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The Effect of Parity and Litter Size on Birth Weight and the Effect of Birth Weight Variations on Weaning Weight and Pre-Weaning Survival in Piglet

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Abstract: This study investigated the effect of litter size and parity on birth weight, weaning weight and survival at weaning and also, the effect of variations of birth weight on number and weight of piglets weaned and on pre-weaning survival. This experiment was performed on 114 sows and their 851 piglets. All piglets were divided into two groups for litter size, parity and birth weight and the main analyses were based on weight groups. Litter size affected birth weight significantly ($p<0.01$), but parity did not affect this trait ($p>0.05$). Furthermore, birth weight was determined to affect weaning weight, the number weaned and survival at weaning ($p<0.01$). It was demonstrated that each unit increase in litter size reduces birth and weaning weight. It was also shown that birth weight is a determining factor for weaning weight and survival at weaning and that high variations in birth weight cause high variations in survival.

Key words: Stillborn, birth weight, survival variation, litter size, weaning weight, piglet

INTRODUCTION

Pre-weaning mortality is a major cause of wastage in pig production. Bilkei and Biro (1999) stated that birth weight variation within litters affects piglet survival and weight gain. Pre-weaning growth rate is determined as birth weight (Akcapinar and Ozbeyaz, 1999). Parity and litter size are some of the factors affecting birth weight. Milligan *et al*. (2002) indicated that parity influences birth weight and generally, sows in first parity have lower birth weight yields than sows in other parities. There is a negative correlation between litter size and birth weight, hence increase in litter size yields reduced birth weight (Damgaard *et al*., 2003). The stillbirth rate is about 8% for pigs (Leenhouwers *et al*., 2003). Although, the exact cause of stillbirth is complex, increased duration of parturition is highly correlated with a higher stillbirth rate. Furthermore, it has been reported that higher litter size may prolong the birth period and elevate the stillborn risk due to perinatal asphyxia. Asphyxiation due to hypoxia is one of the major causes of stillbirths and is associated with later position in the birth order, broken umbilical cord, longer preceding birth intervals and lower piglet hemoglobin (Holm *et al*., 2004; van Dijk *et al*., 2005).

In pig production, weaning number and weaning weight are important parameters. Birth weight and litter size affect weaned numbers and weight. Birth weight is positively correlated with weaning weight, but is negatively correlated with the weaning weight's Coefficient of Variation (CV). In addition, with high birth weights there is high weaning number tendency (Quiniou *et al*., 2002; Gondret *et al*., 2005).

Because newborns partially acquire antibodies from colostrum, the 1st week of life is crucially important with respect to survival (Ozcan and Yalcin, 1985). Litter size, parity and birth weight are some of the factors affecting survival rate. High litter size may cause elevation in mortality rate in the first 10 days (Herpin *et al*., 1996). There is an inverse relationship between birth weight and piglet mortality and the pre-weaning mortality rate is high in piglets with low birth weight (Caceras *et al*., 2001; Damgaard *et al*., 2003; Mesa *et al*., 2006). Marcatti (1986) indicated a high mortality rate of 60% for piglets born under 800 g. Milligan *et al*. (2002) reported a significant effect of parity on survival rate and indicated high variations in survival rates of piglets in the first or later parities.

This study was designed to investigate the effects of litter size and parity on birth weight, weaning weight and survival rate at weaning and also to determine the effects of variations in birth weight on pre-weaning piglet numbers, weight at weaning and survival.

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MATERIALS AND METHODS

Animals and management: This study was carried out on 114 sows and their 854 crossbreed piglets obtained from uncontrolled breeding of Bulgarian large white, large black and Turopolje breeds in a commercial swine production farm in Istanbul, Turkey.

Sows were maintained in 2×2.20 m individual boxes from the last month of pregnancy, until the end of lactation. Piglets were kept with their mothers within the same box until weaning at about 45 days of age. Throughout, the experimental period, without any change in the farm conditions, sows were fed with kitchen wastes during pregnancy and lactation and piglets were fed only mothers milk, until weaning. Sows and piglets were provided with fresh water *ad libitum*.

