Productivity of Cinta senese and Large White x Cinta Senese pigs reared outdoor on woodlands and indoor. 1. Growth and somatic

Productivity of Cinta Senese and Large White x Cinta Senese pigs reared outdoor on woodlands and indoor. 1. Growth and somatic development

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ABSTRACT

Twenty-nine Cinta Senese (CS), 12 Large White (LW) and 29 LWxCS pigs were reared indoor and group fed on commercial mixtures in pens averaging 6 animals according to genetic type and sex. Seventeen CS and 16 LWxCS pigs were reared outdoor on woodland pastures (Quercus ilex, Castanea sativa) with minimum commercial mixtures supplementation. Both males and females were castrated. Since the age of 100 days morphological measures were recorded bimonthly (height at rump, body length, chest girth, width at shoulder, width at rump). To perform a statistical analysis, factors such as regression on age and allometric relationship on weight were taken into consideration, together with the fixed effect of genetic type x rearing system. In the indoor system, CS pigs reached 140 kg of live weight 30 and 100 days later than LWxCS and LW pigs, respectively. Moreover, CS conversion index was worse than that of LW pigs (i.e. 4.54 vs. 3.77 feed/gain) and CS backfat thickness was higher. During spring and summer, the outdoor system worsened the growth of backfat in both genetic types, as a consequence of scarce feed availability. However, cross pigs showed higher growth rate than CS breed. Allometric relationships analysis pointed out that CS pigs were taller, narrower at shoulder and at rump and shorter than LW pigs. Moreover, CS breed had higher chest girth than LW and the difference became more evident at higher weights. Crossbred pigs showed intermediate behaviour compared to parental breeds. Outdoor reared Cinta Senese pigs differed from those indoor in the evolution of body proportion, due to older age at a given weight and to the grazing activity. No differences were found with respect to for width values at rump, but outdoor CS pigs presented higher growth for width at shoulder and for chest girth. Thus, the outdoor system seems to intensify the development of the body forepart in Cinta Senese breed, already emphasised in this breed.

Key words: Cinta Senese, Pig, Outdoor, Growth, Morphological measures.

RIASSUNTO

PRODUTTIVITÀ DI SUINI CINTA SENESE E METICCI CINTA SENESE X LARGE WHITE ALLEVATI AL PASCOLO IN BOSCO E IN STABULAZIONE. 1. ACCRESCIMENTO E SVILUPPO SOMATICO.

Ventinove suini Cinta Senese (CS), 12 Large White (LW) e 29 meticci LWxCS sono stati allevati in stalletti (indoor) suddivisi per tipo genetico e sesso e alimentati "ad appetito" con miscele commerciali. Diciassette suini CS e 16 meticci LWxCS, coetanei ai precedenti, sono stati allevati al brado (outdoor) in territorio boschivo (Quercus ilex, Castanea sati-

va) con minima integrazione alimentare effettuata con le stesse miscele dell'allevamento indoor. In entrambi i sistemi, tanto i maschi che le femmine sono stati castrati. A partire da circa 100 giorni di età e con cadenza bimestrale sono stati rilevati peso, spessore del grasso e alcune misure corporee (altezza della groppa, lunghezza del tronco, larghezza alle spalle e della groppa ai trocanteri, circonferenza toracica). L'analisi statistica, effettuata tramite regressione sull'età e relazione allometrica sul peso ha considerato tra gli altri fattori la combinazione tipo genetico x sistema di allevamento. In allevamento indoor i CS hanno raggiunto il peso di 140 kg circa 1 mese dopo i LWxCS e 100 d dopo i LW facendo registrare, rispetto a questi ultimi, una peggiore conversione alimentare (4,54 vs. 3,77 alimento/incremento) e spessore del grasso sistematicamente più elevato a qualsiasi peso vivo. L'allevamento outdoor ha depresso la crescita e lo sviluppo del grasso dorsale in entrambi i genotipi nel periodo primaverile-estivo, a causa della modesta disponibilità alimentare. I meticci hanno avuto comunque accrescimento più intenso dei CS. Lo studio delle relazioni allometriche evidenzia che, in condizioni indoor, rispetto alla LW la CS si è mostrata sempre più alta, più stretta alle spalle e alla groppa di 2-3 cm e più corta ed ha presentato circonferenza toracica maggiore, con una differenza che è aumentata con il progredire della crescita corporea. I meticci hanno avuto comportamento intermedio rispetto alle razze parentali, sia considerando i coefficienti allometrici che le medie stimate al peso iniziale, intermedio e finale. Rispetto all'indoor, l'allevamento outdoor ha condizionato l'evoluzione delle proporzioni corporee della Cinta Senese e dei meticci. Anche se lo sviluppo della groppa è stato analogo nei suini allevati nei due sistemi, nei suini allevati all'aperto si è registrato maggior ritmo di accrescimento della larghezza delle spalle e della circonferenza toracica, indicando che il sistema outdoor ha esaltato lo sviluppo del treno anteriore, già privilegiato in questa razza rustica.

