Nurse Sows' Reproductive Performance in Different Parities and Lifetime Productivity in Spain

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Abstract

Our objective was to characterize use of nurse sows in Spanish breeding herds. We analyzed 466 111 parity records and lifetime records of 92 716 sows farrowed between 2011 and 2017 in 69 herds having nurse records. Nurse sows were defined as sows that had weaned 2 or 3 litters in the same lactation period. Mixed-effects models were applied to the data to compare reproductive performance and lifetime productivity between nurse and non-nurse sows. Of all the sows, 6 705 (7.2%) sows served as nurse sows at least once in their lifetime, with 10.2% of the nurse sows having a second nurse event in a later parity. Mean values (SE) of lactation length and number of piglets weaned were 31.0 (0.11) days and 21.9 (0.04) piglets in nurse sows, respectively. Across parities 2-6, nurse sows had 1.9-3.0% greater proportions of weaning-to-first-mating interval 7-20 days than non-nurse sows ($P < 0.05$). There was no difference between nurse sows and non-nurse sows in farrowing rate in any parity ($P \geq 0.13$) and piglets born alive in parities 1-5 ($P \geq 0.15$). Also, nurse sows had 3.7-7.4 more annualized lifetime piglets weaned than non-nurse sows ($P < 0.01$), because nurse sows had similar lifetime non-productive days with non-nurse sows ($P \geq 0.07$), but produced 9.3-12.0 more lifetime piglets weaned than non-nurse sows ($P < 0.01$). Using nurse sows could be a good practice to cope with highly prolific sows.

Keywords: herd management, highly prolific sows, lifetime performance, porcine characteristics, swine

1. Introduction

The number of piglets born alive per litter (PBA) has been increasing in breeding herds during the last few decades (Andersson, Frössling, Engblom, Algers, & Gunnarsson, 2016; Małopolska, Tuz, & Lambert, 2018; Nielsen, Kristensen, & Moustsen, 2018). This means that in some prolific sows the PBA can exceed the number of functional teats which is usually 14 (Klopfenstein, Farmer, & Martineau, 2006; Amdi et al., 2017). One way to solve this problem is to use nurse sows, and this practice is intensively applied in Denmark and the Netherlands (Baxter et al., 2013). A nurse sow is a sow that weans its own litter and additional litters or excess piglets from other sows in a same lactation period.

A Danish study investigated the effects of nursing on subsequent reproductive performance, and found that the only negative effect was prolonged weaning-to-first-mating interval (Bruun et al., 2016). Prolonged WMI increases non-productive sow days which can result in a decreased sow lifetime productivity (Koketsu, Tani, & Iida, 2017). It was also reported that sows with WMI 0-3 and 7 days or more had lower subsequent reproductive performance than those with WMI 4-6 days (Hoshino & Koketsu, 2008). Furthermore, it is important to have a stable proportion of sows with WMI 0-6 days for breeding herd producers using a weekly group production system in order to achieve the target number of served sows per week (Kirkwood & De Rensis, 2016). However, there have not been any reports about the effect of nursing on the proportions of WMI 0-3, 4-6, 7-20 and 21 days or more and their subsequent reproductive performance.

Spain is an important pig producing country, but scarce studies have assessed the performance of nurse sows from the first nurse events to their removal. Additionally, no single study has compared nurse sows and

non-nurse sows in different parities for sow lifetime productivity, such as annualized lifetime piglets weaned. Thus, the objective in the present study was to characterize use of nurse sows in Spanish breeding herds.

2. Method

2.1 Studied Herds

A veterinary consultancy firm (PigCHAMP pro Europa S.L., Segovia, Spain) has accumulated a pig database by requesting all client producers to mail their data files on a regular basis. In July 2017, reproductive performance records and lifetime productivity records of sows in 155 Spanish client herds were extracted from the database between 2011 and 2017. Sixty-nine of the 155 herds that had nurse sow records used in this study. The gestation and lactation diets of sows in the studied herds were formulated by using cereals (barley, wheat and corn) and soybean meal. Replacement gilts in the herds were either purchased from breeding companies or home-produced through internal multiplication programs.

Spain is one of the major pig producing countries in Europe; there were 19 630 breeding herds with 2 568 450 sows, and the average herd size was 131 sows in December 2013 (European Commission, 2017). In our study, the average herd size (SE) in 2011-2016 was 1 013 (103.1) sows with a range of 80 to 3 678 sows. Also, the average number of piglets weaned per sow per year was 25.4 (0.25) piglets with a range of 19.3 to 30.0 piglets.

