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The effects of breed, season and parity on the reproductive performance of pigs reared under hot and humid environments

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Abstract
A research aimed at evaluating the reproductive performance of pigs as influenced by breed, season, and parity was carried out. Reproductive performance records of 1383 sows made up of 204 primiparous and 1179 multiparous large white (687) and Duroc × large white crosses (696) obtained over a 3-year period (2013 to 2016) were used. Data on reproductive performance taken were farrowing rate, litter size at birth and at weaning, piglet weight at birth and at weaning farrowing interval and pre-weaning mortality. To determine the effect of season, parity and breed on reproductive performance, the 4-way analysis of variance (ANOVA) was used. A mixed model was fitted using the generalized linear model (GLM) procedure of the GenStat (Discovery Edition) to investigate the fixed effects of breed (two classes), season of birth (three classes) and parity (five classes) on the reproductive traits. Where differences in means were observed, the means were separated using the least significant difference at 5% level of significance. Results obtained indicated litter size at birth of 12.5 ± 0.3 and 14.2 ± 0.5 for the large white and the Duroc × large white respectively and farrowing rates of 90.0 ± 2.3 and 94.5 ± 2.5% for the large white and the Duroc × large white respectively. Litter size at birth and at weaning, farrowing rate and piglet weight at birth were all influenced by parity and season with increasing parity significantly reducing litter size at birth and at weaning. Reproductive traits of the sows were superior during the rainy season, an indication of the need to consider season of birth in making decision.

Keywords Large white · Duroc · Litter size · Season · Parity and breed

Introduction

In Ghana, pig production is practiced mainly by intensive and extensive smallholder farmers under small-, medium- and large-scale commercial enterprises (MoFA 2012) with the prominent breeds reared being the large white (LW). The large white breeds are noted for their desirable reproductive potential. To ensure improved efficiency in pig production, growth and reproductive traits are important economic traits which need much attention. According to Patterson et al. (2010), sows are capable of raising an average of 30–40 piglets annually, hence the need to study the reproductive performance of sows under different environments. Again, the reproductive performance of breeding sows, according to Rekwot et al. (2001), could influence the efficiency of swine production, with high reproductive performance being considered to be of economic significance to the pig industry. Farrowing rate, litter size at birth and at weaning and fertility index are among the primary parameters used to measure the reproductive performance of female pigs (Yilma 2017). These important reproductive traits could be influenced by season, parity, breed, lactation length and nutrition (Bloemhof et al. 2008). Whereas the last two factors can be controlled, season, parity and breed could be difficult to control because they directly affect the volume of production. It is therefore important to perform a detailed analysis on how these could impact on performance. Season of farrowing can directly affect the reproductive performance of pigs (Love et al. 1993) by directly impacting on the litter size and piglet survival after birth (Tummaruk et al. 2010). Additionally, it may affect results in the rearing of piglets, for example due to heat stress and feed intake during lactation. Temperature variation and photoperiodic reaction during a season are considered the main causes influencing

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fertility (Knecht et al. 2013), although the resistance of individuals is dependent on the breed (Wysoko'nska and Kondracki, 2013). The number of times a sow has farrowed (parity order) has been found to be associated with physiology, primarily with growth of the organism, and in particular with the development of the reproductive system.

The inadequate accurate performance records on traits of economic importance coupled with unreliable pedigree information are some of the major challenges to improved pig productivity in developing countries including Ghana, thereby making it difficult to develop well-organized breeding programs to facilitate genetic improvement (Chimonyo and Dzama 2007 and Ilatsia et al. 2008). In Ghana, different crosses of pigs have been imported into the country and distributed to farmers. Apart from the growth performance of the large white breeds have been studied over a period, there is paucity of information on the reproductive performances of the large white and other crosses in the country. The current study was therefore carried out to assess the effect of breed, parity and season on the reproductive performances of the pigs under the hot and humid environments of Ghana.

Materials and methods

Location of the study

The study was carried out at the Teaching and Research Farm of the School of Agriculture, University of Cape Coast, Ghana. The area experiences a bimodal rainfall regime with a mean annual rainfall of 920 mm. The temperature of the area is relatively high with the annual mean temperature of 23 °C (73 °F). The relative humidity is generally high (90%) in the night and decreases gradually to 70% in the afternoon when the temperature is high.

