Effect of Breed (Lean or Fat Pigs) and Sex on Performance and Feeding Behaviour of Group Housed Growing Pigs in a Tropical Climate*

D. Renaudeau, M. Giorgi[1], F. Silou[1] and J. L. Weisbecker[1]**

Institut National de la Recherche Agronomique, Unité de Recherches Zootechniques

97170 Petit Bourg, Guadeloupe, French West Indies, France

ABSTRACT : The effects of breed and sex on individual growth performance and feeding behaviour were studied between 45 and 90 kg BW in two replicates of forty group-housed pigs. The first and the second replicates were carried out during the warm season (i.e. between February and April 2003) and during the hot season (i.e. between August and October 2003), respectively. During the warm season, ambient temperature and relative humidity averaged 25.3°C and 86.0%. The corresponding values for the hot season were 27.9°C and 83.6%. The pigs were grouped in pens of 10 animals on the basis of breed (Creole or Large White) and sex (gilt or castrated male) and given *ad libitum* access to a grower diet (9.0 MJ/kg net energy and 158 g/kg crude protein) via feed intake recording equipment (Acema 48). An ear-tag transponder was inserted into each pig and this allowed the time, duration, and size of individual visits to be recorded. The growth performance and feeding pattern were significantly affected by breed, sex, and season. The Creole pigs (CR) had a lower average daily gain (ADG) (642 vs. 861 g/d, p<0.01) and carcass lean content (LC_{90kg}) (35.4 vs. 54.5%; p<0.01) and a higher backfat thickness at 90 kg BW ($BT_{90\ kg}$) (23.4 vs. 10.4 mm; p<0.01) than Large White pigs (LW) whereas the average daily feed intake (ADFI) was not affected by breed (2.34 vs. 2.22 kg/d, respectively for CR and LW pigs; p>0.10). Consequently, the food:gain ratio was higher in CR than in LW (3.65 vs. 2.58; p<0.01). CR had less frequent meals but ate more feed per meal than LW (5.9 vs. 8.8 meals/d and 431 vs. 279 g/meal; p<0.01). The rate of feed intake was lower (27.6 vs. 33.9 g/min; p<0.01) and the ingestion time per day and per meal were higher in CR than in LW (87.1 vs. 69.7 min/d and 15.8 vs. 8.4 min/meal; p<0.01). The ADFI and $BT_{90\ kg}$ were higher (2.38 vs. 2.17 kg/d and 18.1 vs. 15.9 mm; p<0.05) and $LC_{90\ kg}$ was lower (43.5 vs. 46.4%; p<0.01) in castrated males (CM) than in gilts (G) whereas ADG was not affected by sex (p = 0.12). The difference in lean content between CM and G was greater in CR than in LW. The ADFI and ADG were reduced during the hot season (2.18 vs.2.38 kg/d and 726 vs. 777 g/d, respectively; p<0.05) whereas feed conversion and carcass lean content were not affected by season (p>0.05). Average feeding time per meal and meal size decreased during the hot season (10.9 vs. 13.2 min/meal and 316 vs. 396 g/meal; p<0.01) whereas the rate of feed intake was not affected by season (p = 0.83). On average, 0.69 of total feed intake was consumed during the diurnal period. However, this partition of feed intake was significantly affected by breed, sex, and season. In conclusion, the breed, sex and season significantly affect performance and feeding pattern in growing pigs raised in a tropical climate. Moreover, the results obtained in the present study suggest that differences observed in BW composition between CR and LW are associated with difference in feeding behaviour, in particular, the short-term regulation of feed intake. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 4 : 593-600)***

Key Words : Pigs, Feeding Behaviour, Breed, Sex, Season, Tropical Climate

INTRODUCTION

As the feed cost represents the most expensive component of pig production, it is of the major interest to understand the factor influencing voluntary feed intake in growing pigs. The voluntary feed intake is influenced by many factors such as growth potential (breed, sex, and stage of growth), housing conditions (floor type, space allowance and group size) and climatic factors (temperature, relative humidity, air speed). In addition, some differences in growth performance and protein deposition between breeds and sexes can be connected to variation in feeding pattern (de Haer and de Vries, 1993). The feeding pattern of conventional breeds (Large White, Landrace, Piétrain, Yorkshire) or their crosses is well described in the literature (Quiniou et al., 1999a). However, there are limited published data on the feeding behaviour of fat or obese pigs (Hyun et al., 2001). The Creole pig breed (CR) is the most important Caribbean local breed both in population size and in economic importance. The CR is characterized by early maturity, reduced lean deposition and its good adaptation to harsh environmental conditions in the humid tropical areas (Rinaldo et al., 2003). For this purpose, it was introduced in our experimental station to study the genetic variability of heat tolerance in pig. However, because of its high carcass fat content, CR would be an interesting model to study the relationships between body composition and feeding behaviour in pig.

