Reprod. Nutr. Dev. 38 (1998) 363–375

Original article

Effect of the feeding level during rearing on performance of Large White gilts. Part 1: growth, reproductive performance and feed intake during the first lactation

Yannick Le Cozler[a], Chrystèle David[b], Valérie Beaumal[b], Jean-Claude Hulin[b], Maria Neil[a], Jean-Yves Dourmad[b]*

[a] Centre for Reproductive Biology, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, Funbo-Lövsta, 755 97 Uppsala, Sweden
[b] Station de recherches porcines, Inra, 35590 Saint-Gilles, France

(Received 12 January 1998; accepted 26 June 1998)

Abstract – Fifty pure-bred Large White gilts were allocated to two feeding levels from 28 kg until service. They were fed a standard growing diet (13.4 MJ digestible energy (DE) per kg; 18.1 % crude protein, CP; 0.96 % lysine) either to appetite (AP) or at 80 % of the AP level (R). Growth rate was reduced by about 20 % in R gilts, whereas feed conversion ratio was unaffected by rearing treatment. First oestrus was detected earlier in AP gilts (234 versus 247 d of age). At service, AP females had larger body weight (190 versus 150 kg) and thicker backfat (20.9 versus 13.4 mm). After service, the reproductive performances of 30 of these gilts were studied during the first reproductive cycle. All gilts received 2.6 kg/d of a standard diet (12.6 MJ DE/kg; 13.9 % CP; 0.59 % lysine) during pregnancy and were fed ad libitum a commercial lactation diet (13.1 MJ DE/kg; 17.1 % CP; 0.90 % lysine) from day five after farrowing. At farrowing, AP females were larger (257 versus 225 kg) and had more backfat (23.7 versus 17.4 mm) than R ones. Reproductive performance during the first lactation was not affected by rearing treatment, and weaning to oestrus interval was similar in both groups (4.8 d, on average). During lactation, R sows consumed significantly more feed (+ 650 g/d) and lost less backfat depth (1.5 versus 3.8 mm) than AP ones. © Inra/Elsevier, Paris

gilts / rearing / performance / reproduction / feed intake

Résumé – Effet du niveau d'alimentation pendant la croissance sur les performances de truies Large White primipares. Première partie : performances zootechniques. Cinquante cochettes de race pure Large White ont reçu soit à volonté (AP), soit à 80 % du niveau AP (R), un régime standard de croissance (13,4 MJ/kg d'énergie digestible, ED ; 18,1 % protéines, PB ; 0,96 % lysine) entre 28 kg

* Correspondence and reprints
E-mail: dourmad@st-gilles.rennes.inra.fr

de poids vif et la première insémination. La vitesse de croissance était réduite chez les cochettes R, alors que l'indice de consommation n'était pas affecté par le traitement. En moyenne, le premier œstrus a été détecté plus précocement chez les femelles AP (234 versus 247 j d'âge). Ces femelles étaient également plus lourdes (190 versus 150 kg) et plus grasses (20,9 versus 13,4 mm d'épaisseur de lard) à la première insémination que celles nourries de manière restreinte. Après insémination, les performances de reproduction ont été étudiées au cours du premier cycle de reproduction sur 30 femelles. Elles recevaient toutes 2,6 kg d'aliment en gestation (12,6 MJ ED/kg ; 13,9 % PB ; 0,59 % lysine), et, 5 j après la mise bas, elles étaient nourries à volonté avec un aliment standard de lactation (13,1 MJ ED/kg ; 17,1 % PB ; 0,90 % lysine). À la mise bas, les femelles AP étaient plus lourdes (257 versus 225 kg) et elles avaient davantage de réserves adipeuses (23,7 versus 17,4 mm). Aucune différence n'a été observée pour les performances de reproduction au cours de la première lactation, la durée de l'intervalle sevrage–œstrus étant en moyenne de 4,8 j. Au cours de la lactation, les animaux R ont consommé plus d'aliment (+ 650 g/j), et ont perdu moins d'épaisseur de lard (1,5 versus 3,8 mm) que les femelles AP.

cochettes / croissance / performances / reproduction / niveau d'alimentation

1. INTRODUCTION

The effect of gilt management during rearing on subsequent reproductive performances is of increasing interest in the literature [14, 24, 33, 39]. Many studies, based on field data, have shown the economical and reproductive interest of early conception of gilts [17, 23, 32]. Provided that subsequent reproduction is not compromised, puberty should be encouraged as early as possible with optimised management and nutritional regimens [1]. Nutrition during the rearing period may affect the onset of puberty, but while severe feed and/or energy restriction (less than 70 % of the ad libitum level) delayed its onset, moderate restrictions led to variable results in different studies, as reviewed by Den Hartog and Van Kempen [12].

When gilts begin their reproductive life with low body reserves, nutrient intake during gestation and/or lactation is more likely to be critical in influencing subsequent reproductive efficiency [10, 14, 37, 38]. High nutritional requirements not fully covered during lactation, may adversely affect subsequent reproductive performances, especially the weaning to oestrus interval [15, 28]. Many factors are involved in the variation of feed intake during lactation, as reviewed by Dourmad [4]. For instance, a negative relationship between feeding level during gestation, and the resulting increase in body fat at farrowing, on one hand, and ad libitum feed intake during lactation on the other hand, has been observed in many studies [5, 20, 35, 38].

The aim of the present study was then to obtain information about the effect of feeding level and growth during rearing on body composition changes, reproductive performances and feed intake of sows during the first lactation, and on their ability to return into heat after weaning.