Parole chiave: *Cinta Senese, Suino, Allevamento estensivo, Accrescimento, Misure morfologiche.*

Introduction

Since 1976, Tuscany Administration together with the commitment of some local farmers carried out a conservation policy for farm animal genetic resources in order to stop and reverse the decline of the Cinta Senese pig (Pugliese *et al.*, 2000). In the last years, the breed extended its areas of distribution in Tuscany thanks to the opportunities of a growing niche market. The survival of this breed, similarly to other local breeds, is strictly connected to a good assessment and exploitation of breed performances and market opportunities.

Information on morphological development and on productive characteristics of the Cinta Senese breed is quite scarce: Mascagni (1947) studied the growth rate of sows and piglets; Raimondi (1955) and Magliano and Jannella (1956) reported some results obtained with Large White crosses; finally, Salerno (1953, 1955), in a study on morphology and body composition of some ancient Italian pig breeds, described the Cinta Senese breed in comparison with Yorkshire crosses. However, these out of date data cannot be fully related to the current breed which was recently produced through a severe bottleneck (Gandini *et al.*, 2000). More recent works investigated productive characteristics of Cinta Senese x Large White crosses (Franci *et al.*, 1994a,b) and morphological development of purebred boars and gilts (Campodoni *et al.*, 1998).

The differential body growth in pig, also in its external proportion, was reported to be affected by the rearing system that influences weight gain and relative growth of tissues and regions (Walstra, 1980). These influences could be investigated in the Cinta Senese breed which is today reared under different management conditions, indoor and outdoor.

Within this framework, we carried out an investigation aimed to characterise the Cinta Senese breed and its crosses with Large White, both in outdoor and in indoor rearing systems. This paper reports the results of *in vita* performances and differential growth and development of body regions.

Material and methods

The trial was conducted in two different farms, each characterized by a different system of rearing pigs. In the first farm, pigs were reared on woodland pastures (oaks - *Quercus ilex* - and chestnuts - *Castanea sativa*; outdoor), which provides most of feed resources in autumn and winter; for the rest

of the year, animals were fed by supplementing natural pastures and crop residuals, once they returned from pasture to the stalls in the evening. Feed supplementation consisted of the same mixtures fed in the second farm, where animals were reared in pens (indoor) for all the growing-fattening period. For further information and for comparative purposes with other works, the chemical composition of diets can be found in table 1. Moreover, figure 1 provides a schematic representation of natural resources availability and feed supplementation in the outdoor system. During the first months of the year, when acorn availability was almost finished and feeding needs were moderate because of low body weight, 400 g/head/d of mixtures were administered; subsequently, the amount of feed was increased to 1 kg/head/d in summer, when natural pastures provided very limited feed resources (occasional use of stubbles, leaves and grass). In autumn and in winter, feed supplementation was minimal due to the availability of chestnuts and acorns in large quantity. During this period pigs often remained away from stalls for several days.

