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Original article

The effect of maternal and litter factors on piglet mortality rate

Argimiro Daza[a]*, José Nailton Bezerra Evangelista[b], Marta Glez Gutierrez-Barquin[a]

[a] Departamento de Producción Animal, ETS de Ingenieros Agrónomos, Ciudad Universitaria s/n, 28040 Madrid, Spain
[b] Facultade de Veterinariá, UECE Fortaleza-CE, Brazil

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Abstract — This investigation includes a total of 1 051 piglets, originating from 95 litters, who were offspring of 39 Large White × Landrace sows sired by Piétrain × Duroc boars. The mortality rates at birth and in the period of lactation were 3.2 and 28.3 %, respectively. The number of stillbirths per litter was increased ($P < 0.05$) by greater heterogeneity, measured as a coefficient of weight variation within the litter. The number of piglets lost during lactation increased ($P < 0.05$) with litter size, by an increasing coefficient of variation in average weight of liveborn piglets and by a descending average weight of birth. Parity order, season of farrowing and litter male/female class did not affect mortality at birth. However, a slightly higher number of deaths occurring during lactation was observed in parity 2 compared with parity 4 litters (3.1 vs. 2.4 %). In addition, mortality at birth was slightly higher for suckling piglets born in summer than for those born in spring and autumn (3.2 % vs. 2.4 and 2.5 %, respectively). Piglet losses increased as the milk yield on day 7 post partum was < 4 kg, but the total milk production during lactation did not affect mortality during the lactation period. A large percentage (69 %) of all piglet losses occurred in the 1st week of lactation. Piglet birth weights in the intervals > 1.25 kg, between 1.25 and 1.00 kg and < 1.00 kg resulted in mortality rates of 20, 39 and 61 %, respectively. Piglets lost during the lactation period were observed to have weight losses or low daily weight gains. (© Elsevier / Inra)

piglet / mortality rate at birth / preweaning mortality

Résumé — Effet des facteurs maternels et de la portée sur le taux de mortalité de porcelets. L'étude a porté sur 1 051 porcelets, provenant de 95 portées de 39 truies Large White × Landrace accouplées avec des mâles Piétrain × Duroc. Le taux de mortalité à la naissance et durant la période de lactation a été respectivement de 3,2 et de 28,32 %. Le nombre de porcelets mort-nés par portée a augmenté ($p < 0,05$) avec le coefficient de variation du poids des porcelets à la naissance. Le nombre de porcelets morts pendant la lactation a augmenté ($p < 0,05$) avec la taille de la portée, et avec l'accrois-

* Correspondence and reprints.

sement du coefficient de variation du poids des porcelets nés vivants à la naissance. En revanche, ce nombre a diminué lorsque le poids moyen du porcelet par portée à la naissance augmentait. L'ordre de mise bas, la saison de naissance et le type de portée (relation mâles / femelles) n'ont pas affecté la mortalité à la naissance. Cependant dans les portées de truies de deuxième mise bas, le nombre de porcelets morts a été supérieur à celui des portées de truies de quatrième mise bas (3,1 contre 2,4). En outre, le nombre de porcelets morts à la naissance a été plus important avec les portées nées en été que celles nées en automne et au printemps (3,2 contre 2,4 et 2,5 respectivement). Les pertes de porcelets ont augmenté durant la première semaine de lactation lorsque la production de lait des truies était inférieure à 4 kg en 7 j par porcelet. La production totale de lait pendant toute la lactation n'a cependant pas affecté la mortalité des porcelets de la naissance au sevrage. 69,2 % des pertes de porcelets ont été enregistrées pendant la première semaine après la mise bas. Avec des poids à la naissance > 1 250 g, compris entre 1 000 et 1 249 g et < 1 000 g, des taux de mortalité de 20, 39 et 61 % ont été respectivement observés après mise bas. Les porcelets morts durant la période de lactation étaient ceux qui avaient perdu du poids ou avaient eu de faibles gains de poids journaliers. (© Elsevier / Inra)

porcelet / mortalité à la naissance / mortalité naissance-sevrage

1. INTRODUCTION

On Spanish pig farms, the number of stillbirths averages 0.5 in first parity and 1 in the following parity litters. During lactation, the mortality rate varies between farms from 15 to 28 % [27].

