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Original article

The effect of age at the first mating and herd size on the lifetime productivity of sows

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Abstract — The effect of age at the first mating and herd size were evaluated in the reference Spanish Databank (BDporc) of 37 698 sows born between 1991 and 1995 and with individual lifetime records. The data included dates of births at entrance and culling, first mating, repetitive mating and conception, first farrowing and weaning records. Individual records were validated before the analysis by screening them through a tolerance "filter" in order to eliminate the extreme values from the analysis. The total database of the sows was classified in 7 classes according to age at the first mating (< 210, 210–220, 221–230, 231–240, 241–250, 251–270, and > 270 days) and in 6 classes of herd size (< 200, 200–300, 301–400, 401–600, 601–800, and > 800 sows). The total number of litters and number of weaned piglets obtained from each sow during the lifetime production were significantly ($P < 0.05$) greater for gilts between 221 and 240 d of age at the first mating. There was a significant ($P < 0.001$) effect of the herd size on the reproductive performance of the sow, and the best performance was obtained with herds with 401 to 600 sows compared to < 200 or > 800 sow-herds. Furthermore, a significant ($P < 0.001$) interaction between age at the first mating and herd size was detected and can be associated with a particular pattern for the herd size class 401–600 sows with the best performances obtained for the sows first mated at less than 200 days. For the other herd sizes, the results indicated that sows mated for the first time at the right age, 221–240 days, are more productive, both in the number and size of the parities throughout lifetime production.

age at first mating / sow / productivity / performance / longevity / litter size / pigs

Résumé — **Incidence de l'âge à la mise à la reproduction et de la taille du troupeau sur la productivité des truies.** L'effet de l'âge à la mise à la reproduction (première insémination) et de la taille du troupeau a été évalué à partir de la banque de données espagnole, BDporc. Dans cette étude, ont été considérés les données individuelles de 37 698 truies nées entre 1991 et 1995 et portant sur l'ensemble de la carrière de l'animal. Les données ont inclu les dates de naissance, d'entrée dans l'élevage

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et de réforme, de mise à la reproduction, des mises bas, des fécondations et des sevrages. Préalablement à l'analyse des résultats, les données ont été validées selon un barème de tolérance afin d'éliminer les valeurs extrêmes. Les animaux ont été classés dans 7 groupes distincts selon l'âge à la mise à la reproduction (< 210, 210–220, 221–230, 231–240, 241–250, 251–270 et > 270 jours) et dans 6 groupes selon la taille du troupeau (< 200, 200–300, 301–400, 401–600, 601–800 et > 800 animaux). Le nombre de portées et de porcelets sevrés pendant la carrière de chaque truie a été significativement ($P < 0,05$) plus élevé pour les cochettes âgées de 221 à 240 jours lors de la mise à la reproduction. Les performances de reproduction ont été significativement ($P < 0,001$) affectées par la taille du troupeau. Les meilleures performances ont été obtenues avec les troupeaux de 401 à 600 animaux et les plus faibles avec les troupeaux de moins de 200 ou de plus de 800 truies. L'interaction entre l'âge à la mise à la reproduction et la taille du troupeau a été significative ($P < 0,001$) avec un profil particulier pour les troupeaux de 401 à 600 truies qui présentent les meilleures performances pour les cochettes mises à la reproduction à moins de 200 jours d'âge. Pour les autres tailles du troupeau, les meilleures performances ont été obtenues avec une première mise à la reproduction entre 221 et 240 jours d'âge.

âge à la mise à la reproduction / truie / productivité numérique / performances / longévité / taille du troupeau

1. INTRODUCTION

Herd performance is normally assessed by the average productivity of the sows or the number of piglets weaned per sow per year. A recent study realized with the Spanish databank over the last decade demonstrated that sow productivity for the mean group was significantly increased from 19.7 (year 1990) to 22.7 (year 1999) weaned piglets per productive sow per year [2]. But, the difference in the average sow productivity between the best and worst 20% of the pig farms could be more than 2 piglets [3]. Similar differences between the extreme farms are presented in the French databank [9]. Knowing the management decisions taken at the farm level that may affect sow productivity is very important for the future of the herd's overall performance.