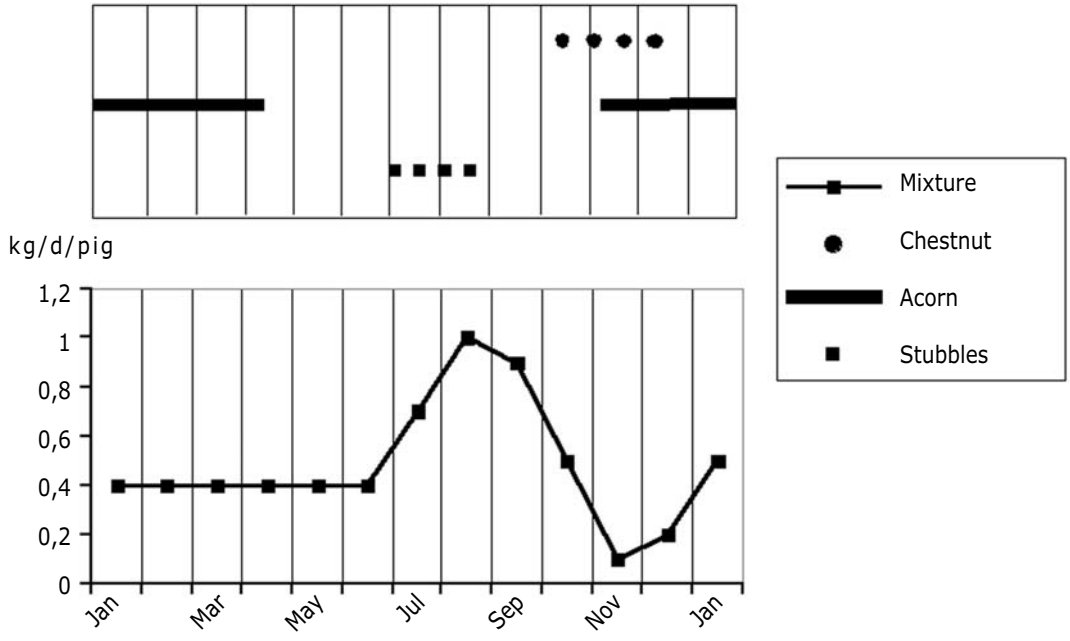
Table 1. Chemical composition of diets (% on wet basis).

	Diet	
	Grower	Fattening
Moisture	9.67	9.69
Crude protein	17.67	16.35
Ether extract	2.12	4.14
Crude fibre	4.47	3.59
N-free extract	60.45	59.45
Ash	5.62	6.78
Ca	1.06	1.33
P	0.69	0.67
Lysine	0.8	0.7

All pigs were born in September. At the age of three weeks, pigs were castrated (including females) to avoid mating with wild boars in the free-range system and to standardise indoor and outdoor experimental treatments.

For the purposes of the trial, a total of 103 pigs

Figure 1. Feeding scheme of outdoor pigs.



were employed. Seventeen (11 males and 6 females) Cinta Senese (CS) pigs and 16 (10 males and 6 females) Large White x Cinta Senese (LWxCS) cross pigs were reared outdoor. Twenty-nine CS pigs (15 males and 14 females in 4 pens), 29 LWxCS cross pigs (17 males and 12 females in 4 pens) and 12 Large White (4 males and 8 females in 2 pens) pigs were reared indoor (in pens of 4x5 meters) according to genetic type and sex. The LW breed was considered only in the indoor system, as a reference treatment.

Animals were weighed at birth, at weaning and on a regular basis every two months. Since the age of 100 days, morphological measures were recorded bimonthly (height at rump, body length, chest girth, width at shoulders, width at rump). Backfat thickness at the last thoracic vertebra was measured by using an ultrasound equipment.

As far as outdoor reared pigs are concerned, feed consumption was recorded without taking into consideration the genetic type. In the case of indoor pigs, daily feed consumption recording was carried out by pen.

Animals were slaughtered at about 140 kg of live weight and at an age of over 8 months, as required by the Italian pig industry to obtain meat suitable for seasoning process. The two experimental groups reached the slaughter weight at different times: indoor-pigs were slaughtered between May and July at the age of 9-11 months, whereas outdoor-pigs were slaughtered between October and January, when they were 13-16 months old.