Sow and piglet measurements: One hundred and fourteen sows in their 1st-4th parity were monitored for 1 year. Litter size and live and dead piglet numbers were recorded. Numbering with an ear ring and weighing of newborns were performed in the first 12 h after birth. For calculation of survival rate of piglets until weaning, piglets were checked each morning and evening and daily death rates were recorded. Piglets were separated from sows on the 45th day after birth and their weaning weights recorded.

Evaluation of the data: Grouping for analysis were performed after determination of the characteristics of sows and piglets. The first grouping was according to litter size. The first group consisted of 8 or less (≤8 L) and the second group consisted of over 8 (>8 L). After grouping according to litter size, the average birth weight of each litter group was determined and those 100 g or more under this birth weight were classified as the Low Weight Group (WG_L). Those of average and above average weight were classified as the High Weight Group (WG_H). Statistical comparisons were based on these groupings. In the classification according to birth weight, piglets born under 600 g were excluded from the study. In addition, the sows giving the first two birthing were allocated to one group (parity ≤2) and the ones giving the 3rd and 4th birthing comprised the second group (parity ≥3). After these groupings according to birth weight, parity and litter size, statistical analysis of the data were carried out.

Modeling and analysis: Simple Pearson correlations were calculated among birth weights, birth weights CV litter size, litter size CV, weaning weights, weaning weight CV and survival at weaning and CV.

The ordinary least square procedure was used to fit general linear models to investigate the effects of litter size groups, birth weight groups, parity and litter groups × weight groups interaction on the mean birth weight and birth weight CV (Cochran and Cox, 1963).

The generalized linear model procedure for fitting Generalized linear Models (GENMOD), as defined by Nelder and Wedderburn (Kotz *et al*., 2000) was used to investigate the effects of season, parity, litter group and birth weight group on the survival rate, censoring day and survival rate CV. In the GENMOD analysis, different distributions and link functions were described to fit the data. For survival data, appropriately distributed Poisson and linked log link function: $g(\mu) = \log(\mu)$ and their CV distributed appropriately Inverse Gaussian with $\lambda = -2$ and the built in link function was: power (-2) as:

$$g(\mu)=\begin{cases} \mu^{-2} & \text{if} \quad \lambda \neq 0 \\ \log(\mu) & \text{if} \quad \lambda = 0 \end{cases}$$

For number of pigs at weaning; binomial distribution function was used, linked with probit functions including

$$g(\mu) = \Phi^{-1}(\mu)$$

Where:

Φ = The standard normal cumulative distribution function (Agresti, 2002)

RESULTS

In this study, three piglets weighing under 600 g were excluded from the data set. Of the 851 piglets used in this study, 445 were under the average birth weight (WG_L) and 406 were average and over average birth weight (WG_H). While, the mean birth weight of the WG_L was 1.09±0.07 kg, it was 1.63±0.01 kg for WG_H and a highly significant difference was determined between the 2 groups ($p<0.001$). Regarding the birth weight groups, the effects of factors such as parity and litter size within the groups, on birth weight, weaning weight and weaning survival are shown in Table 1.

Effect of parity on birth weight was insignificant ($p>0.05$) in both WG_L and WG_H groups, while litter size had highly significant ($p<0.01$) effects on birth weight in both groups. Furthermore, negative correlations (Table 2) among litter size, birth weight and their CV were determined ($p<0.05$). Differences between groups were significant when WG_L and WG_H weight groups were compared regarding litter size ($p<0.01$) and percentage of pigs stillborn ($p<0.05$). Stillborn rate in WG_H and WG_L groups were 7.7%±0.82 and 4.7%±0.82, respectively (Table 3).

Table 1: Effect of mean birth weight, weaning weight and pre-weaning survival on litter size and parity by weight groups

	Low birth Weight Group (WG_L)				High birth Weight Group (WG_H)			
Groups	n	Birth weight (kg)	Weaning weight (kg)	Survival to weaning (%)	n	Birth weight (kg)	Weaning weight (kg)	Survival to weaning (%)
Parity								
≤2	414	1.10±0.08	4.20±0.07	61a	391	1.63±0.01	4.49±0.08	69b
≥3	31	1.02±0.03	3.70±0.19	45b	15	1.56±0.05	3.65±0.38	87a
Litter size								
≤8	252	1.12±0.011a	4.22±0.11	61a	253	1.67±0.01a	4.64±0.12a	69b
>8	193	1.06±0.011b	4.05±0.09	59b	153	1.57±0.02b	4.14±0.10b	70a
Total	445	1.09±0.07	4.15±0.07	60	406	1.63±0.01	4.45±0.09	69

a, b: For each grouping, different letters in the same columns did significant ($p<0.05$)