The first, and perhaps most important management decision to be made by the farmer in defining the long-term productivity of the multiparous sow, is when or at what age a gilt should be initiated into her reproductive life. In this sense, there are relevant differences between the French and Spanish herds. In France, on average, the age of the gilts at the first farrowing is 12.2 days older than the average age of the gilts recorded in Spain [3]. Very early studies [6, 7, 15, 17, 18, 22, 23] show that the number of piglets produced at the first parity by a gilt increases with her age at farrowing. In more recent studies, Le Cozler et al. [11], Koketsu et al. [10] and Tummaruk et al. [24], using data recorded on commercial farms from different countries, concluded that the total number of piglets produced per sow and the parity number at culling decrease with age at the first farrowing. Le Cozler et al. [11], suggest that the age at the first farrowing of around 365 days is the easiest to apply and results in a more efficient reproductive performance. On the contrary, the optimal age at the first successful mating has been suggested to be between 200 and 260 days [21, 25]. This recommended age range would appear to be too wide to be targeted on a well-managed sow herd because the number of estruses that gilts may be able to experience within this time period could be highly variable. It has been reported that the litter size in first litter gilts is positively correlated with the estrus number at the first mating [12, 14] although this effect derived from the estrus number is not maintained for subsequent parities [19, 27].

In practice, the strategic decisions, such as age at the first mating, can be implemented at the farm level and the environmental and management effects associated with the herd can be important. In this sense, the influence of the herd, year and season on the performance of sows has been considered in most of the studies realized (see for example [10, 11, 24, 26]). It is not usual to consider herd size and its influence to explain the sow's performance, although in practice we can expect some relation between herd size and the technological and management level. In the future, this aspect may be important, given the tendency to increase herd sizes in most pig populations, particularly in Spanish and French pig populations [2, 3, 9].

The main objective of this study was to assess the effect of the age at the first mating and herd size on yearly as well as lifetime productivity of sows using the Spanish databank [3].

2. MATERIALS AND METHODS

2.1. Data

The databases used were obtained from the reference Spanish Databank [3] collected, kept and managed by the Institute of Research and Technology of Agrofood (IRTA) in the Centre UdL-IRTA. The data included the records from 340 commercial pig farms belonging to 34 producer organizations in Spain. The individual records of all sows born between 1991 and 1995 and which presently have been culled were used, so that their entire productive life was included in this analysis. The validity of the data was assured by filtering the numerical records as follows: an animal's record that did not fall within the defined acceptable range of performance was eliminated. The range for each variable was: age at the first mating, > 120 but < 365 days; the interval from the gilt's entrance into the herd to the first mating, > 6 but < 90 days; age at the first farrowing, > 251 but < 450 days; age at culling, > 114 but < 3650 days; number of piglets born alive, > 0 but < 18; number of piglets at weaning, > 0 but < 18 and, interval between the last record and culling date, > 0 but < 150 days. The phenotypic mean and variance of reproductive timing and performance variables of the population analyzed (Tab. I) were similar to the values of the Spanish Databank [2, 3]. Additional information about the sow (breed, weight, etc.) and their specific management within the farm (feeding regime, growth pattern, vaccinations, health level, etc.) was not available.

2.2. Calculations and statistical methods

A total of 37 698 hybrid sows were divided into 7 classes according to the age in days at the first mating as follows: < 210, 210–220, 221–230, 231–240, 241–250, 251–270, and > 270 days. The two extreme classes, < 210 and > 270 days had the lowest number of observations, 3 733 and 4 278, respectively. The age at the first mating was selected because this represents the initial direct managerial decision and act directed towards the gilt to become a productive first-litter gilt, although not all first matings are successful. We considered that this record, age at the first mating, was a more direct managerial record of the initiation of reproductive life than the age at the first farrowing of the sow.

A detailed analysis of all the variables involved in the reproductive cycle of the sows, described in Table I, was conducted to assess these parameters on the yearly average productivity of productive and present sows, as well as productivity during the entire life of the sow. The time of presence of the sow was considered as the period between the entrance date of the gilt into the herd, recorded by the farmer, and the culling date. The productive time was considered as the lag period between the

Table I. Summary of the phenotypic values of the whole population of the variables considered.

	Mean	Std
Reproductive timing		
Age at transfer in the herd (days)	211.4	20.3
Age at first mating (days)	241.6	26.3
Age at first successful mating (days)	250.7	26.9
Delay first to successful mating (days)	9.1	17.5
Age at first farrowing (days)	365.6	27.1
First weaning to successful mating (days)	16.6	23.8
Accumulated weaning to conception intervals (days)	53.7	47.8
Last productive record to culling (days)	29.17	37.2
Culling age (days)	1104.7	352.3
Number of parities	5.50	2.4
Reproductive lifetime performance		
Number of piglets born alive in 1st parity	9.4	2.7
Number of piglets born alive in 2nd parity	9.3	3.5
Total piglets born alive during lifetime of sow	55.3	27.9
Number of weaned piglets in 1st parity	8.6	2.2
Number of weaned piglets in 2nd parity	8.5	2.9
Number of weaned piglets during lifetime of sow	48.9	24.2
Number of piglets per productive sow per year	21.1	3.9
Number of piglets per present sow per year	19.1	4.2

first fertile mating and the last productive recorded event, either farrowing or weaning time [13].