Data analysis was carried out with SAS software package (1996) and several models were used:

i) Indoor feed consumption and feed conversion data were analysed by ANOVA, where sex and genetic type are considered as fixed effects;
ii) Live weight and backfat thickness growth data were analysed considering sex and "genetic type x rearing system" (GTxRS, 5 levels) as fixed effects and age (up to the third degree) as infraclass (GTxRS) covariate;
iii) Morphological measures evolution was analysed by using the allometric equation $y=a^{*}x^{b}$ considering the fixed effects of sex and of GTxRS, and the infraclass (GTxRS) regression on live weight, on data transformed logarithmically. Actually, due to the wide range of body weight considered, data were often better fitted by a quadratic logarithmic equation. However, in the results we report the allometric coefficient from the first degree logarithmic equation, which represents relative growth rate, averagely calculated over the entire growth period. In addition, whenever the allometric coefficient of the second degree equation was significant ($P<.05$), we reported its sign. In fact, the positive and the negative signs respectively indicate a positive or a negative relative growth acceleration during the growing period (Giorgetti *et al.*, 1996). Estimates of LS-means were always carried out by using the second degree equations, while t-Student test was used for the comparison between them.

Table 2. LS means for average daily gain (ADG), feed daily intake (FDI) and feed conversion ratio (FCR) of indoor pigs (pen data).

		Breed			Sex		r.s.d.[1]
		CS[2]	LWxCS[2]	LW[2]	Castrated males	Castrated females	
ADG	g	531	582	694	605	599	81.64
FDI	"	2406	2470	2611	2482	2509	311
FCR	feed/gain	4.54 a	4.25 a	3.77 b	4.15	4.22	0.24

[1] residual standard deviation

[2] CS = Cinta Senese; LW = Large White

a, b, means with different letters differ (P<.05)

Results and discussion

Pen data

Table 2 shows food intake and conversion index for indoor-pigs. Daily intake was homogenous among breeds and sexes and it reached an average amount of 2.5 kg/head/d. However, because of the lower weight gain, CS conversion index was worse than LW pigs index. The values observed for LWxCS and LW pigs are comparable to those obtained in a previous work (Franci *et al.*, 1994a).

Growth data

Figure 2 shows trends of body weight in relation to age. As a whole, the indoor animals followed the typical growth curve. LW breed reached 140 kg in 225 days, whereas LWxCS pigs reached the same weight 65 days later, due to an earlier decrease of growth rate. On the other hand, CS pigs showed lower and more regular daily gains reaching 140 kg one month later than crossbred animals, and 100 days later than LW breed. ADG gap (-30%) between the local breed (430 g) and improved breed (622 g) is analogous to the differences found between the Iberian and the Landrace pig (Serra *et al.*, 1998) and between some autochthonous French breeds and LWxLandrace crosses (Legault *et al.*, 1996).

In comparison with the indoor system, the outdoor system worsened growth performances in all genetic types. Also in the case of improved breeds fed *ad libitum* (Enfält *et al.*, 1997), free-range management produces lower weight gain compared to indoor. In the free-range system of this trial weight gain was mainly affected by a discontinuous availability of feed: pigs showed low growth rate during the spring-summer period, when both the pasture and the supplemented feed were scarce, while they increased their weight gain mainly in autumn and winter because of the availability of acorns and chestnuts. These results are in agreement with the results regarding the Iberian pig (Mayoral *et al.* 1999). Also in the outdoor system, LWxCS crosses grew faster than CS pigs.

Figure 2. Evolution of live weight of indoor and outdoor pigs in relation to age (CS = Cinta Senese; LW = Large White).