Factors such as sow, piglet, litter and environmental and housing conditions are involved in piglet mortality. Although several of these factors (litter size, sow's age, weight of piglet at birth and temperature) have been studied previously [3, 5, 8, 13, 19, 21], the findings and conclusions were not decisive. Other factors such as heterogeneity in piglet birth weight, the sow's weight after farrowing and milk yield and changes in the weight of piglets during lactation have not often been considered.

The trend and causes of piglet mortality differ depending on the farm, but a high mortality rate occurs in the first days after farrowing and is mainly due to the fact that piglets are overlain, starving or weak [12, 14, 19, 36].

This study analyses the maternal effect, litter factors and season on piglet mortality rate at birth and during lactation.

2. MATERIALS AND METHODS

This study comprises a total of 1 051 piglets, of which there are 34 stillbirths and 289 piglets lost during lactation. These originated from 95 litters and were offspring of 39 Large White × Landrace sows, sired by Piétrain × Duroc boars. The sows were kept in pregnancy crates (0.5 × 1.8 m) and moved to maternity crates (0.6 × 2 m) 107–108 days after mating, until the piglets were weaned at the age of 42 days. The maternity crates were heated by infrared lamps, and the maximum–minimum temperatures in the middle of the pen and 0.5 m over the floor were recorded every day.

During pregnancy, sows were daily fed 2.5 kg of concentrate containing 2 960 Kcal digestible energy (DE)·kg^{-1}, 14 % crude protein (CP) and 0.61 % lysine. During lactation, the concentrate was administrated ad libitum and contained 3 100 Kcal DE·kg^{-1}, 16.5 % CP and 0.8 % lysine.

Piglets were identified by ear notching and weighed within 12 h after birth and sows were weighed after farrowing (the same day).

Stillbirths were subdivided into antepartum and intrapartum deaths (deaths during pregnancy with tissue degeneration and deaths during farrowing determined as failure of the lungs to float in water, respectively). When the piglet died during the lactation period, its age and weight were recorded.

Daily sow milk production was measured according to the weigh-suckle-weigh technique

on days 7, 14, 21, 28, 35 and 42 of lactation according to Noblet and Etienne [22, 23]. On these days, 12 sucklings were measured for each piglet, with 60-min intervals between sucklings, using an electronic scale with an integration system.

Birth mortality rate per litter, hereafter identified as mortality rate, and the number of stillbirths per litter were studied by an analysis of covariance, including the following fixed effects: the parity order (1, 2, 3 and > 4), the season of birth (December–February, March–May, June–August and September–November) and the litter male/female class (1: litters of more males than females; 2: litters of more females than males; 3: litters with the same proportion of males to females) and parity order × birth season interaction. The statistical model included as covariable number of piglets born, the average piglet birth weight, the coefficient of variation of birth weights within litters and the sow weight after farrowing. During lactation, mortality rate and the number of dead piglets were studied using a similar statistical model as that mentioned earlier. However, the covariable total milk yield per weaned piglet in the 1st week of lactation and during the whole lactation, average weight of piglet, the number of liveborn piglet and the coefficient of variation in the piglet weight at birth within litters were used.

The relationship between the mortality rate and the variables (number of piglets born, piglets liveborn, average piglet weight, coefficient of variation, sow weight after farrowing and total milk yield per weaned piglet) was studied by *t*-test.

Moreover, linear regressions between piglet mortality rate and these variables were calculated. The chi-square test was used to compare mortality rate. The statistical analyses were carried out using the GLM procedure from SAS [28].

3. RESULTS

3.1. Mortality rate at birth

Of a total of 1 051 piglets at birth, 34 (23 females and 11 males) were stillborn, the weight of which averaged 784 g (778 g for males and 794 g for females). Mortality rate for males and females was 2.1 % and 4.4 %, respectively ($P < 0.01$). Of the 34 stillbirths, eight (five females and three males) died during pregnancy and the weight at birth averaged 492 g.

