Iberian pig breeding programme

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Breed

The Iberian pig population is the most important population of the Mediterranean type, one of the three ancient types of domestic pigs. For centuries, this population was maintained with a large effective size submitted to the hard environmental conditions of the semiarid continental climate of the Southwest of the Iberian Peninsula. The characteristic habitat of the Iberian pig is the Dehesa or Montado in Portugal. These are sparse Mediterranean woodlands in which evergreen and cork oaks predominate and in which shrub growth has been reduced by man. The Dehesa constitutes an interesting ecological model of interaction among woodland, grassland and livestock and an important reserve for wild fauna and flora.

Without selective preponderance of any group of breeders, the breed conformation was developed through a process of adaptation to this environment and to the high demand for animal fats. The morphology of the Iberian pig makes it resistant to sunstroke and the high summer temperatures and enables it to travel far in search of food: it has dark skin and hair colour, a pointed snout and legs that are both long and strong. It can endure long periods of hunger because of its low basal metabolism and the early formation of fatty tissues. The thick layer of subcutaneous fat and the high level of intramuscular fat make its meat adequate for dry-cured meat processing, which allows storage and consumption of meat products for the whole year.

Although in the traditional population there were different local varieties (black hairless strains and red, golden or pied varieties), the aforementioned features and others such as short and jowled neck, medium length trunk and pigmented hooves of uniform colour are shared by all Iberian pigs.

Production systems

The main objective of the production of Iberian pigs is to obtain heavy pigs (160-180 kg of slaughter weight) destined to be processed as high quality dry cured meat products. Three different systems of fattening of

castrate animals, with increasing input level and decreasing quality and price of the final products, are used today to produce Iberian pigs for slaughter:

a) The extensive system depends on the seasonal availability of mature acorns (Montanera), usually from early November to late February. The whole productive cycle of the animals is planned to achieve 90-110 kg weight at the beginning of the Montanera, with a minimum age of ten months. In this preliminary period, a common objective is the maximum use of field feeding resources: grazing on the spring pastures, stubble fields and any available crop, but supplementation with concentrate feeds is not unusual with restricted feeding. The feeding in Montanera consists, for the most part, of acorns (6-10 kg/day) and variable intake of grass as well as roots and bulbs. A reference value for the total fattening capacity in Montanera has been 5-6 at (57.5-69 kg, 1 at = 11.5 kg), corresponding to an average carrying capacity of 0.5 pig/ha. The present tendency is to increase this in order to be able to increase the number of pigs produced by the Dehesa, whose total surface cannot be extended in the short term.
b) Unfavourable weather conditions or excessive carrying capacity make it necessary to resort to another extensive system of production called Recebo. In this system, with medium input level, low quantities of acorns are supplemented with concentrate feeds during the fattening period or, alternatively, if the acorns run out and the pigs have not yet attained the required slaughter weight, the fattening is prolonged as necessary with commercial feed stuff.
c) Only 35 percent of the pigs are fattened in the two previous extensive systems. The fattening of the remaining 65 percent is based exclusively on the *ad libitum* intake of concentrate feeds (Pienso). In this system, with the higher input level, pigs are kept indoors or closed in open-air fenced areas. This intensive system is particularly appropriate for Duroc x Iberian cross-bred animals, that are commonly slaughtered at only 10-11 months of age.

The fat of the acorn has a very high concentration of oleic acid (>60 percent of fatty acids) and limited concentration of linoleic and saturated fatty acids. Since the pig is a monogastric animal, the fat of pigs fattened in Montanera has a high concentration of oleic acid and low concentration of linoleic, estearic and palmitic acids. This fact is used to verify the system of fattening and to establish the corresponding prices of fattened pigs according to the analysis of fatty acid composition of samples of subcutaneous fat. A minimum concentration of oleic acid (54 percent) and maximum concentrations of linoleic (9.5 percent), estearic (9.5 percent) and palmitic (21 percent) acids are required to obtain the qualification of Montanera pig, the respective values for Recebo pigs being 52, 10.5, 10.5 and 23 percent and the remaining animals are qualified as Pienso. The price per kg of liveweight in the period 1987-1999 ranged from 2 500 to

4 400 Pts/at (217-383 Pts/kg) for Montanera pigs and from 1 600 to 3 500 Pts/at (139-304 Pts/kg) for pigs fattened with concentrate feed, the prices of pigs fattened by the Recebo system was immediate.

