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Productive performance of the single farrowing system for pigs

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Abstract

This paper reports two experiments, the aims of which were to contribute to the development of the single farrowing production system for pigs. The first reports the induction of oestrus in three groups of 70 Duroc gilts (167 days old, body weight 93.6 kg) via the injection of either 1000, 600 or 400 IU of pregnant mare serum gonadotrophin (PMSG) plus 500, 200 or again 200 IU of human chorionic gonadotrophin (hCG) respectively. No significant differences were observed among these treatments with respect to the percentage of gilts entering oestrus, their fertility or their prolificacy. The average number of piglets weaned per farrowed gilt was 5.61, 5.66 and 6.69 ($P < 0.05$) while the number of pigs weaned per induced gilt was 2.33, 2.67 and 3.34 respectively ($P < 0.05$). The second experiment, designed to analyse carcass quality, involved 30 Duroc gilts aged 167 days and weighing 93.9 kg. Ten empty gilts were slaughtered at 197 days and at a mean weight of 112.1 kg, another 10 in which oestrus was induced with PG-600 —but which were not allowed to nurse their piglets— were slaughtered 4 days after farrowing and at a mean of 136.9 kg, and the remaining 10, which nursed their young, were slaughtered 10 days after a 21 day lactation period and at a mean body weight of 135.4 kg. The average daily weight gain during gestation was 0.418 kg. Weight loss during lactation was 0.159 kg day^{-1}. The mean weight of the pigs at birth, when weaned and at 60 days post-weaning was 1.28, 4.5 and 18.2 kg respectively. The carcass length, carcass yield and the back fat thickness of the farrowing but non-nursing and the nursing gilts were significantly higher ($P < 0.05$) than those of the empty gilts. The weight of their hams and forelegs were, however, lower with respect to overall carcass weight ($P < 0.05$).

Additional key words: gilts, induction of oestrus, productive results.

Resumen

Resultados productivos del sistema de manejo a un solo parto en ganado porcino

Este trabajo incluye dos experimentos que pretenden contribuir al desarrollo del sistema de manejo a un solo parto. En un primer experimento, a tres grupos de 70 cerdas de 167 días y 93,6 kg de peso se les indujo el celo con 1.000 UI de gonadotropina de suero de yegua gestante (PMSG) + 500 UI de gonadotropina coriónica humana (hCG), 600 UI de PMSG + 200 UI de hCG y 400 UI de PMSG + 200 UI de hCG (PG-600), respectivamente. No se observaron diferencias significativas entre tratamientos en el porcentaje de cerdas que salieron en celo, fertilidad y prolificidad. El número de lechones destetados por cerda parida fue 5,61, 5,66 y 6,69 ($P < 0,05$), y el número de lechones destetados por cerda inducida 2,33, 2,67 y 3,34 ($P < 0,05$), respectivamente, para los tratamientos indicados. En un segundo experimento, que trataba de analizar la calidad del canal, se utilizaron 30 cerdas Duroc de 167 días y 93,9 kg de peso. Diez se sacrificaron a los 197 días con 112,1 kg (cerdas vacías), otras 10, que parieron y no amamantaron, se sacrificaron cuatro días después del parto con 136,9 kg, y las 10 restantes, que parieron y amamantaron, se sacrificaron 10 días después de un periodo de lactación de 21 días con 135,4 kg. La ganancia media diaria de las cerdas durante la gestación fue de 0,418 kg y la pérdida media diaria de peso durante la lactación, de 0,159 kg. Los pesos medios de los lechones al nacimiento, al destete y a los 60 días de edad fueron 1,28, 4,5 y 18,2 kg, respectivamente. El rendimiento a la canal, espesor graso dorsal y longitud de la canal fueron significativamente inferiores ($P < 0,05$) en las cerdas vacías que en las paridas, aunque fueron superiores ($P < 0,05$) los porcentajes de jamones y de paletas en la canal.

Palabras clave adicionales: cerda nulípara, inducción al celo, resultados productivos.

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Introduction

The single farrowing system of pig production is based on the joint production of primiparous gilts and either piglets or finishing pigs. The system involves the premature breeding of gilts (via hormonal management strategies), the early diagnosis of gestation, and premature weaning. In this way, the slaughtered gilts have carcass characteristics similar to those of finishing pigs and suffer no reduction in their market price.