Data collection

Reproductive performance records on 687 large white (LW) and 696 cross (Duroc × large white, DLW) consisting of 204 primiparous and 1179 multiparous sows obtained over a 2-year period (2013 to 2016) were used. The large white piglets were sired by large white boars while the crossbred piglets were sired by Duroc boars with large white as the dams. Data on reproductive performance taken were farrowing rate, litter size at birth and at weaning, piglet weight at birth and at weaning and farrowing interval. Farrowing rate was calculated as the percentage of sows farrowing per the number of sows pregnant. Litter size at birth and weaning were measured as the total number of piglets born alive and weaned alive. Farrowing interval was calculated as the interval between two successive farrowing.

Management of the studied animals

Data obtained from the Teaching and Research Farm of the University of Cape Coast were used. The farm practiced the farrow-to-finish system with the animals being intensively kept. Breeding sows were kept in separate clean and ventilated sties. Extra care was provided for pregnant sows and weaned piglets. They were housed and fed separately. Sows were checked for heat twice a day and were naturally serviced by boars whenever oestrous symptoms were observed. Sows were transferred to individual pens; immediately pregnancy was observed, and they were transferred to farrowing pens during the third trimester of pregnancy. Shortly after farrowing, the total number of piglets born alive and stillborn was recorded including the birth weights. All piglets were ear notched and their teeth clipped on the first week after birth. Iron-dextran was injected 1 week after farrowing and creep feed was provided after 2 weeks. Piglets were weaned after 28 days and the body weights and numbers weaned recorded. Pregnant sows were fed 1.0 kg of feed that contained 13% crude protein (CP) and 3100 kcal/kg ME, twice a day. During the last month of gestation, feeding levels were increased to 1.1 kg (CP = 13%), twice a day. During lactation, the sows were fed a 16% CP diet, 4.0 kg per day, plus 0.25 kg per piglet.

To study the effect of season of farrowing on the reproductive performances, the calendar year was divided into three seasons, namely, major rainy season (April–July), minor rainy season (August–November) and dry season (December–March). Average temperatures within the various seasons recorded in the studied area were minor rainy (25.5 °C), major rainy (24 °C) and dry season (32 °C). The humidity for the seasons was as follows: major rainy (80–85%), minor rainy (80–83%) and dry season (75–85%). The average rainfall recorded during the period ranged from 740 to 890 mm per annum.

Data and statistical analysis

To determine the effect of season, parity and breed on reproductive performance, the four-way analysis of variance (ANOVA) was used. A mixed model was fitted using the generalized linear model (GLM) procedure of the GenStat (Discovery Edition) to investigate the fixed effects of season of birth (three classes), parity (five classes) and breed (two classes) on the reproductive traits. Where differences in means were observed, the means were separated using the least significant difference at 5% level of significance.

The model used was as follows: $Y_{ijkl} = \mu + s_i + p_j + b_k + (sp)_{ij} + (sb)_{ik} + (pb)_{jk} + (spb)_{ijk} + \varepsilon_{ijkl}$

where

Y_{ijkl} is the value of the dependent variable

μ	the overall average
s	the main effect of the season (dry, minor rain, major rain)
p	the main effect of the parity (1st parity, 2nd parity, 3rd parity, 4th parity, 5th parity)
b	the main effect of the breed (LW and DLW)
(sp)	the interaction effect of season and parity
(sb)	the interaction effect of season and breed
(pb)	the interaction effect of parity and breed
(spb)	the interaction effect of season, parity and breed
ε_{ijkl}	the random residual effect

Results and discussion

Table 1 shows the effect of breed on the reproductive performance of the sows. Results obtained showed significant ($p < 0.05$) influence of breed on most of the reproductive parameters studied, apart from piglet weight at weaning and farrowing interval. Numerous studies have shown the effect of breed on reproductive performance in pigs (Knecht et al. 2015; Quesnel et al. 2008; Huang et al. 2003). These observations were confirmed in the current study with the crossbred sows (DLW) being superior to the large white (LW) sows. According to Vanderhaeghe et al. (2010), the use of crossbreeds is one of the surest ways of improving reproductive performance due to the low heritability of reproductive traits. Higher litter size at birth is a reflection of the individual potential in the reproductive physiology of the breeds and crossbreeds in terms of not only high uterus capacity but also more resistance to environmental conditions such as climatic conditions, nutrition, etc. (Hoving et al. 2011). The values obtained for litter size at birth (13.2) and at weaning (10.2) in this current study were better than values of 7.3–9.4 and 6.6–8.4 litter size at birth and at weaning respectively by Nkube et al. (2003). The results are also comparable to values of 11.0–14.5 obtained by Knecht et al. (2015), Quesnel et al. (2008) and Huang et al. (2003) in temperate regions where these breeds were developed. The current results are improvements over previous values of 10.2 and 8.0 for litter size at birth and at weaning respectively (MoFA 2012), an indication of some improvement over the years.