The increase of ambient temperature above the thermal

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** Corresponding Author: D. Renaudeau. Tel: +33-590-0-590-255-428, Fax: +33-590-0-590-255-936, E-mail: David.Renaudeau @antilles.inra.fr

1 Unité de Production et de Santé Animale, 97170 Petit Bourg, Guadeloupe, French West Indies, France.

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neutral zone is associated with a significant decrease of growing performance in pigs (Le Dividich et al., 1998). This negative effect of high temperature results mainly from the decrease of ADFI in order to reduce heat production related to digestible and metabolic utilisation of food. As reviewed by Quiniou et al., 2000b), the reduction of ADFI in growing pig is achieved by a reduction of size of the meal whereas its frequency remains constant. In the latter paper, most of these results were obtained in climatic chambers using several levels of ambient temperature kept constant over the days. However, very little information has been published on the effect of season in humid tropical climate on the feeding behaviour of growing pigs.

The objective of the present study was to evaluate the effect of breed and sex on performance and feeding behaviour of groups housed growing pigs in a tropical climate.

MATERIALS AND METHODS

Experimental design and animal management

A total of 80 pigs (40 Large White and 40 Creole) were used in a trial conducted in two replicates at the experimental facilities of INRA in Guadeloupe (16° Lat. N., 61° Long. W), an area characterized as having a humid tropical climate. A total of 10 sires (4 Creole and 6 Large White) and 22 dams (9 Creole and 13 Large White) were represented in this study. The two replicates were carried out during the warm season (i.e. between February and April 2003) and during the hot season (i.e. between August and October 2003). At 12 weeks of age, the pigs were weighed and divided into groups of 10 animals according to each breed (Creole or Large White)×sex (gilt or castrated male) combination. Whilst being weighed, each pig also had a transponder ear tag inserted to enable individual identification by ‘Acema 48’ (ACEMO, Pontivy, France) feed dispenser system. Animals were moved in one of the four pens (5.7×2.7 m) in an open front fattening unit. Therefore, pigs were exposed to natural light, temperature and relative humidity levels. The ambient temperature and relative humidity were recorded continuously (i.e. one measurement every 30 seconds) in the experimental building with a probe (Campbell Scientific Ltd., Shepshed, UK) placed at 1 m above floor level. Each pen was equipped with an ‘Acema 48’ feed dispenser and two nipple drinkers, and animals had 24-h access to feed and water. The feed in the feeder was replenished every day between 0700 and 0800 to ensure a continuous supply. feed was presented as pellets and contained 9.0 MJ/kg net energy and 158 g/kg crude protein. The experiment started after two weeks of adaptation at 14-wk age and ended when pigs reached 90 kg live BW. At the beginning of the experiment, the averages BW were 41.6 and 31.6 for Large White (LW) and Creole (CR) pigs, respectively.

Food and feeding behaviour

All feed dispensers were calibrated at the start of each replicate using a 1-kg test weight. Each feeding stalls allows access to only one pig at a time. After each visit to the feeder, the identity of the animal (via the ear-tag transponder), the feeder entry and exit times and the amount of feed consumed were registered and stored in a central equipment memory. In order to allow comparison with results from other studies, successive feeder visits were grouped into the same meal using a meal criterion defined as the maximum length of a within-meal interval (i.e. short pauses belonging to the same meal) between visits. Visits separated by intervals shorter than the meal criterion were considered to be part of the same meal. The meal criterion was estimated using the log survivor curve technique as described by Labroue et al. (1994). The meal criterion of 2 min was established by the latter authors from LW pigs in experimental conditions similar to the present ones. From daily measurements (n = 4936) obtained on individual pigs, average meal criterion was 0.85 (s.e. 2.07) and 0.94 (s.e. 2.04) min for CR and LW pigs, respectively. Moreover, 94.8 and 93.7% of individual meal criteria were below 2 min for CR and LW pigs, respectively; these cumulative frequencies were then comparable with the study of Labroue et al. (1994) (i.e., 94.0%). According to this 2-min meal criterion, the components of feeding behaviour were calculated. These components were the daily number of meals, daily feed intake (g), total ingestion time per day (i.e. total duration of all feeding bouts, min), ingestion rate (i.e. total feed intake/total ingestion time, g/min), the average feed intake per meal (total feed consumption/number of meals, g), and the average ingestion time per meal (total ingestion time/number of meals, min). Behavioural criteria were also estimated over the day and the night separately.