Although it is an aspect which demands deeper research, the characteristic marbling of the meat of Iberian pigs and the high concentration of oleic acid provided by the acorns are considered essential for appropriate ripening and flavour development of the products.

Census

The Iberian breed was the most important breed of pigs in Spain until 1960, with 567 000 sows recorded in the official census of 1955. Since then, the number has been drastically reduced due to three simultaneous factors, namely the:

- depreciation of animal fats;
- outbreak in Portugal and Spain of African Swine Fever;
- massive introduction in Spain of foreign pig breeds.

Cross-breeding of Iberian with several colour-coated breeds was started: Tamworth, Wessex, Berkshire, Large Black, Duroc-Jersey and even Large White. Crosses with Duroc became predominant over other options, most of the commercial pigs containing 25 or 50 percent of Duroc genes. The old structure, with differentiated varieties locally diffused and rare genetic interchange among herds, was substituted by a new pyramidal structure characterised by:

- a strong dependence on a small number of elite herds in order to supply pure-bred Iberian breeding animals;
- absence of a specific tier of cross-bred multipliers: Iberian x Duroc cross-bred sows are obtained both in nucleus or commercial herds.

Obviously, the elite herds, located both in private and public farms, were the target of the breeding programme, when it was initiated in 1993.

According to the official census of 1986, the number of pure-bred Iberian sows was 72 000 with other 38 000 cross-bred. The corresponding figures were estimated in 1990 as 31 000 and 71 000 sows, respectively, but the tendency has been reversed during the last years. The estimates obtained for 1998 indicate 107 000 pure-bred and 93 000 cross-bred sows, with an increase of the total number of sows and the proportion of pure-bred Iberian sows, although most of them are dedicated to crossing with Duroc boars.

An increased demand for Iberian pig products occurred in recent years and has attributed to a higher standard of living and a revaluation of traditional foods of top quality. The total number of slaughtered pigs registered a twofold increase from 1986 (841 000) to 1998 (1 690 000). The distribution of the latter according to the system of fattening was 354 000 (Montanera), 236 000 (Recebo) and 1 100 000 (Pienso).

The breeding programme approach

A breeding programme for Iberian pigs based on farm records was designed by the Spanish Association of Iberian Pig Breeders (AECERIBER). For this purpose, a Commission on Genetic Improvement was constituted with animal geneticists from research centres and member representatives of farmers, the processing industry and regional and national public institutions related to pig production. The following objectives were adopted to initiate the breeding programme:

- development of the breed herd book, avoiding the introgression of foreign genes from cross-bred animals used as reproducers;
- characterisation of the productive performance in extensive conditions of the diverse surviving varieties of the breed;
- genetic improvement for the most disadvantageous traits of Iberian pigs (growth and conformation of the most valuable cuts: hams, forelegs and loins).

According to the previously described characteristics of the population and the extensive production system, a breeding programme of the Iberian breed must overcome several important difficulties that can be summarised as follows:

- identification of animals and data recording of field and slaughter performances;
- genealogical control;
- limited connection among herds, due to the unusual artificial insemination.

Several risks must also be avoided:

- possible loss of rusticity;
- reduction of meat quality;
- extinction of local varieties of lower performances.