The statistical analyses were done using the SAS statistical package [20]. The GLM procedure (General Linear Models) of analysis of variance was used considering the age at the first mating (7 levels; defined previously) and herd size (6 levels; < 200, 200–300, 301–400, 401–600, 601–800, and > 800) effects as the main factors in the model. Furthermore, the herd (494 levels), year (7 levels; 1991 to 1997) and season (4 levels; December to February, March to May, June to August, and September to November) when the first farrowing took place and the interactions between the age at the first mating and herd size were also considered as cofactors in the model. Least square means (LSM) estimates and their standard errors were estimated using the LSM option in the GLM procedure. The separation of the LSM was done considering their 95% confidence intervals.

3. RESULTS

The lifetime productivity of the sows was significantly affected ($P < 0.05$) by the two main effects considered, age at the first mating and herd size, and their interaction effect. Furthermore, as it could be expected, sow productivity was also influenced ($P < 0.05$) by the environmental conditions at the first farrowing, considered in the model as the herd, year and season.

Next, we focused on the results obtained for the two main factors considered (age at the first farrowing and herd size) and their interaction. These factors were selected because they can be associated to the management decisions of the farmer.

3.1. Effect of age at the first mating

The results of the statistical analysis of the effect of age at the first mating on variables dealing with the reproductive timing of the sows are presented in Table II. The overall results clearly demonstrated that the age at the first mating does have a significant effect ($P < 0.05$) on the reproductive timing of the sow. It is evident from the results that the greater the age at the first mating of the gilt, the greater was the age of entrance to the herd and also the age at the first farrowing.

The adjusted average (LSM) for age at the first mating for the entire population of sows included in this study ranged from 204 to 287 days among the seven classes. These significant differences in age at the first mating were maintained for the average age at the first successful mating and for the age at the first farrowing. Furthermore, the age at the time of transfer of the gilts into the herd was also significantly ($P < 0.001$) increased as was the age at the first mating. It is very apparent that, as the age at the first mating is delayed, the time interval between the entrance into the herd and the first mating is significantly longer. However, the time interval between the first mating and the first successful mating decreased significantly ($P < 0.001$) as the age at the first mating increased. The first parameter of reproductive timing which was relatively independent of the age at the first mating was the time interval between the first weaning and the first successful mating. Similarly, the accumulated weaning to conception intervals in the lifetime of the sow and the time interval between the last productive record and the culling day also appeared to be very similar and were not significantly ($P > 0.05$) different for the different age classes. But, the influence of age at the first mating on the longevity and on the total number of parities of the sow were evident. Thus, the youngest class of age at the first mating (< 210 days) showed a younger culling age, significantly ($P < 0.05$) different from the 6 other classes of sows. Therefore, the class of sows younger than 210 days at the first mating had significantly fewer parities ($P < 0.05$) than the sows with an age at the first mating ranging from 221 to 240 days.

The results of the effect of age at the first mating on reproductive performance of the sows are presented in Table III. At farrowing, the average number of piglets born alive in the first parity was very similar, but with significant differences ($P < 0.05$) between classes with ages at the first mating earlier and later than 240 days. This significant effect was not presented in the number of piglets born alive in the second parity. But the total number of piglets born alive in the lifetime of the sow in the different classes by age at the first mating were significantly ($P < 0.05$) different. For this variable, a maximum plateau value was recorded for age at the first mating between 221 and 240 days. The absolute maximum for the total sum of the piglets born alive (56.6) or weaned (50.3) was obtained with the sows first mated at the age of 221 to 230 days. At weaning, the average number of piglets at the first and second parity

Table II. Effect of age at the first mating on the *reproductive timing* of the sows.

