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Why and how to select a local porcine breed: The case of the Cinta Senese

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SUMMARY – In the eighties the Cinta Senese breed was on the brink of extinction and experienced high inbreeding rates. In this regard the current programme for management of inbreeding and genetic variation is presented. No selection programmes are currently implemented in the Cinta Senese, however, if the current positive demographic trend continues, the need to identify selection objectives and strategies will emerge. The second part of the paper discusses how possible selection objectives must take into account breed characteristics and market trends. Both reproductive (number of teats and litter size) and productive traits (growth rate and carcass composition) are considered. Genetic parameters, as well as the inbreeding effect, are presented. However, besides the need for more investigations on growth and meat quality, the question of which selective objectives should be considered remains open because no clear trends in the market can be detected today. In fact we observe parallel interests for intensive and extensive farming and the market seems to be willing to continue to valorise fat as well as lean cuts.

Keywords: Cinta Senese, local pig, selection objective, genetic management.

RESUME – "Pourquoi et comment sélectionner une race porcine locale : le cas de la race Cinta Senese". Dans les années 80 la race Cinta Senese était en risque d'extinction et avait subi une forte agmentation de la consanguinité. A ce propos, le programme actuel pour la gestion de la consanguinité et de la variation génétique est présenté. Chez la race Cinta Senese aucun programme de sélection n'a été actuellement mis en oeuvre, cependant, si la tendance démographique positive se poursuit, il sera nécessaire d'identifier les objectifs et les stratégies de sélection. Dans la seconde partie de cet article, on discute comment les objectifs possibles de sélection doivent prendre en compte les caractéristiques de la race et les tendances du marché. Les caractéristiques reproductives (nombre de télines et dimension de la portée) et les caractéristiques de production (vitesse de croissance et composition de la carcasse) sont considérées. Les paramètres génétiques et l'effet de la consanguinité sont présentés. Cependant, à côté de la nécessité d'investigations supplémentaires sur la croissance et la qualité de la viande, la question des objectifs de sélection à considérer reste ouverte, puisque aujourd'hui on ne peut pas discerner de tendance claire dans le marché. En effet nous observons des intérêts parallèles pour l'élevage intensif et extensif et il semble que le marché continue à valoriser les pièces grasses aussi bien que les maigres.

Mots-clés : Cinta Senese, porc, race locale, objectif de sélection, gestion génétique.

Overview of Italian autochthonous pigs

Mascheroni (1927) documented the presence in Italy, in the early decades of last century, of twenty-one local pig breeds. Though some of these breeds were characterised by high degree of similarity with other breeds and they should be considered as geographical varieties of a smaller number of distinct breeds, at the beginning of the 20th century Italy accounted for a high pig diversity.

Socio-economic post-war transformations in the agricultural system, intensification and industrialisation of pig farming, modifications in land use and massive utilisation of commercial breeds determined the decline of local Italian breeds. Nowadays only five local breeds are still farmed, in most cases with small numbers of sows: *Mora Romagnola*, *Cinta Senese*, *Casertana*, *Calabrese* and *Siciliana* (also called *Nera Siciliana*). In addition, an heterogeneous pig population is present in Sardinia, which frequently interbreeds with both wild and commercial boars. The National Register (Registro Anagrafico) of local pigs was recently set up (D.M. 20871; 6/3/2001) by the Italian Pig Breeders Association (ANAS) at the request of the Ministry for Agriculture Politics. Size of registered populations is given in Table 1. Percentage of registration is still very low for *Casertana* and in particular for *Siciliana*, but it is expected to increase.

All breeds are still found in their original farming area, with some exceptions for *Cinta Senese* that is progressively spreading out of its original area in the neighbouring regions (Franci and Pugliese, 2004). In the last years some research has been carried out on breeds performances, but information on both quantitative and qualitative traits is still limited (Franci and Pugliese, 2004). In Table 2 in vita performances are reported. Data refer to trials under intensive conditions, that provide indications on breeds genetic potentials and allow comparisons among them. Nevertheless in comparing breeds some caution is necessary as data originate from different trials. In particular, slaughter age or weight varied among breeds in order to obtain mature meat, suitable for ham and salami production. *Cinta Senese*, *Casertana* and *Mora Romagnola*, under intensive management, reach slaughter weight around one year of age, that assures adequate maturity of meat for seasoning processes. On the contrary, *Calabrese* and *Siciliana* pigs show much lower growth rate.