Performance and carcass traits

The pigs were weighed and backfat thickness was determined every two weeks. The backfat thickness was measured ultrasonically (Agroscan, E.C.M., Angoulême, France) at the last rib at 45 mm from the midline. Animals were slaughtered at about 90 kg BW after 24-h fasting period. After cooling for 24-h period at 3°C, carcasses were weighted and the left half-carcass was dissected according to the normalised European procedure. The carcass lean content was estimated according to Métayer and Daumas (1998) from ham, loin and backfat weights.

Statistical analysis

In order to compare the effects of breed, sex and season

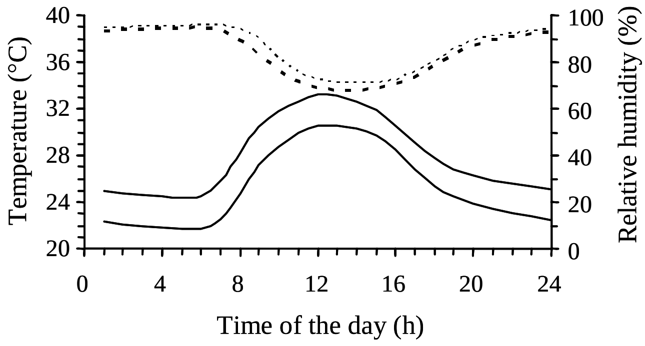

Figure 1. Daily fluctuations of ambient temperature (solid lines) and relative humidity (dotted lines) in warm (thick) and hot (thin) season.

on growth performance and feeding behaviour on a same BW range, the age and backfat thickness at 45 kg was estimated for each pig through linear or quadratic regression between BW or backfat thickness and age from data recorded during the experimental period. The mean growth performance was analysed by an analysis of variance (GLM procedure, Statistical Analysis System Institute, SAS, 1997) including the effect of breed (LW vs. CR), sex type (gilt vs. castrated male), season (warm vs. hot season) and the interactions. The 4,516 daily measurements of feeding behaviour components recorded from 45 to 90 kg were averaged for individual pigs (n = 79). These data were submitted to an analysis of variance including the effect of breed, sex type, season and their interactions. The means feeding behaviour components per pigs were calculated according the photoperiod (day vs. night) and were analysed according the Mixed procedure of SAS (SAS, 1997) with breed, sex type, season, light regimen and their interactions as main effects. The repeated option of the Mixed procedure was used with a compound symmetry (CS) covariance structure. Finally, for each pig, hourly values of feed consumption were calculated and analysed trough a repeated measurement analysis of variance (Mixed procedure, SAS, 1997) by comparison of hourly value to a reference (i.e. between 22:00 and 03:00). The effect of breed, sex, and season on the hourly means of feed intake were analysed from generation of contrasts between adjacent hourly values. Correlation coefficients between growth performance and feeding behaviour parameters were calculated with the CORR procedure of SAS. A Fisher Z transformation was used to compare the effects of breed or sex on correlation coefficients (COMPCORR Macro of SAS/STAT). According to these preliminary statistical tests, correlation coefficients were found to be affected neither by breeds nor by sex.

RESULTS

Description of climatic parameters

During the warm season, ambient temperature and relative humidity averaged 25.3°C (min. = 23.2°C and max. = 27.7°C) and 86.0% (min. = 66.0% and max = 97.6%). The corresponding value for the hot season were 27.9°C (min. = 25.9°C and max. = 29.0°C) and 83.6% (min. = 62.0% and max = 96.0%). The daily variation in ambient temperature showed a similar pattern for both seasons with a minimum and a maximum values of ambient temperature at about 05:00 h and 12:00 h (Figure 1). Daily fluctuation of relative humidity was the opposite of that of temperature. On average, the range of diurnal variation of temperature and humidity was not affected by season (±4.5°C and ±13% on average, respectively). According to data from the French national meteorological institute, the length of the diurnal period was comparable for both seasons (11 h 40

Table 1. Effect of breed, sex, and season on the performance of growing pigs between 45 and 90 kg BW (adjusted means)