Table 2: Phenotypic correlation coefficients among some traits and their Coefficient of Variations (CV)

Traits	Litter size CV	Birth weight	Birth weight CV	Weaning weight	Weaning weight CV	Weaning of survival	Weaning of survival CV
Litter size	-0.145	-0.259*	-0.212*	-0.806**	-0.600**	-0.096	0.176*
Litter size CV	-	0.237*	-0.268*	-0.243*	0.486**	0.061	-0.109
Birth weight		-	0.264*	0.385**	0.596**	0.679**	-0.749**
Birth weight CV			-	0.441**	-0.237*	-0.327*	0.216*
Weaning weight				-	0.246*	0.349**	-0.096
Weaning weight CV					-	0.743**	-0.794**
Weaning of survival						-	-0.989*

*p<0.05; **p<0.01

Table 3: Least square means (±SE) and significance levels of some traits in Low birth Weight (WG_L) and High birth Weight (WG_H) Groups

	Weight groups		
Traits	WG_L	WG_H	P<F
Litter size	9.05±0.08	8.81±0.08	0.0080**
Litter size CV	9.84±0.94	11.01±0.94	0.6746
Pigs born alive (%)	95.30±0.27	93.30±0.27	0.2683
Pigs born alive CV (%)	8.91±0.08	10.18±0.08	0.3671
Stillborn (%)	4.70±0.82	7.70±0.82	0.0410*
Pigs born dead CV (%)	205.5±70.71	133.6±70.71	0.0720ns
Birth weight (kg)	1.09±0.08	1.63±0.01	0.0001***
Birth weight CV	15.15±0.01	16.04±0.01	0.6470
Weaning weight (kg)	4.15±0.07	4.45±0.08	0.0090**
Weaning weight CV	29.85±0.01	33.01±0.01	0.2857
No. of piglets weaned	3.86±0.30	4.15±0.30	0.0040**
No. of piglets weaned CV	65.24±0.01	62.66±0.01	0.3670
Survival at weaning CV (%)	81.74±0.01	66.39±0.01	0.0860

**p<0.01; ***p<0.001

Table 4: Survival rate at weaning for parity, litter size and birth weight groups

Variables	N	Survival (%)	LR chi-square (χ^2) value
Parity			
≤2	522	64.84	0.70
≥3	27	58.70	-
Litter size			
≤8	328	64.95	0.10
>8	221	63.87	-
Weight group			
1	267	60.00	8.33**
2	282	69.46	-

**p<0.01

Parity and litter size did not affect weaning weight in the WG_L group. Similarly, in the WG_H group, parity did not affect weaning weight, whereas the litter size effect was highly significant ($p<0.01$). Piglets in the WG_H group born to sows with ≤2 parity and having litter size ≤8 had higher weaning weight than those in other groups (Table 1). The evaluations of correlations of litter size and birth weight with weaning weight indicated negative correlations between litter size and weaning weight and its CV ($p<0.05$) and there were positive correlations between birth weight and weaning weight and its CV ($p<0.01$; Table 2). Additionally, weaned piglet number ($p = 0.004$) and weaning weights were higher ($p = 0.009$) in the WG_H group than in the WG_L group (Table 3).

The effect of parity and litter size was significant ($p<0.05$) on survival at weaning within WG_L and WG_H groups (Table 1). There were also, negative correlations between pre-weaning survival and litter size ($p<0.05$) and positive correlations between pre-weaning survival and birth weight ($p<0.01$) (Table 2).

The effects of parity, litter size and birth weight on survival at weaning, without considering weight group are shown in Table 4. While, the effect of birth weight on survival at weaning was significant ($p<0.01$), the effects of parity and litter size on this trait were not significant ($p>0.05$). Survival rate of piglets in WG_H group was 69.46% and this was significantly higher than for the WG_L group (60.0%) ($p<0.01$) (Table 4).