2. MATERIALS AND METHODS

2.1. Animals and general design

At 72 d of age and 28 kg live weight on average, 50 pure-bred Large White gilts were assigned to two dietary treatments, in three batches from January to May 1995. They were fed two feeding levels from the start of the experiment until service. The females were group-housed in strawed pens (2.5 kg/d), with five gilts per pen (1.4 m^2/pig), under a 12-h artificial light per day regimen.

Because of a lack of farrowing place, only 30 of these animals were kept in the second part of the experiment that started after service. Two weeks before the expected day of parturition, they were moved into a lactation unit (20–24 °C), where they were individually penned in farrowing crates (1.9 × 2.6 m), on a concrete floor, with straw bedding. Piglets were provided with supplemental heating in a corner of the farrowing crate. They were weaned after 3 weeks of lactation (22 ± 1 d). The experiment ended 2 weeks after weaning. Routine vaccination and prophylactic treatments were applied on all animals.

2.2. Feeding treatments

Two feeding treatments during rearing were compared. In the first one (AP), the females were fed to appetite twice a day for 1 h each time, whereas in the other one (R), they received 80 % of the intake of the corresponding AP animals for the same live weight. All animals were fed individually and the amount of feed consumed was recorded each day. After service, all females were fed 2.6 kg/d of a standard gestation diet, and after farrowing, they received a standard lactation diet (*table I*). The level of feeding was progressively increased from parturition to reach ad libitum from d 5 post-farrowing. From weaning until the end of the experiment, all gilts received 4.2 kg/d of the gestation diet. No creep feed was offered to the piglets before weaning. The composition of the different diets used during the experiment is given in *table I*.

2.3. Oestrus and farrowing synchronisation

From 160 d of age, the animals were checked daily for oestrus with the back pressure test in the presence of a mature Large White boar. As the animals were to be used in a physiological experiment [18], oestrus cycles were synchronised from d 260 on average with oral administration of allyl-trenbolone (Regumate®, Roussel-Uclaf, France). A daily dose of 20 mg as a top dressing on the feed was provided to each gilt for 18 d. Females were inseminated with semen from pure-bred Piétrain boars, at the first detected oestrus after the last feeding of allyl-trenbolone. Pregnancy was confirmed by a blood progesterone test on d 22 post-service by a validated method [25]. Parturition was induced at 114 d post-insemination, by a single intra-muscular injection of 2 mL cloprostenol on d 113 of gestation (Planate®, Pitman-Moore, USA). A myorelaxant (Monzal®, Boehringer Ingelheim, Germany) and oxytocin (Rhône Merrieux, France) were used when farrowing started to stimulate contractions and to facilitate the delivery of the piglets. Supervision of piglet birth and gilt behaviour was provided during parturition. Litters were standardised to 11 piglets within 48 h. When the number of piglets available was too low, piglets from non-experimental sows were fostered.

2.4. Milk sampling

Milk samples were collected on d 2 and d 21 from all functional glands of each sow. After an intra-venous injection of 2 mL oxytocin (Rhône Merrieux, France), 350–500 mL of milk were collected. Samples were stored at –20 °C until chemical analysis.

2.5. Measurements and chemical analyses

All gilts were weighed weekly from the start of the experiment until service, every 2 weeks during gestation, and every week from farrowing until d 14 post-weaning. Piglets were weighed at birth, every week during lactation and at weaning. Backfat thickness (BF) of gilts was measured from 160 d of age, every 3 weeks during rearing and gestation, at the first detected oestrous, at service, at farrowing, weekly during lactation, at weaning and 1 week after weaning. Ultrasonic BF was measured on each side, 6.5 cm from the midline at the level of the last rib. The daily feed allowance and refusals were recorded throughout the entire experiment.

Milk samples were analysed for dry matter, using successive freeze-drying and heat drying in an oven (105 °C) over a 24-h period in two duplicates. Nitrogen content was determined on freeze-dried samples, as gaseous N formed after combustion using a Leco FP 428 apparatus (Leco, St Joseph, MI, USA). Energy content was determined in an adiabatic bomb calorimeter on a previously freeze-dried sample (IKA Calorimeter C400, Heitersheim, Germany). Lipid contents were determined according to the Association of Official Analytical Chemist [2] procedures. The feed samples were analysed for dry matter, energy and nitrogen content as previously described on a fresh sample. Analyses of ash, crude fibre and lipid contents were performed according to the AOAC [2] procedures.

Table I. Experimental diet composition.

	Stage of experiment		
	Rearing[1]	Gestation	Lactation
Ingredients (g/kg)			
Barley	240.0	330.0	250.0
Wheat	243.8	221.5	228.0
Maize	150.0	100.0	120.0
Soya bean meal	230.0	90.0	210.0
Beat molasse	30.0	–	30.0
Wheat bran	50.0	150.0	100.0
L-Lysine HCl (78 %)	0.7	–	0.5
Sodium chloride	4.5	4.5	4.5
Fat	20.0	20.0	20.0
Dicalcium phosphate	12.0	9.0	19.0
Limestone	14.0	20.0	13.0
Vitamin and mineral premix[2]	5.0	5.0	5.0
Analysed contents, per kg			
Dry matter (g)	888.4	890.4	881.7
Ash (g)	58.5	57.0	60.0
Crude protein (g)	181.0	139.1	171.4
Crude fibre (g)	34.3	47.8	37.2
Fat (g)	41.3	38.1	40.9
Crude energy (MJ)	16.5	16.4	16.3
Calculated contents			
Digestible energy (MJ/kg)	13.4	12.6	13.1
Lysine (g/kg)	9.6	5.9	9.0
Methionine + cystine (g/kg)	6.2	4.9	6.0
Threonine (g/kg)	6.5	4.8	4.2
Ca (g/kg)	10.8	12.5	12.0
P (g/kg)	6.3	6.2	7.9