Large white breeds are used as dam lines in most breeding programs due to their superior litter size at birth and heavier litters, while Duroc is commonly used as a sire line because it is noted for its excellent growth rate and feeding efficiency (Baas et al. 1992). A smaller litter size at birth might be due to either the production of fewer zygotes or the higher foetal mortality, or both. The fewer zygotes might be due to inferior semen of the boars. In the present study, it could be seen that the crossbred recorded a significantly higher litter size at birth than the large white breeds. The lower litter size from the large white might be due to poor semen coming from the large white boars used. Kuo et al. (1997) reported that Duroc boars produced less but more concentrated semen than do Yorkshire and large white boars per ejaculation. In contrast, Huang et al. (2003) reported higher litter size from large white as compared to the Duroc. The large white sows were significantly ($p < 0.05$) able to suckle their young ones better than the Duroc × LW sows. This was reflected in the higher litter size at weaning recorded for the LW sows as compared to the DLW sows. It could be said that the LW sows might nurse her offspring sufficiently well to offset any differences in the genetic backgrounds of the piglets.

Farrowing rate was significantly higher in the crossbred than in the purebreds. This agrees with observation by McLaren et al. (1987) that the use of crossbred boars might improve farrowing and conception rates by between 6 and 20% resulting in a higher pregnancy rate and greater number of piglets per litter. It has also been suggested that hybrid vigour in the boar can increase average litter size by 0.25 to 0.75 of a piglet per year (Whittemore 1993). Results of this present study confirm these observations with significant

Table 1 The reproductive performances of the two different breeds

Parameters	Breeds		Overall average ($n = 1383$)	
	LW ($n = 687$)	DLW ($n = 696$)		P values
Farrowing rate (%)	90.0 ± 2.3b	94.5 ± 2.5a	92.5 ± 2.1	0.01
Litter size at birth (no)	12.5 ± 0.3b	14.2 ± 0.5a	13.2 ± 0.2	0.03
Litter size at weaning (no)	10.8 ± 0.3a	9.7 ± 0.3b	10.2 ± 0.2	0.01
Piglet weight at birth (kg)	1.5 ± 0.3a	1.3 ± 0.2b	1.4 ± 0.1	0.01
Piglet wt. at weaning (kg)	7.0 ± 0.1	7.2 ± 0.2	7.1 ± 0.1	0.07
Farrowing interval (days)	152.3 ± 12.3	150.1 ± 12.5	151.1 ± 12.1	0.10
Pre-weaning mortality (%)	13.3 ± 0.2b	32 ± 1.0a	23.1 ± 1.1	< 0.01

Mean values in rows with different lowercase letters differ significantly ($p < 0.05$)

LW large white, *DLW* Duroc × large white differences in the reproductive performance of sows mated to pure or crossbred boars. The higher litter size at birth for the crossbred in this present study agrees with earlier results by Edwards et al. (1992) and Quesnel et al. (2008). Litter weights at birth and at weaning were also found to be significantly ($p < 0.05$) influenced by the type of breed used, with piglets sired by the large white being heavier than their counterparts sired by Duroc. This agrees with observation made by Huang et al. (2003) but disagrees with observation by Edwards et al. (1992) that Duroc-sired litters were larger at birth and at weaning than LW-sired litters.

Significantly ($p < 0.05$) more deaths were recorded in the crossbred piglets as compared to the purebred piglets. Pre-weaning survival of piglets is attributable to the sow and hence if lactating sows are not able to suckle the young ones well, mortalities during that phase will be high. Survival rate of piglets are due to the suckling ability (mothering ability) of the sow, hence higher numbers at birth might sometimes pose challenges if the sow does not get enough feed to produce enough milk during the first 2 weeks of farrowing. It was observed that the crossbred sows were unable to suckle the young ones well, albeit more pre-weaning deaths recorded. There is therefore the need to consider fostering during periods of high litter size during farrowing.