The evaluation of distribution of live/dead piglet numbers in relation to birth weight indicated a higher mortality rate in piglets having 600-1400 g birth weight. The mortality rate decreased gradually after 1400 g birth weight (Fig. 1).

Figure 2 indicates the time of intense pre-weaning mortality. Pre-weaning deaths in piglets of <1400 g birth weight occurred during the first 28 days.

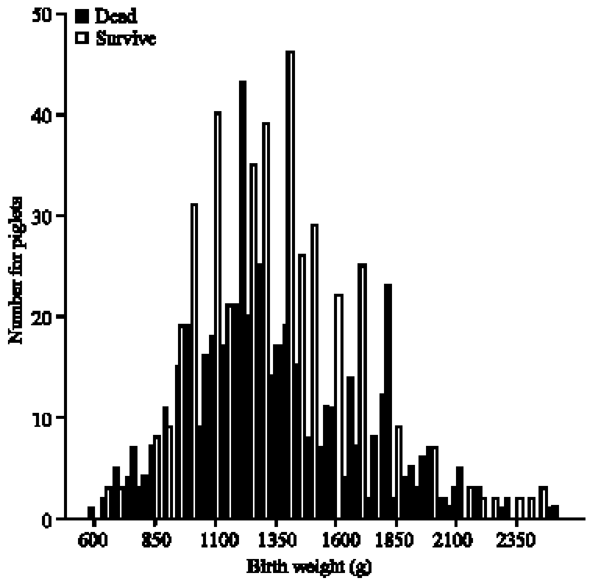

Fig. 1: Distribution of live/dead piglet numbers in relation to birth weight

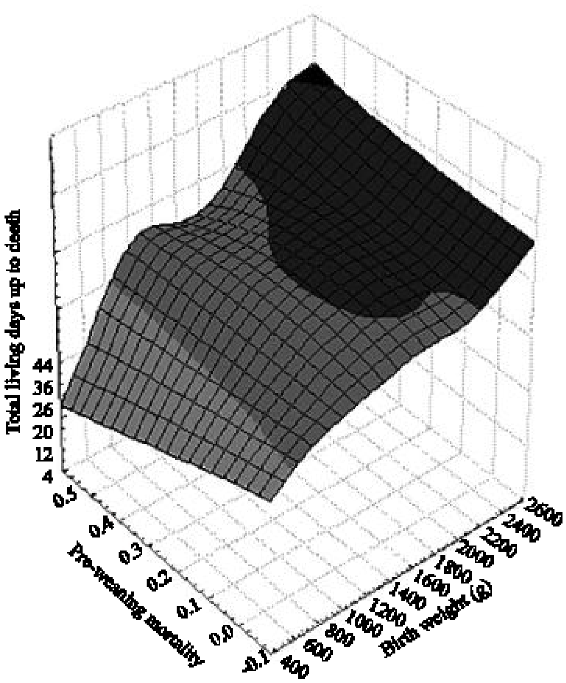

Fig. 2: Response surface graphic showing mortality/day, percentage of pre-weaning mortality and birth weights

DISCUSSION

In the present study, although the effect of parity on birth weight in both WG_L and WG_H groups was not significant, mean birth weight of piglets farrowed by sows having ≤2 parities was higher than that of ≥3 parities, as reported by Milligan *et al*. (2002). However, Milligan *et al*. (2002) reported that the birth weight of piglets farrowed at first parity was higher than for the second parity and after the second parity, mean birth weight decreased as the parity number increased in Yorkshire and Yorkshire × Landrace cross pigs (Milligan *et al*., 2002). Birth weight was affected by litter size in the WG_L and WG_H groups. Also, negative correlations between birth weight and litter size have been determined in present study. These results are supported by Quiniou *et al*. (2002) and Damgaard *et al*. (2003). In other words, higher litter size adversely affects birth weight and actually causes substantial decreases. Thus, when doing a weight groups comparison with regard to litter size, the higher litter size in the WG_L group having lower birth weight supported this result. In addition, percentage of stillborn pigs was higher in the WG_H group than for WG_L. Contrary to this, Herpin *et al*. (1996), Lay *et al*. (2002) and van Dijk *et al*. (2005) reported higher stillborn rates for high litter size. Nevertheless, from a different perspective, it is indicated that if litter size is small, then litters grow above their normal size in the uterus and consequently the risks of stillbirth and dystocia increase because of hypoxia, a phenomenon, which occurs when litters stay a long time in birth canal (Erk *et al*., 1980; Arthur *et al*., 1996). Also, Arango *et al*. (2005) reported a negative correlation between litter size and stillborn number. Thus, the number of stillborn piglets in the WG_H group was higher than for the WG_L group, litter size for WG_H was lower than WG_L and birth weights of the WG_H were also higher than WG_L group in the present study.