2.2 Study Design and Exclusion Criteria

The present study was designed as a retrospective cohort study, coordinating records of 94 919 sows that were entered into the 69 herds between 2011 and 2013. The dataset included all the farrowing records (parity records) from 2011 to 2017 of the sows from their first-farrowing to removal.

At the time the data were collected, 1 241 (1.3%) sows were still active in the herds and so they were not used for analysis because they did not have lifetime records. Also, sows in the 99th percentile for lifetime non-productive days were excluded (262 days or more; 908 sows). In addition, sows were excluded as incorrect records if they had a nurse sow record that showed only 1 litter weaned during a nursing event (54 sows). Thus, the lifetime records of the remaining 92 716 sows were used for lifetime performance analyses (Dataset 1).

In 478 562 parity records of these sows, records were excluded if they met any of the following criteria: total number of piglets born was 0 or 31 piglets or more (500 records; Bloemhof, Mathur, Knol, & van der Waaij, 2013); WMI of 61 days or more (524 records; Marois, Brisbane, & Laforest, 2000); lactation length of 0-9 days (6 167 records; Hoving, Soede, Graat, Feitsma, & Kemp, 2011); and 0 piglets weaned (3 905 records). Parity records of nurse sow were also excluded if they had weaned 4 litters during a nursing event (7 records), because there were too few cases to analyze. In addition, parity records of non-nurse sow were excluded if they had lactation length of 42 days or more (1 348 records; Hoving, Soede, Graat, Feitsma, & Kemp, 2011). Hence, 466 111 parity records of sows were used for analyses of reproductive performance (Dataset 2).

2.3 Categories and Definitions

Sows were categorized into two sow groups: nurse and non-nurse sows in each parity. Nurse sows were defined as sows that had weaned 2 or 3 litters in the same lactation period. Lifetime PBA and piglets weaned were the sums of the number of PBA and piglets weaned in a sow's lifetime, respectively. Annualized lifetime PBA and piglets weaned were defined as the lifetime PBA and piglets weaned, respectively, divided by the sum of reproductive herd life days, multiplied by 365. Reproductive herd life days was defined as the time between the date of first service and the date of removal (Sasaki & Koketsu, 2011). Lifetime non-productive days is the number of days when sows were neither gestating nor lactating in their reproductive herd life.

2.4 Statistical Analysis

All analyses were performed using SAS University Edition 2018 (SAS Inst. Inc., Cary, NC). All significance test levels were set at 0.05. Pairwise multiple comparisons were made using the Tukey-Kramer method.

Generalized linear mixed effect models were applied to the datasets by using MIXED and GLIMMIX procedure. Two statistical Models were created: Model 1 was applied to lifetime performance data (Dataset 1), and compared lifetime productivity between nurse and non-nurse sows; Model 2 was applied to reproductive performance data (Dataset 2), and compared sow reproductive performance between the two sow groups. Model 1 included the sow groups and entry year as fixed effects, whereas Model 2 included sow groups, quarterly farrowing month groups and entry year as fixed effects. A random herd effect was added to the both models to account for the clustering of sows within a herd. Model 1 was repeatedly constructed based on the sow groups in parity 1 to 6. Model 2 was constructed by parity.

A Fisher's exact test was used to access that distributions of the number of piglets weaned and lactation length differ between nurse sows that weaned two litters and three litters. Associations between lactation length in first litter and second litter of nurse sows were also examined.

3. Results

There were 6 705 of the 92 716 sows (7.2%) that served as nurse sows at least once in their lifetime (Table 1) with 7 442 nurse events in 466 111 parity records (1.6%). Mean total lactation length and total number of piglets weaned (SE) in nurse sows were 31.0 (0.11) days and 21.9 (0.04) piglets, respectively. Table 2 shows the parity of the first nurse events and what happened to the nurse sows after weaning. For example, of the 1 223 sows that nursed in parity 1, 13.1% had a second nurse event but 82.6% had no second nurse event in a later parity. Overall, 10.2% of the 6 705 first nurse sows had a second nurse event in a later parity. Also, the proportion of nurse sows culled without any subsequent service increased from 3.9% in parity 1 to 66.6% in parity 6 or higher. Furthermore, 2 988 of 6 705 first nurse sows (44.6%) were parity 5 or higher sows.