	Class of sows according to their age at the first mating in days							Root MSE	S
	< 210	**210–220**	**221–230**	**231–240**	**241–250**	**251–270**	**> 270**		
Number of sows	*3 733*	*5 845*	*5 269*	*6 836*	*5 133*	*6 604*	*4 278*		
Number of herds	*238*	*319*	*310*	*337*	*337*	*324*	*262*		
Age at transfer in the herd (days)	189.7[a]	203.2[b]	207.0[c]	210.7[d]	214.6[e]	220.3[f]	226.8[g]	11	***
Age at first mating (days)	204.4[a]	218.2[b]	227.1[c]	237.2[d]	247.1[e]	262.0[f]	287.3[g]	6	***
Age at 1st successful mating (days)	218.4[a]	231.21[b]	236.9[c]	247.2[d]	255.1[e]	268.0[f]	289.9[g]	15	***
First to 1st successful mating (days)	14.1[a]	13.0[a]	9.8[b]	10.0[b]	8.0[c]	6.1[d]	2.7[e]	14	***
Age at first farrowing (days)	333.3[a]	346.1[b]	351.9[c]	362.2[d]	370.6[e]	383.1[f]	405.0[g]	15	***
1st weaning to 1st succ. mating (days)	16.6	15.3	15.3	16.0	15.9	16.3	16.9	22	ns
Accumulated weaning to conception intervals (days)	50.8	52.3	52.8	53.2	52.0	54.4	54.1	45	ns
Last productive record to culling (days)	29.7	29.5	27.7	27.9	29.0	29.4	30.0	35	ns
Culling age (days)	1038.5[a]	1083.5[b]	1108.0[bc]	1111.4[bc]	1106.5[bc]	1127.0[c]	1132.0[c]	328	***
Number of parities	5.2[a]	5.4[ab]	5.6[b]	5.5[b]	5.4[ab]	5.4[ab]	5.3[ab]	2.3	***

[a-g] Different superscripts indicate a statistical significance for the means in the same row at the $P < 0.05$.
S: significance level; *** $P < 0.001$; * $P < 0.05$; ns $P > 0.05$.

Table III. Effect of age at the first mating on the *reproductive lifetime performance* of the sows.

	Class of sows according to their age at the first mating in days							Root MSE	S
	< 210	**210–220**	**221–230**	**231–240**	**241–250**	**251–270**	**> 270**		
Number of sows	*3 733*	*5 845*	*5 269*	*6 836*	*5 133*	*6 604*	*4 278*		
Number of herds	*238*	*319*	*310*	*337*	*337*	*324*	*262*		
No. born alive in 1st parity	9.2[a]	9.3[bc]	9.3[ab]	9.3[b]	9.4[c]	9.4[c]	9.4[c]	2.6	*
No. born alive in 2nd parity	9.1	9.3	9.2	9.2	9.2	9.3	9.2	3.5	ns
Total sum of all born alive	52.5[a]	55.4[abc]	56.5[bc]	56.3[bc]	55.0[ac]	55.6[bc]	54.4[c]	26	***
No. weaned piglets in 1st parity	8.6	8.5	8.5	8.5	8.6	8.5	8.6	2.2	ns
No. weaned piglets in 2nd parity	8.3	8.5	8.5	8.5	8.5	8.5	8.5	2.8	ns
No. weaned piglets in all parities	46.3[a]	48.7[ab]	50.3[b]	49.6[b]	48.7[ab]	49.16[b]	48.06[ab]	23	***
No. piglets per productive sow per year	20.9[a]	21.1[b]	21.2[b]	21.1[b]	21.1[b]	21.1[b]	21.1[b]	3.5	*
No. piglets per present sow per year	19.0[a]	19.3[ab]	19.5[b]	19.2[ab]	19.1[a]	18.7[a]	18.5[a]	3.7	***

[a-g] Different superscripts indicate a statistical significance for the means in the same row at the $P < 0.05$.
S: significance level; *** $P < 0.001$; * $P < 0.05$; ns $P > 0.05$.

showed no significant ($P > 0.05$) differences as the age at the first mating increased from less than 210 to more than 270 days.

The adjusted average yearly production of both the present and the productive sows showed a similar response as presented for the total average number of piglets produced either alive or weaned. Again, the number of piglets reached a plateau at a maximum for sows mated for the first time at ages ranging from 210 to 240 days. The significant differences ($P < 0.05$) in the number of yearly weaned piglets per present sow indicate that it was more sensitive than per productive sow. A significant difference ($P < 0.05$) in the number of piglets weaned per year and per productive sow was found for the sows with an age at the first mating < 210 days. The greatest number of piglets weaned per present sow and year was 19.5 and was recorded with the sows first mated at the age of 221 to 230 days.

3.2. Effect of herd size

The results of influence of the herd size on the reproductive timing are presented in Table IV. The results show significant differences ($P < 0.05$) in all the variables analyzed, except for the time interval between the first weaning and a successful mating. In general, we can see that the performances for the two extreme classes of herd size considered, < 200 and > 800, are not as good as the performances for intermediate herd size classes, although the numerical differences are not so large. The major differences among the herd size classes were more related to the whole life and long time management of the sows. Thus, the accumulated weaning to conception intervals in the lifetime of the sow ranged from 47.7 (301–400 sows) to 63.5 days (601–800 sows). A similar variation, 17.3 days, was found for the last reproductive record to culling interval, ranging from 22.2 days for a herd size 401–600 to 39.5 days for a herd size < 200. There are also significant differences ($P < 0.05$) in the culling age and number of parities between herds smaller and longer than 400 sows.