	Breed[1]		Sex[2]		Season		Residual SD	Significance[3]
	CR	LW	G	CM	Warm	Hot		
Number of observations	40	39	39	40	40	39		
Initial age (d)	119	102	111	110	113	108	7	B**, Sx*, S*, B×Sx**
Final age (d)	191	156	174	172	174	173	10	B**
Duration (d)	71	54	63	62	61	65	7	B**, S*
Initial BW (kg)	45.0	45.0	45.0	45.0	45.0	45.0	-	
Final BW (kg)	90.3	91.5	90.7	91.1	90.7	91.1	4.3	
ADG (g/d)	642	861	737	766	777	726	81	B**, S*
Initial backfat thickness (mm)	12.7	6.0	9.0	9.7	9.7	8.9	1.5	B**, Sx*, S*, B×Sx**
Final backfat thickness (mm)	23.5	10.4	15.9	18.1	16.7	17.3	2.7	B**, Sx*, B×Sx**
Food intake (kg/d)	2.34	2.22	2.17	2.38	2.38	2.18	0.31	Sx**, S*
Food conversion (kg/kg gain)	3.65	2.58	2.94	3.10	3.10	3.00	0.33	B**, Sx**, B×Sx*
Lean content (%)[4]	35.4	54.5	46.4	43.5	45.4	44.4	4.3	B**, Sx**, B×Sx*

[1] Breed: CR = Creole, LW = Large White.
[2] Sex: G = Gilt, CM = castrated male.
[3] From analysis of variance including breed (B), sex (Sx), season (S) and interactions as main effects.
Statistical significance: ** p<0.01, * p<0.05.
[4] Calculated according to (Metayer et Daumas,1998) from the results of the standard European procedure.

Table 2. Effect breed, sex and season on the feeding behaviour of growing pigs between 45 and 90 kg BW (adjusted means)

	Breed[1]		Sex[2]		Season		Residual SD	Significance[3]
	CR	LW	G	CM	Warm	Hot		
Number of observations	40	39	39	40	40	39		
Mean components of daily feeding behavior								
Number of visits	33.0	36.5	31.6	38.0	38.6	30.9	22.3	
Number of meals	5.9	8.8	6.9	7.8	6.7	8.0	1.9	B**, Sx*, S**
Food intake (kg/d)	2.34	2.22	2.17	2.38	2.38	2.18	0.31	Sx**, S*
Ingestion time (min/d)	87.1	69.7	77.2	79.6	80.6	76.2	13.8	B**
Rate of feed intake (g/min)	27.6	33.9	29.7	31.8	30.6	30.9	5.3	B**
Characteristics of the meal								
Food intake per meal (g)	431	279	361	349	393	316	99	B**, S**
Ingestion time per meal (min)	15.8	8.4	12.9	11.2	13.2	10.9	3.3	B**, Sx*, S**
Diurnal feed intake (% of total)	67.2	71.9	72.1	67.0	72.6	66.4	5.8	B**, Sx**, S**

[1] Breed: CR = Creole, LW = Large White. [2] Sex: G = Gilt, CM = Castrated male

[3] From analysis of variance including breed (B), sex (Sx), season (S) and interactions as main effects.

Statistical significance: ** p<0.01, * p<0.05.

min vs. 12 h 10 min in warm and hot season, respectively).

Growth performance

Because of leg problems, one LW gilt was removed at the beginning of the second replicate. Least square means for the effects of breed, sex or season on growth performances are presented in Table 1. Between 45 and 90 kg BW, LW pigs had higher average daily gain (ADG) (861 vs. 642 g/d, p<0.01) than CR pigs but the average daily feed intake (ADFI) was not significantly affected by breed (2.28 g/d on average). Consequently, CR pigs have a higher food:gain ratio (3.65 vs. 2.58 kg/kg, p<0.01). At 45 kg BW, backfat thickness was higher in CR than in LW pigs (12.7 vs. 6.0 mm, p<0.01) and this difference was twice as great at 90 kg BW (23.5 vs. 10.4 mm, p<0.01). Lean meat percentage estimated from measurement of carcass cuts was substantially higher in LW than in CR pigs (54.4 vs. 35.4%, p<0.01). Sex had no effect on ADG (737 vs. 766 g/d, respectively for gilts and castrated males; p = 0.12) and on duration of growth period (63 vs. 62 d, respectively for G and CM; p = 0.49). However, castrated males (CM) had a higher ADFI and food:gain ratio compared to gilts (G) (2.38 vs. 2.17 g/d, and 3.10 vs. 2.94 kg/kg, respectively, p<0.01). The backfat thickness at 45 or at 90 kg was higher (+0.7 and +2.2 mm, p<0.05) and lean meat percentage was lower at 90 kg (-2.9%, p<0.01) in CM than in G. There was a significant interaction between breed and sex (p<0.01) for which variables, with the effects of sex on growth performance and carcass quality being more pronounced in CR pigs. During the hot season, the reduced ADFI (2.18 vs. 2.38 kg/d, p<0.01) was associated with a lower ADG (-51 g/d, p<0.01). However, food:gain and lean meat percentage were not affected by season (p = 0.35 and p = 0.33, respectively). Even though the breed×season interaction was not statically significant for all measured performance traits, the decrease of ADFI and ADG during the hot season were numerically higher in LW than in CR pigs (-273 vs. -124 g/d, p = 0.29 and -80 vs.-21 g/d, p = 0.11, respectively). As a consequence, ADFI and ADG were less depressed in hot season for CR pigs (-5 and -3%, respectively) than for LW pigs (-12 and -9%, respectively).

