Estimation of realised genetic trends in French Large White pigs from 1977 to 1998 using frozen semen: farrowing and early lactation periods

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An experiment was set up in order to estimate realized genetic trends in the French Large White (LW) pig breed. Two groups of pigs (G77 and G98) were produced by inseminating LW sows with semen of LW boars born in 1977 or in 1998. Three generations of G77 and G98 pigs were produced by inter se matings. Farrowing and early lactation periods were thoroughly investigated on a total of 137 first and second parity litters from second generation G77 and G98 sows (68 and 69 litters, respectively). The data were analysed using mixed and generalized linear models (for binary data). The total number of piglets born per litter and farrowing length did not significantly differ between G77 (11.9±0.5 and 244±23 min, respectively) and G98 (12.7±0.5 and 275±25 min, respectively) sows. G98 piglets were heavier at birth than G77 (+0.11±0.05 kg when adjusted for TNB), but had a higher probability of being stillborn (odds ratio of 1.5). More detailed analyses of the farrowing process (kinetics of birth,…), of sow behaviour and of piglet vitality at birth (time to first suckling,…) are also presented.

Key words: stillbirth, selection, litter size, farrowing, lactation, kinetics of birth

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Introduction

As most commercial pig populations, the French Large White breed has been selected for several decades to improve growth efficiency and carcass lean content (Tribout et al., 2003). Since the early nineties, litter size has become a major element of the overall selection goal, and has been successfully selected through hyperprolific selection schemes (Legault et al., 1976, Herment et al., 1994), the use of BLUP animal model and of artificial insemination. This improvement has unfortunately been accompanied by an increase of perinatal and, to a lesser extent, birth to weaning mortality (GTTT, 2005).
In an experiment aiming at estimating genetic trends from 1977 to 1998 in French Large White breed using frozen semen, Tribout et al. (2003) showed an increase of 2.9 piglets born per litter, of which 0.8 were additional stillbirths. This increase can be due to a higher risk of hypoxia, which may result from uterine contractions, an early placenta detachment, the rupture of the umbilical cord and/or an increase of farrowing length (Bille et al., 1974; English and Wilkinson 1982; Fraser et al., 1995, 1997; Herpin et al., 1996). Later, sow physiology (colostrum and milk production) and behaviour (litter responsiveness and motivation to nurse), as well as piglet vitality and litter characteristics (mean and heterogeneity of birth weight) contribute to piglet survival and growth (Edwards et al., 2002). The experiment set up by Tribout et al. (2003) has then been extended to more thoroughly investigate the different causes of the increased piglet mortality between 1977 and 1998. This paper presents preliminary results on these investigations.

1. Materials and methods

1.1 Animals and housing

Two groups of animals (referred to as G77 and G98) were produced by inseminating Large White sows with semen from artificial insemination boars born either in 1977 or 1998. Three generations of G77 and G98 pigs were then produced by inter se mating of randomly chosen G77 or G98 boars and gilts (figure 1). Additional details on the experimental design can be found in Tribout et al. (2003).

The current experiment used 38 G77 and 41 G98 randomly selected females from the third generation produced in the INRA experimental herd of Bourges (18520 Avord, France). They were inseminated with frozen semen from second generation boars in the first parity and with fresh semen from third generation boars in the second parity. A total of 137 litters and 1679 piglets were produced. Their distribution according to experimental group and parity are shown in table 1.