Table 1. Registered populations of the five Italian pig breeds (National Register, 2003)

	<i>Mora Romagnola</i>	<i>Cinta Senese</i>	<i>Casertana</i>	<i>Calabrese</i>	<i>Siciliana</i>
Boars	22	201	9	16	10
Sows	67	886	6	102	54
Young pigs [†]	298	1958	59	587	557
Herds	27	188	5	6	10

[†] Piglets tattooed in the year.

Table 2. In vita performance of five Italian pig breeds, reared with commercial feed

Breed	<i>Cinta Senese</i>	<i>Casertana</i>	<i>Mora Romagnola</i>	<i>Siciliana</i>	<i>Calabrese</i>
Reference	Acciaiuoli <i>et al.</i> , 2002	Pilla, pers. com.	Fortina, pers. com.	Pugliese <i>et al.</i> , 2003	Cosentino <i>et al.</i> , 2003
Slaughter age (d)	312	371	374	448	540
Slaughter weight (kg)	136	151	150	102	134
ADG [†] (g/d)	436	407	401	228	248

[†] Weight/age.

The recent history of the Cinta Senese

The recent history of the Cinta Senese can be analysed in three different periods.

Early registration – The first national herd-book was instituted in 1934 with the aims of standardising and improving the breed (Tornar, 1934; Mascagni, 1947). At that time, the Cinta Senese was the only Italian pig breed with an official selection program. Animals identification and registration were under the responsibility of the local Administration (Siena) and selection was carried out in four nucleus herds. Selection objectives included morphological traits, prolificacy, growth rate and body size. Fattening and feed consumption trials, also, were carried out. Progeny testing was proposed to detect boars carrying the gene of extension of the black colour with the aim of fixing the white belt as standard coat. In reality the emphasis was given to morphological trait, mainly coat colour, legs defects, body shape and size. Functional parameters, such as prolificacy and growth rate, were less considered, also because the Cinta Senese begun to be more and more used as maternal breed crossed with Large White boars to produce "tramacchiato" pig. Nevertheless, it is likely that current performances of the Cinta Senese, which are higher than those of the other Italian local breeds, reflect the selection activities of this period.

Period of decline – In the fifties the Cinta Senese population counted 160.000 heads (Raimondi, 1954). Since 1955 the number of sows started to decline and both herd book and selective activities lost importance, because the aforementioned economical and structural transformations. In the seventies the breed survived in few herds (less than ten) and in the 1986 reached the minimum size

of 81 sows and 3 boars recorded. To avoid extinction, since 1980 the Tuscany Region instituted a new regional herd-book and provided economic incentives to breeders in order to compensate the lower profitability of the local breed compared to commercial genotypes. The animals present in this bottleneck period are the founders of the current registered population.

Period of recovery – The economic incentives of the local administration and the affection of a few farmers to their breed saved the Cinta Senese from extinction. However population size remained low (less than hundred males and females registered) for a period of about fifteen years. After 1996 a renewed interest for the breed emerged, and in 1997 registration started again at the national level in the National Herd-book. The growing commercial interest for Cinta Senese products, well appreciated by a consumer niche, determined in the most recent years an exponential increase of the population, as shown in Fig. 1.

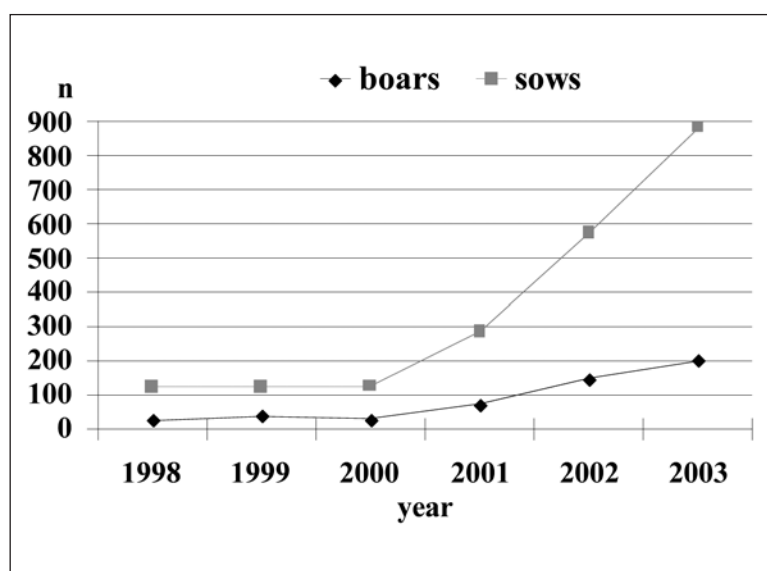


Fig. 1. Evolution of Cinta Senese population recorded in the National Register since 1998.