Previous research into this system has mainly been concerned with the development of carcass and meat quality in primiparous gilts (Friend *et al*., 1979; Elliot *et al*., 1982; Ellis *et al*., 1996; Zbinden, 1998). However, these studies emphasize that in Anglo-Saxon countries the main limiting factor of this system is the acceptability of carcasses that are really too heavy for those markets.

The single farrowing system has been used with some frequency in Spain for the production of the Iberian pig (Escribano *et al*., 1997; Cabeza de Vaca, 2001), although there is insufficient information to compare with the results of the present study. This system could be of economic interest to markets such as that of Spain, where the consumption of manufactured pork products is particularly important. Interest might further increase if high meat quality breeds, such as Duroc breed, could be produced in this way.

This paper reports two experiments, the aims of which were to contribute to the development of the single farrowing production system. The first examined the effect of different hormonal treatments for the induction of oestrus on the numerical productivity of gilts. The second examined the system's productive results, including the performance of mothers and piglets from premature breeding to slaughter, and from the birth of the piglets to the end of their weaning phase and through to 60 days of age.

Material and Methods

The first experiment involved 210 prepubertal Duroc gilts (167 ± 5.6 days of age, body weight 93.6 ± 3.6 kg) that received feed (containing 3,100 kcal ME kg^{-1}, 16.5% crude protein and 0.81% lysine) *ad libitum* during the growing period. These were randomly assigned to three groups (70 animals each) that underwent different oestrus induction treatments: group A received 1,000 international units (IU) of pregnant mare serum gonadotrophin (PMSG) + 500 IU of human chorionic gonadotrophin (hCG) (in two injections separated by three days), group B received 600 IU of PMSG + 200 IU of hCG (in two injections separated by three days), and group C received 400 IU of PMSG + 200 IU of hCG (PG-600) (single injection). On the day of induction, all the gilts received a vitamin flushing with vitamins A, D and E, and were inseminated at the first signs of oestrus and then again 24 h later (Martin, 1996). Each gilt was then lodged in an individual gestation pen. During gestation all were fed a diet based on 2 kg day^{-1}of feed containing 3,000 kcal ME kg^{-1}, 14% crude protein and 0.54% lysine. During lactation they were fed *ad libitum* with a feed containing 3,200 kcal ME kg^{-1}, 18% of crude protein and 1% lysine. In all treatment groups, the litters were levelled to 8 piglets per gilt.

The percentage of gilts entering oestrus, their fertility, their prolificacy, and the piglet mortality rate (own and adopted) under the different treatment conditions were compared using the test χ^2. The reproductive results were analysed by analysis of variance using the treatment as the main variable.

In the second experiment, designed to examine carcass quality, 30 Duroc gilts aged 167 ± 2.7 days were divided into three equal groups according to age and body weight. These were lodged in individual pens for the entire experimental period. Ten empty gilts were sacrificed at 197 ± 1.6 days of age. Another 10 were allowed to gestate and farrow following hormonal induction with PG-600; these were slaughtered four days after farrowing. The remaining 10 gilts were induced with PG-600 and allowed to farrow and nurse levelled litters (6-7 of their own piglets and 2-3 adopted) for a 21 day period. They were then slaughtered 10 days later after a recovery period. The feed compositions and method of administration were the same as described in Experiment 1. The empty gilts received 2 kg day^{-1} of gestation diet from 167 days of age until slaughter, while the group of gilts that farrowed received the lactation diet. Feed consumption by nursing gilts was monitored during the 21 day nursing period. Finally, all farrowed but non-nursing, as well as nursing gilts, received 1.5 kg day^{-1} of the gestation diet to provide nutritional recovery (after farrowing and weaning respectively). Bodyweight was recorded at breeding, after farrowing, after weaning and before transport to the slaughterhouse. Piglets weight was determined at birth, at weaning and at 60 days of age. Piglet post-weaning feed consumption was also determined. During this period the piglets were lodged in eight pens holding 10-11 animals.

