ESTIMATION OF GENETIC PARAMETERS FOR RECTAL TEMPERATURE IN LACTATING SOWS ITS ASSOCIATION WITH PERFORMANCE : PRELIMANARY RESULTS

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ABSTRACT

The objective of this study was to evaluate the genetic parameters of thermoregulation traits and its association with sow's performance during lactation. A total of 94 lactating Large White (LW) sows, rearing in a tropical humid climate were used in this experiment. The genetic parameters of rectal temperature measured at 0700 and 1200 (RT_7 and RT_{12}), the difference between RT_{12} and RT_7 (dRT), sow daily feed intake during *ad libitum* period in lactation (DFI), the litter growth rate (LGR) and sow relative body weight loss during lactation (BWL) were estimated. The method of REML with an animal model has been used. The heritability estimates were 0.28 5 (± 0.03), 0.32 (± 0.05) and 0.49 (± 0.14) for RT_7, RT_{12} and dRT, respectively. The genetic correlations estimated between thermoregulation traits and lactating performance characters ranged from -0.63 ± 0.13 (between RT_{12} and LGR) to 0.87 ± 0.42 (between dRT and BWL). These preliminary results showed the existence of genetic variability for thermoregulation suggesting that selection may change thermoregulation capacity in lactating LW sows.

KEY WORDS: Thermoregulation, Lactation, sows, Rectal temperature, Genetic.

INTRODUCTION

Like other homeothermic animals, pigs have to maintain inner temperature into close boundaries (around 38.6°C for lactating sow) by maintaining a balance between heat production and heat loss. When ambient temperature increases above the thermoneutral zone (between 12 and 20°C, Black *et al*., 1993), homeothermy is maintained by modification in the posture and an increase of skin blood flow. With further increase in ambient temperature above the evaporative critical temperature, pigs have to increase their evaporative heat loss via an increase of respiratory rate and decrease their metabolic heat production via a reduction of voluntary feed intake to maintain homeothermy until the pathways implicated in body temperature regulation are saturated to prevent an increase of inner temperature (Renaudeau, 2001).

In tropical areas, ambient temperature and humidity are frequently high. Moreover, buildings for animal production systems are usually opened or semi-opened to the outdoor ambient environment. Under these conditions, lactating sows, more than pigs in other physiological stages, often suffer from heat stress because of their high nutrient requirements for milk production (Quiniou and Noblet, 1999). In consequence, performance of sows in hot conditions depends on their ability to tolerate heat (Gourdine *et al*., 2004). Different genetic improvement strategies can be used to attenuate the effects of heat stress, such as crossbreeding, improvement within local population or the option of breeding programmes for heat tolerance within the highly productive breeds, present in tropical areas and selected in developed countries. This alternative will be an original and durable solution in pigs. It is significant that no reference was available on genetic variation for heat tolerance in pig which contrasts with other species like ruminants (Burrow, 2001) or chickens (Taouis *et al*., 2002).

To establish whether higher heat tolerance can be achieved by selecting more heat-tolerant animals, genetic variation of thermoregulation traits and its relationships with production traits must be better understood. Rectal temperature (RT) is one of the criteria most frequently used in the literature to characterize animal's thermoregulatory responses to heat stress (Holmes, 1973; Kadzere *et al*., 2002). Interpretations have often been based on the assumption that RT is the result of the entire thermoregulation process and therefore in genetic selection view, RT is one of the heat tolerance parameters for which estimations of heritability and correlations with other traits are available (Mackinnon *et al*., 1991; Burrow, 2001).

Purpose of this work is to estimate genetic parameters of thermoregulation traits and its association with performance during lactation in our tropical humid experimental conditions, through RT measurements of Large White (LW) lactating sows.

MATERIALS AND METHODS

Data description and traits measured

The data used in this study were collected on a total of 94 LW lactating sows between 1999 and 2005 at the INRA experimental farm of Duclos – Petit Bourg Guadeloupe, in French West Indies (Latitude 16°N, Longitude 61°W). This area is characterized by a tropical humid climate. Two seasons were determined from means and daily variation in ambient temperature and relative humidity recorded from a meteorological station (Campbell Scientific Ltd., Shepshed, UK) within 50 m of the experimental unit: a warm season from November to April (23.8 ± 0.8°C) and a hot season from May to October (26.0 ± 0.5°C). Relative humidity averaged 85% and was comparable in both seasons. The data structure is shown in Table 1. The 94 lactating sows were the progenies of 24 sires and 57 dams; a total of 356 litters were produced. The pedigree of each generation (sires and dams) till foundation generation was available and used in this study (246 animals).