The activities of the National Register of local pigs

According to laws 30/1991 and 280/1999, the National Pig Breeders Association (A.N.A.S., www.anas.it) manages two official registers, the Libro Genealogico and the Registro Anagrafico, that have different targets.

Libro Genealogico – It is the herdbook of commercial breeds, including Italian Large White, Italian Landrace, Italian Duroc, Pietrain and Belgian Landrace. It is responsible for genetic improvement, including genetic evaluation of boars with sib-test procedure. Main selection objectives are growth rate, feed conversion, carcass quality (lean cuts and backfat thickness), meat quality (salting loss for ham; intramuscular fat in the Italian Duroc).

Registro Anagrafico – Besides two foreign breeds with limited distribution in Italy (Hampshire and Spot), the Registro Anagrafico focuses on the five Italian local breeds Cinta Senese, Mora Romagnola, Casertana, Calabrese and Siciliana. The Registro Anagrafico is the instrument for those breeds where management of genetic variation is the main objective and no specific selective activities are carried out. Concerning the local breeds, it aims to maintain their rusticity, to monitor and manage inbreeding, to improve productivity under extensive farming. It defines morphological standards and registration rules. The technical rules for registration of Cinta Senese pigs are: (i) threshold of 10 functional teats both in males and females; and (ii) absence of morphological defects (e.g. absence of white belt, extension of white belt on more than 50% of trunk, presence of red hair, presence of white spots). The Registro Anagrafico records reproductive performance of sows, including number of born alive, of still born and of weaned piglets per litter.

No selective schemes are currently in use and the only selective activity refers to number of functional teats, with the threshold at registration. In Fig. 2 the frequency distribution of the number of teats is reported, comparing the current situation to that of 1940-1950. The present population shows a higher number of functional teats, probably because the higher threshold of 12 teats set in the first years of activity of the Registro Anagrafico.

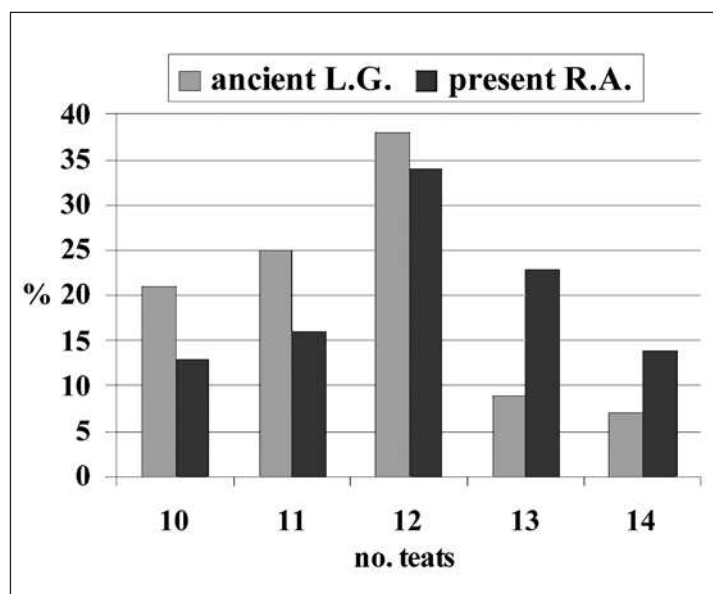


Fig. 2. Distribution of recorded animals (males and females) according to number of functional teats.

