Short communication

Average daily weight gain of Iberian fattening pigs when grazing natural resources

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ARTICLE INFO

Article history:
Received 17 March 2010
Received in revised form 19 November 2010
Accepted 24 November 2010

Keywords:
Acorn
Compensatory growth
Extensive farming
Free ranging
Grass
Organic farming
Sustainable production

ABSTRACT

In spite of the growing interest in organic farming and sustainable production, there is a lack of information about the performance of pigs when they feed only on natural resources. This research studied the fattening pattern during the montanera (free-range grazing on acorns and grass during autumn and winter, without any supplementary feed or mineral complement) of the Iberian pig in the dehesa (Quercus ilex open woodlands) in order to know the average daily gain (ADG) and to analyze the influence of three factors: year of montanera, age and sex of pigs. The fattening data were obtained from two flocks of castrated pigs during the first two months (from November the first) of two consecutive montaneras (2003 and 2004) on the same farm. Pigs (from 111.8±0.9 kg BW at introduction) were individually weighed every 15 days in the early morning, with no food intake since the previous evening. The ADG for all pigs was 0.76±0.01 kg/day; however, some variations were observed according to the year (0.74±0.02 kg/day in 2003 vs. 0.78±0.02 kg/day in 2004; p<0.05), the sex (0.78±0.02 kg/day for males vs. 0.72±0.02 kg/day for females; p<0.01) and the age (0.71±0.02 kg/day for pigs younger than a year vs. 0.83±0.02 kg/day for pigs older than a year; p<0.001); however a factorial 3-way ANOVA does not show significant interaction between factors. Comparing the fortnights periods, the lowest ADG was measured in the first 15 days of montanera (0.60±0.02 kg/day), and the highest ADG occurred in the second one (0.85±0.02 kg/day).

Later on, the datasets were adjusted with the GLM procedure for the fixed effects of the year of the montanera, the age and the sex. With the adjusted datasets, different regression models for the fattening in montanera were established; the best adjusted of those was the potential model (\(Y=0.32X^{1.22}\); X = days of montanera; and Y = kg life weight gained during the montanera). According with this model pigs would need an average of 58 d to fatten 46 kg, as the Iberian Breed Quality Standards demand. Finally, the results show that the age and sex, as factors that influence the ADG, should be taken into close account to choose pigs and that it is possible to reach a high ADG grazing only with natural resources, following appropriate management strategies such as rationing in order to obtain the benefits of compensatory growth.

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1. Introduction

Consumer demands related to organic farming and sustainability have generated an interest in outdoor swine production systems. However, works studying growing pigs fed with grass and concentrates are very scarce (e.g., Edwards, 2003) and there is no known research dealing with the average daily weight gain (ADG) of domestic pigs in a natural environment without any supplementary feed.

The traditional finishing system of the Iberian pig is linked to the "dehesa" (Quercus sp. open woodlands), in order to use...
the abundance of food provided by acorn ripening (called montanera), when pigs only eat grass and fallen acorns (Rodríguez-Estévez et al., 2009a).

This finishing system has its own legal regulation (MAPA, 2007) and it does not allow to begin finishing at an age lower than 10 months and limits the beginning weight from 80.5 to 115 kg. Since acorns are a limited resource, it is of highest interest to know which factors have influence to a good ADG, in order to gain the minimum of 46 kg as it is established by the cited Quality Standards in the shortest possible time (legally defined as a minimum of 2 months).

The great genetic variability between varieties of the Iberian pig determines different ADGs, varying between 0.47 and 0.64 kg/day (Barba et al., 2000). The knowledge of the ADG in the montanera is important for establishing its approximate length and to make the most efficient use of the acorn mast. Hence the goal of the present study is to contribute to the description of fattening patterns of the Iberian pig during the first two months of the montanera, and to evaluate a likely influence of several factors (sex, age, and year) on the rate of gain.

2. Materials and methods

2.1. Area of study

The study was performed during the montanera seasons of 2003–2004 (M1) and 2004–2005 (M2), starting in November, in 111 ha of dehesa with Q. ilex rotundifolia. The pastureland resources available were estimated at 8–14 kg acorns/tree and 200–500 kg dry matter of the autumn grass production per hectare (Rodríguez-Estévez et al., 2009a). Mean temperatures during the study periods (between 1/11 and 30/12) were 9.3 ± 0.34 °C and 7.81 ± 0.33 °C respectively for M1 and M2.