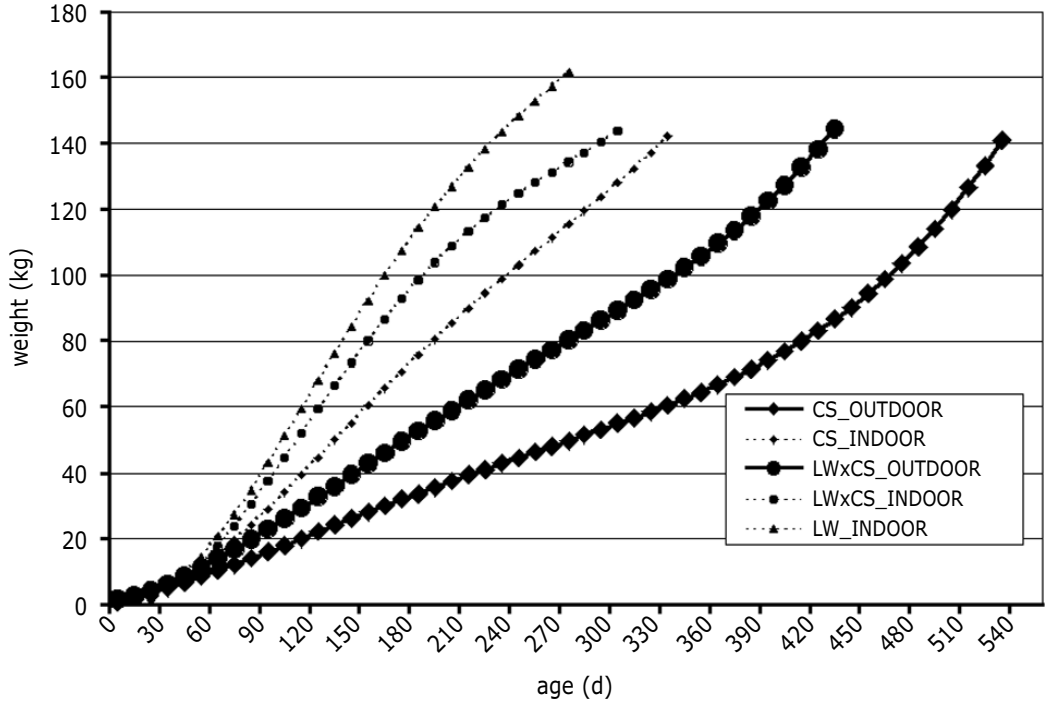
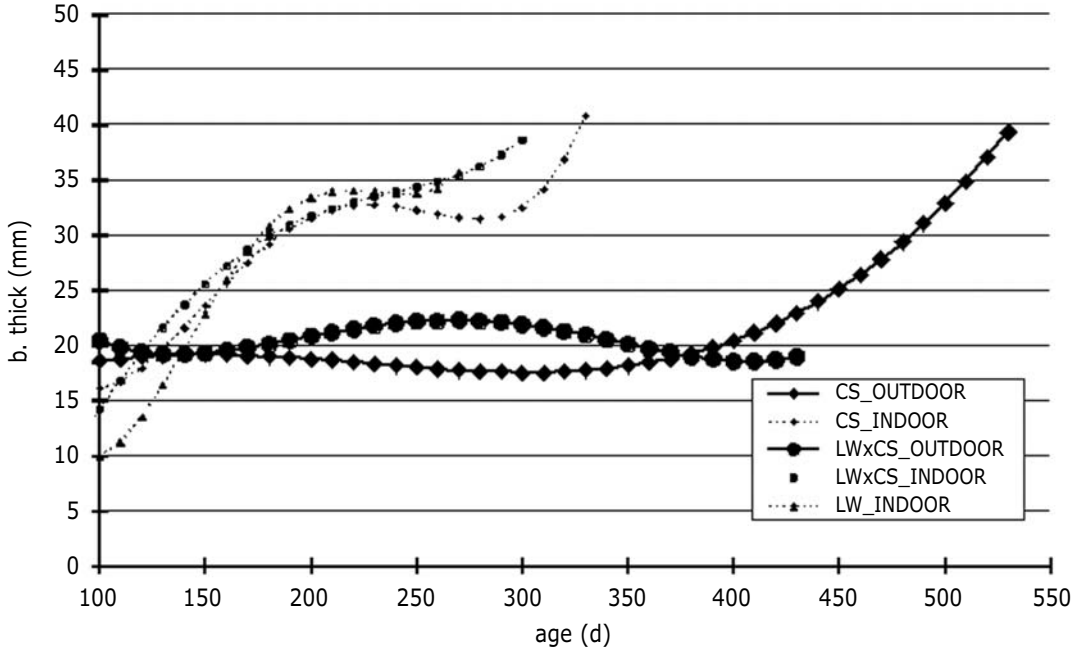


Figure 3. Evolution of backfat thickness of indoor and outdoor pigs in relation to age (CS = Cinta Senese; LW = Large White).