[1] Corresponds to the period from the beginning of the experiment (28 kg) to service.
[2] Contributed per kilogram of rearing diet (between parentheses, the value for gestating and lactating diets when they differed from the rearing diet): 5 000 IU of vitamin A (10 000); 1 000 IU of vitamin D3 (1 500); 20 mg of vitamin E (30); 2 mg of vitamin K3; 2 mg of thiamine; 4 mg of riboflavin; 15 mg of niacin (20); 10 mg of pantothenic acid; 1 mg of pyridoxin (3); 0.02 mg of biotin; 1 mg of folic acid (3); 0.02 mg of vitamin B12; 500 mg of choline; 80 mg of iron; 10 mg of copper; 40 mg of manganese; 100 mg of zinc; 0.1 mg of cobalt; 0.2 mg of iodine (0.6); 0.15 mg of selenium.

2.6. Calculations and statistical analyses

Data were analysed by the General Linear Model procedures of SAS [31]. The model included the effects of treatment, batch number and interaction between treatment and batch (*tables II–V*). Milk composition (*table VI*) at the beginning and at the end of lactation were compared by split plot analyses. The model tested the effect of treatment against animal nested within treatment as residual error, whereas the effect of lactation stage and the interaction between treatment and lactation stage were tested against the error term of the model.

3. RESULTS

3.1. Changes in live weight and backfat depth

The AP gilts, which were fed to appetite during rearing, reached the usual commercial body weight (BW) of 100 kg 26 d earlier than the R ones, restrictedly fed to 80 % of the AP level during rearing ($P < 0.001$; *table II*). At this stage of the experiment, the AP gilts had thicker backfat (9.3 versus

Table II. Effect of the feeding level from 28 kg to service on growth, puberty and characteristics at service of Large White gilts[1].

Treatment[2]	AP	R	Statistical significance[3]			
			rsd[4]	T	B	T*B
Start						
n	24	26				
BW (kg)	28.2	28.0	2.7	ns	***	ns
Age (d)	72.3	71.2	2.3	ns	***	ns
100 kg						
n	24	26				
BW (kg)	100.3	100.0	1.8	ns	ns	ns
Age (d)	173.5	199.4	9.0	***	**	ns
Daily gain (g/d)	736.9	585.5	33.1	***	**	ns
Feed conversion ratio[5]	2.64	2.68	0.12	ns	ns	***
BF (mm)	9.27	8.46	1.3	*	*	ns
Feed intake (kg/d)	1.94	1.57	0.06	***	*	*
Puberty (first detected oestrus)						
n	23	17				
Age (d)	234.5	247.0	14.3	*	ns	ns
Daily gain (g/kg)	767.9	611.0	68.6	***	ns	ns
BW (kg)	150.1	133.0	12.2	***	*	*
BF (mm)	15.85	11.21	2.83	***	ns	ns
Service						
n	24	26				
BW (kg)	189.9	150.2	8.7	***	ns	ns
Age (d)	286.5	288.5	4.4	ns	***	ns
BF (mm)	20.93	13.42	3.56	***	**	ns
30 kg-to service						
n	24	26				
Daily gain (g/kg)	766.5	575.8	33.8	***	ns	ns
Feed conversion ratio[5]	3.44	3.38	0.14	ns	***	ns
Feed intake (kg/d)	2.63	1.94	0.08	***	***	*

[1] Abbreviations: n, number of observations; BW, body weight; BF, backfat thickness; AP, fed to appetite from start to service; R, 80 % of AP feed level from start to service; T, feeding treatment during rearing; B, batch effect; T*B, interaction between batch and feeding treatment.
[2] Feed treatment during rearing.
[3] Statistical significance: ***, $P < 0.001$; **, $P < 0.01$; $P < 0.05$; ns, $P > 0.05$.
[4] rsd, residual standard deviation.
[5] kg of feed per kg of body weight gain.

8.5 mm; $P < 0.05$). From the start of the experiment until 100 kg BW, AP females grew on average 150 g/d faster than R ones ($P < 0.001$). At the first detected oestrus, AP gilts were significantly younger by 13 d, heavier by 27 kg and had more BF (+ 4.6 mm) than R females. Animals from both treatments were served at the same age, 287 d on average. At that time, R females were 20 % lighter and had one third less BF than AP ones ($P < 0.001$).

Only 30 gilts (13 AP and 17 R) were kept in the second part of the experiment that started after service. Body weight of the AP and R females increased linearly with gestation stage (*figure 1*). Backfat depth increased slowly during the first part of gestation and remained quite constant after d 70 of pregnancy. During pregnancy, R gilts gained significantly more BW (+ 7.3 kg) than AP ones, whereas no significant difference was observed in the gain of BF (*figure 1* and

Table III. Average daily feed intake during lactation (g/d) in gilts fed to appetite (AP) or 80 % of the appetite level (R) during rearing (n = 30)[1].

Treatment[2]	AP	R	Statistical significance[2]			
			rsd	T	B	T*B
n	13	17				
0–22 d	5 234	5 888	1 975	***	***	*
0–4 d	3 217	3 042	1 774	ns	ns	ns
5–22 d	5 796	6 655	2 043	***	***	**
5–12 d	5 444	6 288	1795	***	***	ns
13–22 d	6 076	6 934	2179	***	***	*

[1] See *table II*.
[2] Statistical significance: ***, $P < 0.001$; **, $P < 0.01$; $P < 0.05$; ns, $P > 0.05$.