All the gilts were slaughtered following a 16 h fasting period. Records were made of the carcass weight, the length of the carcass between the ischial-pubic symphysis and the mid-point of the anterior edge of the first rib, and the thickness of the back fat (using a calibrator at the position of the 14th rib). The weights of the non-trimmed hams and forelegs (following commercial cutting lines for Iberian pigs) (Dobao *et al.,* 1987) were also recorded.

Variations in gilt weight and feed conversion were examined by analysis of variance using the type of gilt (empty, farrowing but not nursing, and nursing) as the fixed variable. Piglet growth (own compared to adopted) was studied by analysis of covariance using the type of piglet as the fixed variable and piglet birth weight as the covariable. The interaction *piglet type x gilt type* was therefore analysed.

The mortalities of the gilts' own and adopted piglets were compared using the χ^2 test. Carcass characteristics according to type of gilt were studied by analysis of variance. Carcass weight or slaughter weight were deliberately not included as covariables in the statistical model. All analyses were performed using the GLM procedure of the SAS software package (SAS Institute, 1990). Statistical significance was set at $P < 0.05$.

Results

Table 1 shows the influence of inducing oestrus on the reproductive performance of the prepubertal gilts (Experiment 1). No significant differences were seen among treatments in terms of the percentage of gilts that entered oestrus, their fertility, or the number of piglets born alive or dead. Nevertheless, treatment C (PG-600) produced significantly more ($P < 0.05$) weaned piglets per farrowed gilt and per induced gilt than did treatment A. Compared to treatment B, treatment C tended to increase ($P < 0.1$) the number of piglets born alive per litter (6.86 compared to 5.91), the percentage of lactating gilts (88.6% compared to 72.7%), and the number of weaned piglets per farrowed (6.69 compared to 5.66) and induced gilt (3.34 compared to 2.67). Group A lactating gilts produced fewer ($P < 0.05$) weaned piglets than did the other two groups, and the mortality of their piglets was greater ($P < 0.05$). The χ^2 test showed no significant differences between the percentage mortalities of the gilts' own and adopted piglets.

Tables 2, 3 and 4 show the reproductive performance and the carcass characteristics of single farrowed gilts

Table 1. Reproductive results achieved with different hormonal treatments for inducing oestrus (Experiment 1)[a]

Treatments	A	B	C
Nº gilts induced	70	70	70
Age (days)	167.5 ± 6.0	165.8 ± 5.3	167.7 ± 4.6
Weight (kg)	94.0 ± 3.3	92.6 ± 4.1	94.1 ± 3.8
Gilts in oestrus (%)	85.7	81.4	81.4
Fertility (%)	48.3	57.9	61.4
Nº farrowed gilts (1)	29	33	35
Total born	6.86 ± 3.4	6.67 ± 3.0	7.31 ± 2.6
— Born alive	6.41 ± 3.3	5.91 ± 3.1	6.86 ± 2.6
— Born dead	0.45 ± 0.7	0.76 ± 1.3	0.45 ± 0.8
Nº of nursing gilts (2)	23	24	31
Lactating piglets:	8.08 ± 0.3^a	8.12 ± 0.3^a	7.74 ± 0.4^b
— Own	7.04 ± 0.8^a	6.71 ± 0.8^b	6.83 ± 0.7^{ab}
— Adopted	1.04 ± 0.7^a	1.41 ± 0.6^b	0.91 ± 0.8^a
Weaned piglets:	7.08 ± 0.28^a	7.79 ± 0.4^b	7.55 ± 0.5^b
— Own	6.17 ± 0.76^a	6.45 ± 0.64^{ab}	6.67 ± 0.6^b
— Adopted	0.91 ± 0.91^a	1.33 ± 0.47^b	0.87 ± 0.8^a
Lactation whole mortality (%)	12.37^a	4.06^b	2.45^b
— Own (%)	12.36^a	3.87^b	2.34^b
— Adopted (%)	12.50^a	5.67^b	4.39^b
Weaned piglet/farrowed gilt	5.61 ± 3.1^a	5.66 ± 3.9^{ab}	6.69 ± 2.5^b
Weaned piglet/induced gilt	2.33 ± 2.8^a	2.67 ± 2.9^{ab}	3.34 ± 3.4^b

Groups: A: 1,000 IU PMSG +500 IU hCG. B: 600 IU PMSG +200 IU hCG. C: 400 IU PMSG + 200 IU hCG. (1): (farrowed gilts/inseminated gilts) × 100. (2): gilts that farrowed ≥ 5 piglets born alive. Different letters within the same row mean that the differences are significantly different ($P < 0.05$). [a] Means ± standard error.