Backfat thickness was also clearly affected by the rearing system (Figure 3). All indoor pigs showed a fast initial growth rate, followed by a slowdown in the final phase of the trial; LW pigs, the leanest at the beginning, showed a faster backfat growth rate and reached the same thickness of the other genetic types at 225 days of age, but at a higher live weight. Crossbred pigs lowered the backfat growth at the end of the trial, whereas in CS pigs backfat thickness increased continuously. This confirms the ability for strong fat deposition of the unimproved pigs, as already reported by Labroue *et al.* (2000) with respect to autochthonous French breeds. It appears that outdoor pigs developed adipose tissues as a function of feed availability. At the slaughter age of the indoor pigs, outdoor animals showed lower backfat thickness as feed availability during spring and summer did not allow fat deposition. Then, during autumn-winter, outdoor CS pigs increased intensively their backfat thickness with a pattern similar to that reported for Iberian pigs (Mayoral *et al.*, 1999). Conversely, crossbred pigs were unable to exploit woodland pasture resources because in October they had already reached slaughter weight.

Allometric study

The study of body proportions variation during growth was carried out by applying the allometric equation to morphometrical parameters in relation to the weight. It has to be pointed out that isoauxesis between linear measures and weight corresponds to a value of 0.333, instead of the unit (Walstra, 1980). Table 3 reports the allometric coefficients for each GTxRS combination. As mentioned in Material and Methods, these coefficients derive from the first degree logarithmic equation and express the average relative growth rate during the whole period. However, due to the wide range investigated, the second degree of the logarithmic equation was often significant. It denoted a variation of the allometric coefficient during growth. For this reason, table 3 reports also the sign of the significant quadratic regression coefficient which indicates a decrease (minus sign) or an

Table 3. Allometric coefficients of body measures on body weight.

Rearing system	Outdoor		Indoor		
Breed	CS[(1)]	LWxCS[(1)]	CS[(1)]	LWxCS[(1)]	LW[(1)]
Height at rump	0.273 (-)	0.288 (-)	0.302 (+)	0.319	0.301 (+)
Body length	0.318	0.331	0.316 (+)	0.317	0.347
Width at shoulder	0.421 (+)	0.365 (+)	0.338 (-)	0.316 (-)	0.305 (-)
Width at rump	0.374 (+)	0.324 (+)	0.327 (-)	0.332 (-)	0.303 (-)
Chest girth	0.390 (+)	0.372	0.373 (+)	0.362	0.354

[(1)] CS = Cinta Senese; LW = Large White

In brackets, the sign of the second degree allometric coefficient, when significant (P<.05) (see text).

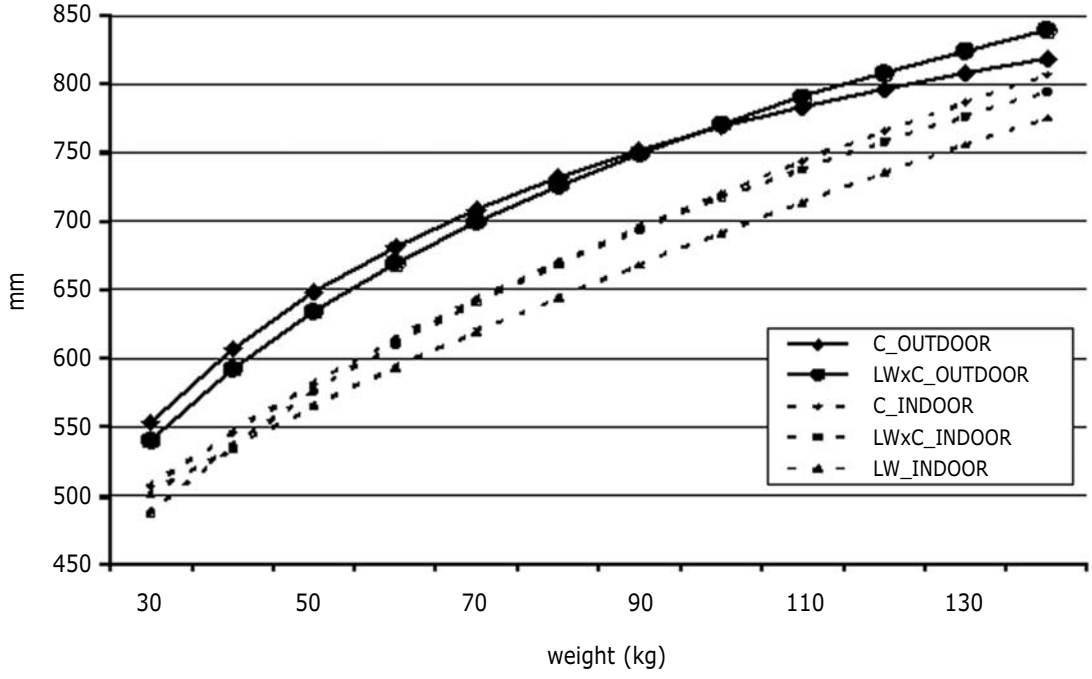
increase (plus sign) of the relative growth rate during the growth period. Table 4 reports estimated (least square) means at three different weights on the basis of the second degree allometric equations. Figure 4 illustrates, as an example, least square means for height at rump. The values in table 4 help both to explain the allometric coefficients and to understand which variation of the measures is due to genotype (comparison among breeds within rearing system) and which to environment (comparison between rearing systems within genotype).