Feeding behaviour

According to the analysis of variance, most of the feeding behaviour components were affected by breed, sex, and season (Table 2). Creole compared to LW pigs made less frequent meals (5.9 vs. 8.8 meals/d, p<0.01) whereas ADFI was not affected by breed. In consequence, meal size was significantly higher for CR pigs (431 vs. 279 g/meal, p<0.01). The feeding time expressed per day or per meal increased for CR pigs (+17.4 and +7.4 min, respectively) and this was associated with the reduced feeding rate (27.6 vs. 33.9 g/min, p<0.01). The nycthemeral pattern of feed intake was significantly affected by breed (p<0.01); proportionately over 0.72 of feed intake occurred during the diurnal period for LW pigs whereas corresponding value for CR pigs was 0.67. Sex effect was significant (p<0.01) for number of meals per days; castrated males ate more frequently (+0.8 meal/d on average) which was connected with their higher ADFI. A lower proportion of diurnal feed intake was measured in castrated males (0.67 vs. 0.72, p<0.01). However, expressed in kg/d, both nocturnal and diurnal feed consumption increased in males but the difference was more accentuated for nocturnal intake (0.82 vs. 0.63 kg/d). The reduced ADFI in hot season was associated with a decrease of meal size (316 vs. 393 g/meal, p<0.01) rather than a reduction of meal frequency. In fact, the daily number of meals increased during the hot season (8.0 vs. 6.7, p<0.05). As the season did not influence the rate of feed intake, the total ingestion time and the duration of meal decreased during the hot season (-2.4 min/d and 2.3 min/meal) in connection with the decrease of ADFI. However, the effect of season was statically significant (p<0.01) only for meal duration. The proportion of diurnal