2.2. Animals and handling

Two herds, of 84 purebred Iberian (Silvela variety) fattening pigs each, were studied. All animals were the progeny in successive years of the same outdoor breeding herd, with batches every 3 weeks. Pigs were of both sexes and had a live weight of 113.4 ± 1.1 and 110.2 ± 1.3 kg at the start of the study, respectively, for M1 and M2. To study the possible influence of age every flock had pigs from 4 different batches; besides, in order to better classify pigs into two age categories, between the two younger batches and the two older there were two batches from which no pigs were chosen. Hence, in accordance to their age, the pigs were classified into those younger than 1 year (10 to 11.5 months) and older than 1 year (13–14.5 months).

Like in the traditional breeding system, all pigs (males and females) were castrated under anaesthesia after weaning, following the Spanish regulations. Adaptation and handling during the study have been previously described by Rodríguez-Estévez et al. (2009a, 2010a, 2010b)). Throughout the experiment, no additional feed or mineral supplements were provided; the pigs were fed exclusively on natural resources (Rodríguez-Estévez et al., 2009a).

2.3. Data collection

Fortnightly weighing was carried out from the first day of the montanera, until 2 months later. The ADG for each period was calculated by dividing the increase in weight of that period by the 15 days that had passed. The weighing was done in the morning, after a fast since the previous evening, in an immobilization cage with an electronic scale (accuracy = ± 0.5% of displayed weight). Pigs that fell ill and presented a weight loss without a re-gain for the next weighing were eliminated from the study (and received appropriate veterinary treatment); resulting in 161 studied Iberian pigs: 88 of them were male and 73 female.

2.4. Statistical analysis

For the analysis of the data it was tested whether the data adjusted to a normal distribution and a simple variance analysis was carried out to determine the effect of three main factors: , age (<1 and ≥1 year), sex (barrows and castrated gilts), and the year of montanera or trial replicate (M1 and M2) on the fortnightly ADGs and on the total period gain (60 days). Besides a factorial 3-way ANOVA with the initial LW as a covariate was performed (using the GLM procedure). The existence of significant differences in these factors was interpreted as an effect on the ADG, and therefore a covariance analysis was carried out, considering the sex, the year of the montanera, and the age group as fixed factors; besides age and weight at the beginning of the montanera were considered co variables. After the method of step-by-step introduction and elimination of variables was applied (criterion: probability that $F$ is ≤0.05 to enter and ≥0.1 to eliminate), it left as a factor of regression the age in months at the beginning of the montanera fattening.

The weight increase data were adjusted for the fixed effects of year, age, and sex, with the univariate GLM procedure. The observed and adjusted datasets formed the archives that were then analyzed. From the datasets of the increase of the adjusted ADG, the biweekly LW increments were established, that were used to establish the model of regression of the weight gain during the montanera fattening; the following four types of equations were taken into account: Linear $(Y = a + bX)$; 2nd grade polynomial $(Y = a + bX + cX^2)$; Potential $(Y = ax^n)$; Exponential $(Y = a(1 − e^{-bx}))$.

3. Results and discussion

3.1. Evolution of weights and average daily weight gains

Table 1 shows the descriptive statistics of the evolution of ADGs for the entire group of animals and for each subgroup (year, sex and age) and fortnight. From an initial weight of 111.8 ± 0.9 kg the pigs passed to 157.7 ± 1.1 kg after the two months of montanera fattening, which equals a global ADG of 0.76 ± 0.01 kg/day.

The largest global ADGs correspond to the older pigs (0.83 ± 0.14 for pigs ≥1 year vs. 0.71 ± 0.18 kg/day for pigs <1 year; $p < 0.001$) and to the males (0.80 ± 0.02 vs. 0.72 ± 0.02 kg/day; $p < 0.01$); the year of the montanera also had an influence (0.74 ± 0.19 in M1 vs. 0.79 ± 0.14 kg/day in M2; $p < 0.05$). In a previous paper it has been stated that the montanera diet and the daily ingestion depends on the precipitation during the masting
acorn season and on the availability of water when grazing (Rodríguez-Estévez et al., 2009a). Both in M1 and M2 the largest individual global ADG is 1.10 kg/day and corresponds to males > 1 year.