Of the 7 442 nursing events, 98.5 and 1.5% weaned two and three litters, respectively. There were differences between the nurse sows that weaned two and three litters in the distributions of the total number of piglets weaned and total lactation length ($P < 0.01$; Figure 1). For example, 70% of the nurse sows that weaned two litters produced 20-24 piglets weaned, whereas 70% of the nurse sows that weaned three litters produced 29-36 piglets weaned (Figure 1A). Also, 70% of the nurse sows that weaned two litters had total lactation length of 19-33 days, whereas 70% of the nurse sows that weaned three litters had lactation length of 22-42 days (Figure 1B). In addition, the frequency distributions (%) of lactation length differed between the first and second litter in nurse sows that weaned two litters ($P < 0.05$; Figure 2). For example, 60% of the nurse sows had 18-24 days of lactation length for the first litter, whereas for the second litter the lactation length of 60% of sows were only 3-9 days.

Nurse sows had 3.8-8.6 days longer total lactation than non-nurse sows across parities ($P < 0.01$; Table 3). Also, nurse sows had 0.3-0.6 fewer PBA prior to the nurse events in parity 3 or higher, and had 0.2 more piglets weaned in the first lactation in parities 1, 2 and 4 than non-nurse sows ($P < .05$). With regard to reproductive performance after nurse event, there was no difference between nurse and non-nurse sows in farrowing rate in any parity ($P \geq 0.13$) and in PBA in parities 1-5 ($P \geq 0.15$). However, 2.5-19.9% more nurse sows than non-nurse sows were culled without subsequent service after parity 1 ($P < 0.01$). Nurse sows had 3.8-5.4 days longer farrowing-to-first-mating intervals than non-nurse sows across parities ($P < 0.01$).

The proportion of WMI 4-6 days was 3.4-10.0% lesser in nurse sows than in non-nurse sows in parities 2 and 4 or higher, but the proportion of WMI 7-20 days was 1.9-3.1% greater in parity 2 or higher ($P < 0.05$; Table 4). In addition, nurse sows had 2.1-5.3% greater proportions of WMI 0-3 days than non-nurse sows in parities 5 and 6 ($P < 0.05$).

Table 5 shows comparisons of lifetime productivity between nurse sows and non-nurse sows that were categorized in different parities. Sows that nursed in any parity had 9.3-12.0 more lifetime piglets weaned and 3.7-7.4 more annualized lifetime piglets weaned than non-nurse sows ($P < .001$), but there was no difference between the groups for lifetime non-productive sow days ($P \geq 0.07$). However, the parity at removal for sows that nursed in parities 5 and 6 was 0.2 lower than non-nurse sows ($P < 0.01$). Also, sows that nursed in parity 3 or higher had 1.6-3.5 fewer lifetime PBA, and sows that nursed in parity 2 or higher had 0.4-0.8 fewer annualized lifetime PBA than non-nurse sows ($P < 0.05$).

Table 1. Lifetime and parity records of sows in 69 Spanish commercial breeding herds

Measurements	N	Mean (SE)	Medium (IQR)
Lifetime records			
Sows that had nurse events, %	92 716	7.2 (0.09)	-
Parity at removal	92 716	5.2 (0.01)	6 (3-7)
Lifetime piglets born alive	92 716	64.5 (0.11)	68 (35-92)
Lifetime piglets weaned	92 716	56.4 (0.10)	61 (32-80)
Lifetime non-productive days	92 716	66.9 (0.16)	52 (31-90)
Annualized lifetime piglets born alive	92 716	29.0 (0.02)	30 (25-33)
Annualized lifetime piglets weaned	92 716	25.4 (0.02)	26 (23-29)
Parity records			
Farrowed parity	466 111	3.7 (0.01)	3 (2-5)
Piglets born alive prior to any nurse event	466 111	12.6 (0.01)	13 (11-15)
Total number of piglets weaned	466 111	11.1 (0.01)	11 (10-12)
Piglets weaned in the first litter of nurse sows in nursing parity*	7 330	11.0 (0.02)	11 (10-12)
Piglets weaned in the second litter of nurse sows in nursing parity*	7 330	10.7 (0.02)	11 (10-12)
Total lactation length, days	466 111	23.0 (0.01)	22 (20-26)
First litter lactation length in nurse sows, days*	7 330	21.0 (0.06)	21 (18-24)
Second litter lactation length in nurse sows, days*	7 330	9.8 (0.08)	7 (5-14)
Farrowing-to-first-mating intervals, days	407 426	28.8 (0.01)	27 (25-31)
Weaning-to-first-mating interval, days	407 426	5.8 (0.01)	5 (4-5)
Proportion of weaning-to-first-mating interval 0-3 days, %	407 426	7.7 (0.04)	-
Proportion of weaning-to-first-mating interval 4-6 days, %	407 426	81.2 (0.06)	-
Proportion of weaning-to-first-mating interval 7-20 days, %	407 426	7.8 (0.04)	-
Proportion of weaning-to-first-mating interval 21 days or more, %	407 426	3.3 (0.03)	-
Farrowing rate, %	407 426	88.4 (0.05)	-

Note. SE: standard error; IQR: interquartile range.