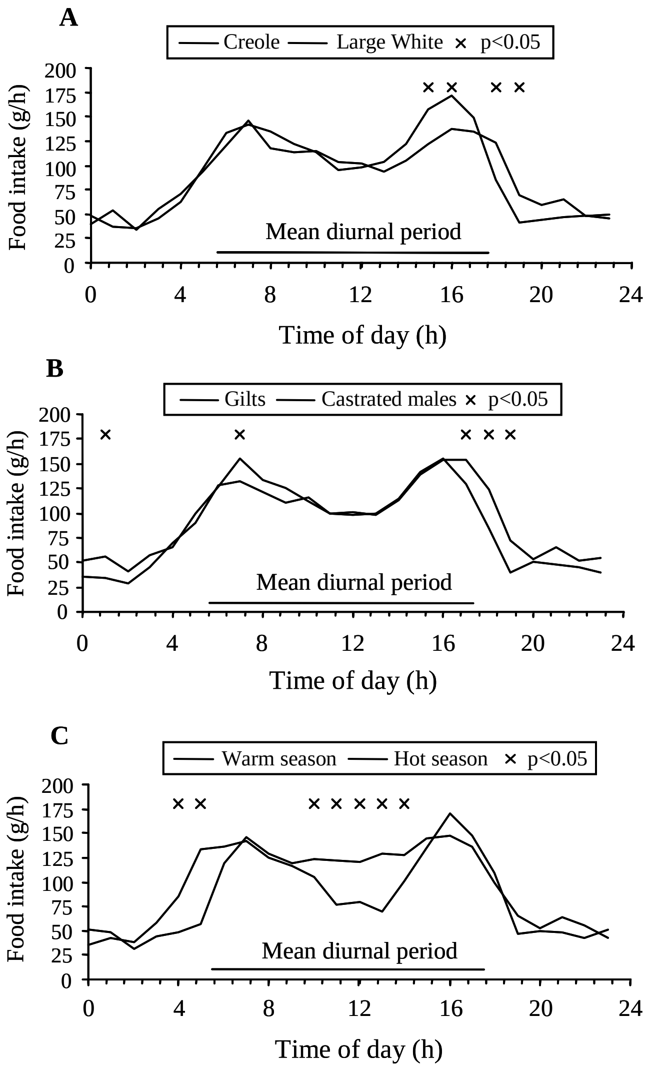

Figure 2. Effect of breed (A), sex (S) and Season (S) on the kinetics of daily feed intake in growing pigs between 45 and 90 kg BW×hourly feed consumption was significantly affected by breed, sex or season.

feed intake was reduced during the hot season (0.66 vs. 0.73, p<0.01).

Hourly feed intake peaked twice a day as illustrated in Figure 2. On average, the first and the second peaks were observed between 03:00 and 11:00 and between 13:00 and 20:00, respectively. The kinetic of hourly feed intake was affected by breed, sex and season. Moreover, the breed×season×hour interaction was not significant (p = 0.075). Compared to LW pigs, the hourly feed intake values were significantly lower at 15:00 and 16:00, and higher 18:00 and 19:00 for CR pigs. The mean feed intake per hour was significantly higher (p<0.05) for CM compared to G at 0100, 0700, and between 1700 and 1900 h. Finally, the hourly feed intakes were significantly different among seasons at 0400, 0500, and between 1000 and 1400 h.

Relations between growth performance and feeding behaviour

Correlations between feed intake pattern traits and growth performance traits are shown in Table 3. The number of meals and rate of feed intake were negatively correlated (p<0.05) with the backfat thickness and were positively correlated with average BW gain and lean carcass content. Conversely, the total ingestion time and the average meal size were positively correlated with the mean age and the average backfat thickness and were negatively correlated with average BW gain and lean carcass content. The correlations show, that pigs that eat rapidly in numerous small meals, will have a greater ADG and a higher carcass lean percentage. The correlations between average feed intake and the average daily gain or the average backfat thickness were low but positive whereas the correlation with lean carcass content was negative. Correlation between RFC and performance traits were not significantly different from zero (p>0.05) except for feed conversion (r = 0.34 on average). RFC was positively correlated with the number of visits per day (i.e. r = 0.35 on average) and with ingestion time (i.e. r = 0.24 on average).

DISCUSSION

Little information on the feeding behaviour in growing

Table 3. Spearman correlation between traits of feed intake behaviour and performance traits[†]

		Feeding behaviour						Performance traits			
		NV	NM	FID	FIM	ITD	RFI	ADG	FC	$ABT_{90\ kg}$	$LC_{90\ kg}$
Number of visits	NV	1.00	0.23	0.35	-0.13	0.11	0.11	0.32	-0.05	-0.15	0.16
Number of meals	NM		1.00	-0.02	-0.95	-0.22	0.24	0.46	-0.44	-0.46	0.42
Feed intake (g/d)	FID			1.00	0.26	0.54	-0.06	0.31	0.40	0.30	-0.33
Feed intake (g/meal)	FIM				1.00	0.34	-0.22	-0.34	0.49	0.48	-0.46
Ingestion time (min/d)	ITD					1.00	-0.80	-0.22	0.58	0.53	-0.57
Rate of feed intake (g/min)	RFI						1.00	0.53	-0.50	-0.48	0.48
Average daily gain (g/d)	ADG							1.00	-0.72	-0.70	0.68
Food conversion (kg/kg gain)	FC								1.00	0.89	-0.91
Backfat thickness at 90 kg BW (mm)	$ABT_{90\ kg}$									1.00	-0.95
Lean carcass content at 90 kg BW (%)	$LC_{90\ kg}$										1.00

[1] Probability: r≥0.23: p<0.05; r≥0.30: p<0.01.

pigs is available in tropical climate. During the warm season, two peaks of feeding activity occurred during the day, one peak in the morning (i.e. similar to sunrise) and the other in the afternoon (before the beginning of the night). This results agree with that obtained in the same experimental conditions in lactating sows (Renaudeau et al., 2003). In growing pigs similar results were found by De Haer and Merks (1992), Hyun and Ellis (2002), and Nielsen et al. (1995). In contrast, Hyun et al. (1997) reported only a single peak of feeding activity in the mid-day. In fact, the continuous lighting regimen over the 24-h period employed in the later study could explain the discrepancy between the studies. According to Feddes et al. (1989), feeding activity appears to be driven by light changes with two peaks occurring near the time the lights are switched on or off. Moreover, according to our results, the two peak of feeding activity tended to coincide with the minimum daily temperature during the morning and the evening period suggesting that other environmental factors such as ambient temperature can also influence the nycthemeral feeding pattern of growing pigs.