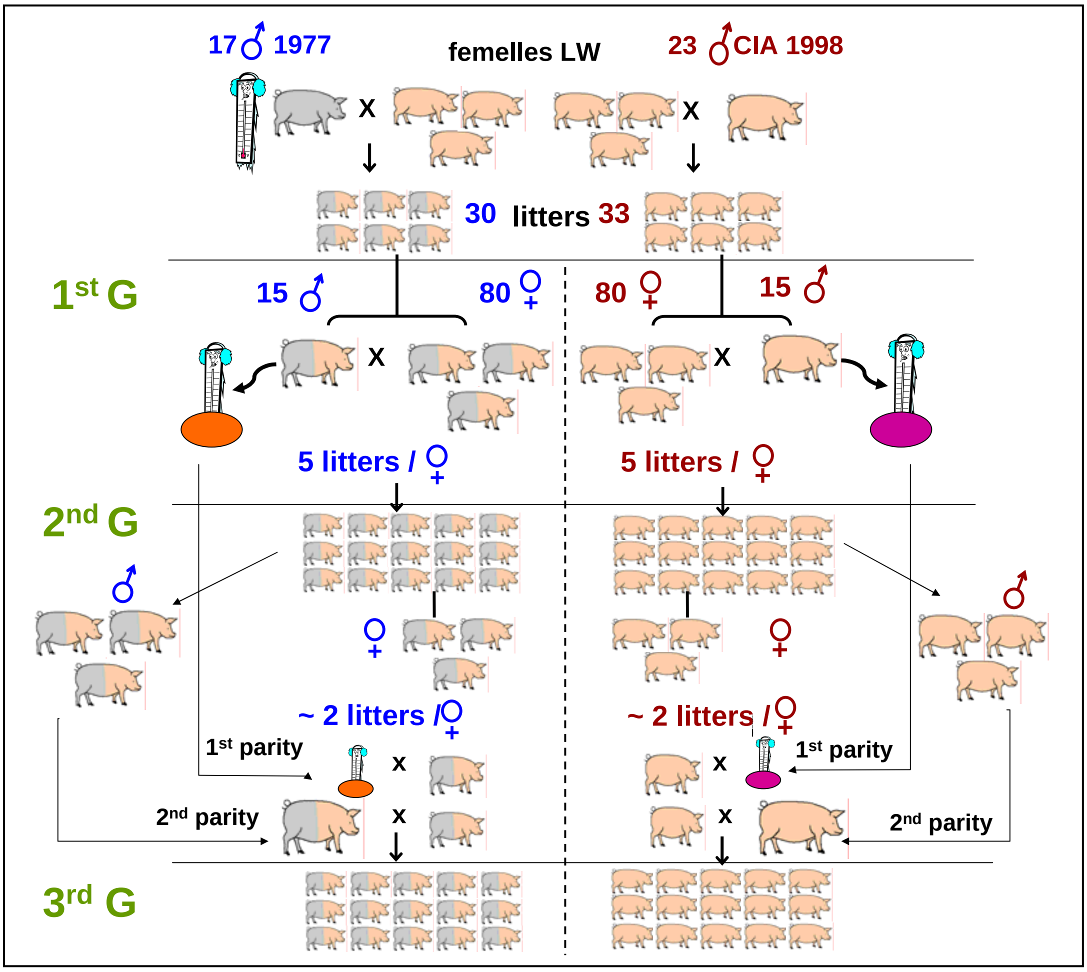


Figure 1. Experimental design

Table 1. Distribution (number) of animals according to the experimental group and parity.

Parity	Experimental group	Dams	Boars	Piglets
1	G77	39	10	464
	G98	41	10	493
2	G77	29	11	348
	G98	28	5	374

Sows were managed under a batch farrowing system, with a 3-week interval between contiguous batches. They were fed 2.5 to 3 kg commercial sow diet twice daily at 8:00 am and 4:30 pm during the whole gestation period. They entered the farrowing unit one week before the expected farrowing date. Each farrowing unit contained 20 individual crates but was not necessary filled. As often as possible, G77 and G98 sows were placed in neighbouring farrowing crates in an alternative way (a G77 female had G98 neighbour sows).They were blocked with partially slatted-floor covered with a thin floor of straw. Successive crates were separated with a low wall (50 cm high), so that sows could see at least their neighbours. The room was permanently artificially illuminated, but also received natural light. Straw was removed twice daily at feeding times. Feed was also distributed twice a day at 8:00 am and 4:30 pm and sows had free access to water provided by a low-pressure nipple drinker. Feed allowance was progressively increased by 1 kg each day until the fifth day of lactation (L5). Sows were offered feed *ad libitum* from L5 to the day before weaning. Parturition was not induced and birth assistance treatments (oxytocin and vaginal palpation) were provided only in cases of extreme necessity involving sow survival. Only 3 G77 and 4 G98 sows were treated over the whole experiment.

1.2 Data recordings

Various physiological and behavioural measurements from traits potentially involved in early mortality of the litter have been recorded. Only some of these measurements were analyzed in this preliminary study.

From day 111 of gestation (G111), animals were daily visited for tail blood sample and human reaction tests and to identify signs of impending parturition (milk let down and vulvar swelling and mucous secretion). Hence, they got accustomised to the presence of the supervisor. Sow parturition was observed continuously in 98 of the 137 farrowings. Piglet birth time and order were individually recorded. Each expelled piglet was immediately caught. Its umbilical cord was cut and a blood sample taken (Canario et al., 2005).The remaining part of the umbilical cord was then ligated with a surgical silk. Subsequently, the piglet was dried with straw and drying paper, weighed, sexed and marked on its back with a number corresponding to its birth order. Apart from these manipulations that stimulate newborn vitality, we tried to avoid any interference with the natural delivery of the piglets. For instance, there was no human intervention to control aggression toward newborns or avoid crushing, and no piglet assistance to find a teat. Only piglets blocked in their envelope and about to die from asphyxiation were helped. Adoption was prohibited. Piglets didn't receive any additional feed before 3 weeks of age.

The different causes of mortality were recorded daily from birth to weaning. Sow behaviour was recorded from day 111 of gestation to at least 48 hours after the end of farrowing using 24 time lapse video (VHS Panasonic video recorder associated with DPX9 *multiplexer Advanced Technology Video*). Yet, sow and piglet behaviour analysis was limited to a 6h period beginning with the birth of the first piglet in the present study. Video tapes were analysed by a single person. Registrations included sow postural changes, nesting behaviour, responsiveness to piglet contact and attentiveness to the litter as well as udder activity of the litter. Details on the behavioural criteria used are shown in table 2. Kneeling posture was scarce and was then not considered. Behavioural indicators of piglet vitality at birth were time until first udder contact and time until first colostrum intake.

1.3 Statistical analysis

All analyses were carried out using SAS software (version 8.1).

Table 2. Behaviours (criteria) used for observation from onset of parturition until 6 hours after birth of the first piglet

Behaviour (criterion)	Definition
Lying ventrally (duration)	Lying in sternal recumbency, udder not exposed
Lying laterally (duration)	Lying in lateral recumbency with udder exposed
Sitting (duration)	Sitting continuously for at least 5 seconds
Standing (duration)	Standing upright, on four feet
Postural changes (occurrence)	All changes between the 4 positions mentioned above
Nest-building (occurrence)*	Nose contact with the floor or nest material, in a scaterring way
Piglet exam (occurrence)	Movement of the snout toward the approaching piglet, located at less than one piglet length from the sow snout
Piglet indifference (occurence)	No visible reaction to the approaching piglet, located at less than one piglet length from the sow snout
Piglet attentiveness (occurence)	Head directed attentively to at least one piglet, located at more than one piglet length from the sow snout
Activity at the udder (#)	Number of piglets suckling (teat in mouth or massaging the udder actively)
Time to first udder contact	Touching the udder with its nose
Time to first colostrum intake	Immobilized at the udder, holding a teat in mouth with rapid mouth movements for at least 5 seconds