The lowest biweekly and total ADGs were reached by females < 1 year in M1 (0.61 ± 0.04 kg/day), as opposed to the males > 1 year in M1 (0.89 ± 0.04 kg/day). This lower growth of female pigs is well known (e.g., English et al., 1988; Whittmore and Kyriazakis, 2005), as well as the lower ADG in the montanera for animals younger than 8 months as opposed to animals 12 or 14 months old, probably due to compensatory growth, as a result of the previous food restriction (Daza et al., 2008) and because those pigs with food restrictions in their growth period could have better conversion rates during finishing (Chiba et al., 2002). Table 2 shows the factorial 3-way ANOVA but no significant interaction between factors has been found.

3.2. Regression models

The predicted ADG values resulted in the following fortnightly averages: 0.60 ± 0.01 kg/day between days 0 and 15, 0.85 ± 0.01 kg/day between days 16 and 30, 0.83 ± 0.01 kg/day between days 31 and 45, and 0.78 ± 0.01 kg/day between days 46 and 60.

The lower ADGs in the first 15 days could be related to the adaptation of the consumption of acorns. On the other hand, the largest biweekly ADGs correspond to the second and third 15-day periods, probably coinciding with the abundance of acorns as Aparicio Macarro (1969) points out. Finally, the low ADGs in the last fortnight could be explained because the energy expenditure during grazing depends on the size of animal: 0.26 kJ/min per kg W0.75 for standing (Noblet et al., 1993) and 10.1–11.3 kJ/kg/W0.75 for each km walked (Edwards, 2003); besides at the end of the montanera season pigs could need to visit more trees looking for acorns and to find their favourite ones (Rodríguez-Estévez et al., 2009b).

From the predicted ADG values, we obtained the accumulated fattening (ALW) during the montanera and its regressions that are shown in Table 3. Out of all of those, the potential function is the one that the data adjusts to best. Finally, according to the adjusted potential model the Iberian pigs (Silvela variety) need 58.7 days to achieve the minimum of 46 kg live weight gain established by the Quality Standards.

3.3. Comparison of results

The results obtained in this study surpass both the average of 0.57 kg/day and the maximum of 0.89 kg/day that Barba et al. (2000) indicate for castrated males of this variety and surpass the average of 0.64 ± 0.01 kg/day and the maximum of 1.02 kg/day for the Torbiscal variety, which according to Barba et al. (2000) has a higher ADG in montanera than other varieties, which fluctuate between 0.48 and 0.58 kg/day. The global ADG obtained is similar to the 0.77 kg/day of Torbiscal variety in intensive husbandry with 121 g of fodder/kg per LW0.75 and day (fodder of 13.06 MJ ED/kg and 6 g of lysine/kg) after food restrictions during the growing stage (Daza et al., 2007) and it is higher than the 0.65 kg/day of Torbiscal castrated males with 3.72 kg of fodder/day (fodder of 12.53 MJ EM/kg and 7.7 g of Lysine/kg) obtained by Daza et al. (2006).

According to earlier data, the results of montanera fattening were not expected to outperform the ADG for intensive husbandry, since the montanera has higher energetic costs because of the physical activity and the weather conditions (25.7 ± 0.38 MJ ME per day, which represents 51.2 ± 2.71% of the ME ingested) and because it presents a low consumption of digestible proteins (Rodríguez-Estévez et al., 2009a, 2010a). On the contrary Lopez-Bote et al. (2008) did not observe

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**Table 1** Descriptive statistics (mean ± SE) of the fattening (average daily gain) of Iberian pigs during the montanera (kg/day).