Results of the present study confirm a negative effect of hot season in tropical climate on voluntary feed intake in pigs in accordance with previous results obtained in our experimental facilities (Rinaldo et al., 2000) or in Taïwan (Lee et al., 1995). These results confirm that pigs adapt to hot conditions by reducing ADFI in order to limit thermogenesis and heat stress. Taking into account that the relative humidity was similar in the two seasons, it can be suggested that the reduced ADFI during hot season was related to an increase of the daily average ambient temperature. From our results, each degree increase in ambient temperature between 25.3 and 27.9°C resulted in a reduction of feed intake equivalent to 77 g/d/°C. This calculated reduction was similar to the 65 and 73 g/d/°C reduction of ADFI reported by Massabie et al. (1996) and Quiniou et al. (2002) in 25-110 kg group-housed pigs over approximately the same temperature range (i.e. between 24 and 28°C), respectively. In the later studies, temperature was kept constant while in our experimental conditions it fluctuates over the days. However, the decrease of ADFI between 25.3±4.5 and 27.9±4.5°C in present study is comparable to the value reported by Quiniou et al. (2002) (-70 g/d/°C between 24±4.5°C and 28±4.5°C). Diurnal feeding pattern was affected by season and more specifically by the daily kinetics of temperature and humidity. During the hot season, hourly feed intake was reduced during the hottest period of the day and increased during the cooler period of the day in early morning. However, the increase of nocturnal feed intake under cooler temperatures was not sufficient to compensate the reduced feed intake under hot temperature. This resulted in a reduced proportion of the diurnal feed consumption during the hot season. This specific feeding behaviour adaptation to help to maintain feed intake level when ambient temperature fluctuate is also reported in growing pigs by Feddes et al. (1989) and Xin et DeShazer (1991) and in lactating sows by Quiniou et al. (2000c) and Renaudeau et al. (2003). In addition, Quiniou et al. (2002) suggest that in hot conditions, these behavioural adaptations are mainly related to the range of diurnal variation of temperature; the higher is the diurnal variation of temperature the lower is the proportion of diurnal feed consumption.

According to our results, the lower ADFI during hot season was achieved by a significant reduction of meal size while the number of meal increased slightly. The results are in agreement with data obtained in group housed pigs by Nienaber et al. (1993) and Quiniou et al. (2000a) showing that the reduced ADFI under hot condition is achieved by a reduction of meal size rather than a decrease of meal frequency. As the rate of feed intake was not significantly affected by season, the decrease of ADFI was associated with a reduced ingestion time. In the present experiment, the season did not significantly affect feed conversion in agreement with Rinaldo et al. (2000). The ADG was reduced during the hot season of about 20 g/d/°C in agreement with results of Quiniou et al. (2002) who reported an ADG reduction of 25 g/d/°C between 24±4.5°C and 28±4.5°C. In consequence, the reduction of ADG during the hot season was directly attributable to decline in feed intake suggesting that ADFI is the major limiting factor of growth performance in tropical areas. Finally, the carcass lean content was not affected by season in agreement with Rinaldo et al. (2000).