Generally, height at rump presented the lowest allometric coefficient (table 3) confirming the well-known early development of the limbs. In the indoor system, CS was taller than LWxCS and LW pigs in that order (figure 4), even if the rank became fully evident at the heaviest weights (table 4). Because of the older age, outdoor pigs were systematically taller than the indoor ones, showing a significant advantage already at 40 kg. In the case of outdoor system pigs, this initial advantage determined allometric coefficients (with a variation in diminution) lower than those of indoor pigs. The values of height at rump of CS pigs of the present work are in agreement with those found in the ancient Cinta Senese breed study by Salerno (1955) which showed an average of 82.4 and 80.1 cm in males (at 141 kg l.w.) and in females (at 149 kg l.w.), respectively.

Body length was substantially in isoauxesis with body weight (table 3), with limited variation among genetic types. However, it was evident the fastest growth rate of LW pigs which, at the end of the trial, exceeded the other genetic types in the indoor system by 2 cm, and reached the body length of outdoor reared CS and LWxCS pigs which were considerably older.

As far as width at shoulder and width at rump values are concerned, LW pigs showed allometric coefficients lower than CS and LWxCS pigs in the indoor system (table 3) and this was probably due to the higher values at 40 kg (table 4). The differences among genetic types remained almost unchanged during the trial and the LW pigs showed an advantage of about 2 to 3 cm for width at shoulder and at rump, respectively, when compared to the Cinta Senese breed. Likewise, it is noticeable the intermediate behaviour of the crossbred pigs in comparison to parental breeds. Within genetic type, the outdoor system generally produced higher allometric coefficients (table 3) with a trend to increase (plus sign of second degree coefficient), in contrast with those reported for the indoor system. These higher coefficients are the effects of the lower initial values that suggest an initial depression of muscle development in those specific body regions. At the end of the growth period, values of width at rump were similar between rearing systems, whereas those of width at shoulder were higher in outdoor pigs with dimension similar to those of LW pigs in indoor system. This suggest that the development of this body region is probably more influenced by age

Figure 4. Evolution of height at rump of indoor and outdoor pigs in relation to weight (CS = Cinta Senese; LW = Large White).



and exercise. Values of width at rump in CS pigs were higher than those reported by Salerno (1955) for males at the same live weight (141 kg).

Chest girth showed higher growth rate than body weight (all allometric coefficients were >.333). This demonstrates its late development, and it allowed to underline the differences according to genetic types and rearing systems. An additional genetic effect was fully explained by both allometric coefficients and estimated means in the indoor system with the LWxCS pigs values in average with respect to parental breeds. At 40 kg of live weight, CS breed showed chest girth values higher than LW pigs and it increased the advantage during development due to its higher relative growth rate. Transversal diameters indicated LW as the broadest breed. The higher chest girth observed in the Cinta Senese breed was due to a greater development of the thorax depth as expected for a respiratory morphological type. Both outdoor CS and LWxCS pigs showed a greater increase in chest girth in comparison to those reared indoor; this is in agreement with the results found for the width at shoulder and it is probably due to the more intense physical exercise during grazing activities and their older age favouring the late developing fore regions. Although comparison with the data published in the fifties can be considered hazardous, it can be noted that Salerno (1955) reported smaller chest girth of 123.7 and 120.7 cm in Cinta Senese males and females of analogous live weight (140 kg), respectively.

