>1085</td>
<td>1405</td>
<td>729</td>
<td>150</td>
</tr>
<tr>
<td>Daily gain (g/day)</td>
<td>801</td>
<td>898</td>
<td>885</td>
<td>839</td>
</tr>
<tr>
<td>Food conversion (food/gain)</td>
<td>2.80</td>
<td>2.56</td>
<td>2.70</td>
<td>2.77</td>
</tr>
<tr>
<td>Meat percent (%)</td>
<td>64.10</td>
<td>64.30</td>
<td>61.70</td>
<td>63.00</td>
</tr>
</tbody>
</table>

Source: Svineavl og-Produktion i Danmark, 1984

The search for breeds surpassing those already discussed, in growth rate, efficiency and leanness, does not appear to have produced any recent discovery of breeds with all round superiority. Thus, for example, while the Lacombe breed of Canada demonstrates excellent growth rate and efficiency, its leanness does not appear to be competitive with that of some other white breeds.
COMPARISONS OF BREEDS AS CROSSBREDS

A. Reproduction

Numerous crossbreeding experiments have shown maternal heterosis to be such an important component of female productivity that choice of a breed based on its performance as a constituent of a crossbred sow becomes all important. Although the number of potential crossbred combinations reaches daunting proportions, far beyond the scope of most experimental resources, a surprisingly large number of experimental crosses have been compared over the years. Of the many crosses that have been tried, one common one, that of the Yorkshire (or Large White) with the Landrace has tended to emerge near the top of the ranking for prolificacy, although not always for litter weight (Fahmy and Holtmann, 1977). The same finding in later experiments, for example, Buchanan and Johnson (1984) confirms the high prolificacy of this particular crossbred female. Other contending crosses are the Hampshire x Landrace, Duroc x Landrace and Duroc x Yorkshire, which appear to benefit from more heterosis than that found in the Yorkshire x Landrace sow. For example, Kuhlers et al (1982) found comparing three crosses that litters from Spot x Landrace sows were smaller than from Duroc x Landrace and Hampshire x Landrace. In the Netherlands, the Duroc x Landrace crosses have been found to have practical advantages over Yorkshire Landrace sows in a greater survival of sows to later parities, but were not acceptable to some breeders because of aggressive behaviour (Brascamp and Buiting, 1984).

The availability of two prolific Chinese breeds for crossbreeding has resulted in an interesting series of experiments from France (Legault and Caritez, 1983). The finding was that crosses of the Meishan and Jiaxing Black with Large White and Landrace produced crossbred sows coming into sexual maturity at the same age as their Chinese parents and also having comparable litter sizes (or considerably larger in the case of Jiaxing, Table 2). A prolific Chinese breed crossed with a Large White or Landrace thus produces a crossbred sow with far greater reproductive potentiality than the more usual Large White/Landrace, and, since that sow is small in body size, the feed costs are also reduced. This finding is a stimulus to further work which will certainly ensue as soon as the Chinese breeds become more generally available.

B. Production

The contribution of breeds when used as a constituent of a crossbred dam may be analysed in a variety of ways. One of the most direct ways is to analyse separately the breed of sire and breed of dam effect as done in the summary by Johnson (1981). The comparison of the effects from the two sexes showed that they were not always the same and this is understandable if there are important maternal effects affecting performance. From the summary quoted, the breed of dam effects for growth rate differ with the Duroc breed contributing to rapid growth and the Chester White to slow growth. For carcass backfat the biggest effect found was for the Landrace breed which was also found to have a small area of longissimus dorsi. As with the purebreds, the Hampshire emerges as having low backfat and a large area of longissimus dorsi.

Results from Europe for the Duroc and Hampshire tend to confirm these results with the Duroc standing out for its contribution to growth rate. The difference is, however, that in Denmark, for example, both Yorkshire and Landrace cross sows produce progeny with lower fat measurements and greater lean content than both Duroc and Hampshire crosses (Legault et al, 1985).
Results are also available for the crosses of the Chinese breeds (Legault et al., 1985) and these show them to contribute thick backfat and low leanness to their crosses along with low growth rates and poor food conversion efficiency. These differences are also found when crossbred sows are backcrossed to a Western breed, thus making the three-quarters Western, one-quarter Chinese slaughter pig of an inferior value for growth and carcass (Table 4).