* The remaining records (7 442-N) were nurse sows that weaned three litters, and there were no individual records of number of piglets weaned and lactation length for each litter.

Table 2. Subsequent service, second nurse events and removal information in 6 705 sows that had a first nurse event in each parity

Parity of first nurse event	N	Nurse sows with subsequent service							Sows with no second nurse event, %	Sows culled without subsequent service, %	Sows that died without subsequent service, %
		Sows with second nurse event (%) at each subsequent parity									
		2	3	4	5	6	≥ 7	Total			
1	1 223	4.3	2.9	2.0	0.9	1.4	1.6	13.1	82.6	3.9	0.4
2	925	-	4.1	3.7	2.8	2.1	2.3	14.9	78.6	5.7	0.8
3	801	-	-	5.7	2.9	2.0	4.1	14.8	75.1	9.5	0.6
4	768	-	-	-	4.4	3.8	3.6	11.9	75.5	11.9	0.7
5	669	-	-	-	-	5.1	2.7	7.8	71.4	20.2	0.6
≥ 6	2 319	-	-	-	-	-	5.3	5.3	27.1	66.6	1.0
Total	6 705	0.8	1.1	1.6	1.4	1.7	3.4	10.2	60.0	29.1	0.7

Table 3. Comparisons of reproductive performance between nurse and non-nurse sows*

Nurse groups	Parity 1	Parity 2	Parity 3	Parity 4	Parity 5	Parity 6
	-- Mean (SE) --					
Number of piglets born alive prior to the nurse events						
Nurse sows	11.7 (0.13)	12.2 (0.13)	12.6 (0.13)[b]	12.8 (0.13)[b]	12.6 (0.14)[b]	12.2 (0.14)[b]
(No. of sows)	(1 220)	(976)	(875)	(879)	(767)	(949)
Non-nurse sows	11.7 (0.10)	12.4 (0.08)	13.0 (0.09)[a]	13.1 (0.09)[a]	13.0 (0.09)[a]	12.8 (0.09)[a]
(No. of sows)	(88 944)	(79 021)	(71 420)	(63 368)	(55 080)	(45 563)
Number of piglets weaned in the first lactation						
Nurse sows	11.1 (0.10)[a]	11.2 (0.10)[a]	11.1 (0.10)	11.1 (0.09)[a]	10.9 (0.10)	10.6 (0.10)
(No. of sows)	(1 220)	(976)	(875)	(879)	(767)	(949)
Non-nurse sows	10.9 (0.08)[b]	11.0 (0.07)[b]	11.0 (0.07)	10.9 (0.07)[b]	10.8 (0.07)	10.7 (0.08)
(No. of sows)	(88 944)	(79 021)	(71 420)	(63 368)	(55 080)	(45 563)
Total lactation length						
Nurse sows	28.1 (0.33)[a]	28.2 (0.31)[a]	29.0 (0.32)[a]	28.8 (0.32)[a]	30.0 (0.33)[a]	32.5 (0.35)[a]
(No. of sows)	(1 220)	(976)	(875)	(879)	(767)	(949)
Non-nurse sows	24.3 (0.32)[b]	23.9 (0.30)[b]	23.9 (0.30)[b]	23.9 (0.30)[b]	23.9 (0.31)[b]	23.9 (0.33)[b]
(No. of sows)	(88 944)	(79 021)	(71 420)	(63 368)	(55 080)	(45 563)
Proportion of sows culled without subsequent service, %						
Nurse sows	4.1 (0.63)	6.0 (0.83)[a]	8.2 (1.02)[a]	10.4 (1.21)[a]	19.1 (1.83)[a]	34.2 (0.03)[a]
(No. of sows)	(1 220)	(976)	(875)	(879)	(767)	(949)
Non-nurse sows	4.3 (0.27)	3.5 (0.22)[b]	4.2 (0.37)[b]	5.3 (0.36)[b]	7.8 (0.53)[b]	14.3 (1.35)[b]
(No. of sows)	(88 944)	(79 021)	(71 420)	(63 368)	(55 080)	(45 563)
Farrowing-to-first-mating intervals, days						
Nurse sows	35.5 (0.45)[a]	34.1 (0.38)[a]	34.3 (0.39)[a]	33.9 (0.38)[a]	33.9 (0.40)[a]	34.6 (0.40)[a]
(No. of sows)	(1 167)	(911)	(791)	(775)	(614)	(528)
Non-nurse sows	31.7 (0.39)[b]	29.8 (0.33)[b]	29.7 (0.33)[b]	29.5 (0.33)[b]	29.4 (0.34)[b]	29.2 (0.33)[b]
(No. of sows)	(84 170)	(75 981)	(67 929)	(59 456)	(50 308)	(37 571)
Farrowing rate, %						
Nurse sows	87.8 (1.13)	89.7 (1.13)	88.6 (1.24)	87.3 (1.26)	90.1 (1.23)	86.2 (1.63)
(No. of sows)	(1 167)	(911)	(791)	(775)	(614)	(528)
Non-nurse sows	86.4 (0.52)	88.9 (0.44)	89.0 (0.36)	88.7 (0.37)	88.9 (0.37)	87.9 (0.42)
(No. of sows)	(84 170)	(75 981)	(67 929)	(59 456)	(50 308)	(37 571)
Subsequent piglets born alive						
Nurse sows	12.4 (0.12)	13.1 (0.14)	13.3 (0.14)	13.1 (0.15)	12.9 (0.16)	12.8 (0.17)[a]
(No. of sows)	(1 095)	(852)	(728)	(700)	(554)	(476)
Non-nurse sows	12.4 (0.08)	13.0 (0.09)	13.1 (0.09)	13.0 (0.08)	12.8 (0.09)	12.5 (0.10)[b]
(No. of sows)	(77 952)	(70 878)	(63 142)	(54 812)	(45 718)	(33 025)