Table 2. Weight changes, average daily weight gain and feed conversion (Experiment 2)[a]

Groups	I	II	III
Nº of gilts	10	10	10
Breeding age (days)	166.7 ± 1.6	167.3 ± 2.3	167.0 ± 3.2
Breeding weight (kg)	94.1 ± 1.5	94.3 ± 1.3	93.3 ± 2.9
Post-farrowing weight (kg)		141.0 ± 1.2	141.9 ± 1.5
Post-weaning weight (kg)			138.6 ± 2.5
Slaughter weight (kg)	112.1 ± 1.3^a	136.9 ± 0.83^b	135.4 ± 2.8^b
Daily weight gain during gestation (kg day^{-1})		0.409 ± 0.017	0.426 ± 0.016
Weight loss during the lactation (kg day^{-1})			0.159 ± 0.59
Weight loss from farrowing or weaning to slaughter (kg day^{-1})		1.0 ± 0.216^a	0.315 ± 0.082^b
Intake during lactation (kg day^{-1})			3.35 ± 0.24
Average daily gain from breeding to slaughter (kg day^{-1})	0.598 ± 0.052^a	0.366 ± 0.01^b	0.289 ± 0.01^c
Feed conversion from breeding to slaughter (kg kg^{-1})	3.37 ± 0.34^a	5.44 ± 0.25^b	7.48 ± 0.29^c

Groups: I: empty gilts. II: farrowing gilts no lactation. III: farrowed, nursing gilts. Different letters within the same row mean that the differences are significantly different $P < 0.05$. [a] Means± standard error.

Table 3. Reproductive performance of gilts and piglet performance (Experiment 2)[a]

Variable/type of gilt	II	III
Nº of gilts	10	10
Piglets born/gilt	7.3 ± 0.8	7.5 ± 0.7
Piglets born alive	6.9 ± 0.9	6.9 ± 0.6
Piglets born dead	0.4 ± 0.5	0.6 ± 0.7
Piglets in lactation:		9.0 ± 0.0
— Own		6.9 ± 0.6
— Adopted		2.1 ± 0.5
Lactation mortality (%):		6.66 (n = 6)
— Own		7.25 (n = 5)
— Adopted		4.76 (n = 1)
Weaned piglets:		8.4 ± 0.5
— Own		6.4 ± 0.8
— Adopted		2.0 ± 0.4
Weight at birth (kg):	1.33 ± 0.12	1.28 ± 0.11 (n = 90)
— Own		1.27 ± 0.10 (n = 69)
— Adopted		1.31 ± 0.15 (n = 21)
Weight gain in lactation (kg day^{-1}):		0.151 ± 0.021 (n = 84)
— Own		0.150 ± 0.020 (n = 64)
— Adopted		0.155 ± 0.028 (n = 20)
Gain weaning 60 days (kg day^{-1}):		0.352 ± 0.039 (n = 80)
— Own		0.351 ± 0.028 (n = 61)
— Adopted		0.355 ± 0.042 (n = 19)
Feed conversion (kg kg^{-1})		1.43 ± 0.12
Mortality weaning 60 days (%):		4.91 (n = 4)
— Own		5.00 (n = 3)
— Adopted		4.76 (n = 1)

n: piglets. Groups: II: farrowed, non-nursing gilts. III: farrowed, nursing gilts. [a] Means ± standard error.