Regarding the for effect of parity and litter size on weaning weight within the weight groups, parity did not affect weaning weight in both groups, whereas litter size within both weight groups differed only for WG_H. Furthermore, negative correlations between weaning weight and litter size (Roehe, 1999; Milligan *et al*., 2002) and positive correlations between weaning weight and birth weight (Quiniou *et al*., 2002; Gondret *et al*., 2005) were determined in the present study. In other words, an increase in litter size is related with decrease in weaning weight and higher birth weight is related with higher weaning weight. The results of comparison between weight groups showed the WG_H group with smaller litter size and higher birth weight, compared to the WG_L group (Roehe, 1999; Milligan *et al*., 2002; Quiniou *et al*., 2002; Gondret *et al*., 2005).

In analyzing results within the groups, the effect of parity and litter size on weaning survival was significant in both WG_L and WG_H groups. The survival rate in the

WG_L group of piglets farrowed by sows having lower parity and litter size was lower than that of the other group (Milligan *et al*., 2002). On the contrary in the WG_H group, survival of piglets in higher parity (parity $\geq$3) and litter size (>8 L) groups was higher than that of the other group. Negative correlations between pre-weaning survival and litter size (Roehe, 1999; Milligan *et al*., 2002; Lay *et al*., 2002; Damgaard *et al*., 2003) and positive correlations between pre-weaning survival and birth weight (Herpin *et al*., 1996; Caceras *et al*., 2001; Damgaard *et al*., 2003; Casellas *et al*., 2004; van Rens *et al*., 2005) were determined. In the other words, any increase in litter size and decrease in birth weight causes decreases in the survival rate. Furthermore, these results support finding from the WG_L group.

The effect of parity and litter size on survival was significant according to results within weight groups, whereas the effect of birth traits on survival was not significant, if classification was not done according to birth weight. Two different scenarios were encountered in evaluation of the overall and within group effects of litter size and parity on survival. This situation can be attributed to high variation in birth weight. Milligan *et al*. (2002) reported that high variation in birth weight could cause high variation in survival. Many reports support the concept that increase in variation of birth weight causes decrease in pre-weaning survival (Roehe and Kalm, 2000; Caceras *et al*., 2001; Milligan *et al*., 2002; Damgaard *et al*., 2003). The determination that birth weight had a significant effect and survival at weaning and survival of the WG_L group being lower than the WG_H group, support this result. In other words, mortality rate is higher in piglets with low birth weight (Caceras *et al*., 2001; Quiniou *et al*., 2002; Casellas *et al*., 2004; van Rens *et al*., 2005).

When considering dead/live birth piglet number distribution according to birth weight, it was determined that mortality frequency was elevated in piglets with low birth weight and the majority of mortality was distributed in the first 28 days after farrowing (Fig. 2). The reason for the high mortality within this interval may be attributed to their inability to produce antibodies, until 28 days of age (Albrecht and Goodman, 1993). Figure 2 indicates that piglets having birth weight <900 g have very high mortality risk within 11 days of birth (Marcatti, 1986; Herpin *et al*., 1996; Casellas *et al*., 2004). Mortality rate was also, moderate in piglets having 900-1400 g birth weight, compared to those having <900 g, with mortality intensified within the first 28 days of birth. The mortality rate decreased gradually in piglets 1400 g and above at birth (Casellas *et al*., 2004).

CONCLUSION

It was determined that litter size affects birth and weaning weight and any unit increase in litter size brings both decrease in birth and weaning weight. It was also observed that birth weight is a determining factor for weaning weight and survival at weaning and high variations of birth weight cause high variations in survival.

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