Table IV. Effect of feeding level during rearing on body weight and backfat depth changes during pregnancy and lactation in primiparous sows[1].

Treatment[2]	AP	R	Statistical significance[2]			
			rsd	T	B	T*B
n	13	17				
BW at mating (kg)	190.5	151.2	9.3	***	ns	ns
BF at mating (mm)	20.4	13.7	3.4	***	**	†
BW changes (kg)						
During gestation	+ 66.8	+ 74.1	5.0	***	ns	ns
At farrowing	– 32.3	– 31.0	5.1	ns	*	ns
During lactation	– 17.1	– 8.5	9.7	†	ns	ns
BF gain (mm)						
During gestation	+3.3	+3.7	2.1	ns	**	ns
During lactation	–3.8	–1.5	1.5	**	***	ns

[1] See *table II*.
[2] Statistical significance: ***, $P < 0.001$; **, $P < 0.01$; $P < 0.05$; †, $P < 0.1$; ns, $P > 0.1$.

table IV). At the end of gestation, AP gilts remained heavier (257 versus 225 kg) and had more BF (23.7 versus 17.4 mm) than R females. No difference was observed in BW loss at farrowing (31.5 kg on average; *figure 2* and *table IV*). From farrowing to weaning, R gilts tended to lose less weight than AP ones ($P < 0.1$; *figure 2* and *table IV*), and the decrease in their BF depth was significantly lower (1.5 versus 3.8 mm).

3.2. Feed intake

Feed intake increased continuously over the rearing period (*figure 3*). At service, it reached 3.4 and 2.6 kg/d in the AP and R sows, respectively. No effect of feeding treatment was noted on the feed conversion ratio from the start of the experiment until 100 kg BW or until service (*table II*). During gestation, no feed refusal was observed. Feed intake during lactation was significantly higher by 650 g/d on average in R females than in AP ones (*table III* and *figure 4*). During the first 5 d of lactation, all sows were restrictedly fed, and no difference in feed intake was observed between treatments. When that period of feed restriction at the beginning of the lactation was excluded,

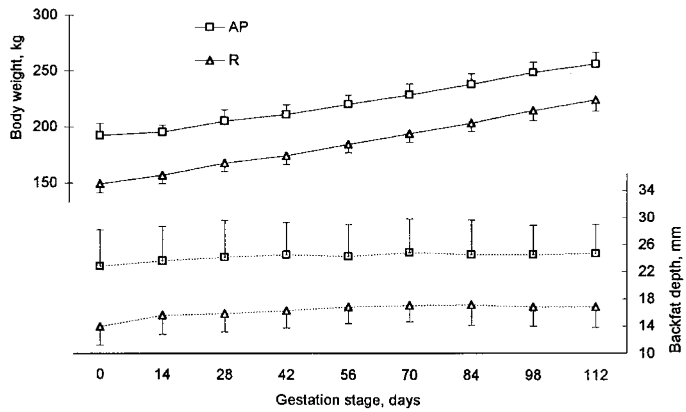

Figure 1. Development of body weight and backfat depth during gestation (mean values ± s.e.m.)

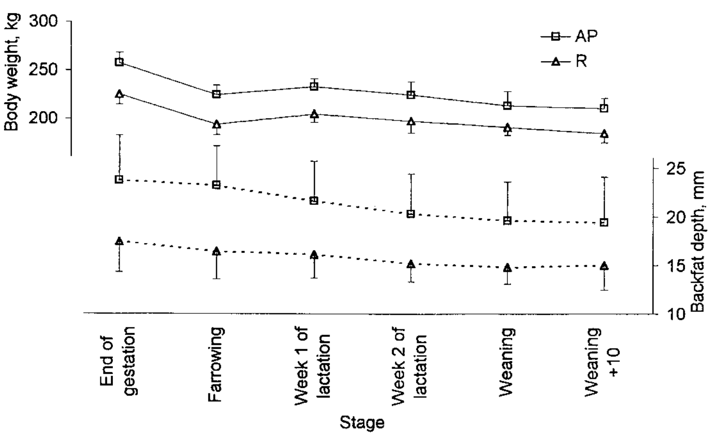

Figure 2. Feed intake during rearing according to body weight (mean values ± s.e.m.).

the R females consumed about 850 g more feed per day than the AP ones. During the second (d 5–12) and the third part of the lactation (d 13–22), differences in feed intake between R and AP sows remained the same (844 and 858 g/d, respectively) (*table III* and *figure 4*). Over the whole lactation, R sows consumed 15.5 kg more feed on average than AP ones.

3.3. Litter and sow performance

There was no significant difference among rearing treatments, either in the average weight of piglets or the total weight of the litter at birth (*table V*). But, the total number of piglets born tended to be higher by one piglet in AP than in R gilts ($P < 0.1$). At weaning, average number and weight of piglets, and total weight of the litters were similar in the two treatments (with mean values of 10.0 piglets, 6.6 kg and 66.3 kg, respectively).

3.4. Weaning to oestrus interval

The average delay from weaning to oestrus was similar in AP and R animals: 4.7 and 4.9 d, respectively. Only four among

Table V. Effect of feeding level during rearing on reproductive performances of primiparous sows at farrowing and weaning[1].