The mortality rate and the number of stillborns were not affected by parity order, season of birth and litter male/female class. However, a non-significant increase of mortality rate was observed in litters of older sows and in litters of less male than female or an equal number of male and female foetuses (*table I*).

The higher average weight of piglet and the lower coefficient of variation in piglet weight at birth, the lower the number of stillbirths per litter (*table II*). The effect of the average piglet weight (x_2 in kg) and the coefficient of variation in the piglet weight at birth (x_3 in %) on mortality rate at birth (Y) are shown in the following linear regression equations:

$$Y = 14 - 7.5\, x_2 \; (R^2 = 0.45;\; P < 0.04)$$
$$Y = -5.0 + 0.4\, x_3 \; (R^2 = 0.17;\; P < 0.001)$$

The mortality rate and the number of stillbirths were not affected by litter size or sow's weight after farrowing.

3.2. Mortality rate during lactation

Of 1 017 liveborn piglets, 289 or 28.4 % were lost during lactation. The mortality rates averaged 28.5 % for males and 28.3 % for females ($P > 0.05$).

The parity order, season of birth and the litter male/female class had no influence on mortality rate (*table I*), but the number of piglets lost was higher ($P < 0.05$) in the second litters and for summer farrowings.

However, as the litter size and the number of liveborn piglets increased and the average weight of liveborn decreased, the number of piglets lost and mortality rate during lactation increased significantly (*table III*). The following linear regression equations show the relationship between mortality rate during the lactation period

Table I. Effect of parity order, season of birth and litter male/female class on mortality (least square means ± standard error).

	Number of litters	Litter performance				
		Number of liveborn piglets	Number of stillborn piglets	Percentage of stillborn piglets	Number of piglets lost during lactation period	Mortality rate during lactation %
Parity order						
1	21	8.9 ± 3.1	0.1 ± 0.28	1.6 ± 2.8	2.9 ± 0.23[ab]	24.8 ± 6.0
2	22	11.9 ± 2.1	0.1 ± 0.22	1.7 ± 2.2	3.1 ± 0.27[a]	31.8 ± 4.7
3	18	10.4 ± 3.1	0.4 ± 0.19	3.3 ± 1.8	2.9 ± 0.24[ab]	30.0 ± 4.1
> 4	34	11.2 ± 3.4	0.6 ± 0.22	5.5 ± 2.3	2.4 ± 0.19[b]	24.6 ± 5.5
Birth season[1]						
Dec–Jan (14.5 °C)	24	10.8 ± 3.5	0.3 ± 0.17	3.1 ± 1.7	3.0 ± 0.22[ac]	25.6 ± 3.5
Mar–May (22.4 °C)	29	11.9 ± 2.4	0.3 ± 0.14	3.1 ± 1.6	2.5 ± 0.18[ab]	24.8 ± 3.1
Jun–Aug (27.8 °C)	17	9.8 ± 3.2	0.3 ± 0.20	2.9 ± 2.0	3.2 ± 0.28[c]	34.3 ± 4.4
Sept–Nov (18.7 °C)	25	10.0 ± 3.4	0.4 ± 0.15	3.0 ± 1.4	2.4 ± 0.19[ab]	23.3 ± 3.2
Litter male/female class[2]						
M > F	39	10.8 ± 3.8	0.1 ± 0.12	0.8 ± 1.2	2.7 ± 0.17	28.6 ± 2.5
M < F	37	10.9 ± 2.6	0.3 ± 0.12	3.4 ± 1.2	2.6 ± 0.16	22.0 ± 2.6
M = F	19	10.1 ± 3.2	0.5 ± 0.18	4.8 ± 1.8	3.1 ± 0.24	30.4 ± 3.9

[1] Mean environmental temperatures in farrowing pen.
[2] M > F = litters of more males than females; M < F = litters of more females than males.
M = F = litters of equal numbers of males and females.
[a b c] Means with different superscript letters differ at $P < 0.05$.