1.3.1 Sow and litter characteristics

Gestation length was analyzed with a model including the fixed effects of experimental group (G77 or G98), parity (1st or 2nd) and a random batch (contemporary group) effect using the MIXED procedure of the SAS software (SAS Institute, 1999). The same model plus an additional random effect of the sow was used to analyse prolificacy data.
The model for piglet weights and survival included fixed batch, experimental group and dam parity effects and a random birth litter effect. Piglet survival was analysed as a binary trait (0=dead; 1=alive) with Generalized Estimating Equations from the GENMOD procedure of SAS (SAS Institute, 1999) using an exchangeable correlation matrix on records of piglets of the same litter.
Farrowing length (FL) was defined as the interval of time between the births of the first and the last piglet of a litter. Birth interval (BI) was the period of time between successive births. The first piglet born had no birth interval. When two piglets were born at the same time, the second piglet was attributed 1 second birth interval. Farrowing terminating more than 10 hours after the birth of the first piglet were considered as abnormal and discarded. The analyses of FL and mean, standard deviation and maximum of BI were performed after a Box Cox transformation in order to normalise their distribution. The model included experimental group and parity as fixed effects, as well as batch and sow as random effects.

1.3.2 Sow and piglet behaviour

Video tapes were analysed on 14 second parity sows of each genetic group. Nesting behaviour was only visible during the first 2 hours and was consequently not considered during the remaining 4 hours. Several other behaviours occurred infrequently. In particular, 4 G77 sows and 2 G98 sows had no change of posture during the 6 hours considered. Udder activity could be recorded on only 12 parturitions in each genetic group because of the low quality of some video tapes. Among the 268 born piglets from these 24 sows, 38 and 61 piglets didn't have records for first udder contact and colostrum intake respectively. Two situations occurred: 1/ these pigs showed no motivation to suckle and therefore observation periods became extremely long. Since the moment that observation wasn't fixed, they were not considered in the analysis; 2/ in large litters, it became more and more difficult to see individual piglets reaching the udder while the number of born piglet increased.

All behavioural traits except piglet responsiveness had asymmetric distributions and were consequently analyzed assuming they followed a Poisson distribution using the GEE option from the SAS GENMOD procedure (SAS Institute, 1999). Piglet responsiveness was analysed as a binary trait (1=response of the sow, 0=no response). The model included the fixed effects of farrowing batch (except for nursing behaviour), experimental group (G77 or G98). Period of Time (PT = 1st to 6th hour after onset of farrowing), the EG x PT interaction and a random sow effect. The covariance between measurements at different time intervals within the same sow was allowed to vary according to an exchangeable structure. Time to first udder contact and first colostrum intake were analysed with a model including the fixed effects of the experimental group, farrowing batch and a random effect of birth litter.

1.3.3 Realised genetic trends

The realised genetic trends from 1977 to 1998 (ΔG) and their standard errors (seΔG) were estimated for each considered trait as proposed by Smith (1976):

ΔG=2*(G98 mean – G77 mean) and seΔG=2*se(G98 mean – G77 mean).

2. Results

2.1 Sow and litter characteristics

Pre-weaning mortality was observed on 29.2% of the G77 piglets and 32.2% of the G98 piglets. In total, 1679 piglets were born from 137 farrowing events of which 57 and 102, respectively, (7.0% and 11.8%) in G77 and G98 group were stillborn. Aggressive behaviour was very scarce and only one piglet was killed by the sow in each group. Most of piglet mortality occurred in the first week (figure 2).

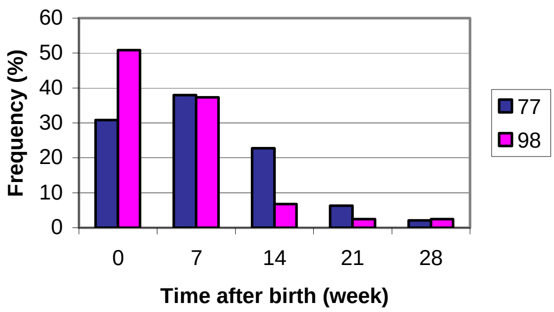


Figure 2. Distribution of piglet mortality from birth to weaning in G77 (n=237) and G98 (n=279) group.

Experimental group least squares means and estimated genetic trends for litter and farrowing traits are shown in table 3. Age at insemination was similarly high in the two groups for experimental programming reasons. G77 sows had a longer gestation length (P=0.018). First parity litter size was similar in the two experimental groups (P=0.809), probably in relationship with the use of frozen semen. Total number born tended to be higher in G98 sows in the second parity (+1.4 piglets; P=0.18), but number born alive was similar in both groups due to a higher number (P=0.014) and a higher probability of being stillborn in the G98 group (odds ratio of 1.5, P=0.003). G98 piglets were heavier at birth than G77 piglets (+0.13±0.04 kg when adjusted for litter size). Time to first udder contact and to first colostrum intake were similar in both experimental group of pigs.