Table 4: Percent difference in productive traits of Chinese breeds compared to Large White and/or Landrace controls in France

<table>
<thead>
<tr>
<th>Trait</th>
<th>MS/4</th>
<th>JX/4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily gain</td>
<td>-3.4</td>
<td>-7.8</td>
</tr>
<tr>
<td>Food conversion kg (feed/gain)</td>
<td>+6.8</td>
<td>+10.0</td>
</tr>
<tr>
<td>Killing out percentage</td>
<td>-1.2</td>
<td>+0.1</td>
</tr>
<tr>
<td>Estimated lean percentage</td>
<td>-7.1</td>
<td>-8.1</td>
</tr>
</tbody>
</table>

Source: ^Sellier and Legault (1986)

CHOICE OF DAM BREEDS - INTEGRATION OF REPRODUCTION AND PRODUCTION

Although for review purposes the main characteristics of breeds in respect of production and reproduction have been separated, they have to be considered together in the choice of breeds for use as dams or as part of a crossbred dam. This tends to complicate the issue in that certainly the most prolific breeds, the Chinese Taihu breeds, have the poorest performance in respect of growth and carcass. This does not appear to be a general dilemma in that the more prolific breeds such as the Yorkshire and Landrace also tend to have good growth and carcass characteristics. The need to consider both aspects of performance does, however, mitigate against some breeds such as the Lacombe which has good growth efficiency, but less good carcass traits and against some prolific breeds such as the Chester White with good reproductive performance but not competing in other respects.

COMPLICATIONS IN THE CHOICE OF BREEDS AS DAM LINES

The choice of specific combinations for use as dam lines is complicated by several issues. Although the performance of purebreds can be used as a preliminary guide to the performance of crosses, examples have already been quoted as showing some of the complexities that arise. Specification of a genetic model as, for example, by Dickerson (1969) leads to many parameters for estimation and in the final analysis the comparison of particular combinations will be necessary. This is particularly so with rotation crossing systems where the knowledge of recombination loss in later generations is so far rudimentary. Evidence from some backcross sows, for example, Stewart and Drury (1983), sometimes gives results which are not in line with those of first crosses.

Maternal effects have already been mentioned, complicating the issue, and seem to be particularly important as regards growth and carcass for some particular combinations of breed such as the Duroc and Yorkshire. Cross-fostering experiments carried out by Toelle and Robison (1983) are particularly interesting and relevant to this phenomenon. They found that Duroc mothers had a prenatal effect which led to increases in backfat and growth rate and also a postnatal effect increasing backfat. The interpretation of those results was somewhat complicated by competition between piglets from different sources but remains
a powerful way of tackling such complexities which, if they were better understood, might lead to further increase in performance.

Interactions between performance of the crosses and the conditions under which they perform will remain a major consideration. Experiments such as those of Stewart and Drury (1983) who compared the maternal performance of the Hampshire, Duroc and Landrace backcross females on normal and high fibre diets, are therefore particularly welcome. Although in this instance the dietary difference had no effect on reproductive performance and interactions were not found, this field of enquiry should be a fruitful one.

It has been noted that interactions between parity and the particular combination of female are in general not found (Schneider, 1978). The introduction of Chinese breed crosses would make this conclusion worth examining in more detail because during their sexual development, Chinese sows appear to ovulate at an early age with comparatively low numbers of ova and then to build up to high ovulation rates over a number of oestrus cycles.

**FUTURE DEVELOPMENTS**

This review has in many ways been simplistic in that breeds have tended to be regarded as non-changing entities. This is clearly not so because we have different national samples of the majority of major breeds, changing in different ways as selection practices differ in different countries. In an interesting development it has been decided in the Netherlands to divide the Yorkshire herd book between a general purpose section and one for pigs intended for use in dam lines. Special selection programmes such as those for hyperprolific sows (Legault and Gruand, 1976; Bichard and Seidel, 1982) may alter the characteristics by a major step and with changes of up to one piglet per litter might be a way of introducing new breeds into dam lines and so increasing the choice currently available. On balance the calculations of Avalos and Smith (1986) suggest that this is unlikely in that the sacrifice of production traits during the selection for reproduction will offset much of the gain in reproductive rate.

It is interesting to note that the Chinese breeds introduced into France have yet to justify their integration into an economical (intensive) system of production. A maximum contribution of one-eighth Chinese breeds seems so far the point of equilibrium in economy of production by European standards. More precisely, this is the point where the high litter size of Chinese breeds compensates for their poor growth and carcass characteristics (see Legault et al, 1985 and Bruel et al, 1986). Clearly more work is needed to incorporate other outstanding attributes of Chinese breeds (ie, low age to puberty and small mature size) into a more complete model of economy of production. However, the costs of keeping the other stocks (ie, purebred and half-bred Chinese) necessary to maintain such crossbreeding systems also need to be considered.

Further into the future we can look forward to transgenic animals with differing performance characteristics. It is known that administration of growth hormone (Chung et al, 1985) will increase growth rate and to muscle fat ratio so that if this can be done by transgenic means the characteristics of breeds may be changed. Assuming that such changes are made with equal facility in different stocks, then presumably the molecular biologist will choose to work with improved animals and perhaps the ranking of breeds will not be changed radically.

Overlaying all these discussions there is a great need to characterise breeds
in a better fashion than is usually done at present. The ability to deep freeze boar semen and to ship it around the world with increasing facility does give new opportunities for making comparisons both between breeds and between the local varieties of particular breeds. The ease with which this can be done with bull semen is leading to regularised schemes for comparisons across countries, and we should organise a similar exercise with pig breeds in the future.

REFERENCES