Inbreeding and genetic variation management in the Cinta Senese

In the Cinta Senese inbreeding has been rapidly increasing by about 1% per year from 1975 to 1995 when reached 20%. Inbreeding rates per generation of 0.5-1% are generally considered acceptable. Assuming a generation interval of 3 years, inbreeding rates in the Cinta Senese were 3 to 6 times higher than suggested rates. Several factors contributed to this trend, namely a low number of breeding animals, an unbalanced use of boars and a limited exchange of animals among herds. As above mentioned, the breed experienced a long and severe bottleneck in the seventies and eighties. Table 3 reports the number of sires in 1976 and, at five years intervals, in the eighties and early nineties. The extremely low number of boars resulted in very low effective population sizes and consequently high inbreeding increments. In addition, in the nineties, when population size began to progressively increase, boars were not used homogeneously, resulting in high variance of male family size and an additional reduction of effective population size. In 1995 inbreeding was approximately 60% higher than expected under the hypothesis of random mating, indicating a lack of circulation of animal among herds, resulting in consanguineous mating.

Table 3. Number of Cinta Senese sires registered per year

	Year					
	1976	1983	1988	1993	1998	2003
No. of sires	1	2	1	5	26	> 126

In 1999 a program for inbreeding control was launched, which includes boar selection and mate planning. Periodically group of males are pre-selected, by minimising their relationship, and their codes are published on the Breeder Association web-site. Breeders are invited to use these males as

herd renewal because they allow to reduce mean relationship in the populations, to equilibrate unequal founder contributions and consequently to control population inbreeding rates. To facilitate breeders to select, among the pre-selected males, the animals to be used in their herd, the program computes average relationship between pre-selected males and female herds. This information is distributed to all breeders. In addition it is possible to compute directly on the web-site the relationship among animals. Most breeders are participating to the program. A major operational constraint of this scheme is the fact that when the information is available to breeders, many pre-selected males are not any more available (being castrated for fattening, or slaughtered, or simply not any more available for exchange). To avoid this problem, since 2004, every year 5-10 young males of particular importance for inbreeding control will be acquired by the program and subsequently distributed to selected herds. It is too early to evaluate the efficiency of the program started in 1999. However some data, reported in Table 4, seem promising. Average relationship seems progressively to decrease. By comparing 1999 and 2003 data, the efficiency in male pre selection in terms of reducing mean relationship among future boars seems improving consistently, as in 2003 relationship among pre-selected males was almost 50% lower with respect to population relationship. Mean inbreeding in the offspring has considerably decreased since 1995. However this result should be more likely attributed to an increased exchange of animals among herds and the consequent reduction of consanguineous mating than to minimisation of relationship among boars (i.e. use of pre selected boars).

Table 4. Relationship and inbreeding before (1995) and during the program for inbreeding control (1996-2003)

	Year		
	2003	1999	1995
No. of sires of the offspring of the year	> 126	45	14
Mean relationship among males	0.22	0.25	0.26
Mean relationship among pre-selected males (see text)	0.12	0.22	†
Mean inbreeding in the offspring of the year	0.14	0.17	0.21

† Data not available as male pre-selection started in 1999.

Some considerations of selection objectives

As aforementioned, no selection programmes are currently implemented in the Cinta Senese. The breeding structure of the last two decades with a low number of small herds scattered in the farming area and lack of both artificial insemination and performance recording did not favour development of selection programmes. However, if the positive demographic trend of the breed will continue and the population will stabilise on consistent numbers, the need to identify selection objectives and strategies will arise. Selection objectives must take into account both breed characteristics and market trends, as we discuss below.

Reproductive traits

Using data recorded in three reliable herds on 672 parities from 167 sows, through 5 years, average values of 7.2 born alive and 6.3 weaned piglets per litter were observed. The Cinta Senese shows poor reproductive performances, similarly to other Italian local breeds (Franci and Pugliese, 2004) but slightly higher than those of Iberian pig strains which produced, on average, 6.45 and 6.07 piglets per litter at birth and at weaning, respectively (Barba *et al.*, 2001). The distribution of litter size at birth is shown in Fig. 3. Only few cases exceeded 10 born alive (about 4%) indicating that, at the moment, there is not the need to increase the threshold of teats number for registration in Registro Anagrafico.

Genetic parameters of litter size were estimated on the same dataset (Table 5). The statistical model included parity order, herd and inbreeding coefficient of sows and litters as fixed effects. Very low h^2 values were found both for piglets born alive and for weaned piglets, confirming what emerged from previous research on Cinta Senese (Bozzi *et al.*, 2002), on Iberian pig (Silió *et al.*, 2001) and on high selected breeds (Chen *et al.*, 2003; Holm *et al.*, 2004). Maternal effect doesn't seem to affect significantly

these two traits, as the repeatability coefficient was 0.15 and 0.09 for litter size at birth and at weaning, respectively. Inbreeding of sows and piglets had significant effects on these traits. In conclusion, selection for litter size will have to take into account the low heritability, but also the difficulties of measuring the trait under extensive farming conditions.