The reproductive performances of the pigs as influenced by parity have been presented in Table 2. Earlier studies by Engblom et al. (2007), Hoving et al. (2011) and Knecht et al. (2015) showed significant influence of parity on reproductive traits, with performance increasing with increasing parity but declining after fourth parity. Other authors (Scholman and Dijkhuizen 1989 and Faust et al. 1993) have advocated the use of sows for up to the 5th parity, especially sows with large number of litters must be used over a long time. This, they explained, was because young gilts/sows were most vulnerable to various types of dysfunctions. Results from the current study showed a significant influence ($p < 0.05$) of parity on litter size at birth with litter size reaching maximum at the fourth parity and decreasing thereafter. According to Engblom et al. (2007), Hoving et al. (2011) and Knecht et al. (2015), there is high correlation between parity and litter size. Quesnel et al. (2008) also found that sows in the first and second parities showed the most homogeneous litters. This might be due to the lower number of piglets born and therefore the increased space for foetal development in the uterus. According to Tummaruk et al. (2010) and Suriyasomboon et al. (2006), increased litter size with increased parity might be due to more follicles released during ovulation, increased uterus capacity as the sows advance in age. There was also a likelihood of a greater number of fertilized oocytes, culminating in higher number of piglets born after the gestation time.

According to Lucia et al. (2002) and Van Dijk et al. (2005), even though sow's age and parity number affect reproductive performance, the physiological mechanism underlying this remains unknown, especially in older sows. In the present study, farrowing rates were lowest in first and fifth parity sows, an indication of younger and older sows being lowly reproductive. Sows should not be used when too young or too old if one wants to achieve higher rate of pregnancy (Schwarz and Kopyra 2006) because reduced farrowing rates are associated with the use of older sows. The current results however disagrees with that of Schwarz et al. (2009) who found the poorest farrowing rates from early parity sows as compared to late parity ones.

Even though pre-weaning mortality was significantly influenced by parity, there is however no special trend. The highest pre-weaning mortality was recorded in piglets farrowed from the fourth parity with the least mortality recorded in the second parity sows. At fourth parity, the sows were mature and becoming old and might be heavy, making them difficult to control their body. Some of the older sows were often found to

Table 2 Effect of parity on the reproductive performance of the two breeds

Parameters	Parities					
	1st Parity ($n = 204$)	2nd Parity ($n = 254$)	3rd Parity ($n = 285$)	4th Parity ($n = 400$)	5th Parity ($n = 240$)	P values
Farrowing rate (%)	90.0 ± 2.3c	94.5 ± 2.5a	92.5 ± 2.1b	92.3 ± 2.5b	90.2 ± 2.5c	0.01
LSB (no)	10.2 ± 0.1b	10.1 ± 0.8b	13.2 ± 0.9a	14.2 ± 0.2a	10.2 ± 0.2b	0.01
LSW (no)	8.5 ± 0.2b	9.0 ± 0.2b	11.2 ± 0.4a	11.5 ± 0.2a	8.8 ± 0.2b	0.02
PWB (kg)	1.3 ± 0.1c	1.2 ± 0.1c	1.5 ± 0.1b	1.7 ± 0.2a	1.3 ± 0.2c	0.02
PWW (kg)	7.1 ± 1.1b	7.5 ± 1.2b	8.8 ± 1.1a	8.6 ± 1.1a	7.3 ± 1.2b	0.01
FI (days)	150.3 ± 2.3	150.1 ± 2.5	153.3 ± 2.3	150.1 ± 2.5	150.2 ± 2.5	0.10
Pre-weaning mortality (%)	17.3 ± 0.2b	10.1 ± 4.0d	15.3 ± 0.2c	21.4 ± 4.0a	14.5 ± 1.1c	0.01

Mean values in rows with different lowercase letters differ significantly ($p < 0.05$)

LSB litter size at birth, *LSW* litter size at weaning, *PWB* piglet weight at birth, *PWW* piglet weight at weaning, *FI* farrowing interval be lying over (crushing) their piglets when they tried to lie down from standing position. Young sows were continuously growing and therefore had to channel some of their energies for their own physiological activities with little left for milk production. As a result, they were unable to produce enough milk to suckle the piglets, or sometimes complete lack of milk or poor maternal responsiveness resulting in deaths brought about by starvation. Pre-weaning piglet mortality from early parity sows might be due to the immaturity or inexperience of primiparous sows albeit poor mothering ability. Birth weight could also affect mortality in that grossly underweight piglets might fail to make it and hence die at birth, while too overweight piglets might also tend to be farrowed with difficulty (dystocia) and are likely to die at birth.