Treatment[2]	AP	R	Statistical significance[2]			
			rsd	T	B	T*B
n	13	17				
At farrowing						
Number of piglets	12.9	11.9	1.4	†	*	*
Piglet weight (kg)	1.52	1.52	0.18	ns	†	ns
Litter weight (kg)	19.8	18.0	2.8	ns	*	ns
At weaning[3]						
Number of piglets	10.4	9.8	1.5	ns	ns	ns
Piglet weight (kg)	6.49	6.71	0.89	ns	ns	ns
Litter weight (kg)	67.1	65.7	13.3	ns	ns	ns
Litter weight gain (d1–21)	46.8	48.3	12.1	ns	ns	ns

[1] See *table II*.
[2] Statistical significance: ***, $P < 0.001$; **, $P < 0.01$; $P < 0.05$; †, $P < 0.1$; ns, $P > 0.1$.
[3] Litter were standardised to 11 piglets within 2 d after farrowing.

Table VI. Effect of feeding level during rearing and stage of lactation on milk composition[1].

Treatment	AP		R		Statistical significance			
Stage of lactation (d)	2	21	2	21	rsd	T	S	T*S
Dry matter (%)	22.5a	18.6b	20.4c	18.3b	1.8	†	***	†
Crude protein (%)	7.12a	5.41b	6.47a	5.34b	0.84	ns	***	ns
Fat (%)	8.98	7.38	7.56	7.39	1.8	ns	ns	ns
Energy (kJ g^{-1})	6.51a	4.96b	5.73c	4.90b	0.68	ns	***	†

[1] See *table II*; S: lactation stage effect.
[2] Statistical significance: ***, $P < 0.001$; **, $P < 0.01$; $P < 0.05$; †, $P < 0.1$; ns, $P > 0.1$. Within a row, values with different letter significantly differ at $P < 0.05$.

the 30 sows (two in each treatment) did not come into heat within 2 weeks after weaning. Among the 26 sows that showed oestrus within 14 d post-weaning, 21 came into heat within 5 d (70 %), without any difference between treatments.

3.5. Milk composition

The milk composition was significantly affected by the stage of lactation, but not by the feeding strategy (*table IV*). Average dry matter, crude protein and energy content of the milk decreased significantly with lactation stage (–2.1 %, –1.4 % and –1.2 kJ/g, respectively), whereas the fat content was not affected (*table VI*). At the beginning of lactation, the milk produced by AP sows tended to have a higher amount of dry matter (+10.1%) and energy (+13.6 %) than the milk produced by R females, whereas no effect of treatment on milk composition was observed at the end of lactation.

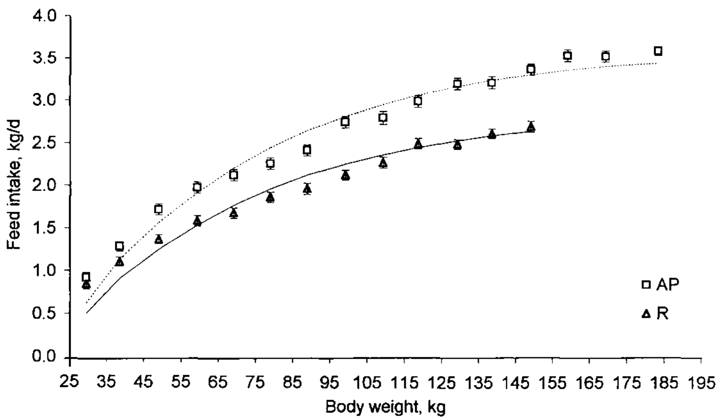

Figure 3. Evolution of body weight (BW) and backfat depth (BF) during lactation (mean values ± s.e.m.).

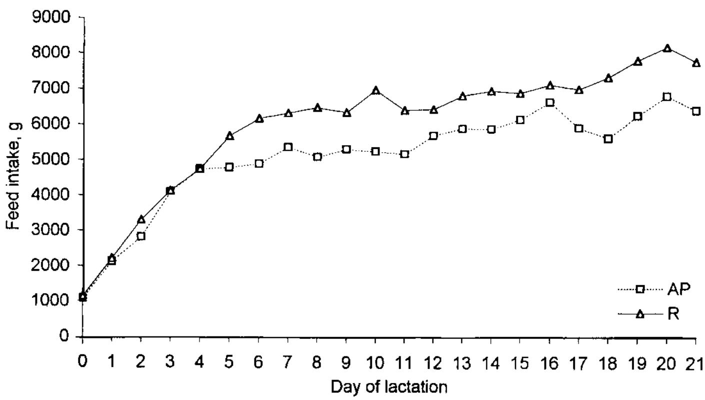

Figure 4. Changes in daily feed intake with stage of lactation (mean values).

4. DISCUSSION

The growth performances of gilts during the rearing period were as expected and in agreement with the previous results obtained by Metz et al. [19], Dourmad et al. [6] and Simmins et al. [33]. The difference between treatments in the daily feed allowance resulted in a faster growth, a heavier weight and more body fat reserves at service in gilts fed to appetite. No effect of treatment was observed on feed conversion ratio, as generally found with a limited feed restriction. Metz et al. [19] have demonstrated that lower growth intensity resulted in a higher bone proportion in the carcass. In addition, Newton and Mahan [21] found a higher percentage of proteins in the body components of gilts restricted to 75 % of ad libitum level during rearing compared to those fed ad libitum (16.2 and 15.7 %, respectively). In the present work, the body fatness, estimated from the backfat/body weight ratio [39], was equal to 9.3 and 8.5 mm/100 kg at 100 kg live weight. At service, AP and R gilts weighed 190 and 151 kg and their body fatness were 11.3 and 8.5 mm/100 kg, respectively. These results confirmed that during the growing period, the feeding level affects more fat than bones and lean tissue deposition, resulting in gilts with higher percentages of lean and bones when restrictedly fed.