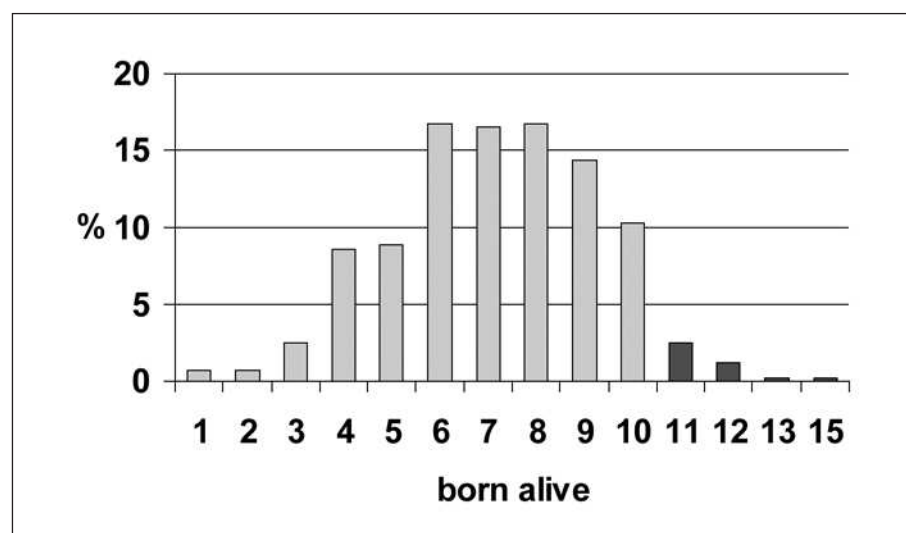


Fig. 3. Distribution of litter size at birth in 3 herds of Cinta Senese.

Table 5. Genetic parameters for number of born alive and number of weaned piglets

	Litter size at birth	Litter size at weaning
Mean (range)	7.16 (1.00-15.00)	6.27 (0.00 – 12.00)
h^2	0.07	0.02
c^2	0.08	0.07
Effect of 0.1 of inbreeding		
– individual (range 0-0.48)	-0.08 (-1.2%) [†]	-0.19 (-3.0%) [†]
– maternal (range 0-0.56)	-0.14 (-1.9%) [†]	-0.22 (-3.6%) [†]

[†] Relative to average value.

Productive traits

As mentioned above, the production structure of the Cinta Senese was until recently constituted by a very small number of traditional farmers selling on farm their production. In the last years the breed has been experiencing a growing interest and fast expansion with the progressive appearance of different farmer and production typologies. In this situation the analysis of the market of breed products, which is necessary to identify possible selection objectives for productive characters, is difficult and we can only depict some elements, which often appear unstable, and no clear trends.

A production consortium was recently created aiming to obtain for the breed products the Denomination of Protected Origin (D.O.P.) "Suino Cinto Toscano". Production rules refer to both fresh and seasoned products and include: (i) pigs are offspring of registered animals; (ii) pigs are born, reared and slaughtered in Tuscany; (iii) pigs are reared in outdoor or extensive systems from four months of age; (iv) feeding system is pasture, supplementation being allowed but without animal products; and (v) minimum age at slaughter is 12 months.

However, the attention given by the consortium to the rearing system does not seem to interest the market, which does not distinguish products from specific rearing/feeding regimes, conversely from what occurs in Iberian pig production with the "montanera, recebo and cebo" systems.

With reference to carcass composition, today the market favours prime lean cuts, such as cured ham, but also recognises some value to fat cuts (e.g. lardo). Table 6 reports market values for the components of the carcass. Data refer to the situation of a complete productive cycle (rearing, transforming and commercialisation) and indicate that fat cuts, which represent 17% of the carcass, provide 12% of the carcass value and that salami, which include some separable fat, insure an additional 26%.