Table 1. Structure of the data studied

	Number
Sows with measurements	94
Sires	24
Dams	57
Total animals	246
Batch	63
Litters produced	356

Feed was distributed once per day between 0700 and 0800 and sows had free access to water provided by a low-pressure nipple drinker. Postpartum sows received 1 kg of standard gestation diet (13.0 MJ/kg of digestible energy, 140 g/kg of crude protein and 0.55% of digestible lysine) on farrowing day and controlled amounts of feed increased by 1 kg each day until d 4 of lactation to avoid overconsumption at the beginning of lactation and agalaxia problems. From d 5 to d 26 postpartum, sows were fed to appetite. The lactation diet was formulated to meet requirements for all nutrients (NRC, 1998). It was based on maize, wheat middlings, soya beans and containing 14.4 MJ/kg of digestible energy, 175 g/kg of crude protein and 0.82 % of digestible lysine. Lactation length was approximately 4 weeks (27.4 ± 2.4 d). During the 48-h post farrowing period, litter size was standardized by cross-fostering at 10 or 11 piglets per litter. Body weight was measured on the day after farrowing and at weaning. Piglets were individually weighed at birth, at d 7, 14 and 21 of lactation and at weaning. For all sows, daily feed intake was determined as the difference between the amount of feed offered and the amount of refusals collected on the next morning between 0600 and 0800. Rectal temperature (RT) was measured with a digital thermometer (Microlife Corporation, Paris, France), twice daily (i.e. at 0700 and 12000 when daily ambient temperature was minimum and maximum), every Monday and Thursday during the lactation period.

Six traits were individually recorded and analyzed as following : RT_7: rectal temperature during lactation measured at 0700; RT_{12}: rectal temperature during lactation measured at 1200; dRT: the calculated difference between RT_7 and RT_{12} ; DFI: sow daily feed intake during *ad libitum period* (i.e. from d 5 to d 26 of lactation); LGR: litter growth rate during lactation; BWL: sow relative body weight loss during lactation (i.e., expressed as a percentage of BW at farrowing).

Statistical analysis

All records were first analysed using SAS Univariate procedure (SAS Institute Inc., Cary, N.C., 1999), to calculate means and standard deviations (sd). All traits were normally distributed so that standard mixed linear procedures were considered adequate to analyze the data. Thus, heritabilities and genetic correlations of the 6 characters were estimated by the restricted maximum likelihood methodology (REML) applied to univariate and multivariate animal models. The VCE 5.1 package developed by Kovač and Groeneveld. (2003) was used. Two levels of repetition were considered : successive lactations of the same sow and for RT_7, RT_{12} and DFI repeated measurements during lactation on the same trait. LGR and BWL were single traits. Because of the low number of sows per batch (5.7 ± 2.5), contemporaneous groups were formed by the combination of consecutive batches within the same season and the same year (20 groups).

For univariate analyses, the model for repeated data included the batch-season-year interaction, the parity (1, 2-3 and more than 3) and the stage of lactation as fixed effects, with the direct additive genetic value of each sow, the permanent environment effect, the effect of repeated measurements of the sow within the same lactation and the residual as random effects. The same model, but without the stage of lactation effect was used for LGR and BWL. Metabolic body weight was added as a covariate for DFI and LGR.

For multivariate analysis, mean values of repeated data were considered. Tha data set was too small to allow a single five-trait REML analysis. Hence, fifteen successive bivariate analyses were performed with the same model as for univariate analyses.

RESULTS AND DISCUSSION

Means, estimated phenotypic and genetic standard deviations are given in Table 2. In our experimental tropical humid conditions, the daily feed intake of LW lactating sows during the fed-to-appetite period averaged 4.73 kg/d, litter growth rate was around 1.93 kg/d and sows lost on average 0.072 of their BW at farrowing. Average parity and metabolic body weight were 3.4 and 60.31 $kg^{0.75}$, respectively.

Rectal temperature was higher at 1200 (RT_{12}) than at 0700 (RT_{07}) which coincides as expected with the higher values of ambient temperature at 1200 (28.2 and 31.9°C in the warm and the hot seasons, respectively) than at 0700 (21.7 and 24.2°C in the warm and the hot seasons, respectively).