The influence of the herd size on the reproductive lifetime performance of the sows is presented in Table V. No influence of the herd size was found on the number of piglets born alive in the first and second parities, but there was a significant influence ($P < 0.05$) on the total number of piglets born alive in the lifetime of the sows. Moreover, the herd size presented a significant influence ($P < 0.05$) on all variables related to the litter size at weaning. That is, the number of piglets weaned in the first, second and in the whole productive lifetime and also the average number of piglets per productive or present sow per year. The highest performances observed for all these variables were recorded for the herd size with 401 to 600 sows, with significant differences between the LSM estimated for this class and the estimates for the two extreme farm sizes considered, < 200 and > 800 sows.

3.3. Interaction between the herd size and age at first mating

The results indicated a significant ($P < 0.05$) interaction between the herd size and age at the first mating. In order to describe this interaction, the three main variables in the lifetime performance of the sow are depicted in the tri-dimensional Figures 1 to 3. These variables were, the total number of parities, the total number of weaned piglets and the average number of piglets weaned per present sow per year.

In the figures we can visualize a similar tendency for herds with 401 to 600 sows, in which the number of parities, the number of total weaned and the number of piglets weaned per present sow and year declined as the age at the first mating increased. In the other herd sizes considered, sow performance tended to increase with age at the

Table IV. Effect of farm size on the *reproductive timing* of the sows.

	Class of sows according to the farm size						Root MSE	S
	< 200	**200–300**	**301–400**	**401–600**	**601–800**	**> 800**		
Number of sows	*8 692*	*6 401*	*6 328*	*5 532*	*4 718*	*6 027*		
Number of herds	*113*	*86*	*69*	*45*	*21*	*26*		
Age at transfer in the herd (days)	212.0[a]	206.8[b]	209.5[c]	208.0[bc]	212.4[d]	213.9[e]	11	***
Age at first mating (days)	240.1[a]	241.4[b]	240.3[a]	240.0[a]	241.3[b]	239.6[a]	6	***
Age at 1st successful mating (days)	253.1[a]	248.4[b]	248.4b	247.7[b]	249.1[bc]	250.7[c]	15	***
First to 1st successful mating (days)	12.9[a]	7.0[b]	8.1[b]	7.7[b]	7.8[b]	11.1[c]	14	***
Age at first farrowing (days)	3367[a]	363.4[b]	363.4[b]	362.7[b]	364.1[bc]	365.6[c]	15	***
1st weaning to 1st succ. mating (days)	17.1	17.0	16.5	13.8	16.3	15.6	22	ns
Accumulated weaning to conception intervals (days)	51.3[ab]	48.9[ab]	47.7[a]	51.9[ab]	63.5[c]	53.5[b]	45	***
Last productive record to culling (days)	39.5[a]	28.7[b]	29.7[b]	22.2[c]	24.7[b]	28.8[b]	35	***
Culling age (days)	1060.4[a]	1079.4[ab]	1052.4[a]	1156.4[c]	1146.4[c]	1112.4[bc]	328	***
Number of parities	4.8[a]	5.2[bc]	5.1[ac]	5.9[d]	5.8[de]	5.5[be]	2.3	***

[a-g] Different superscripts indicate a statistical significance for the means in the same row at the $P < 0.05$.
S: significance level; *** $P < 0.001$; * $P < 0.05$; ns $P > 0.05$.

Table V. Effect of farm size on the *reproductive lifetime performance* of the sows.

	Class of sows according to farm size						Root MSE	S
	< 200	**200–300**	**301–400**	**401–600**	**601–800**	**> 800**		
Number of sows	*8 692*	*6 401*	*6 328*	*5 532*	*4 718*	*6 027*		
Number of herds	*113*	*86*	*69*	*45*	*21*	*26*		
No. born alive in 1st parity	9.3	9.4	9.3	9.4	9.3	9.4	2.6	ns
No. born alive in 2nd parity	9.0	9.1	9.2	9.3	9.4	9.2	3.5	ns
Total piglets born alive	49.4^{a}	53.5^{bc}	51.5^{ab}	61.6^{d}	58.6^{de}	56.0^{ce}	26	***
No. weaned piglets in 1st parity	8.3^{a}	8.4^{a}	8.5^{a}	8.8^{b}	8.7^{ab}	8.5^{a}	2.2	***
No. weaned piglets in 2nd parity	8.2^{a}	8.2^{ab}	8.5^{bc}	8.8^{c}	8.8^{c}	8.5^{bc}	2.8	***
No. weaned piglets in all parities	42.9^{a}	46.9^{bc}	45.5^{b}	55.0^{d}	52.2^{de}	49.7^{ce}	23	***
No. piglets per productive sow per year	19.9^{a}	20.7^{b}	21.0^{bc}	22.1^{d}	21.5^{cde}	21.3^{ce}	3.5	***
No. piglets per present sow per year	17.6^{a}	18.6^{b}	18.9^{b}	20.3^{c}	19.7^{cd}	19.4^{d}	3.7	***

$^{a\text{-}g}$ Different superscripts indicate a statistical significance for the means in the same row at the $P < 0.05$.
S: significance level; *** $P < 0.001$; * $P < 0.05$; ns $P > 0.05$.