(Experiment 2). The average daily weight gain during gestation was 0.418 kg day^{-1}. The nursing gilts lost a mean of 0.159 kg day^{-1} during the 21 day lactation period with an average feed consumption of 3.35 kg day^{-1}. The average daily weight increase of the pregnant gilts (ADW) showed a non-significant trend with litter size and body weight (correlation coefficients values were close to zero). Nevertheless a significant regression with gilt breeding weight (BW) was detected, which responded to the equation:

$$\text{ADW (g day}^{-1}) = 3{,}103.1 - 591.3 \ln \text{BW (kg)}$$
$$(n = 20;\ R^2 = 0.61;\ P < 0.001).$$

The weight loss of the lactating gilts was not influenced by their weight at farrowing, by the litter size, or by the weight of the weaned piglets. Nevertheless, the relationship between the weight loss during the period of lactation (WPL) and the average daily intake (I) fitted the following regression equation:

$$\text{WPL (g day}^{-1}) = 877.95 - 214.46\ \text{I (kg)}$$
$$(n = 10;\ R^2 = 0.74;\ P < 0.0001).$$

The gilts that farrowed but did not nurse showed a mean weight loss of 1 kg day^{-1} between farrowing and slaughter (4 days after farrowing), while the gilts that nursed their piglets for 21 days showed a mean weight loss of 0.315 kg day^{-1}, despite the provision of a maintenance diet. Clearly, the empty gilts achieved better growth and feed conversion indices between breeding and slaughter than did the farrowing gilts. The nursing gilts obtained the worst indices of all (Table 2).

The fertility, prolificacy and mortality recorded were similar to figures obtained in the first experiment. Piglet mean birth weight was 1.3 kg, the mean daily weight gain of piglets over lactation was 0.151 kg, and the mean daily weight gain and feed conversion efficiencies during the post-weaning period (60 days) were 0.352 kg and 1.43 kg kg^{-1} respectively (Table 3). The interaction gilts x own or adopted piglets had no significant effect on growth and mortality during lactation and the post-weaning period. On the contrary, the carcass length, carcass yield and the back fat thickness of the farrowing but non-nursing and nursing gilts were significantly higher ($P < 0.05$) than those of the empty gilts. The weight of their hams and forelegs were, however, lower with respect to overall carcass weight (Table 4).

Table 4. Carcass characteristics of single farrowing gilts (Experiment 2)[a]

Variable/type of gilts	I	II	III
Nº of gilts	10	10	10
Carcass weight (kg)	89.2 ± 1.7^a	111.7 ± 1.3^b	110.2 ± 3.0^b
Carcass performance (%)	79.6 ± 0.8^a	81.6 ± 0.5^b	81.2 ± 0.5^b
Carcass length (cm)	81.1 ± 1.4^a	92.4 ± 1.2^b	93.4 ± 1.3^b
Back fat thickness (mm)	23.0 ± 0.4^a	25.5 ± 0.3^b	24.1 ± 0.9^b
Ratio ham weight/carcass (%)	23.0 ± 0.4^a	21.3 ± 0.4^b	21.4 ± 0.5^b
Ratio foreleg weight/carcass (%)	12.5 ± 0.3^a	12.0 ± 0.3^b	11.9 ± 0.6^b

Groups: I: empty gilts. II: farrowed, non-nursing gilts. III: farrowed, nursing gilts. Different letters within the same row mean that the differences are significantly different $P < 0.05$. [a] Means ± standard error.

Discussion

The premature breeding of gilts from the finishing unit in the single farrowing production system is a desirable practice, although it has been reported that first-time breeding in pubertal oestrus is associated with low prolificacy (Brooks and Cole, 1973; MacPherson *et al*., 1977). Puberty onset can be induced at an earlier age by hormonal treatments that include PMSG to stimulate follicle development (Flowers *et al*., 1989) and hCG to control the precise moment of ovulation (Mattioli *et al*., 1989). Mösch and Henne (1993) report that the treatment of prepubertal gilts with 500 IU PMSG + 250 IU hCG led to 79.8% of a herd entering oestrus. A previous experiment which included two consecutive inductions produced very interesting reproductive results with 95% and 100% of gilts entering oestrus, 57.7% and 68.5% fertility rates, and mean litter sizes of 8.59 and 8.95 of piglets born alive (Heidler, 1989). Increasing the dose of PMSG in the present work was aimed at increasing the fertility rate, and especially gilt prolificacy, through an increase in ovulation (Bergfeld *et al*., 1990). However, King *et al*. (1990) reported that increasing the PMSG dose from 500-600 IU to 1,000 IU did not improve the number of gilts entering oestrus, nor did it improve gilt fertility or prolificacy; this agrees with the results obtained in Experiment 1 of the present study.