Conclusions

This study considered two extremely different rearing systems which are today in use in the Cinta Senese farming and it compared the local breed with both the LW, the most famous improved breed, and their crosses.

In the intensive system, the local breed showed its productive potential attaining an average daily gain 30% smaller than the LW breed, in agree-

Table 4. LS means, according to the allometric function, for body measures (cm) at initial (40 kg), intermediate (90 kg) and final (140 kg) live weight.

Rearing system	Outdoor		Indoor		
Breed	CS[(1)]	LWxCS[(1)]	CS[(1)]	LWxCS[(1)]	LW[(1)]
Height at rump:					
- 40 kg l.w.	60.7 d	59.2 c	54.6 b	53.5 a	53.4 a
- 90 kg l.w.	75.2 c	74.9 c	69.6 b	69.3 b	66.8 a
- 140 kg l.w.	81.9 c	84.0 d	80.7 c	79.5 b	77.6 a
Body length:					
- 40 kg l.w.	70.1 b	70.2 b	68.3 a	69.3 ab	68.0 a
- 90 kg l.w.	90.6 c	91.9 d	88.1 a	89.7 bc	90.7 c
- 140 kg l.w.	104.0 ab	105.6 b	102.8 a	103.0 a	105.1 b
Width at shoulder:					
- 40 kg l.w.	21.1 a	22.1 b	22.9 c	24.2 d	24.3 d
- 90 kg l.w.	29.8 a	29.6 a	30.3 b	31.4 c	32.3 d
- 140 kg l.w.	36.4 c	35.8 bc	34.0 a	35.2 b	35.8 bc
Width at rump:					
- 40 kg l.w.	20.1 a	21.8 b	22.4 c	23.3 d	24.2 e
- 90 kg l.w.	27.4 a	28.3 b	29.4 c	30.5 d	31.9 e
- 140 kg l.w.	33.5 b	33.2 ab	32.6 a	34.9 c	35.6 c
Chest girth:					
- 40 kg l.w.	78.0 c	76.0 ab	77.6 c	76.7 b	75.2 a
- 90 kg l.w.	107.4 d	102.7 b	104.9 c	102.8 b	100.9 a
- 140 kg l.w.	129.8 e	121.9 c	124.7 d	120.5 b	117.4 a

(1) CS = Cinta Senese; LW = Large White

In the same row, means with different letters differ (P<.05)

ment with observations on other European autochthonous breeds. Allometric studies allowed to compare morphological proportions during growth. When compared to LW breed, the Cinta Senese was taller and narrower both at shoulder and at rump along the entire growth period; and shorter only at higher weights moreover CS breed showed higher chest girth from the beginning, and this initial advantage progressively increased with body development. This is the typical growth pattern of unimproved animals with greater relative growth of forelimb and thorax in depth. In the case of the indoor system, which assures a constant growth, backfat thickness was higher in the Cinta Senese breed than in the LW along the whole period. This showed that the differentiation of fat tissue growth in pig occurred from an early development phase. Crossed pigs always showed intermediate behaviour between parental breeds.

In the outdoor system, Cinta Senese pigs showed a different evolution of body proportions in comparison to the indoor system, and this was due to the combined effects of both the older age at a given weight and the higher exercise with grazing activities. Particularly, outdoor CS pigs presented higher growth rate for width at the shoulder and for chest girth, whereas no difference was found for width at rump. Thus, the outdoor system seems to intensify the development of body forepart, already emphasised in this breed. As far as backfat thickness is concerned, it is surprising that Cinta Senese pigs reared in the two systems

reached the same final values, even if the growth curves differed substantially as consequence of feed availability.

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