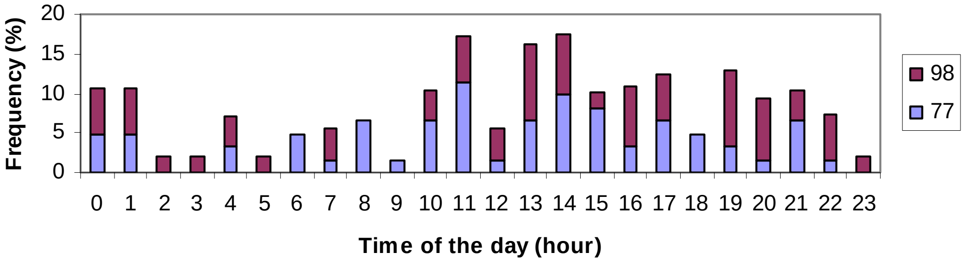
Table 3. Experimental group least squares means and estimated genetic trends from 1977 to 1998 (ΔG) and standard error (se ΔG) for sows and piglet descriptive traits.

		No. G77	No. G98	G77 mean	G98 mean	ΔG ± se ΔG	Pr>|t| H0 : ΔG = 0
Sow traits							
Age at insemination (days)	parity 1	39	41	401.9 (26.8)	417.8 (26.7)		
	parity 2	29	28	528.0 (19.6)	539.9 (19.7)		
Gestation length (days)		68	69	113.5 (0.2)	112.9 (0.2)	1.2 (0.6)	0.018
Prolificacy traits							
Total Number Born (TNB) (#)	parity 1	39	41	11.9 (0.6)	12.1 (0.6)	0.4 (1.8)	0.809
	parity 2	29	28	12.0 (0.7)	13.4 (0.7)	2.8 (2.0)	0.179
Number Born Alive (#)	parity 1	39	41	11.2 (0.6)	10.7 (0.6)	-1.0 (1.6)	0.554
	parity 2	29	28	11.0 (0.7)	11.9 (0.7)	1.8 (2.0)	0.359
Number of stillborn piglets (#)	parity 1	39	41	0.69 (0.26)	1.45 (0.26)	1.52 (0.72)	0.036
	parity 2	29	28	0.96 (0.34)	1.76 (0.36)	1.60 (0.94)	0.095
Proportion of stillborn piglets (%)	parity 1	39	41	5.1 (1.7)	10.3 (1.7)	10.4 (4.6)	0.027
	parity 2	29	28	7.6 (2.2)	12.5 (2.3)	10.0 (6.4)	0.127
Probability of being stillborn Exp(OddRatio)		812	867	-2.85 (0.22)	-2.13 (0.14)	1.44 (0.48) 2.98 (0.24)	0.003
Farrowing traits							
Farrowing length (min)	parity 1	34	29	158	156	4	0.880
	parity 2	24	19	196	240	8	0.248
Birth interval (BI) (min)	parity 1	31	25	16	15	2	0.836
	parity 2	20	16	18	22	6	0.393
Standard Deviation in BI (min)	parity 1	31	25	16	15	2	0.855
	parity 2	20	16	16	25	18	0.167
Maximum BI (min)	parity 1	31	25	51	46	10	0.645
	parity 2	20	16	52	73	42	0.246
Piglet traits							
Weight at birth (kg)		580	562	1.30 (0.04)	1.37 (0.04)	0.14 (0.10)	0.138
Weight at birth (kg) corrected for TNB		580	562	1.24 (0.03)	1.37 (0.03)	0.26 (0.08)	0.003
Time to first udder contact (min)		105	116	32 (4)	33 (4)	2 (12)	0.83
Time to first colostrum intake (min)		98	105	58 (6)	53 (6)	12 (16)	0.52

2.2 Farrowing process and kinetics

2.2.1 Time for onset of parturition

The distribution of onset of farrowing during the day and night is shown on figure 3. No between-group difference was observed in the distribution of onset of parturition when dividing the day into 6 intervals of 4 hours (χ^2=7.082, p=0.215). However, G98 sows started farrowing more frequently outside the staff working time (8-12 am and 2-5 pm) (χ^2=4.225, p=0.039).