Despite a similar feed allowance during gestation, gilts restrictedly fed during rearing gained 7.4 kg more body weight. This higher body weight gain during pregnancy could not be explained by differences in conceptus weight gain, because no difference was observed in total loss at farrowing. Other authors [8, 11, 30, 33] have previously obtained similar results. Thus, it has been suggested that lighter females with lower maintenance requirements are able to deposit larger amounts of body tissues than heavier ones, when they receive the same amount of feed. The absence of difference in the backfat gain or in changes in the backfat/ body weight ratio during pregnancy indicates that all body components were affected.

When compared to the results available in the literature [33, 36, 38], the BW achieved by R and AP gilts (225 and 255 kg, respectively) at the end of gestation were higher than the usual recommendations (160–200 kg), whereas BF depth (17.5 and 24 mm, respectively) could be considered as normal and high. At farrowing, body fatness, estimated from the ratio BF/BW, was 7.8 and 9.4 mm per 100 kg BW in R and AP sows, respectively. This is below the estimate value of 10 mm per 100 kg and more in the usual recommendations [36]. Thus, despite that BW at first farrowing was higher for both groups of sows than usually observed in first-litter sows, the AP females can be considered as targeting the usual recommendations for backfat depth, whereas R females can be considered as being too lean sows.

Gilts in the present study reached puberty at a relatively old age, 240 d on average, probably because they were not highly stimulated and not moved to a new environment when oestrus detection started. The 13-d delay observed in the onset of puberty in the restrictedly fed animals during rearing was close to the 10 d reported by Den Hartog and Noordewier [13], when gilts were fed a low level of energy during rearing. Prunier et al. [26] observed that at 200 d of age, the percentage of pubertal gilts in animals fed ad libitum during rearing was much higher than in gilts fed restrictedly. In addition, they observed that at 125 kg live weight, the percentage of cyclic gilts was much higher in animals fed restrictedly during rearing than in those fed ad libitum. In the present study, the small difference in age and the significant differences in body weight and backfat depth at puberty, tend to confirm that age, rather than body weight, is the main factor involved in the puberty onset, in good agreement with the results of Den Hartog [11], Aherne and Kirkwood [1], Prunier et al. [26] and Newton and Mahan [21].

In the present work, the gilts receiving the highest feeding level during rearing tended to give birth to non-significantly larger litters. Den Hartog [11] also observed that gilts reared with a high energy level produced more piglets at birth. Duée [7] found a linear relationship between daily weight gain and ovulation rate at first oestrus, and, according to him, the variation in ovulation rate was mainly related to differences in body weight. Litter size in primiparous sows has also been related to age and oestrus number at first breeding [3]. The results of the present study agree with Rozeboom et al. [30], who also observed that the weight of the piglets at birth was not affected to the body composition of the gilt at first breeding, but increased with oestrus number at first service.

As a consequence of litter standardisation at birth and of similar post-natal mortality rates, the number of piglets weaned was not affected by feeding treatments. Feeding level during rearing had no effect on litter or piglet weights at weaning. In agreement with King [14], this result suggests that the growth rate of the piglets is unaffected by differences in body weight and body composition of sows at first farrowing, provided that body weight and fatness at this time are above minimum threshold and provided that animals are offered feed to appetite during lactation and consume sufficient amounts of feed, as was the case in the present experiment. During lactation, partition of nutrients is prioritised toward milk production at the expense of catabolising maternal tissue if feed intake is too low [5, 40]. Milk yield is mainly dependent on the size of the litter, the parity, the stage of lactation [9] and, when gilts are not fed ad libitum during lactation, on the level of body reserves at farrowing [16, 20]. Thus, it can be considered that in the present study, body reserves at farrowing and feed consumption during lactation were sufficient in both treatments to prevent any deleterious effect on milk production and piglet growth.

With the progress of lactation, dry matter, fat, crude protein and energy content of the milk decreased, in agreement with Noblet and Etienne [22]. At the beginning of lactation, gilts with higher backfat depth at farrowing tended to produce a milk with higher contents in dry matter and energy than those with lower backfat. In multiparous sows, Klaver et al. [16] suggested that the body condition of the sow is the primary factor influencing milk production, as well as the energy and protein content in the sow's milk during early lactation. In contrast, Ranford et al. [27] observed that milk yield, but not milk composition, was affected by body fatness in primiparous sows.

The reduction of the feed allowance during rearing, and consequently of backfat depth at farrowing, was associated with an increase in voluntary feed intake, and with lower body weight and backfat losses during lactation. Similarly, Yang et al. [38], Dourmad [5], Revell et al. [29] and Trottier and Easter [34] observed lower losses of body weight and backfat during lactation in primiparous sows fed restrictedly during gestation and with low body reserves at farrowing, compared with sows fed a higher level and with more body reserves at farrowing. Appetite during lactation appears then to be closely connected to the amount of body reserves at farrowing.