Table II. Effect of piglets born (BP), average piglet weight at birth (PW), coefficient of variation of piglet birth weight within litter weight (CV) and sow weight after farrowing (SW) on the number of stillbirths per litter.

Stillborn piglets	N	BP	PW (kg)	CV (%)	SW (kg)
0	71	10.72 ± 3.4^{a}	1.47 ± 0.23^{a}	18.0 ± 7.1^{a}	220.0 ± 19.4^{a}
1	18	12.44 ± 1.9^{b}	1.34 ± 0.17^{b}	21.4 ± 5.9^{a}	220.0 ± 14.7^{a}
> 2	6	11.00 ± 3.5^{ab}	1.31 ± 0.09^{ab}	28.7 ± 8.0^{b}	209.5 ± 29.7^{a}

N: number of litters.
[ab] Within columns means with different superscripts differ at $P < 0.05$.

Table III. Effect of liveborn piglets (LBP), average piglet weight at birth (PW), coefficient of variation of piglet weight within litters (CV), sow weight after farrowing (SW), milk yield per weaned piglet on day 7 (MP7) and milk production during the whole lactation (MP) on the number of stillbirths per litter during lactation.

Stillborn piglets	N	LBP	PW (kg)	CV (%)	SW (kg)	MP7 (kg)	MP (kg)
0–1	33	8.1 ± 3.4^{a}	1.55 ± 0.23^{a}	15.8 ± 8.6^{a}	219 ± 20.1^{a}	5.0 ± 2.8^{a}	29.2 ± 7.4^{a}
2–3	29	10.6 ± 2.5^{b}	1.43 ± 0.23^{b}	21.2 ± 6.7^{b}	216 ± 21.0^{a}	4.4 ± 1.2^{ab}	29.8 ± 6.9^{a}
> 4	33	13.0 ± 2.2^{c}	1.33 ± 0.16^{c}	20.7 ± 5.9^{b}	222 ± 16.8^{a}	4.0 ± 1.1^{c}	32.1 ± 7.4^{a}

N: number of litters.
[ab] Within columns means with different superscripts differ at $P < 0.05$.

(Y in %) and the number of liveborn piglets (x_1) and average piglet weight (x_2 in kg) and the coefficient of variation (x_3 in %).

$$Y = 26.8 - 2.22\,x_1 + 0.19\,x_2\ (R^2 = 0.12;\ P < 0.002)$$
$$Y = 48.0 - 14.50\,x_2\ (R^2 = 0.044;\ P < 0.04)$$
$$Y = 17.9 + 0.45\,x_3\ (R^2 = 0.04;\ P < 0.04)$$

The results of the analyses of covariance and linear regressions between mortality rate and the variables such as sow weight after farrowing and milk yield on day 7 and during the whole lactation showed that these variables had no significant effect on mortality rate during lactation. However, it was observed that milk yield was lower on day 7 in litters with four or more stillbirths than with no or only one stillborn piglet (*table III*).

The mortality rate increased significantly ($P < 0.005$) as the piglet weight at birth decreased (*table IV*). Only 38 % of the piglets, with birth weight < 1.00 kg, were weaned compared to 80 % in the class > 1.25 kg.

During the preweaning period, 69 % of the losses occurred during the 1st week and the piglets showed a low weight loss as birth weight decreased. In weeks 2–6, the mortality rate was significantly lower ($P < 0.05$) than in week 1 (*table IV*).

4. DISCUSSION

It is well established that piglet mortality rate at farrowing is increased by parity order. The stillbirths in the first three parities ranged from 0.5 to 0.6, increasing from 0.65 to 0.9 in litters from parity 4 sows [9]. In agreement with our studies, the mortality in parity 1–3 litters had been found to vary and to increase thereafter [7, 29, 35]. However, other studies have shown that parity order had no significant influence on mortality rate [26] and that the mortality rate decreased in consecutive parities ([8] in Hampshire sows).

Our finding that the season of farrowing did not affect mortality rate at birth agrees with Siewerdt et al. [30] and Sreckovick et al. [32], whereas other authors [8] reported a higher number of stillbirths in spring farrowings. Lynch et al. [20] found that environmental temperature had no effect on the number of stillborn per litter.