Note. SE: standard error.

*Means and SE were estimated by using mixed models.

[ab]Different superscripts within a column represent significant differences in means ($P < 0.05$).

Table 4. Comparisons of four groups of proportions of weaning-to-first-mating interval between nurse and non-nurse sows*

Nurse groups	Parity 1	Parity 2	Parity 3	Parity 4	Parity 5	Parity 6
-- Number of sows --						
Nurse sows	1 167	911	791	775	614	528
Non-nurse sows	84 170	75 981	67 929	59 456	50 308	37 571
-- Mean (SE) --						
Proportion of weaning-to-first-mating interval 0-3 days, %						
Nurse sows	2.5 (0.49)	3.6 (0.66)	3.8 (0.69)	5.3 (0.89)	8.0 (1.31)[a]	11.6 (1.84)[a]
Non-nurse sows	2.0 (0.23)	3.1 (0.36)	4.5 (0.49)	4.8 (0.54)	5.9 (0.66)[b]	6.3 (0.72)[b]
Proportion of weaning-to-first-mating interval 4-6 days, %						
Nurse sows	76.8 (1.87)	80.5 (1.70)[b]	82.7 (1.67)	81.4 (1.77)[b]	77.8 (2.22)[b]	74.6 (2.54)[b]
Non-nurse sows	78.5 (1.19)	85.1 (0.83)[a]	84.1 (0.93)	84.8 (0.93)[a]	84.1 (1.11)[a]	84.6 (1.09)[a]
Proportion of weaning-to-first-mating interval 7-20 days, %						
Nurse sows	11.3 (1.37)	10.3 (1.27)[a]	9.9 (1.21)[a]	8.2 (1.13)[a]	8.8 (1.34)[a]	7.5 (1.30)[a]
Non-nurse sows	11.1 (0.93)	7.2 (0.54)[b]	7.1 (0.48)[b]	6.3 (0.43)[b]	5.9 (0.47)[b]	5.3 (0.41)[b]
Proportion of weaning-to-first-mating interval 21 days or more, %						
Nurse sows	6.2 (0.93)	3.5 (0.73)	2.1 (0.57)	3.2 (0.76)	2.6 (0.71)	3.1 (0.84)[a]
Non-nurse sows	5.5 (0.45)	2.6 (0.22)	2.4 (0.20)	2.2 (0.19)	2.0 (0.19)	1.8 (0.17)[b]

Note. SE: standard error.

* Means and SE were estimated by using mixed models.