2.2.2 Birth intervals

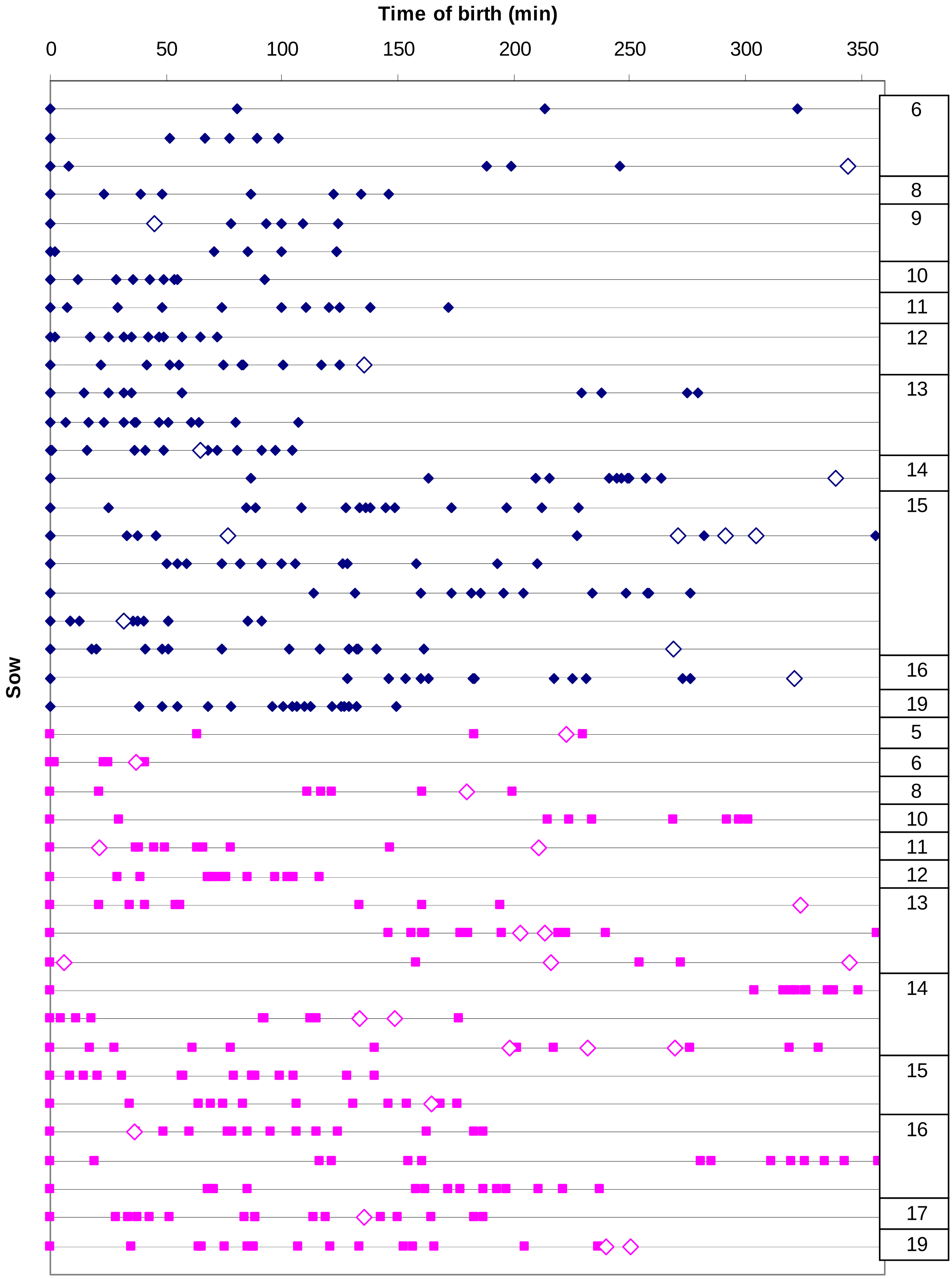


Figure 4. Farrowing process for each sow within each experimental group (G77 and G98 successively), classified by litter size for second parity litters. Only the first 6 hours from the onset of parturition are represented. ◆ G77 born alive piglets ◇ G77 stillborn piglets; ■ G98 born alive piglets ◇ G98 stillborn piglets. Note that dots may coincide if interval is low.

Farrowing length was equivalent in G77 and G98 groups but tended to be longer in second parity sows (P=0.25 Table3). No difference was detected for mean birth interval and inter-birth regularity (P>16), but a trend for larger standard deviation and maximum interval in second parity G98 sows was detected.
The realised genetic trend in the second parity was +1.6(0.94) number of stillborn piglets. Beyond the first 6 hours, the proportion of stillborn piglets was similar (7/10 and 11/15 births in G77 and G98 groups, respectively). In the first 6 hours after the onset of farrowing, the proportion of stillborn piglets tended to be higher in G98 litters (21/228 *versus* 12/256 in G77, χ^2=3.2, P=0.073). The farrowing process for these second parity sows is depicted on figure 4.