Choi and Shin [8] observed a higher mortality rate at birth in litters with a high proportion of males. Our results, although statistically non-significant, point to the opposite. This could be attributed to males presenting a greater embryonic development than females during pregnancy [6].

In our study, no clear relationship between litter size and the number of stillbirths per litter could be shown. Similar results were reported by Gnjidic [16] and Stolic [34], although different observations were reported by other researchers [2, 13, 33, 37].

Zaleski and Hacker [37] found an increase in mortality rate in heterogeneous litters and Bereskin et al. [3] and Horugel et al. [17] reported a relationship between birth mortality and extremely low weights of piglets at birth.

In our investigation, sow weight after farrowing did not affect piglet mortality at farrowing, thus corroborating results by Schoeps and Huhn [29]. However, Bilkei-Papp [4] showed a higher stillbirth rate for litters of overweight sows, although no relationship could be demonstrated between fattening grade and the duration of parturition.

Although some authors [3, 24, 25] indicated a high survival rate for females during the preweaning period, no mortality differences between males and females were observed in our experiment.

Piglet mortality rate during lactation period is increased by parity order [18, 19], and is quite significant for sows with eight or nine parities [5, 21], but only slightly different between the first and fifth parity [8, 11, 31].

Table IV. Effect of birth weight and changes in piglets' weight from birth to death on the weekly evolution and mortality rate during lactation.

	Birth weight interval < 1.00 kg			Birth weight interval 1.00–1.25 kg			Birth weight interval > 1.25 kg			Total	(%)
N	102			213			702			1 017	
Weeks of life	*n*	Birth weight	Weight change (kg)	*n*	Birth weight	Weight change (kg)	*n*	Birth weight	Weight change (kg)		
1	57	0.79 ± 0.01	–0.15	61		–0.21	82	1.50 ± 0.20	–0.33	200	69.2[a]
2				10	1.10 ± 0.07	+0.64	9	1.44 ± 0.18	+0.25	19	6.5[b]
3	2	0.97 ± 0.10	+0.19	3		+2.21	15	1.40 ± 0.10	+1.81	20	6.9[b]
4				7	1.13 ± 0.12	+1.37	15	1.73 ± 0.20	+3.40	22	7.6[b]
5	2	0.86 ± 0.20	+0.16	1		+1.15	16	1.48 ± 0.20	+3.90	19	6.5[b]
6	1	0.75	+0.80	2	1.16 ± 0.20	+2.13	6	1.61 ± 0.21	+4.20	9	3.1[b]
Total	62			84			143				
(%)	60.8[a]			39.4[b]			20.30[c]				

N: liveborn piglets; *n* = dead piglets.
[abc] Means with different superscripts differ at $P < 0.05$.

In farrowing pens heated by infrared lamps, the seasonal differences in mortality during lactation are not significant [10, 11].

Most studies show that litter size has the greatest influence on preweaning mortality [13, 31], being higher in litters of more than 12 piglets [11, 12]. Our results, as well as those reported by Dyck and Swietra [12], indicate that mortality rate varies with litter size expressed by a quadratic regression ($R^2 = 0.125$; $P < 0.002$).

English and Morrison [14] reported that the average weight of piglets at birth was not the most significant variable for survival rate. However, in agreement with our results, Dick and Swiestra [12] observed a lower death rate as the average weight of piglet at birth increased.

The variation in piglet weight within litters was found to be a factor affecting mortality rate during the lactation period and corroborates the work by English and Morrison [14]. However, Dick and Swiestra [12] found no relationship between these variables.

The sow weight after farrowing, milk yield on day 7 of lactation and milk production during the whole lactation period had no influence on the mortality rate from birth to weaning. Although 69.2 % of the piglet mortality occurred in the 1st week after farrowing (losing weight from birth to death), this does not mean that the sow is responsible for inadequate milk production, but rather that litter behaviour during suckling is unsuitable [1]. As a result, it seems that homogeneization in the number and in the weight of piglets and artificial rearing for light-weight piglets after farrowing may improve survival rate from birth to weaning [15].

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