[ab] Different superscripts within a column represent significant differences in means ($P < 0.05$).

Table 5. Comparisons of sow lifetime productivity between nurse sows and non-nurse sows*

Nurse groups	Parity 1	Parity 2	Parity 3	Parity 4	Parity 5	Parity 6
-- Number of sows --						
Nurse sows	1 223	977	877	882	768	952
Non-nurse sows	91 493	80 704	72 764	64 688	56 262	46 925
-- Mean (SE) --						
Parity at removal						
Nurse sows	5.3 (0.11)	5.7 (0.09)	6.1 (0.08)	6.5 (0.07)	6.7 (0.07)[b]	7.1 (0.06)[b]
Non-nurse sows	5.3 (0.08)	5.8 (0.07)	6.2 (0.06)	6.6 (0.05)	6.9 (0.05)[a]	7.3 (0.05)[a]
Lifetime piglets born alive						
Nurse sows	65.9 (1.37)	71.3 (1.25)	76.0 (1.16)[b]	80.4 (1.06)[b]	84.0 (1.01)[b]	89.0 (0.92)[b]
Non-nurse sows	65.7 (0.95)	72.3 (0.81)	77.6 (0.74)[a]	82.6 (0.72)[a]	87.5 (0.70)[a]	92.5 (0.71)[a]
Lifetime piglets weaned						
Nurse sows	68.7 (1.16)[a]	73.4 (1.05)[a]	78.2 (0.96)[a]	82.4 (0.87)[a]	84.5 (0.82)[a]	88.9 (0.74)[a]
Non-nurse sows	56.7 (0.81)[b]	62.5 (0.70)[b]	67.0 (0.63)[b]	71.1 (0.61)[b]	75.2 (0.60)[b]	79.3 (0.59)[b]
Lifetime non-productive days						
Nurse sows	71.1 (2.29)	74.7 (2.41)	75.1 (2.49)	73.7 (2.46)	71.6 (2.52)	73.1 (2.41)
Non-nurse sows	71.7 (1.80)	73.4 (1.84)	73.7 (1.88)	73.4 (1.89)	72.3 (1.93)	70.3 (1.96)
Annualized lifetime piglets born alive						
Nurse sows	28.5 (0.30)	29.1 (0.28)[b]	29.3 (0.28)[b]	29.8 (0.28)[b]	30.3 (0.29)[b]	30.4 (0.28)[b]
Non-nurse sows	28.7 (0.23)	29.5 (0.22)[a]	30.1 (0.23)[a]	30.5 (0.23)[a]	30.8 (0.24)[a]	31.2 (0.25)[a]
Annualized lifetime piglets weaned						
Nurse sows	32.2 (0.27)[a]	31.3 (0.25)[a]	31.0 (0.25)[a]	31.1 (0.24)[a]	30.7 (0.24)[a]	30.5 (0.24)[a]
Non-nurse sows	24.8 (0.21)[b]	25.6 (0.21)[b]	26.1 (0.22)[b]	26.3 (0.21)[b]	26.5 (0.22)[b]	26.8 (0.22)[b]

Note. SE: standard error.

* Means and SE were estimated by using mixed models.

[ab] Different superscripts within a column represent significant differences in means ($P < 0.05$).

4. Discussion

Our study clearly showed that nurse sows produced lifetime piglets weaned more efficiently than non-nurse sows, regardless of the nursing parity, but still had similar farrowing rates and PBA to non-nurse sows. These results suggest that the use of nurse sows may be a good practice in breeding herds to cope with the large numbers of piglets born per litter in highly prolific sows. This practice can also increase the number of lifetime piglets weaned in low prolific sows.

One concern regarding the use of nurse sows is the increase in WMI, reflected in our data by a lesser proportion of WMI 4-6 days and a greater proportion of WMI 7-20 days for nurse sows than for non-nurse sows in parity 2 or higher. These nurse sows would suffer from a loss of body weight or backfat thickness due to insufficient feed intake during the prolonged lactations (S. S. Anil, L. Anil, Deen, Baidoo, & Walker, 2006). So, the prolonged WMI in pairty 2 or higher nurse sows could be suppressed by providing sufficient lactational feed. Meanwhile, the prolonged suckling intervals or changed suckling intensity when nurse sows receive a second or third litter could cause an occurrence of estrus during lactation (van Nieuwamerongen, Bolhuis, van der Peet-Schwering, & Soede, 2014). Such prolonged suckling intervals or changed suckling intensity might be a cause of the increased occurrence of 0-3 days WMI in high parities in our study.