2.3 Farrowing behaviour

2.3.1 Sow postural activity and nest-building behaviour

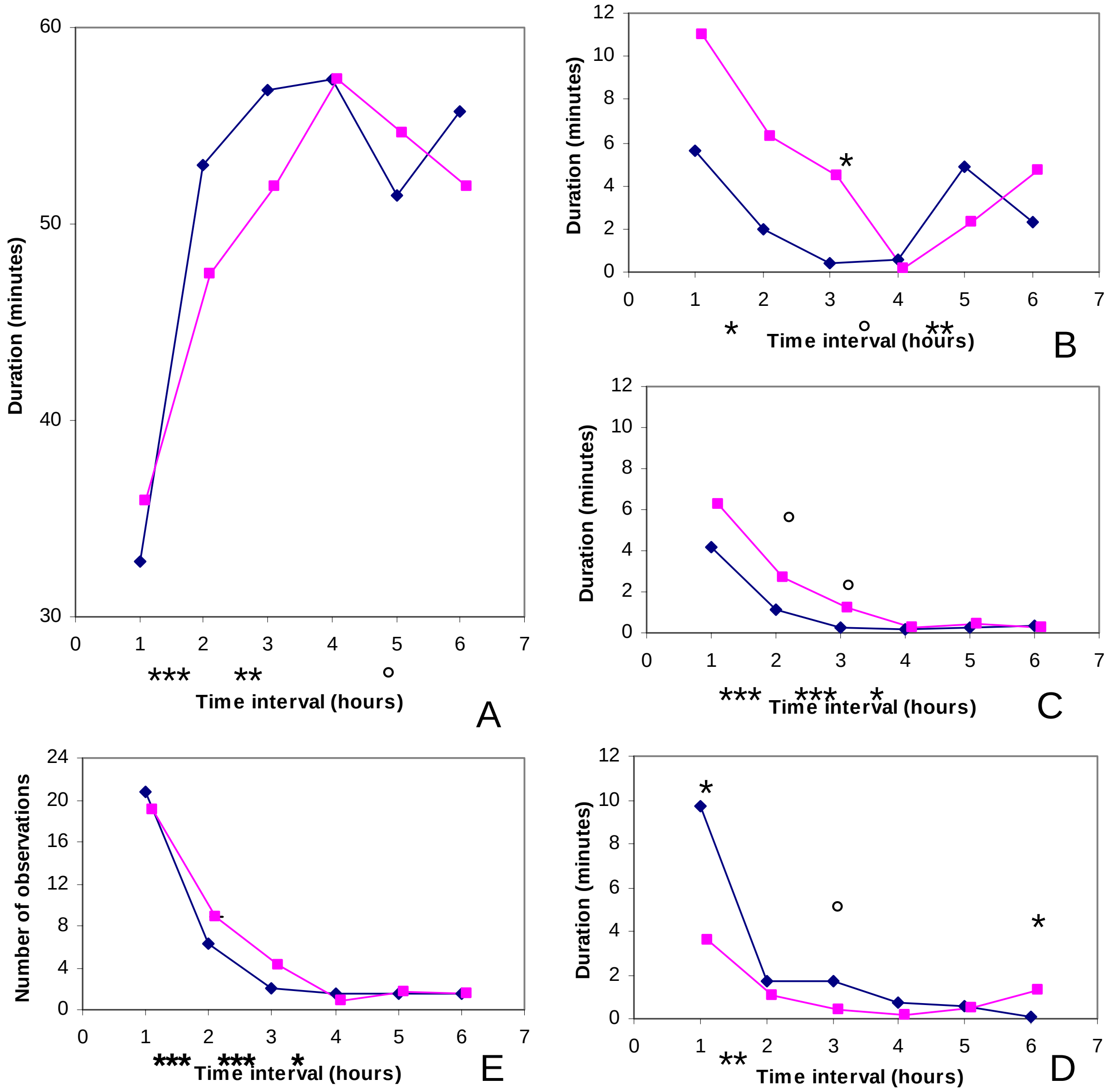


Figure 5. Least squares means for lying laterally (A) and lying ventrally standing (B); sitting (C); standing (D) and postural changes (E) are shown for second parity sows from G77 (◆) and G98 (■) experimental groups. Significance levels below the X axis refer to differences between successive periods of time, both experimental groups merged together. Significance levels reported on the graph above mean values, refer to experimental group differences. Significance levels: ° : p<0.10 ; * : p<0.05 ; ** : p<0.01 ; ***: p<0.001.

Results regarding sow postures and postural changes are shown in figure 5 and table 3. A significant experimental group effect on standing posture and a trend on sitting posture were obtained. No interaction between experimental group and the interval from the birth of the first piglet was detected (P>0.31). G77 sows were more often in standing position then G98 sows (P=0.03), which tended to spend more time in a sitting position (P=0.10). A significant effect of the time interval was also observed (P=0.02). Though sows spent most of the 6 first hours in lying laterally position, they spent significantly more time standing at the beginning of farrowing. The increase in lying laterally reached a maximum during the fourth hour when sows spent most of their time in this posture. A trend to decrease was observed between the fourth and the fifth hour where sows spent more time in a ventral position. Finally, G98 sows spent more time in a standing position during the 6th period.
G77 and G98 sows didn't differ in realisation of nesting behaviour during farrowing (P=0.53) but G77 sows realised more nest-building behaviour than G98 sows in the first hour after onset of farrowing (P<0.05). A general drop in this activity was observed from the first to the second hour (P<0.01).

2.3.2 Maternal attentiveness toward the litter

The experimental group did not significantly affect maternal responsiveness and attentiveness (P=0.17 and P=0.97 respectively). Conversely, both traits were affected by the time interval from the beginning of farrowing. Responsiveness was increased in G98 sows during the first three hours after onset of parturition and the difference disappeared after (figure 6). Attentiveness was the highest in the first hour, decreased significantly in the second hour and was constant and low in the next four hours.

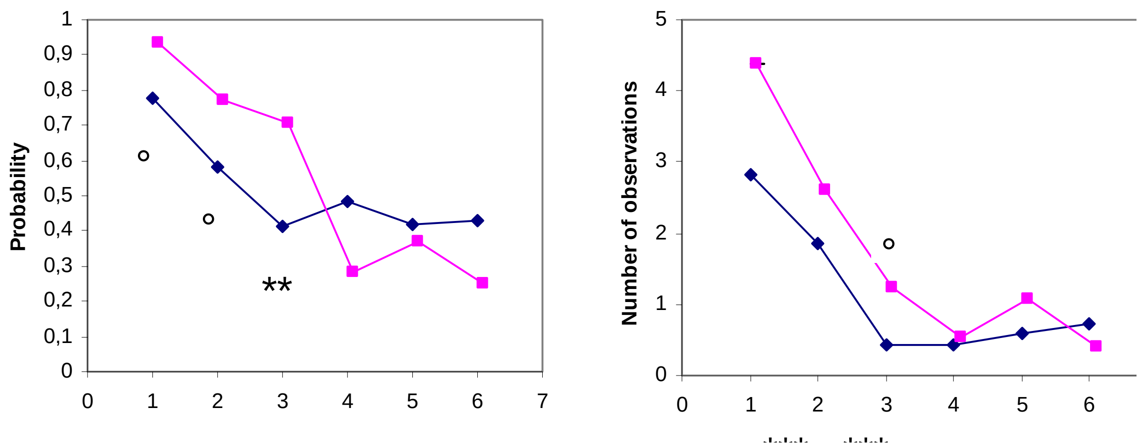


Figure 6. Least squares means for maternal responsiveness (A), defined as the number of nose contacts with progeny leading to exam performed by the sow, and maternal attentiveness (B) are shown for second parity sows from G77 (◆) and G98 (■) experimental groups. Time zero corresponds to the birth of the first piglet. Significance reported under graph B refers to differences between successive intervals, both experimental groups merged together. It was not noted on graph because of a significant interaction between EG and TI. Significance levels: ° : p<0.10 ; * : p<0.05 ; ** : p<0.01 ; ***: p<0.001.