The piglet birth weight and weaning weight in this study was moderately higher in the first parity and increased thereafter for both breeds. This was observed in earlier works by Lucia et al. (2002), Van Dijk et al. (2005), Engblom et al. (2007), Hoving et al. (2012) and Knecht et al. (2015) that sows in mid-parities had higher piglet size and litter birth weight than those in their first and older parities. This could be due to the fact that very young sows are still physiologically immature and hence have to partition nutrients between their own growth requirements and those of the foetuses resulting in lower birth weight (Knecht et al. 2015). In addition, the uterine capacity tends to limit the birth weights of piglets in young sows. On the other hand, old sows tend to undergo a physiological deterioration and hence may not fully utilize their feed resources most efficiently in providing nutrition to the foetuses in utero (Mungate et al. 1999).

The effects of season on the reproductive performance of the pigs are shown in Table 3. Season of birth significantly ($p < 0.05$) affected all the reproductive traits studied. This confirms the observations by Peltoniemi et al. (2000) that there is seasonal effect on farrowing rate, litter size at birth and at weaning, onset of oestrus and farrowing interval. Hansen et al. (2001) also observed seasonal effects on expression of oestrus behaviour, follicular development, impairment of oocytes, the number of fertilized ova and embryonic development in cattle. Seasonal variations are manifested in the changes in day length, temperature and humidity, with temperature and humidity being more significant under tropical conditions and photoperiod being more important in temperate environments (Love et al. 1993; Prunier et al. 1997; Tantasuparuk et al. 2000). Farrowing rates were significantly ($p < 0.05$) higher during the rainy seasons than during the dry season. Dry season was associated with high temperatures which could affect sperm production and quality. In this current study, mating was natural so if boars were heat-stressed, it could affect sperm production and quality, which could eventually affect farrowing rate. This is because semen volume and total number of motile spermatozoa were influenced by photoperiod (Knecht et al. 2013).

There was also significant ($p < 0.05$) seasonal effects on litter size at birth and at weaning, with more litters recorded during the rainy seasons, an observation which was also made by Knecht and Duziński (2014). The reduced litter size in the dry season might be due to reduced feed intake in in-pigs brought about by heat stress. Reduced feed intake could affect the growth and development of the growing embryos resulting in either pre-natal (embryonic) death or post-natal mortality (Prunier et al. 1997). Litter sizes at birth and at weaning are influenced by ovulation rate, embryonic survival and uterine capacity (Tummaruk et al. 2001). The dry season period in the study area was characterized by higher temperatures (35 °C) causing heat stress during most periods of the day. Heat stress is associated with decreased follicular growth and reduced follicular fluid concentration of estradiol-17β (Hansen et al. 2001). During low temperatures too, there could be reduced concentrations of LH in the blood serum of sows (Basset et al. 2001). The impaired development of follicles, according to Einarsson et al. (1996) and Bracken et al. (2003) could impact on ovulation rate making oocytes not fully valuable, thereby causing higher embryo mortality and reduced live litter born.

Table 3 Effect of season on the reproductive performance of the two breeds

Parameters	Seasons			
	Dry season ($n = 400$)	Minor rain ($n = 450$)	Major rain ($n = 533$)	P values
Farrowing rate (%)	92.5 ± 2.5b	94.5 ± 2.1a	94.3 ± 2.5a	0.01
Litter size at birth (no)	10.1 ± 0.8b	14.1 ± 0.9a	14.6 ± 0.2a	0.01
Litter size at weaning (no)	9.0 ± 0.2b	10.2 ± 0.4a	10.5 ± 0.2a	0.01
Piglet weight at birth (kg)	1.3 ± 0.1c	1.5 ± 0.1b	1.7 ± 0.2a	0.02
Piglet weight at weaning (kg)	7.5 ± 1.2b	8.4 ± 1.1a	8.8 ± 1.1a	0.01
Farrowing interval (days)	158.1 ± 2.5b	150.3 ± 2.3a	148.1 ± 2.5a	0.01
Pre-weaning mortality (%)	10 ± 4.0c	14.3 ± 0.2b	28.1 ± 4.0a	< 0.01

Mean values in rows with different lowercase letters differ significantly ($p < 0.05$)

There is therefore the need to time farrowing not to coincide with periods of too low or too high temperatures so as to reduce the extent of pre- and post-natal piglet mortality.