Our study showing the lack of any effect of nursing on farrowing rates and PBA, and negative effect on WMI in parity 2 or higher is consistent with a Danish study (Bruun et al., 2016). These counter-effects of nursing can be explained by the different reproductive mechanism between WMI and farrowing rates, or between WMI and PBA. The WMI is directly related to the estrus resumption which is highly related to gonadotropic secretion and follicle development in the hypothalamus-pituitary-ovary axis (Hoving, Soede, Graat, Feitsma, & Kemp, 2011). In contrast, farrowing rates and PBA are not directly associated with this estrus resumption (Vinsky, Novak, Dixon, Dyck, & Foxcroft, 2006; Bertoldo, Holyoake, Evans, & Grupen, 2012). In addition, our study showed that nurse sows had longer farrowing-to-first-mating intervals than non-nurse sows. This could be due to prolonged lactation length and prolonged WMI in nurse sows, and cause the fewer annualized lifetime PBA in nurse sows than in non-nurse sows.

Sows that nursed in parity 1 had similar lifetime PBA and proportions of WMI 4-6 days to non-nurse sows in our study. This suggests that nurse sows are chosen as suitable sows to nurse a second litter based on their body reserve and feed intake, but not on PBA in their first litter. These sows could have enough body reserves and sufficient feed intake during the first lactation, and so still be able to resume normal estrus postweaning (Eissen, Apeldoorn, Kanis, Verstegen, & de Greef, 2003).

Our study indicates that nurse sows that does not show postweaning estrus or had health problems during their lactation are culled without subsequent service. A previous study also reported a high risk of nurse sows having udder wounds and bursa on joint legs (Sørensen, Rousing, Kudahl, Hansted, & Pedersen, 2016), which might be caused by the occurrence of teat fights by piglets (Schmitt, Baxter, Boyle, & O'Driscoll, 2019), and by the prolonged stay in farrowing crate. Higher culling rate and lower parity at removal in nurse sows also can explain the discrepancy between the increased WMI in nurse sows but no difference between nurse and non-nurse sows in lifetime non-productive days.

The Spanish herds in our study had fewer nurse events than Danish herds where studies have reported parity records containing 20% or more nurse sow records (Hales, Moustsen, Nielsen, & Hansen, 2015; Bruun et al., 2016). The herds in our study had fewer PBA than the Danish herds, and so there could be not such frequent use of nurse sows. Also, the second litter lactation length of 3-9 days for 60% of the nurse sows in our study is considerably shorter than Danish nurse sow strategy of having 3 weeks of lactation length (Bruun et al., 2016).

Our study suggests that selection of nurse sows depended on the number of piglets weaned in relatively low parity and on PBA in relatively late parity. In parities 1, 2 and 4, nurse sows weaned more piglets in their own litter than non-nurse sows. Meanwhile, in mid or late parities, producers chose nurse sows that had farrowed few PBA. These sows might be prospective sows to be culled due to low prolificacy or management reasons. The reason that only 10% of the nurse sows were repeatedly used as a nurse could be due to that approximately half of all nurse sows were parity 5 or higher sows. There are several other criteria for choosing nurse sows, such as sows having good body condition, normal or high feed intake and good nursing behavior (Bruun et al., 2016; Sørensen, Rousing, Kudahl, Hansted, & Pedersen, 2016; Schmitt, Baxter, Boyle, & O'Driscoll, 2019).

5. Conclusion

The nurse sows in our study appeared to be mainly used by producers to provide additional lactation for older piglets that failed to grow sufficiently or where the mother sow died or suffered agalactia (Alexopoulos, Lines,

Hallett, & Plush, 2018). However, this situation may change in the near future due to increasing PBA in more prolific sows. Nurse sows can produce more efficiently lifetime piglets weaned than non-nurse sows, while having no reduced farrowing rate, PBA and no prolonged lifetime non-productive days. The disadvantage of slightly greater proportion of WMI 7-20 days in parity 2 or higher nurse sows could be overcome by providing sufficient lactational feed for nurse sows and having the necessary numbers of replacement gilts available to meet the target number of served sows per week.