Generally, a high ovulation rate is associated with an increase in embryonic mortality during the first days of gestation (Van der Lende, 2001). This is probably why the treatments with doses of over 400 IU PMSG did not improve the reproductive results in Experiment 1. From the results of both experiments, the PG-600 treatment seems the best for obtaining good reproductive and productive results in gilts. This agrees with the results of other recent studies (Drion *et al*., 1998; Kirkwood, 1999; Knox and Tudor, 1999; Holtz *et al*., 1999; Knox *et al*., 2000). The results of Experiment 2 agreed with those observed in other studies in which diets with similar energy levels were provided during the gestation period (Brooks and Cole, 1973; MacPherson *et al*., 1977; Friend *et al*., 1979; Elliot *et al*., 1982; Ellis *et al*., 1996). Although the voluntary feed consumption of gilts during lactation is low (Noblet *et al*., 1998), if the litter size is small (6-8 piglets/litter) and/or milk production and piglet growth is not excessive, gilts barely lose any weight (Friend *et al*., 1979; Ellis *et al*., 1996).

The variation in gilt weight during gestation and lactation in Experiment 2 was not influenced by the small variability in litter size or litter weight at birth and weaning. Nevertheless, the negative relationship between the breeding weight/net weight gain during gestation and the consumption of feed/loss of weight during lactation were similar to those reported by Whittemore (1993). Similarly, the weight losses between farrowing and the slaughter of the gilts that farrowed but did not nurse, and of those that farrowed and nursed (from weaning to slaughter), were probably due to the regression of the uterus, the abdominal muscles and mammary tissue (Hovell *et al*., 1977; Zoiopoulos *et al*., 1978). This agrees with the results observed by Friend *et al*. (1979), Elliot *et al*. (1982) and Ellis *et al*. (1996).

The birth weight of the piglets obtained in Experiment 2 was higher than that obtained by Friend *et al*. (1979), perhaps due to the low prolificacy of the type of gilt used by the latter authors. The small weaning weight (4.5 kg) of the present piglets was probably caused by the reduced voluntary intake of feed during lactation, which resulted in low milk production. Friend *et al*. (1979) reported that piglet weight at weaning (21 days) fluctuated between 5.5-5.9 kg but with an average nursing gilt daily feed intake close to 5 kg day^{-1}. The observed non-significant effect of piglet type (own compared to adopted) on piglet mortality and growth has also been reported in previous experiments (Falkenberg and Zschorhich, 1990; Neal and Irvin, 1991; Price *et al*., 1994). This is an important feature to verify in the single farrowing production system because of the frequent need to distribute piglets among mothers with similar farrowing dates.

As expected, the carcass characteristics of the animals of Experiment 2, such as carcass yield, carcass length and back fat thickness, increased with slaughter weight. This has been reported by other authors (Puigvert *et al*., 1997; Tibau *et al*., 1997). Gestation *per se* does not result in a reduction of back fat thickness (Legault *et al*., 1974), but lactation does tend to reduce it if the female loses weight during lactation (Whittemore, 1993).

The differences in carcass length among the gilts from the different groups agree with those observed by Ellis *et al*. (1996) (assuming that lactation delays the growth of animals in weight loss situations during this period). Legault *et al*. (1974), Leach *et al*. (1996), Espárrago *et al*. (2001) and Latorre (2003) indicate that the absolute weight of hams and forelegs increased with the slaughter weight and carcass weight. However, the proportion of these pieces with respect to carcass weight diminished as carcass weight increased, coinciding with the results obtained in Experiment 2. Individual hams over 9.5 kg (fresh weight) can be legally used for preparing Spanish hams as a guaranteed traditional specialty (Regulation EEC No. 2419/1999).

The hormonal treatments used to induce puberty in the gilts led to very low productivity per farrowed and induced gilt. This has economic implications for the implementation of the single farrowing production system, even if treatment with PG-600 (which seems to be the best) is adopted. The carcass characteristics of the gilts generally complied with those required by the Spanish ham industry. The greatest objection to the single farrowing system is the premature breeding of prepubertal gilts. A delay in first-time breeding (from 6 until 7 months of age) would probably improve the reproductive results, but lead to a heavier carcass of lower commercial value to the meat industry. Further research on these aspects of the system are therefore warranted.

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