Table 3. Estimated realized genetic trends from 1977 to 1998 (ΔG) and standard error (se ΔG) for sow farrowing behaviour traits during the first six hours after onset of parturition [a]. Results are expressed on a logarithmic scale.

	No. G77	No. G98	alpha [b]	G77 mean	G98 mean	ΔG ± se ΔG	Pr>|t| H0 : ΔG = 0
Lying ventrally	14	14	0.123	0.71 (0.40)	1.27 (0.24)	1.14 (0.84)	0.17
Lying laterally	14	14	0.079	3.92 (0.04)	3.90 (0.04)	-0.06 (0.08)	0.51
Sitting	14	14	0.125	-0.61 (0.33)	-0.10 (0.19)	1.02 (0.62)	0.10°
Standing	14	14	0.136	0.36 (0.37)	-0.47 (0.44)	-1.68 (0.78)	0.03*
Postural changes	14	14	0.132	1.19 (0.27)	1.24 (0.18)	0.12 (0.64)	0.86
Nest-building	14	14	0.568	0.65 (0.46)	0.29 (0.34)	-0.72 (1.14)	0.53
Piglet responsiveness	14	14	0.094	-0.03 (0.24)	0.37 (0.22)	0.80 (0.74)	0.29
Piglet attentiveness	14	14	0.100	-0.17 (0.25)	0.25 (0.17)	0.84 (0.62)	0.17
Activity at the udder	12	12	0.143	1.17 (0.09)	1.17 (0.12)	0.00 (0.30)	0.97

[a] except for nesting behaviour for which only the two first hours were considered ; [b] alpha stands for within sow repeated measurement coefficient of correlation. Significance levels: °: $p<0.10$; *: $p<0.05$.

2.3.3 Litter activity at the udder

During the first 6 hours after birth of the first piglet, the average number of piglets that suckled was similar (Table 2) for G77 and G98 groups. No difference in the evolution of activity at the udder was observed (figure 7). Piglet activity increased during the first three hours and then remained stable.

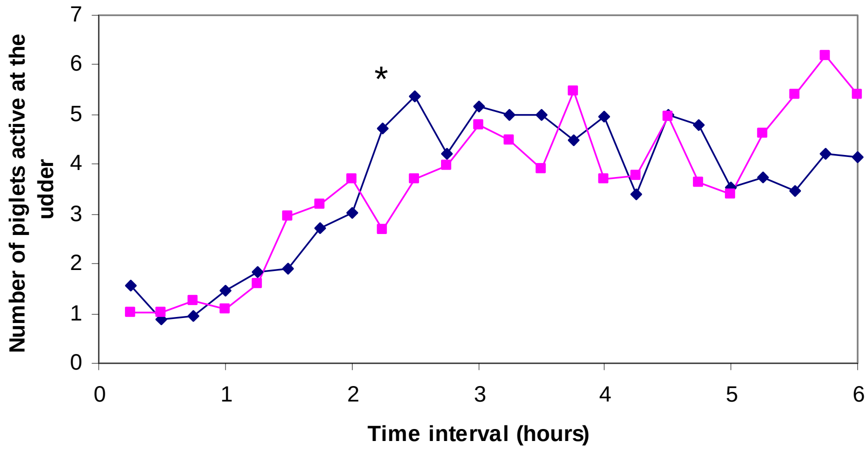


Figure 7. Least squares means for litter activity at the udder in the second parity in G77 (◆) and G98 (■) experimental groups. Time zero corresponds to the birth of the first piglet. Significance levels reported on the graph above mean values refer to differences between experimental groups. Significance levels: *: $p<0.05$.

3. Discussion

Stillbirth was a rather important cause of death, particularly in the G98 group. Values are higher than the results reported by Tribout et al. (2003) and than average French National results. The experimental constraints, i.e. no adoption, no complementary food before 21 days of age and the amount of interventions at farrowing, which may have stressed females, are likely to have contributed to this high mortality rate. Sows also suffered from extremely high temperature in the Summer 2003, which may has affected their current litters. Finally, the fact that sows were mated at a rather old age in first parity might also be involved.

3.1 Statistical approach for behavioural traits

In most studies of sow maternal behaviour found in the literature, the problem of infrequent behaviours is overcome by grouping successive intervals (Damm et al., 2002). Such an approximation may in some cases be justified. In our case, the use of a generalized linear model appeared as necessary. Some sows spent most of their time in the same position and/or had low mothering behaviour. This created a subpopulation of zero for nearly each trait investigated. In such a situation, the use of generalized linear models is highly recommended.
Maternal responsiveness was analysed in a somewhat different way than previous studies (e.g. see Jarvis et al., 1999 or Pedersen et al., 2003). The common index used by these authors (exam-indifference)/(exam+indifference) is a normal approximation. We chose to use a logistic regression, which allows the binary nature of the response (trials and success) to be taken into account.