There were some limitations in this observational study, such as that our herd analyses did not survey genotype, nutrition, herd hygiene or semen quality. However, even with such limitations, this research provides worthful information for veterinarians and producers about the use of nurse sows to cope with highly prolific sows.
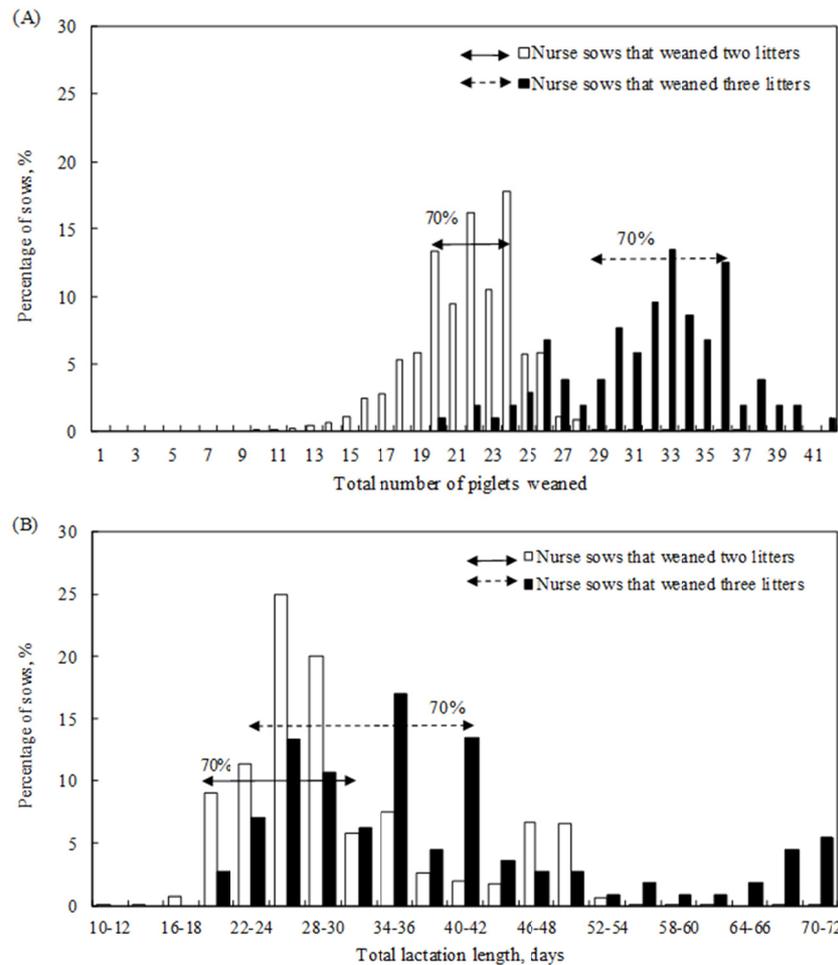
Figure 1. Relative frequency distributions (%) of (A) the total number of piglets weaned and (B) total lactation length for 7 330 parity records of nurse sows that weaned two litters, and 112 parity records of nurse sows that weaned three litters

Note. Frequencies within each group total 100%. Relative frequency distributions differed between nurse sows that weaned two and three litters ($P < 0.01$; Fisher's exact test).
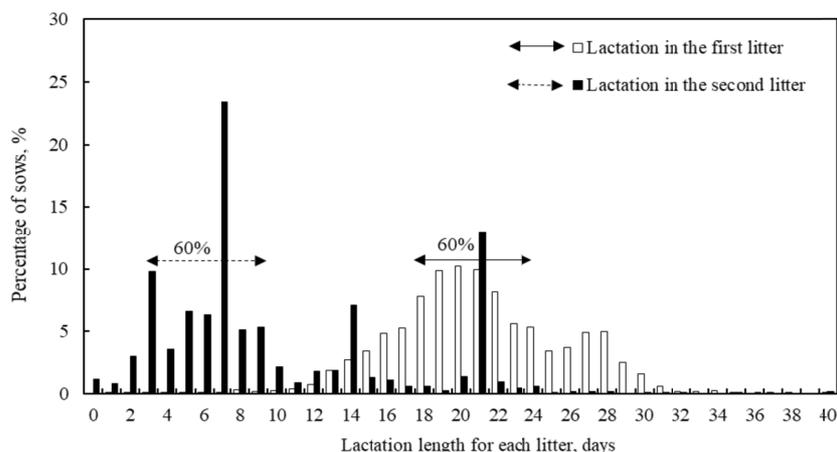
Figure 2. Relative frequency distributions (%) of the lactation length in the first and second litter for 7 330 parity records of nurse sows that weaned two litters

Note. Frequencies within each group total 100%. Relative frequency distributions differed between lactation length in the first litter and second litter ($P < 0.05$; Fisher's exact test).

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