The current study also showed a significant ($p < 0.05$) seasonal effects on farrowing interval with reduced interval in the rainy season and longer interval in the dry season (Table 3). Tummaruk et al. (2001) and Marchev and Szostak (2007) also reported of a prolonged period of appearance of oestrus during the drier months. One of the reasons for the prolonged onset of oestrus in the dry season was reduced feed intake, as reported by Prunier et al. (1997) and Škorjanc et al. (2008). However, it has been shown that the survival of embryos as a result of feeding and the progesterone-mediated mechanism were effective only for 3–4 days after copulation (Foxcroft 1997) and did not affect vital embryonic survival (Hoving et al. 2012). A consequence of reduced feed intake was the reduced release of LH leading to impaired follicular development and thus disorders in the occurrence of oestrus after weaning (Bloemhof et al. 2008). Farrowing interval also depends on follicular populations before weaning and the rate of follicular development after weaning (Bracken et al. 2003), hence the prolonged farrowing interval during the dry season.

It was observed that pre-weaning mortality was significantly higher in the rainy seasons. Rainy seasons were associated with low temperatures and cold nights which predisposed the piglets to pneumonia. Apart from deaths coming through crushing or lying over by the sows, there were deaths through pneumonia brought about by cold nights. This might be caused by low temperatures within the pens during the rainy seasons. The present study also recorded lower litter weights at birth and at weaning in the dry seasons which confirm the results by Knecht et al. (2015). Lower post-weaning piglets' weights in the dry season might be as a result of microclimate conditions affecting lactation. Pigs are sensitive to high temperatures, mainly because of lack of sweat glands resulting in reduced ability for perspiration (Nardone et al. 2010). It is very important to observe a body condition of sows during late pregnancy because of the later litter performance (Beyga and Rekiel 2010). Physiological changes during farrowing and lactation are compounded by a change in diet, postnatal stress and microclimatic factors (Quesnel et al. 2009). Heat stress during dry season could affect milk production and composition thereby resulting in decreased feed consumption (suckling) by piglets. Reduced milk production affects suckling ability, hence resulting in weak piglets and eventually death due to starvation (Table 4).

Table 4 The impact of the season, parity, breed and their interaction on the reproductive performance of sows

Factor	Parameters						
	FR	LSB	LSW	PWB	PWW	FI	PWM
Season	*	*	*	*	*	*	*
Parity	*	*	*	*	*	NS	*
Breed	*	*	*	*	NS	NS	*
Season × parity	*	*	*	*	*	NS	*
Season × breed	*	*	*	*	NS	NS	*
Breed × parity	*	*	*	*	NS	NS	*
Season × parity × breed	*	*	*	*	NS	NS	*

FR farrowing rate, *LSB* litter size at birth, *LSW* litter size at weaning, *PWB* piglet weight at birth, *FI* farrowing interval, *PWW* piglet weight at weaning, *PWM* pre-weaning mortality

The asterisks mean significant differences at 5% level of significance

Results from the present study show significant interactive effects among the various parameters studied. Research has shown that the worst reproductive parameters were noted in first parity. Litter size at birth and at weaning and piglet weights at birth and at weaning were significantly influenced by the type of breed used, the season in which the piglets were farrowed and the number of times the sow has given birth. It was realized that litter size at birth was highest in the first three parities during the rainy season for the crossbred sows. Irrespective of the season, parity and the type of breed used, the interval between two successive farrowing did not significantly vary.

Conclusion

The reproductive performances of purebred (large white) and the crossbred (Duroc × large white) kept at Teaching and Research Farm of the University of Cape Coast, Ghana, are within acceptable levels for the tropics, an indication of gradual improvement in performance over the years. Further backcrossing with the large white breeds as dam line is advocated in order to confer on the future crossbred mothering ability so as to improve on litter size at weaning. The significant seasonal effect on the reproductive performance is an indication that breeding be timed to ensure that the piglets are not unduly stressed during periods of unfavourable seasons. Parity also had significant effect on litter weight, hence the need to cull old sows to ensure improved reproductive performances especially litter size at birth and piglet weights at birth. The significant interactive effects observed is an indication that to improve on the reproductive performance of pigs, there is the need to consider the type of breed used, the season in which farrowing takes place and how long the sow must be used before being replaced.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

References

Baas, T. J., Christian, L. L. and Rothschild, M. F. 1992. Heterosis and recombination effects in Hampshire and Landrace Swine: I. Maternal traits. J. Anim. Sci. 70:89–98.

Basset J.M., Bray C.J., Sharpe C.E. (2001). Reproductive seasonality in domestic sows kept outdoors without boars. Reproduction, 121: 613–629.

Beyga, K. and Rekiel, A. 2010. The effect of the body condition of the late pregnant sows on fat reserves at farrowing and weaning and on litter performance, Arch. Tierz., 53, 50–64.