3.2 Trends for prolificacy traits

The significant improvement of litter size (number of piglet born per litter) found by Tribout et al. (2003) was confirmed in second parity: both studies showed a progress of almost +3 piglets born. Yet, due to the limited number of litters, the trend did not reach significance in the current experiment (p-value is only 0.18 in second parity). Conversely, the estimated trend for number born alive is slightly lower than that obtained by Tribout et al. (2003) (+1.8 *vs* +2.1 born piglets). As a consequence, the deterioration of piglet survival was much higher than that found by Tribout et al. (2003).The higher probability of stillbirth may be due to a lower maturity of G98 piglets at birth, as recently shown by Canario et al. (2005). Indeed, piglet maturity has been shown to be favourably associated with piglet survival (Herpin et al., 1993). Conversely, It has to be noted that piglet birth weight, which is also a key factor for survival, has increased over the last 20 years (+140 g and even +260g / piglet when adjusting for litter size), presumably as a consequence of selection for growth rate in finishing pigs. A similar increase (+180 g/piglet for birth weight for litter size) was obtained by Tribout et al. (2003). They also showed an increase in the maximum birth weight among G98 litters that could hypothetically be associated with farrowing difficulties and a decelerating rhythm of expulsion, which may result in a higher risk of hypoxia. Yet, Leenhouwers et al. (2001) found an independence between farrowing survival and birth weight. The decrease in gestation length may be an additional factor involved in the deterioration of birth survival, as also suggested by Roehe & Kalm (2000) and Hanenberg et al. (2001). Another hypothesis might be a change in the resource allocation pattern due to selection for leanness. Commercial sows have an excessive mobilisation of body reserves (Ten Napel, 1996 *in* Janczak 2002). Selection for litter size has increased resource demanding processes of pregnancy and lactation. Since both groups of animals were fed equivalently during gestation, G98 sows may have been restricted in their ability to provide enough nutrient to their foetus in late gestation.

3.3 Trends for farrowing traits

Stillbirth occurred all along parturition, which disagrees with the hypothesis commonly advanced of more stillbirths at the end of parturition (Fraser et al., 1997). Stillbirths were more numerous in the first six hours after birth of the first piglet in G98 sows than in G77 sows, partly due to the larger litter size in G98 second parity sows. Several authors have hypothesized that the increase in farrowing length associated with an increased litter size would result in higher risks of hypoxia and of stillbirth. In spite of the much higher proportion of stillbirth in G98 animals, no significant trend was found for farrowing length. No relationship with mean and regularity in birth interval was found.

3.4 Evolution of behavioural farrowing traits

Our results confirm that the three first hours after onset of parturition are a sensitive period where most adaptation (accustomization to piglets appearing in the close environment of the sow) and mother-offspring bonding) occurs. In agreement with Jarvis et al. (1999), Fraser et al. (1997), Thodberg et al. (1999), our study shows that sows are more active in the initial stage of parturition than later. On the whole, the activity of the sow has not changed much during the last two decades, in agreement with previous observations in the framework of an evaluation of the consequences of domestication (Jensen 2001). Sow periparturient behaviour is assumed to be important for piglet survival and growth. Nest building behaviour and postural changes during parturition are considered as unfavourable behaviours (Cronin et al., 1993; Thodberg et al., 1999). Conversely, sow responsiveness to neonatal piglets (Pedersen et al., 2003) is an indicator of good maternal care. At the piglet scale, time to first udder contact and first suckle are commonly considered as signs of vitality at birth and important for survival and growth.

Less postural changes and activity were *a priori* expected in modern sows if selection for litter size was associated with painful parturition. G77 sows spent more time in standing position at the beginning of farrowing (mainly in the first hour), which might be related to a higher difficulty to finish nesting behaviour. Similarly, when comparing a mice line selected for litter size to its control, Rauw (2001) found that control females spent more time in floor nosing activity than females from the selected line. Performance and completion of nesting behaviour seem to be regulated both hormonally and via environmental feed-back (Damm et al., 2000). More precisely, materials provided and confinement can affect nest building (Damm et al., 2002). In the present comparison of “old” versus “modern” sows, assuming that “modern” animals cope more quickly with a change in housing accommodation (from tethering in gestation stalls to blocking in farrowing unit) and/or are less disturbed by the lack of space and material to perform nest-building behaviour could explain the overlap. However, standing activity doesn’t seem to influence mortinatality of the litter since G77 sows have a lower proportion of stillbirth.
On the contrary, G98 sows tend to spend more time sitting and lying ventrally during the first three hours. A better bonding between G98 sows and their progeny, i.e. a higher responsiveness to nose contact and a better attentiveness, is also observed in the three first hours. After this period of discovery, sows stay in lying position to allow a better access to the udder for as many as piglets as possible. However, no difference in time to reach the udder and time to first colostrum intake was observed.

3.5 Trends for coping strategies and relationships with human

Baxter & Petherick (1980) speculated that the farrowing environment might be responsible for large variation in the rate of stillbirth. In particular, a stressful environment would lead to a deficiency in piglet expulsion. In the present study, due to physiological measurements (daily tail blood sampling), humans were often present around the farrowing crate during the days preceding and at farrowing. The higher proportion of G98 sows farrowing outside working hours might indicate an increased anxiousness of modern animals and a higher fear of human that might also explain their higher stillbirth rate (English et al 1999, Hemsworth et al 1999 *in* Edwards et al 2002, Janczak et al., 2003).

4. Conclusion & perspectives

This study shows that selection has been associated with a deterioration in farrowing survival and an increase in maternal care after farrowing, which is likely to favour first survivability in the first stages of lactation. This possible compensation has to be analysed. Behavioural analyses will be carried out on a larger data set including first parity sow in order to confirm or invalidate the observed trends. The effects of additional factors (number of born piglet, farrowing length) on behavioural traits remains to be tested. Much work remains to be done to get a precise idea of the effects of selection on sow and piglet behaviour under various management/housing conditions, as well as to check the interest and the possibilities to include behavioural traits in the selection goal and find adequate selection criteria.

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