According to the productive cycle of their farms, the Iberian pig breeders can be grouped into two types that require different approaches: farmers producing piglets, that are sold at three months of age and farmers that extend the productive cycle until the obtention of heavy pigs for slaughter (Complete Cycle). Consequently, the scheme of genetic evaluation developed by AECERIBER combines:

- intra-herd genetic evaluation for weight at 90 days, focused on breeders producing piglets in farms controlled by AECERIBER;
- genetic evaluation for growth in the fattening period and carcass composition based on data annually recorded in family groups of animals sampled from some of the previous herds and tested under uniform extensive management, including fattening in Montanera.

Reproductive traits like litter size are not included in any of the two types of evaluation, mainly because of the scarce genealogical information available in each one of the farms is not sufficient to accurately estimate

the breeding values of low heritable traits such as prolificacy. On the other hand, the production costs of piglets represent a very small proportion of the production costs of heavy pigs.

Genetic evaluation for liveweight at 90 d

This evaluation utilises records obtained in the farms from piglets when both parents are known. A modification of the traditional system of mating, in which two groups of boars and sows are confined in a pen for four weeks, is required to control the paternity using only one boar. Individual electronic microchips are used to identify the piglets born in litters with known pedigree. These litters constitute the main input of genealogical information for the recently established herd book of the Iberian breed. A panel of seven microsatellites (CGA, IGF1, Sw2419, Sw911, S0106, S0068, Sw936) mapped in different chromosomes and simultaneously genotyped in multiplex, can be used to check pedigrees in Iberian pigs, with the joint probability of exclusion of paternity equal to 99.91 percent.

The ensemble of information used in the last evaluation for this trait is summarised in the following table:

Regions	Farms	Breeding animals	Piglets with records
Extremadura	12	756	4 683
Andalucía	13	515	3 525
Total	26	1 271	8 208

This information has been used, separately for each one of the farms, to estimate the breeding values for weight at 90 d (EBV_{WT90d}) of the controlled piglets and their parents. Details of the methodology of genetic evaluation can be found in the Annex. Given the poor connection among herds, the validity of these evaluations is restricted to the corresponding farms. In the absence of other recorded traits, the value of the estimated breeding value for WT_{90d} constitutes the genetic index adopted in this type of evaluation.

Genetic evaluation for growth and carcass composition

The breeding goal for the farms of complete cycle was defined according to the results of an economic study of the production of Iberian pigs during the last decade. The following economically most important traits were combined in the breeding goal:

- average daily growth during the final fattening period, that also measures the rusticity as adaptation to the Montanera;
- weight of the most valuable cuts (hams, forelegs and legs) adjusted for a common carcass weight.

Since 1993 AECERIBER has carried out annual tests of performance for these traits based on family groups of animals sampled from different herds and transferred to a common farm in order to estimate the:

- productive differences among the main varieties and lines;
- breeding values for growth and carcass composition of the breeding animals genetically related with the tested animals.

These tests are executed under uniform extensive handling and allow the comparison of the EBV of reproducers born in different herds despite the weak genetic connection between herds. Due to sanitary and management causes, two separate trials have been performed including herds from the Extremadura and Andalucia regions. Pigs are finally slaughtered and cut in the same slaughterhouse, where the weight of carcass and most valuable cuts are recorded. At present, a total number of 753 castrate pigs from 60 boars and 258 sows have been tested in Extremadura and another 735 castrate pigs from 55 boars and 255 sows were tested in Andalucia.

One of the most remarkable results of these analysis is the evidence of strong differences in performance between some of the varieties or lines used in the different farms. The line of higher productive performance is a composite line (*Torbiscal*) resulting from the blending of four ancient Portuguese and Spanish strains in 1963 and posteriorly selected in an experimental farm. The less productive varieties for these traits are two types of hairless pigs. The differences between these extreme lines are: 201 g/d (ADG) and 2.4, 1.3 and 0.8 kg for the adjusted weight of hams, forelegs and loins, respectively. Expressed as percentages of the mean, these figures correspond to: 33.7, 11.6, 9.5 and 25 percent. These differences reinforce the specialisation of the diverse lines, with an increasing diffusion of the most productive lines specifically to obtain commercial pure-bred Iberian pigs and limit the use of the hairless varieties to cross-breeding with Duroc.