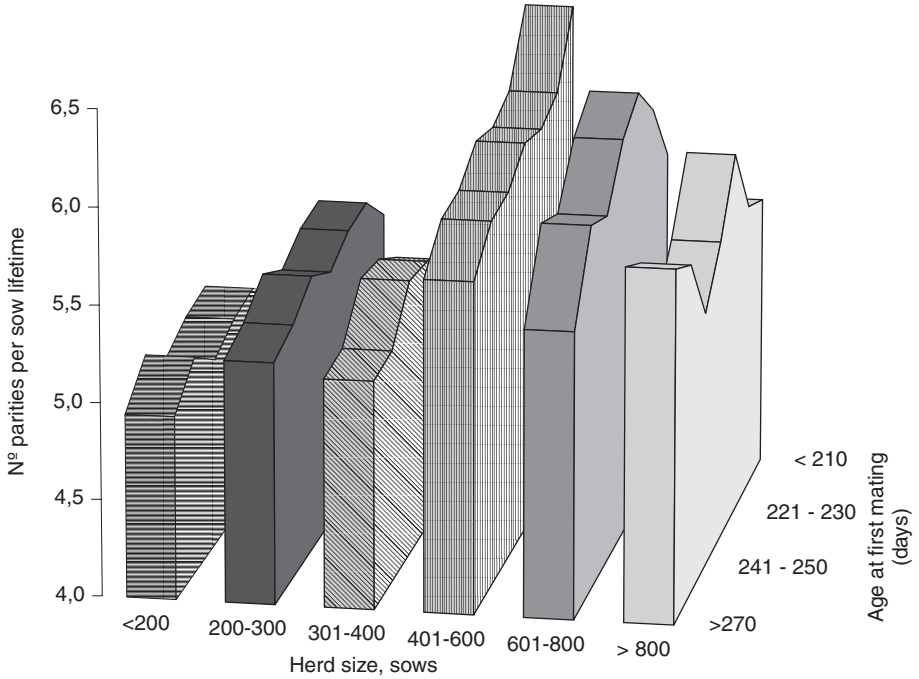

Figure 1. Least square means for the number of parities during the lifetime of the sows in different herd sizes and with different ages at the first mating.

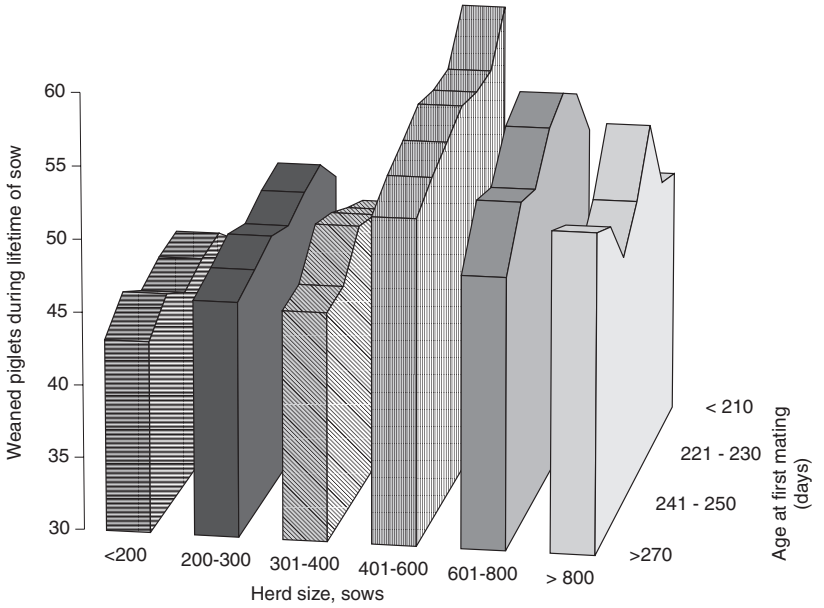

Figure 2. Least square means for the number of total weaned piglets produced during the lifetime of the sows with different herd sizes and with different ages at the first mating.