The feeding level during rearing, and consequently the level of body reserves at farrowing, did not affect the weaning to oestrus interval (WOI) in the present study. Mullan and Williams [20] and Yang et al. [38] observed that fertility in primiparous sows is affected by the mobilisation of body reserves during lactation, but it also depends on the amount of body reserves at farrowing. However, according to Rozeboom et al. [30], delayed return into oestrus after parity is not only related to body reserves at first farrowing, but also to short-term performance measures, such as milk production which reflect metabolic demands during lactation. To achieve similar milk production, fat gilts from the AP treatment had to mobilise greater amounts of body reserves to compensate their lower feed intake. Different authors [15, 28] have shown that the level of feeding during lactation has a key role in the length of the WOI and it could be considered as more important than the level of body reserves at farrowing. Mullan and Williams [20] concluded then that when primiparous sows are able to eat a sufficient amount of food during lactation, the level of body reserves does not affect their subsequent reproductive performance. From a survey of the literature, Aherne and Kirkwood [1] noted that a daily energy intake during lactation of 50 MJ digestible energy (DE) would greatly improve the reproductive performance and that no or only small improvements should be expected above this level. In the present study, the average energy intake was higher than 65 MJ DE in all sows, and this would explain the lack of effect on subsequent reproduction of the large differences between the two treatments in the body reserves at farrowing. The adequate body weight and fatness at farrowing in AP sows, and the high lactation feed intake in R sows, allowed all animals to have reserves at weaning and, consequently, their ability to return into heat was maintained.

5. CONCLUSION

The present experiment confirmed that feed restriction during rearing largely influences growth, body composition and age at puberty onset of replacement gilts. The experiment succeeded in obtaining animals with low and normal levels of body reserves at service (10–15 and 15–20 mm backfat depth, respectively). At farrowing, gilts fed to appetite or at 80 % of the appetite level during rearing achieved large body weight (255 and 225 kg, respectively) and backfat thickness (23.7 and 17.4 mm, respectively). The absence of significant effects of rearing treatments on the reproductive performances appeared to be mostly the results of the high levels of the body reserves at farrowing and of a high feed intake during lactation. This study also demonstrated a positive effect of reducing growth, probably through reduced body fatness at farrowing, on feed intake during lactation. The effects on the physiological status of these animals are presented in a second paper [18].

ACKNOWLEDGEMENTS

The authors wish to thank M. Massard, M. Lefebvre, J. Gauthier, G. Conseil, and all the staff at the Pig Research Station for taking care of the animals. They also wish to thank Dr M.C. Père and Dr H. Quesnel, from Inra, St-Gilles and Dr N. Quiniou, from ITP, Le Rheu, for reading the manuscript.

REFERENCES

[1] Aherne F.X., Kirkwood R.N., Nutrition and sow prolificacy, J. Reprod. Fert. 33 (1985) 169–183.

[2] AOAC, Official methods of analysis, 15th ed., Association of Official Analytical Chemists, Washington, DC, 1990.

[3] Clowes E.J., Aherne F.X., Foxcroft G.R., Effect of delayed breeding on the endocrinology and fecundity of sows, J. Anim. Sci. 72 (1994) 283–291.

[4] Dourmad J.Y., Ingestion spontanée d'aliment chez la truie en lactation : de nombreux facteurs de variation, Inra Prod. Anim. 1 (1988) 141–146.

[5] Dourmad J.Y., Effect of feeding level in the gilt during pregnancy on voluntary feed intake during lactation and changes in body composition during gestation and lactation, Livest. Prod. Sci. 27 (1991) 309–319.

[6] Dourmad J.Y., Prunier A., Etienne M., Le Jossec P., Influence des apports énergétiques sur les performances de croissance, la composition corporelle et le développement sexuel de jeunes truies destinées à la reproduction, J. Rech. Porcine en France 22 (1990) 251–258.

[7] Duée P.H., Influence de la nutrition azotée sur le métabolisme et la reproduction chez la truie, Thèse de Doctorat d'Etat ès Sciences Naturelles, Université Pierre et Marie Curie, Paris-6, 1984, 134 p.

[8] Duée P.H., Treil F., Camous S., Influence de l'apport protéique pendant la croissance et la première gestation sur les performances de reproduction et la composition corporelle chez la truie, Ann. Zootech. 29 (1980) 121–136.

[9] Elsley F.W.H., Nutrition and lactation in the sow, in: Falconer R. (Ed.), Proceedings of the 17th Easter School in Agricultural Science, Butterworths, London, 1970, pp. 393–411.

[10] Guéblez R., Gestin, J.M., Le Hénaff J., Incidence de l'âge et de l'épaisseur de lard dorsal à 100 kg sur la carrière reproductice des truies Large White, J. Rech. Porcine en France 17 (1985) 113–120.

[11] Hartog L.A. den, The effect of energy intake during rearing on reproductive trait in gilts, Neth. J. Agric. Sci. 32 (1984) 281–292.

[12] Hartog L.A. den, Kempen G.J.M. van, Relation between nutrition and fertility in pigs, Neth. J. Agric. Sci. 28 (1980) 211–227.

[13] Hartog L.A. den, Noordeweir G.J., The effect of energy intake on age at puberty of gilts, Neth. J. Agric. Sci. 32 (1984) 263–280.

[14] King R.H., A note on the effects of nutrient intake during the later stages of rearing and early reproductive life on the subsequent reproductive efficiency of gilts, Anim. Prod. 48 (1989) 241–244.

[15] King R.H., Williams I.H., The effect of nutrition on the reproductive performance of first-litter sows. 1. Feeding level during lactation and between weaning to mating, Anim. Prod. 38 (1984) 241–247.