The present results show a significant effect of breed on performance traits and feed intake pattern. In particular, the growth rate was lower in CR than in LW pigs whereas ADFI was not affected by breed which is consistent with previous results of Canope and Raynaud (1981). The higher backfat thickness and lower carcass lean content for CR pigs was related to their lower muscle growth potential. The major consequence of this lower capacity for lean deposition is the increase of the energy available for fat retention. Similar conclusions were reported when Meishan pigs were compared to conventional lean pigs (Noblet et al., 1994). The present study shows that a similar ADFI can be achieved by a very different feeding behaviour in lean (LW) and fat type pigs (CR). In comparison with LW pigs, the lower number of meals measured in CR pigs was counterbalanced by a higher meal size. Moreover, the longer ingestion time in CR pigs was associated with a reduced feeding rate. These differences in feeding behaviour are very similar to those reported in the literature when Meishan pigs or obese Ossabaw pigs were compared to lean pigs between a same range of BW (Wangsness et al., 1980). Such differences for meals characteristics could be related to a early maturity of CR pigs. It could be hypothesised that a large meal size in CR pigs was related to the increase of mouth or gut size. Moreover, in agreement with (Labroue et al., 1994), the average meal size was positively correlated with backfat thickness and negatively correlated with carcass lean content. According to Houpt (1984), the size of each meal appears to be determined by rapidly acting negative feedback controls or satiety factors initiated by the presence of feed in the digestive tract and involving a qualitative and quantitative evaluation of the food. Moreover, in transgenic obese mice, Azzara (2004) showed that the ability of these factors to impact meal size is modulated by the size of body reserve. These results suggest that a greater meal size measured in CR pigs could be related to their higher propensity for fat deposition. Finally, the higher amount of nutrient consumed per meal in CR would be associated with a higher magnitude of the plasma loads of nutrient which resulted in a higher inter meal duration in CR than in LW.

Between 45 and 90 kg BW, the rate of feed intake in LW (i.e. 28 g/min) was lower than values reported by Labroue et al. (1994) in group housed LW pigs over the same BW range (i.e. 38.1 and 40.1 g/min). According to (Nielsen 2001), these differences could be explained by an increase of group size in the latter studies (i.e. 12 to 14 pigs). In addition, the rate of feed intake is also affected by chemical characteristics of the feed (Levasseur et al., 1998), BW or physiological stage of the pig (Quiniou et al., 2000b), and breed (de Haer et de Vries, 1993) when conventional breeds were compared to synthetic lines. In present study, the rate of feed intake was reduced in CR than in LW pigs. Similar conclusions were reported when Meishan pigs were compared to conventional pigs over the same BW range Quiniou et al., 1999a). As mentioned for meals characteristics, the rate of feed intake would be also affected by body composition and/or the type of nutrient deposed. As the rate of feed intake decreased in CR, the total time spent at feeding increased of about 17 min/pigs/d. This longer feeder occupation time compared to LW pigs would be lead to an increase of competition for feeder access with concomitant changes in the nycthemeral feed intake pattern. It can be hypothesised that the increase of the nocturnal feed intake for CR pigs can be explained by pigs which did not succeed in accessing to feeder during the day. Similar diurnal pattern of feeding behaviour was reported between Meishan and Yorkshire pigs (Hyun et al., 2001).

Even if the breed×season interaction was not statically significant for growth performances, the effects of hot season on ADG and ADFI were numerically attenuated in CR suggesting that CR seemed to better tolerate hot conditions than LW. In contrast to other species like ruminants (Kadzere et al., 2002), the existence of a variability of heat tolerance between breeds is poorly documented in pigs. Nienaber et al. (1997) indicated that pigs from high lean growth potential line were more sensitive to heat stress than those from moderate line. This result suggests that the better heat tolerance in CR pigs could be related to their lower growth potential. Moreover, in an experiment involving 4 piglets, Berbigier (1975) showed that non-evaporative heat loss capacity was lower in LW than in CR×LW crossbred pigs. From this result, it can be hypothesised that the best heat tolerance in CR is connected to a greater ability to lose heat.

Present results show a significant effect of sex on performances and feeding behaviour traits. The ADFI was higher in castrated males whereas ADG was not affected by sex which resulted in a higher feed conversion rate and body fatness and a lower carcass lean content in castrated males than in gilts. These results suggest that for castrated males, the extra energy intake was used for fat deposition and that sex effect on slaughter body composition was probably associated to difference in energy intake rather than in the rate of protein deposition (Quiniou et al., 1999b). The effect of sex on body composition was emphasised for CR pigs. The higher ADFI in castrated males resulted from an increase of nocturnal feed intake and from an increase of the number of meals rather than from their size. In contrast, Hyun et al. (1997) did not report significant difference in feeding pattern between gilts and barrows.

In conclusion, the present experiment confirms the effect of seasonal variation in ambient temperature on feed intake and performance in growing pigs reared in a tropical climate. Moreover, our result suggest that performance and feeding behaviour of growing pigs were also affected by animal related factors such as sex and breed and that CR pig would represent a good model to study the short-term control of feeding behaviour. Finally, further studies are required to verify the greater ability to tolerate climatic stress in CR pigs.

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