Table 6. Composition and market value of saleable products deriving from half carcass (60 kg) of Cinta Senese pigs

Product	Weight (fresh)		Market value	
	kg	% on total	Price €/kg	% on total
Cured ham	12.5	29.3	34	46.8
Salami (salame, capocollo)	11.6	27.2	17-20	25.5
Cured fat cuts (guanciale, pancetta, lardo)	7.1	16.6	12-15	12.2
Fresh meat (salsiccia, loin, liver)	11.5	26.9	7-11	15.5
Total	42.7			

As growth rate is concerned, Acciaioli *et al.* (2002) showed that growth in Cinta Senese significantly varies between the two extreme production systems of intensive rearing in box and extensive farming with occasional feed supplementation. In particular the latter system imposes a marked compensative growth on acorn pasture in fall, following a summer period of moderate body development. A similar pattern has been described in Iberian pig raised in the Montanera system (López-Bote, 1998). Considering the specific features of extensive Mediterranean pig production, it has been proposed (Casabianca *et al.*, 2000) to select local pigs for "rusticity", measured as the ability of animal to gain weight after a period of feeding restriction. The fact that extensive systems can allow high characterisation of pig meat (Mayoral *et al.*, 1999) with high organoleptic and economical value of cured ham would support research in this direction. However, this is not yet the case of the Cinta Senese, if we consider that the market has not yet identified clear production objectives and many breeders are oriented toward selection for growth under intensive farming conditions. Additionally, the threshold of 12 months of age at slaughter imposed for DOP, does not suggest selection for growth rate.

Table 7. Genetic parameters for growth and carcass traits in Cinta Senese

	ADG (kg)	Fat cuts %	Lean cuts %	Ham %
Mean	0.376	35.2	59.6	23.3
Min.	0.183	25.4	51.0	20.0
Max.	0.516	44.6	69.2	26.1
h^2	0.22	0.42	0.33	0.29
F_x effect (per 10%)	-0.011 (-2.9%) [†]	0.00	0.02	-0.12

[†] Relative to average value.

Some investigations were recently carried out on productive characters. Table 7 reports heritability for average daily gain (ADG), fat cuts, lean cuts and ham percentages, estimated in some fattening trials on a total of 111 Cinta Senese subjects (Crovetti *et al.*, 2005). Low-medium heritability value (0.22) for ADG was obtained, slightly lower than in improved breeds (Xuewei Li *et al.*, 1994) and in the Iberian pig (Fernández *et al.*, 2002), but similar to more recent observations on commercial breeds (Johnson and Nugent, 2003). For carcass composition, medium heritability values were found (Table 7) similar to those reported in Iberian (Silió *et al.*, 2001) and in improved pig (e.g. Johnson and Nugent, 2003). Genetic parameters for meat quality parameters are given in Table 8. Heritability values are somehow contradictory and they need to be confirmed on larger data sets. In the Cinta Senese intramuscular fat is lower than in other local pigs and higher than in selected breeds such as Large White.

In swine, selection for leanness and growth rate must taken into account their well-known antagonism with the qualitative traits of products, namely fresh or cured meat. Several researches reported this

genetic antagonism, in local pig also (Silió *et al.*, 2001), and we can accept to transfer the information to Cinta Senese pig, for which, at moment, it is impossible to obtain directly genetic correlation among qualitative and quantitative traits because of the small size of dataset.

Table 8. Genetic parameters for some chemical-physical traits of meat (on Longissimus lomborum) in Cinta Senese pig

	Intramuscular fat %	Colour a*	Cooking loss %	pH ₄₅
Mean	3.03	12.48	27.66	6.36
Min.	1.20	8.03	14.04	5.61
Max.	6.93	20.24	37.89	6.90
h ²	0.02	0.14	0.29	0.09
F _x effect (per 10%)	0.30	0.02	1.81	0.06

Another aspect related to meat quality which deserves some attention is the presence of the 1843T allele at the RyR1 locus at a frequency of about 4% (Fontanesi *et al.*, 2005). Selection against this allele (halotano gene) is therefore necessary. However, beside the need of more investigations on growth and meat quality in the Cinta Senese, the question of which selective objectives should be considered remains open because no clear trends in the market can be today detected. In fact we observe parallel interests for intensive and extensive farming and the market seems willing to continue to valorise fat as well as lean cuts.

Finally, as already observed for reproductive parameters, the inbreeding clearly depress growth rate (Table 7) (-11 g/d per 10% of inbreeding), as already reported for Iberian pigs (Fernández *et al.*, 2002; Silió *et al.*, 2001).

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