Breeding goal and standardised genetic index

In the present approach, all the traits included in the breeding goal are used as index criteria. The genetic evaluation based on several traits requires the weighting of the corresponding estimated breeding values (EBV). Economic weights for ADG, hams and loins were calculated with conventional methods according to data of prices and costs in the last ten years. A singular calculation was carried out for the forelegs, a trait where a minimum weight (5.5 kg) is required by the industry. In this case, the trait distribution in the population and the price difference between forelegs within and outside the optimum range must be considered to calculate the corresponding economic weight. The resultant genetic-economic index that has been used in the genetic evaluations of the complete cycle was:

$$6.90*EBV_{ADG} + 2000*EBV_{HAMS} + 1300*EBV_{FORELEGS} + 2200*EBV_{LOINS}$$

A standardised index (mean = 100; SD = 10) was also calculated, transforming the previous values. The estimated breeding values for the diverse traits and the global and standardised indices are facilitated to the farmers for easier interpretation of the genetic merit of the animals. Standardised indices (Std. Index) allow the single classification of breeding animals such as:

- Very Good (Std. Index > 120)
- Good (105< Std. Index < 120)
- Acceptable (95< Std. Index < 105)
- Bad (Std. Index < 95)

These indices are used in the public auctions which constitute an important way to dissemination of improved males and females.

Financial support for this breeding scheme is provided by the central and regional governments: a fund of 4 500 000 Pts is supplied annually by the Ministry of Agriculture, Fish and Food (MAPA) of Spain, related to the management of the herd book of the breed and a total of 8 000 000 Pts are annually supplied by the Agriculture Regional Departments of Extremadura and Andalucia to carry out the performance tests of the complete cycle. Policy aspects of the herd book and the implementation of the breeding scheme are specified in two Resolutions of MAPA of Spain adapted to EU regulations.

Inefficiencies of the breeding programme

The level of acceptance of the scheme increases over time and the performance of 500 heavy pigs will be annually tested in future campaigns. Four main inefficient aspects have been evidenced in the execution of the breeding programme:

- pig identification is not always guaranteed by the electronic microchip due to the thick and soft subcutaneous fat which may require regular replacement; the parallel use of eartags is required despite the high proportion of lost tags which are necessary to replace regularly; this problem will be especially important in the next campaigns due to the increasing number of tested animals;
- genetic evaluation for fattening growth and carcass composition is achieved for a low number of breeding animals with more than two and a half years; increased controlled matings are necessary to build a more dense pedigree with a large number of young animals genetically related to the performance tested pigs;
- a number of boars lower than foreseen is utilised by some farmers in controlled mating, resulting in a biased sampling of the correspondent herds where boar family and herd risk being confused;
- separation of the two trials (Andalucía and Extremadura) restricted the validity of the comparison of genetic merit to the breeding animals from farms of the same region; in the future, both trials must be connected overcoming the present barriers.

Other changes must be introduced to the scheme in order to avoid some of the risks quoted in the previous paragraph, namely:

- meat and fat quality parameters (percent of intramuscular fat and profile of fatty acids) will be individually recorded in future campaigns using cheap and non-invasive techniques (Near Infrared Spectroscopy applied to samples from the masseter muscle); these traits will be included in the breeding goal in the next three years in order to attain genetic progress for growth and carcass traits compatible with the preservation of meat quality;
- the possible substitution and / or extinction of hairless varieties due to their lower performance can be attenuated with their appropriate use in cross-breeding schemes; it requires a differentiated standardisation of the index for the ensemble of pig lines mainly destined to cross-breeding, based on the proper mean and standard deviation.