<table>
<thead>
<tr>
<th>Montanera 1</th>
<th>Montanera 2</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 year</td>
<td>&gt; 1 year</td>
<td>&lt; 1 year</td>
</tr>
<tr>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–15 days</td>
<td>0.42 ± 0.04 ab</td>
<td>0.38 ± 0.05 a</td>
</tr>
<tr>
<td>15–30 days</td>
<td>0.83 ± 0.04 abc</td>
<td>0.71 ± 0.05 a</td>
</tr>
<tr>
<td>30–45 days</td>
<td>0.86 ± 0.03 abc</td>
<td>0.71 ± 0.03 a</td>
</tr>
<tr>
<td>45–60 days</td>
<td>0.83 ± 0.03 abc</td>
<td>0.65 ± 0.04 a</td>
</tr>
<tr>
<td>0–60 days</td>
<td>0.74 ± 0.03 abc</td>
<td>0.61 ± 0.04 a</td>
</tr>
</tbody>
</table>

Different letters indicate significant differences (p < 0.05).

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**Table 2** Factorial 3-way ANOVA with the initial live weight (LW0) as a covariate, and average daily gain during 60 days as a dependent variable.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III sum of squares</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.307(3)</td>
<td>8</td>
<td>0.163</td>
<td>7.329</td>
</tr>
<tr>
<td>Sex</td>
<td>2.008</td>
<td>1</td>
<td>2.008</td>
<td>90.071</td>
</tr>
<tr>
<td>Age (&lt; 1 year or &gt; 1 year)</td>
<td>0.330</td>
<td>1</td>
<td>0.330</td>
<td>14.795</td>
</tr>
<tr>
<td>Montanera year or trial replicate</td>
<td>0.347</td>
<td>1</td>
<td>0.347</td>
<td>15.572</td>
</tr>
<tr>
<td>Sex*Age</td>
<td>0.666</td>
<td>1</td>
<td>0.666</td>
<td>29.883</td>
</tr>
<tr>
<td>Montanera year or trial replicate replicate</td>
<td>0.002</td>
<td>1</td>
<td>0.002</td>
<td>0.072</td>
</tr>
<tr>
<td>Error</td>
<td>3.389</td>
<td>152</td>
<td>0.022</td>
<td>1.359</td>
</tr>
<tr>
<td>Total</td>
<td>98.860</td>
<td>161</td>
<td>0.616</td>
<td>0.160</td>
</tr>
</tbody>
</table>

*R square = 0.278 (Adjusted R square = 0.240).
the effect of exercise for live weight gain when comparing sedentary, exercised and free-range fattening Iberian pigs from 111.1 to 171.4 kg and the mean ADG found was also lower with 0.531, 0.530 and 0.514 kg/day, respectively. Also the 0.69 kg/day sedentary, exercised and free-range fattening Iberian pigs from the effect of exercise for live weight gain when comparing Regression models for the fattening in montanera.

Table 3

<table>
<thead>
<tr>
<th>Models</th>
<th>$R^2$</th>
<th>SE</th>
<th>$F$</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y = -3.09 + 0.82X$</td>
<td>0.89</td>
<td>4.90</td>
<td>5084.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>$Y = 0.32X^{2.22}$</td>
<td>0.87</td>
<td>0.24</td>
<td>4333.1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>$Y = 5.80(1 - e^{-0.04X})$</td>
<td>0.82</td>
<td>0.29</td>
<td>2905.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>$Y = -4.26 + 0.90X^2 - 0.001X^3$</td>
<td>0.89</td>
<td>4.89</td>
<td>2545.0</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

$X$: days of montanera; and $Y$: kg life weight gained in the montanera.

4. Conclusions

When pigs are extensively or organically managed, the rate of growth is important in order to maximize the use of natural resources such as acorns. Therefore the age and sex, as factors that influence the ADG, should be taken into close account because of the energetic penalty associated with grazing. It is possible to achieve an outstanding ADG when fattening pigs on natural resources without any supplementary feed under organic farming conditions. However, in order to do this, it is essential to organize the breeding system (farrowing dates) to have appropriate pigs for the masting season (enough age and weight to manifest compensatory growth) and to adapt these to graze. It would be necessary to study the ADG for other varieties of the Iberian breed to compare performances with acorn diet.

Acknowledgments

This research has been supported by the Dirección General de la Producción Agrícola y Ganadera of Junta de Andalucía and the company Turcañada S.L. (Fuente Obreguina, Córdoba).

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