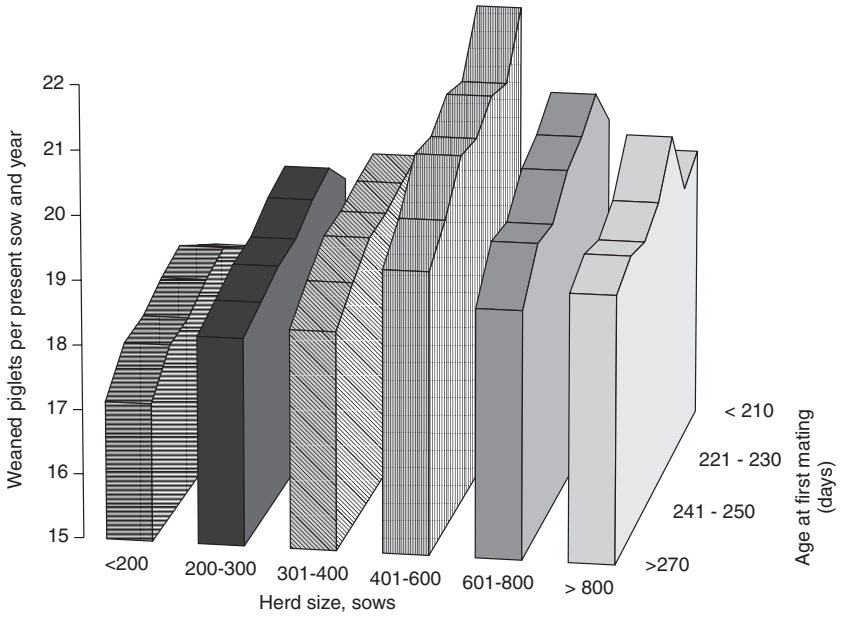

Figure 3. Least square means for the number of total weaned piglets per present sow and year with different herd sizes and with different ages at the first mating.

first mating for young mated sows, this tendency being similar to that previously presented for the mean population (Tabs. II to IV).

Within the 401–600 sow-herds there was a significant difference ($P < 0.05$) in performance between the sows mated < 210 days and > 270 days of age. In contrast, within the herd size classes 200–300 and > 800 sows no statistical differences ($P > 0.05$) were found among the different ages at the first mating. In the other cases, statistical differences ($P < 0.05$) were only found between the age at the first mating with the maximum response value and the age with the minimum response. This minimum response value was obtained for the age class < 210 days in the herd size classes < 200 sows and 301–400 sows, and for the age class > 270 days for herds with 601–800 sows.

The highest performance recorded for the total number of parities and the total number of piglets weaned were for the classes of age at the first mating 221–230 days, 241–250 days and 251–270 days for herd sizes 601–800, 301–400 and > 200 sows, respectively. For all these three cases of herd size, the maximum number of piglets yearly weaned for the present sow was consistent with the other results and obtained for the age at the first mating between 210 and 220 days.

4. DISCUSSION

4.1. Age at first mating

A significant difference in age at the first mating of the gilts, which was subsequently maintained for the age at the first farrowing, significantly affected the lifetime productivity of the sows. However, due to the significant interaction between the herd size and age at the first mating, the expected lifetime performance depended on both factors.

Our results show that the age at the first mating below 221 days and beyond 250 days negatively affected the performance records. In agreement with Tummaruk et al. [24], this detrimental effect of the out-of-optimum range of the age at the first mating seems more pronounced for premature than delayed mating. These results were also in concordance with the most recommended [25] interval for the age at the first mating, between 210 and 250 days, and with the optimal "economical age" recommended for the first conception [21], between 200 and 220 days of age. The average age at the first farrowing, of around 356 days, recommended by Le Cozler et al. [11] would require a first successful mating at approximately 242 days of age according to the optimum age range reported here.

The influence of the age at the first mating was very important for the sow's performance in the first parity, and especially for the number of piglets born alive. These results were consistent with those of Schukken et al. [21], Xue et al. [25], Le Cozler et al. [11] and Tummaruk et al. [24]. Increasing the age at the first mating most likely increased estrus number, and consequently the ovulation rate [1, 4, 5] resulting in a response in the litter size of piglets born alive in the first parity. Working with data from French commercial herds, Le Cozler et al. [11] obtained an increase in the average number of piglets born alive and weaned per litter when the age at the first farrowing increases from 317 to 404 days. In the present study, with a range of age at the first mating between 204 and 287 days, similar results were obtained for litter size at birth in the first parity, but no significant difference ($P > 0.05$) was observed in the number of piglets weaned in the 1st or 2nd parities. From our results, the number of piglets weaned can be less related to age at the first mating if cross fostering has been used and the results obtained at weaning do not only reflect the effect of age at the first mating.