Future progress

Once these changes have been implemented, the future of this scheme will depend on the ability of the market to relate to the top quality, dry-cured products with the pure-bred Iberian pigs fattened under the extensive system. In this case, the number and size of the pure-bred Iberian herds will be augmented, increasing the probability of achieving the relevant genetic progress for the breeding goal. For this purpose, some other operational changes can be suggested in order to increase the selection differentials applied to both sexes and to reduce the long generation intervals, namely:

- the use of artificial insemination can be recommended as a tool to increase the use of boars with higher genetic merit, dissemination of genetic progress and connection among herds, although it requires important changes in the present extensive management of sows that make the detection of estrus difficult;
- the integration of several connected herds in group schemes can facilitate the selection across herds, development of performance tests based on farm data for fattening growth and carcass composition and the eventual inclusion of litter size in the breeding goal.

Adaptation to the Dehesa ecosystem, top quality of dry cured products and preservation of the genetic diversity of the population are the basis of the Iberian pig production, that cannot be removed by the genetic progress attained from the breeding programme.

Annex: Performance results and statistical models

An Animal Model was used to estimate the breeding values for weight at 90 d (EBV_{WT90d}), including the litter common environmental effect as a second random effect:

$$y = Xb + Z_1u + Z_2c + e$$

where, y = vector of records; b = vector of fixed effects (mean, sex, year, batch of farrowings); u, c, e = vectors of additive genetic effects, litter common environmental effects and residuals and X, Z_1, Z_2 the corresponding matrices of incidence. The genetic parameters used in the evaluation for this trait were estimated from data recorded in the farm with more available information, being the corresponding values: $h^2 = 0.21$ (s.d. 0.11) and $c^2 = 0.16$ (0.04).

A summary of the information recorded in the tests for complete cycle are presented in the following tables:

Growth and carcass data recorded in Extremadura trial (pigs from ten herds).

Trait	Tested pigs	Mean	SD	CV	Minimum	Maximum
ADG†, g / day	753	597	153	26	174	1 345
Slaughter wt., Kg	753	162.5	16.7	10	90	216
Carcass wt., Kg	753	134.0	15.3	11	72.0	181.2
Hams, Kg	753	20.6	1.8	9	12.5	27.7
Forelegs, Kg	753	13.6	1.2	9	8.7	17.3
Loins, Kg	570	3.2	0.4	14	1.9	5.1

†recorded in the final fattening period (Montanera)

Growth and carcass data recorded in Andalucia trial (pigs from nine herds).

Trait	Tested pigs	Mean	SD	CV	Minimum	Maximum
ADG†, g / day	683	597	132	22	157	1 033
Slaughter wt., Kg	735	167.5	18.6	11	104	223
Carcass wt., Kg	735	138.9	15.3	11	85.2	192.6
Hams, Kg	735	20.8	2.2	11	12.4	28.3
Forelegs, Kg	735	14.3	1.6	11	9.7	19.7
Loins, Kg	582	3.1	0.4	14	2.0	4.4

†recorded in the final fattening period (Montanera)

The previous information has been used separately for each one of the trials, to estimate genetic parameters and breeding values for ADG, weight of hams, forelegs and loins adjusted for carcass weight of the tested pigs and their parents, using the following Animal Model:

$$y = Xb + Zu + e$$

where, y = vector of records; b = vector of fixed effects (mean, sex, year, herd and carcass weight as co-variable in the analysis of prized cuts); u, e = vectors of additive genetic effects and residuals and X and Z, the corresponding matrices of incidence.

The estimates of heritabilities (in the diagonal) and genetic correlations between the diverse traits, with their standard errors are presented in the following table:

Genetic parameters for traits included in the breeding goal.

	ADG	Hams.	Forelegs	Loins
ADG	0.445 (0.043)	0.743 (0.074)	0.693 (0.079)	0.591 (0.090)
Hams		0.484 (0.050)	0.894 (0.038)	0.742 (0.058)
Forelegs			0.544 (0.063)	0.667 (0.070)
Loins				0.522 (0.069)