Bloemhof S., van der Waaij E.H., Merks J.W.M., Knol E.F. 2008. Sow line differences in heat stress tolerance expressed in reproductive performance traits. J. Anim. Sci., 86: 3330–3337.

Bracken C.J., Lamberson W.R., Safranski T.J., Lucy M.C. 2003. Factors affecting follicular populations on day 3 postweaning and interval to ovulation in a commercial sow herd. Theriogenology, 60: 11–20.

Chimonyo, M. & Dzama, K., 2007. Estimation of genetic parameters for growth performance and carcass traits in Mukota pigs. Animal 1, 317–323.

Edwards, S.A., Wood, J.D., Moncrieff, C.B. and Porter, S.J. 1992. Comparison of the Duroc and Large White as terminal sire breeds and their effect on pig meat quality. Animal Production 54: 289–297.

Einarsson S., Madej A., Tsuma V. 1996. The influence of stress on early pregnancy in the pig. Anim. Reprod. Sci., 42: 165–172.

Engblom, L., Lundeheim, N., Dalin, A. M., and Andersson, K. 2007. Sow removal in Swedish commercial herds, Livest. Sci., 106, 76–86.

Faust, M. A., Robison, O. W., and Tess, M. W. 1993. Genetic and economic analyses of sow replacement rates in the commercial tier of a hierarchical swine breeding structure, J. Anim. Sci., 71, 1400–1406.

Foxcroft G.R. 1997. Mechanisms mediating nutritional effects on embryonic survival in pigs. J. Reprod. Fert., Suppl. 52: 47–61.

Hansen P.J., Drost M., Rivera R.M., Paula-Lopes F.F., Al-Katanani Y.M., Krininger III C.E., Chase C.C. (2001). Adverse impact of heat stress on embryo production: causes and strategies for mitigation. Theriogenology, 55: 91–103.

Hoving, L. L., Soede, N. M., Graat, E. A. M., Feitsma, H., and Kemp, B. (2011). Reproductive performance of second parity sows: Relations with subsequent reproduction, Livest. Sci., 140, 124–130.

Hoving, L.L., Soede N.M., Feitsma H., Kemp B. (2012). Embryo survival, progesterone profiles and metabolic responses to an increased feeding level during second gestation in sows. Theriogenology, 77: 1557–1569.

Huang, Y.H. Yang, T.S. Lee, Y.P. Roan, S.W. and Liu, S.H. (2003). Effects of sire breed on the subsequent reproductive performances of Landrace sows. Asian-Aust. J. Anim. Sci. Vol. 16, No. 4: 489–493.

Ilatsia, E.D. Githinji, M.G. Muasya, T.K. Okeno, T.O. and Kahi, A.K. (2008). Genetic parameter estimates for growth traits of Large White pigs in Kenya. South African Journal of Animal Science, 38 (3): 166–173.

Knecht, D. and Duziński, K. (2014). The effect of parity and date of service on the reproductive performance of Polish Large white X Polish Landrace (PLW X PL) crossbred sows. Ann. Anim. Sci., Vol. 14, No. 1: 69–79

Knecht, D., Środoń, S., Szulc, K., and Duziński, K. (2013). The effect of photoperiod on selected parameters of boar semen, Livest. Sci., 157, 364–371.

Knecht, D., Środoń, S. and Duziński, K. (2015). The impact of season, parity and breed on selected reproductive performance parameters of sows. Arch. Anim. Breed., 58, 49–56.

Kuo, Y. H., Huang, S. Y. and Lee, Y. P. (1997). Effect of breed and season on semen characteristics of boars in subtropical area. J. Chin. Soc. Vet. Sci. 23:114–122.

Love, R.J., Evans, G. & Klupiec, C., 1993. Seasonal effects on fertility in gilts and sows. J. Reprod. Fertil. (Suppl.) 48, 191–206.

Lucia Jr. T., Correa M.N., Deschamps J.C., Bianchi I., Donin M.A., Machado A.C. (2002). Risk factors for stillbirths in two swine farms in the south of Brazil. Prev. Vet. Med., 53: 285–292.

Marchev Y., Szostak B. (2007). The opening periods of sows depending on conditions of rearing system and season (in Polish). Ann. UMCS, sectio EE Zootechnica, 25 (2): 27–32.

McLaren, D.G., Buchanan, D.S. and Johnson, R.K. 1987. Growth performance for four breeds of swine: crossbred females and purebred and crossbred boars. Journal of Animal Science 64: 99–108.

MoFA (2012). Agriculture in Ghana, Facts and Figures. Statistical, Research and Information Directorate, Ministry of Food and Agriculture, Ghana.