The age at the first mating seems to be less important for the sow performance after the second parity. Thus, the reproductive performance after four parities was found to be similar for gilts mated at the first, second or third observed estrus ranging in age between 168 and 205 days of age [27]. These results, although consistent with the results reported herein, are not comparable because the age at the first mating was in all cases below the optimum range established here, and the overall productivity was very low, with less than 28 weaned piglets in four parities. In their study [25], with gilt age at the first mating ranging from 170 to 320 days, no effect of age at the first mating on litter size was reported ($P < 0.05$) for multiparous sows. On the contrary, the number of piglets produced can be affected by the extreme values of age at the first mating. Thus, Tummaruk et al. [24] showed a decrease ($P > 0.05$) in litter size for sow parities 4 and 5 when age at the first mating increases from 5–7 to 11 months.

The results obtained on culling age and on the number of total parities were consistent with those obtained by Dagorn et al. [8] and Le Cozler et al. [11]. In the present study, however, early breeding could be clearly associated with a significant reduction of the number of parities. This tendency was also observed in previous results presented by Le Cozler et al. [11], but in their case no significant differences were found. In contrast, Rozeboom et al. [19] have concluded that sow longevity in the breeding herd does not seem to be influenced by the age of the gilts at the first breeding and sow conditions (body weight, composition, or backfat depth) although their study included only 87 gilts and three parities. A more recent study reported by Yazdy et al. [26], based on a Swedish *Landrace* population, also showed that neither growth rate nor backfat thickness influence the longevity of sows. Initial studies have also found that age, rather than body weight or body condition assessed by

backfat thickness, appears to be the main factor influencing puberty onset and reproductive performance [5, 16].

Thus, the influence of age at the first mating in the annual productivity of sows is the consequence of the influence of age at the first mating on reproductive performance and on longevity. This can explain the greater variation presented in the number of piglets weaned per present sow and year in relation to the yearly performance of the productive sow. The lifetime performance records of the sum of all the piglets weaned in all parities, as well as on a per productive or present sow per year bases, clearly indicated that the optimum target age is between 221 and 240 days. Because a significant interaction between the age at the first mating of the sow and herd size was established, it is evident that the lifetime reproductive performance of the gilt depends on the herd size. The herd size in essence represents a level of technology and managerial skill of the personnel involved.

4.2. Herd size

Herd size plays a significant role in the lifetime productivity of the sow. The average records of the reproductive performance of the sows for the six farm sizes considered were consistent and in agreement with the results obtained for the entire population of the sows. The significant interaction between the farm size and age at the first mating of the sows represents a distinctive reproductive response of the sows housed in different herd sizes. This distinctive response may be related to the overall welfare of the individual animals in different herd sizes. It seems that a different optimum herd size could be defined at a given technological level.

The differential response within a given farm size population of sows with a different age at the first mating was more pronounced with the farm of medium herd size, in part because the performance recorded was significantly higher. However, the problems of low productivity recorded in large farms (> 800 sows) however, even though superior to the farm with small herds (< 200 sows), appeared to be fundamentally more complex than just the age at the first mating. In a similar manner, the significant interactions between the feeding level during rearing, estrus number at the first service and the feeding level during the first estrus cycle may greatly affect the reproductive performance of the sows [12]. Large herd size showed more variability with sow classes mated at different ages. This can be associated to the difficulty on big farms of the individual control of the sows managed in bigger batches. These differences in lifetime productivity associated with herd size represent in essence the quality degree of the management system. It is not surprising to find an optimum size for managerial outcome that coincides with a medium herd size, neither too small to allow expenses associated with higher technology nor too big to reduce the individual animal care in the daily routine.

Herds of medium size definitely appeared to be the most productive and small herd-sizes the least productive, regardless of the age at the first mating. Sow classes in larger herd sizes seemed to match the corresponding sow classes in the medium herd size productivity but, generally, lifetime production fell while still managing to stay above the small herd size performance in all sow classes. It is not usual to analyze herd size as a factor of productivity and there is little literature available. Our results have shown the importance of herd size and the necessity of more analyses to better understand its influence on sow performance under different management conditions.

5. CONCLUSIONS

The present study clearly demonstrated that age at the first mating and herd size affect lifetime productivity of the sow. For

reproductive purposes, planning the age at the first mating of the sow between 221 days and 240 days of age appears to be an optimal decision. Furthermore, the interaction between age at the first mating and herd size must be considered, and an optimal management policy for age at the first mating must be associated with herd size.

However, apparently the herd size in which the sow is managed also has equal and perhaps a larger influence on the lifetime productivity of the sow. Medium herd size appears to be the best managerial dimension to obtain good overall performance; even an early age at the first mating seems to be less detrimental when compared with large and small herd size, as well as with the entire sow population.

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