[16] Klaver J., Kempen G.J.M. van, de Lange P.G.B., Verstegen M.W.A., Boer H., Milk composition and daily yield of different milk components as affected by sow condition and lactation/feeding regimen, J. Anim. Sci. 52 (1981) 1091–1097.

[17] Le Cozler Y., Dagorn J., Lindberg J.E., Aumaître A., Dourmad J.Y., Effect of age at first farrowing and herd management on long-term productivity of sows, Livest. Prod. Sci. 53 (1998) 135–142.

[18] Le Cozler Y., David C., Beaumal V., Johansen S., Dourmad J.Y., Effect of feeding level during rearing on performance of Large White gilts. Part 2: effect on metabolite profiles during gestation and lactation, and glucose tolerance, Reprod. Nutr. Dev. (1998) (accepted for publication).

[19] Metz S.H.M., Bergström P.L., Lenis N.P., De Wijs M., Dekker R.A., The effect of daily energy intake on growth rate and composition of weight gain in pigs, Livest. Prod. Sci. 7 (1980) 79–87.

[20] Mullan B.P., Williams I.H., The effect of reserves at farrowing on the reproductive performance of first-litter sows, Anim. Prod. 48 (1989) 449–457.

[21] Newton E.A., Mahan D.C., Effect of feed intake during late development on pubertal onset and resulting body composition in crossbred gilts, J. Anim. Sci. 70 (1992) 3774–3780.

[22] Noblet J., Etienne M., Effect of energy level in lactating sows on yield and composition of milk and nutrient balance of piglets, J. Anim. Sci. 63 (1986) 1888–1896.

[23] Noguera J.L., Guéblez R., Incidence de l'âge à la première mise-bas et de la taille de la portée sur la carrière de la truie, J. Rech. Porcine en France 16 (1984) 134–144.

[24] Prunier A., Influence of age at nutritional restriction on growth and sexual development of gilts, Reprod. Nutr. Dev. 31 (1991) 647–653.

[25] Prunier A., Mounier A.M., Influence of the presence of a mature female on puberty attainment in gilts, Theriogenology 36 (4) (1991) 537–542.

[26] Prunier A., Bonneau M., Etienne M., Effect of age and live weight on the sexual development of gilts and boars fed two planes of nutrition, Reprod. Nutr. Dev. 27 (1987) 689–700.

[27] Ranford J.L., Revell D.K., Mullan B.P., Williams I.H., Toussaint J.K., Milk yield, but not milk composition, may be influenced by body fatness in primiparous sows, J. Anim. Sci. 72 (1994) suppl. 1, 389.

[28] Reese D.E., Moser B.D., Peo E.R. Jr, Lewis A.J., Zimmerman D.R., Kinder J.E., Stroup W.W., Influence of energy intake during lactation on the interval from weaning to first estrus in sows, J. Anim. Sci. 55 (1982) 590–598.

[29] Revell D.K., Williams I.H., Mullan B.P., Smits R.J., Body fatness influences voluntary feed intake and liveweight loss during lactation in primiparous sows, J. Anim. Sci. 72 (1994) suppl. 1, 389.

[30] Rozeboom D.W., Pettigrew J.E., Moser R.L., Cornelius S.G., El Kandely S.M., Influence of gilt age and body composition at first breeding on sow reproductive performance and longevity, J. Anim. Sci. 74 (1996) 138–150.

[31] SAS, SAS user's guide, Version 6.12, SAS Inst. Inc., Cary, NC, 1996.

[32] Schukken Y.H., Burman J., Huirne R.B.M., Willemse A.H., Vernooy J.C.M., van den Broek J., Verheijden J.H.M., Evaluation of optimal age at first conception in gilts from data collected in commercial swine herds, J. Anim. Sci. 72 (1994) 1387–1392.

[33] Simmins D.M., Edwards S.A., Spechter H.H., Growth and body condition of sows given different regimes during the rearing stage and through eight parities when housed in group with straw bedding, Anim. Prod. 58 (1994) 271–283.

[34] Trottier N.L., Easter R.A., Dietary and plasma branched-chain amino acids in relation to tryptophan: effect on voluntary feed intake and lactation metabolism in the primiparous sow, J. Anim. Sci. 73 (1995) 1086–1092.

[35] Weldon W.C., Lewis A.J., Louis G.F., Kovar J.L., Miller P.S., Postpartum hypophagia in primiparous sows: II. Effect of feeding level during gestation and exogenous insulin on lactation feed intake, glucose tolerance, and epinephrine-stimulated release of nonesterified fatty acids and glucose, J. Anim. Sci. 72 (1994) 395–403.

[36] Whittemore C.T., Nutrition reproduction in primiparous sows, Livest. Prod. Sci. 46 (1996) 65–83.

[37] Whittemore C.T., Franklin M.F., Pearce B.S., Fat changes in breeding sows, Anim. Prod. 31 (1980) 183–190.

[38] Yang H., Eastham P.R., Phillips P., Whittemore C.T., Reproductive performance, body weight and body condition of breeding sows with differing body fatness at parturition, differing nutrition during lactation, and differing litter size, Anim. Prod. 48 (1989) 181–201.

[39] Young L.G., King G.J., Walton J.S., Mc Millan I., Klevorick M., Age, weight, backfat and time of mating effects on performance of gilts, Can. J. Anim. Sci. 70 (1990) 469–481.

[40] Zak L.J., Cosgrove G.R., Aherne F.X., Foxcroft G.R., Pattern of feed intake and associated metabolic and endocrine changes differentially affect postweaning fertility in primiparous lactating sows, J. Anim. Sci. 75 (1997) 208–216.