Mungate, F., Dzama, K., Mandisodza, K. & Shoniwa, A., 1999. Some non-genetic factors affecting commercial pig production in Zimbabwe. S. Afr. J. Anim. Sci. 29, 164–173.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., and Bernabucci, U. 2010. Effects of climate changes on animal production and sustainability of livestock system, Lives.t Sci., 130, 57–69.

Patterson, J. L., Beltranena, E., and Foxcroft, G. R. 2010. The effect of gilt age at first estrus and breeding on third estrus on sow body weight changes and long-term reproductive performance, J. Anim. Sci., 88, 2500–2513.

Peltoniemi, O.A.T., Tast, A., Love, R.J. 2000. Factors effecting reproduction in the pig: seasonal effects and restricted feeding of the pregnant gilt and sow. Anim. Reprod. Sci., 60–61: 173–184.

Prunier, A., Messias, de Braganca, M., Le Dividich, J. 1997. Influence of high ambient temperature on performance of reproductive sows. Livest. Prod. Sci., 52: 123–133.

Quesnel, H., Brossard, L., Valancogne, A., and Quiniou, N. (2008). Influence of some sow characteristics on within-litter variation of piglet birth weight, Animal, 2, 1842–1849.

Quesnel, H., Meunier-Salaün, M. C., Hamard, A., Guillemet, R., Etienne, M., Farmer, C., Dourmad, J. Y., and Pére, M. C. (2009). Dietary fiber for pregnant sows: Influence on sow physiology and performance during lactation, J. Anim. Sci., 87, 532–543.

Rekwot, P.I, Jegede, J.O, Ehoche, O.W. and Tegbe, T.S.B. Reproductive performance in smallhlder piggeries in northern Nigeria. Trop Agric (Trinidad). 2001; 78: 1–4.

Scholman, G. J. and Dijkhuizen, A. A. (1989). Determination and analysis of the economic optimum culling strategy in swine breeding herds in Western Europe and the USA, Neth. J. Agric. Sci., 37, 71–74.

Schwarz, T., Kopyra, M. (2006). Influence of age on insemination process and reproductive performance in sows. Anim. Sci. Pap. Rep., 24, Suppl. 3: 229–239.

Schwarz, T. Nowicki, J. and Tuz, R. (2009). Reproductive performance of polish large white sows in intensive production – effect of parity and season. Ann. Anim. Sci., Vol. 9, No. 3: 269–277.

Škorjanc D., Hohler M., Brus M. (2008). Effect of backfat loss during lactation on weaning-tooestrus interval of sows at gonadotropin application. Arch. Tierz., 51 (6): 560–571.

Suriyasomboon, A., Lundeheim, N., Kunavonkrit, A. & Einarson, S., 2006. Effect of temperature and humidity on reproductive performance of crossbred sows in Thailand. Theriogenology 65, 606–628.

Tantasuparuk, W., Lundeheim, N., Dalin, A.M., Kunavongkrit, A. & Einarsson, S., 2000. Reproductive performance of purebred Landrace and Yorkshire sows in Thailand with special reference to seasonal influence and parity number. Theriogenology 54, 481–496.

Tummaruk P., Lundeheim N., Einarsson S., Dalin A.M. (2001). Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Anim. Reprod. Sci., 66: 225–237.

Tummaruk, P., Tantasuparuk, W., Techakumphu, M., and Kunavongkrit, A. (2010). Seasonal influences on the litter size at birth of pigs are more pronounced in the gilt than sow litters. J. Agric. Sci., 148, 421–432.

Van Dijk, A.J., van Rens, B.T.T.M., van der Lende, T., Taverne, M.A.M. (2005). Factors affecting duration of the expulsive stage of parturition and piglet birth intervals in sows with uncomplicated, spontaneous farrowings. Theriogenology, 64: 1573–1590.

Vanderhaeghe, C., Dewulf, J., Ribbens, S., de Kruif, A., and Maes, D. (2010). A cross-sectional study to collect risk factors associated with stillbirths in pig herds, Anim. Reprod. Sci., 118, 62–68.

Whittemore, C. 1993. The Science and Practice of Pig Production. Longman Group UK Limited, Harlow, Essex, pages 184–188.

Yilma, T. (2017). Study on reproductive performance of breeding sows and ultrasound monitoring of ovarian follicle activity and ovulation of post-weaning sows in a commercial pig farm of central Ethiopia. Vet Med Open J. 2017; 2(3): 76–82.