Table 2. Means phenotypic and additive genetic standard deviation (S.D) for the six traits studied

Traits	N	Mean	Phenotypic S.D	Genetic S.D.
Rectal temperature, °C				
RT_7	2,647	38.53	0.56	0.30
RT_{12}	1,219	39.58	0.68	0.39
dRT	1,219	1.02	0.26	0.18
Lactating traits				
DFI, kg/d	7,082	4.73	1.32	0.13
LGR kg/d	356	1.93	0.39	0.00
BWL	356	0.072	0.034	0.013

Estimates of additive genetic parameters and phenotypic correlations are given in Table 3. To our knowledge, no reference was available on genetic variation for heat tolerance in pigs. In this study, heritability estimates for RT_7 and RT_{12} were moderate and were close to available estimations of rectal temperature in other species (Obeidah *et al*., 1974; Turner, 1984).

Table 3. Estimates of heritability (diagonal), phenotypic (below diagonal) and genetic (above diagonal) correlations between the traits studied

	RT_7	RT_{12}	dRT	DFI	LGR	BWL
RT_7	0.28 (0.03)	0.91 (0.03)	0.29 (0.15)	0.82 (0.67)	-0.35 (0.12)	0.16 (0.69)
RT_{12}	0.78	0.32 (0.05)	0.70 (0.05)	0.67 (0.23)	-0.63 (0.13)	-0.18 (0.04)
dRT	-0.06	0.58	0.49 (0.14)	0.88 (0.43)	-0.61 (0.25)	0.87 (0.42)
DFI	0.05	0.13	0.20	0.01 (0.03)	-0.96[1]	0.52 (0.45)
LGR	-0.12	-0.26	-0.63	0.33	0.00 (0.00)	0.75[2]
BWL	0.15	0.09	0.04	0.18	0.50[2]	0.14 (0.1)

[1]: no convergence, best point found; [2]: no convergence but variation between iterations tended toward zero
( ): Standard errors of the estimates

The aim of this preliminary study was to determine whether thermoregulation traits were heritable characters for LW sows and could be used to selected more heat tolerant animals. According to the estimated heritabilities, selection may change thermoregulation capacity in lactating sows in LW breed. However, inner temperature of homeothermic animals is a constrained trait which tends to return to a basis value (around 38.6°C for sows). Consequently, the possibility to select animals for lower rectal temperature is questionable. It is possible that genetic estimation of thermoregulation parameters made from fluctuation with diurnal or seasonal variation is more interesting (Koga *et al.*, 2004). In the present study, heritability and variability for dRT was higher (0.49 ± 0.14) and it seems to be more useful.

Estimates of phenotypic correlations showed large positive correlations between RT_7 and RT_{12}. Phenotypic correlations between thermoregulation traits (RT_7, RT_{12} and dRT) and both DFI and BWL were generally low. Low to large negative phenotypic correlations were obtained between thermoregulation traits and LGR.

In the present study, a negative correlation between thermoregulatory parameters and LGR can be observed. However, the genetic correlations were estimated with large standard errors so that the association between thermoregulation and performance traits in lactation have to be interpreted with caution. In tropical beef cattle, negative genetic correlations were found between rectal temperature and growth performance (Turner, 1984; Mackinnon *et al.*, 1991), suggesting that selection for production traits in tropical environment will be most effective in conjunction with selection for heat tolerance. Similarly to our results, the accuracy of genetic correlations obtained in these studies were low, probably because of the low number of observations. Furthermore, Turner (1984) suggested that the low accuracy of genetic correlation between beef inner temperature and production characters are due to the fact that several regulation ways with different effects on production performance can be used to maintain a constant body temperature. This suggests that it will be useful to investigate in some indicators of animal's ability to lose heat or to product heat such as respiratory rate, cutaneos heat conductivity or residual feed intake (Renaudeau *et al.*, 2004). Nevertheless, careful attention will be necessary to take into account the direct and collateral effects of artificial selection in pigs (Menèndez-Buxadera and Mandonnet, 2006).

CONCLUSION

This study shows the existence of a genetic variability for thermoregulation in our population of Large White sows, which means that there is space for breeding methods. However, additional studies and observations are required to confirm our results and evaluate the relationship between RT and production parameters, in order to establish an adequate selection criterion with an optimum between production traits and adaptation traits.

Moreover, as RT is the result of the entire thermoregulation process, this trait can not reflect underlying physiological mechanisms involving in thermoregulation, such as the ability to lose heat or to produce heat. Finally, it seems unrealistic to generalize measurements on a large number of animals. Some investigations are needed on the choice of useful characters to realize selection for heat tolerance using large volume of data from low cost measurements on individual animals.

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