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Original article

Effects of genetic and non genetic factors on sow performance – a case of an imported multiplier herd in Zimbabwe

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Effects of genetic and non-genetic factors on traits of economic importance in pigs at an imported multiplier herd in Zimbabwe were studied using data collected from 1166 litters. The traits studied were number of piglets born alive (NBA) and average birth weight (ABWT). The independent variables in the study were breed of boar (BOB), breed of sow (SOWBRD), parity, season of farrowing (SOF) and year of farrowing (YOF). The season was classified into four categories namely, cold dry (May, June, July), hot dry (August, September, October), post rain season (Late February, March, April), and hot wet season (November, December, January and early February). Data were analyzed using the general linear models (GLM) of the statistical analysis software (SAS). NBA and ABWT were significantly higher for the mid-parities (2 to 7) than for the first parity and later parity (8 and above) sows. NBA was significantly lower in the hot wet season than at any other time of the year and the litters came from mating done in the hot dry months of August, September and October. Average birth weights were significantly lower in the hot dry season, the period where NBA was largest. Different breeds reached peak productivity at different parities. The Landrace breed recorded the highest NBA, whereas Duroc sows produced litters with the highest ABWT. The conclusion from this study is, the Large White and the Landrace breeds are ideal dam lines for the traits NBA and ABWT, and a cross between the two would further exploit heterosis effects for the reproductive traits which are known to be lowly heritable. The Duroc breed, excellent in carcass traits such as weight, is most suitable as a terminal sire breed crossed to the Large White*Landrace F1 gilts for the production of fattener pigs. In the hot dry season boar fertility is poorest and could be enhanced by sprinkling the animals with cold water. Wet feeding could be practiced to encourage feed intake in sows. Both interventions would mimic conditions prevailing in the post rain season where optimal NBA and ABWT are recorded due to cool temperatures and less dry air. When a farmer practices on-farm rearing and selection of replacement gilts it is important to take parity as one of the most important criteria for selection. Gilts below parity 3 should not be considered for breeding replacement gilts as their records are not fully dependable. On the other hand, poorly performing gilts in terms of NBA and ABWT can still do better if allowed to grow to maturity rather than being culled; hence culling decision should be less hush for gilts.

1. Introduction

The pig industry in Zimbabwe is based on both indigenous and imported breeds. The imported breeds dominate commercial production whereas the indigenous breeds play an insignificant role. A small number of registered stud breeders produce their own replacement boars and gilts from either great grand-parents (GGP) or grandparents (GP) and parents (P) imported from primary breeders in Europe, Canada and South Africa. The stud breeders have their pigs tested at the Pig industry Board Central Testing Station (Dzama and Shonhiwa 2005). Approved gilts are either retained by the stud breeder for multiplication or sold to commercial producers. The progeny of retained boars are performance tested on the breeder`s farm (Takaendesa 2005). Animals which pass the test are also made available to commercial producers.

The fact that the genetic material is exposed to a production environment essentially different from the European and American conditions under which it was developed may potentially lead to a significant genetic by environment interaction. Genotype by environment interaction can in some cases lead to a change in ranking among breeds, whereby a superior breed for certain traits becomes inferior in a new environment.

Several factors are considered environmental components to the expression of an organism in a particular trait. Parity, Season and year of birth, level of nutritional management, and age at first service are all non-genetic factors known to influence animal performance, whereas breed effects are genetic. There is need to determine and quantify the specific effects of both genetic and non-genetic factors on animal performance (Silveira et al 2009). Such data are relevant in breed selection as it increases accuracy of breeding value estimates by adjusting for the effects of these non-genetic factors such that selection decisions are based more on genetic merit rather than environmental advantage which cannot be passed on to descendents(Cavalcante-Neto et al 2009a; Leite et al 2011). Such data are also important to the farmer as he will be able to determine the most appropriate levels of non-genetic factors so as to optimize productivity for particular breeds present. For example, one will be able to know the most optimal age at first farrowing to maximize pig productivity in terms of longevity, production and reproductive performance in the Landrace breed.

The general objective of the study was to characterize productivity of the multiplier herd of pigs at the Gilt Edge farm and to determine the effects of genetic and non-genetic factors on sow reproductive performance.

2. Materials and methods

2.1. Study Site

The field data was from pigs which were part of the herd at the Gilt Edge Multiplier farm, located in Shamva, about 100km North East of Harare, the capital city of Zimbabwe. The farm lies in Natural Region 2b in an intensive mixed crop and livestock farming area. The altitude is 1500 m above sea level. Mean temperature during the warm humid summer (October to March) is 21 0C, while the cool dry winter averages 15 0C. Mean annual rainfall is 800 mm. The farm was involved in multiplication of the Large White, Landrace and Duroc purebreds as well as developing F1 crosses between Large White and Landrace. The pure lines were under constant improvement through the importation of both semen and live boars.

2.2. General management of the animals

2.2.1. Breeding and housing

Breeding sows and gilts were observed for oestrus using the riding test, and those in standing heat were served. The gilts were normally mated at 6.5 months of age, or when they were about 120 kg live weight, whichever came first. They were mated on their second or third heat. The mating was done naturally, except when knew semen had been imported in place of live animals in which case artificial insemination was employed. All sows were mated three times using the same boar at 12hour intervals after standing heat. All mating were supervised and fitted into a daily work schedule. Early morning was normally the best mating time as it would be still cool, with not much animal disturbances and before feed time. Pregnancy diagnosis was carried out 21 to 28 days after mating and sows that returned to heat were served again. Sows failing to conceive after the second mating chance were culled. Sows were brought to the farrowing crates seven days before parturition. Immediately after farrowing the umbilical cord of each piglet was cut and dipped in iodine solution. Litter size and farrowing mortality were recorded after which piglets were ear-notched for purposes of identification. Eye-teeth were also removed. Piglets from litter sizes in excess of 12 were fostered to other sows which had farrowed within a week of each other. Piglets were given access to moistened red soil as a source of iron. Sometimes they received iron through injection. Creep feed was introduced after seven days and was fed ad libitum until weaning. Mortality between birth and weaning was recorded.

2.2.2. Nutrition and health

Replacement gilts were fed 4kg of sow meal per day until they were mated. Older sows were fed 5kg of sow meal per day from weaning to mating. All breeding females were given 2kg of the meal per day from mating to farrowing. All new stock of five and half months of age were administered an Escherichia Coli injection and at six months of age a porcine parvovirus and leptospirosis vaccine. The boars were dosed for worms every six months. The boars` sheaths were treated with an antibiotic once every five months to kill the buildup of bacteria. Gilts were vaccinated against the parvovirus two to three weeks before mating. Sows were vaccinated only in the event of an outbreak of a disease.

2.2.3. Data collection and statistical analysis

The traits studied were number of piglets born alive (NBA) and average birth weight (ABWT). The independent variables in the study were breed of boar (BOB), breed of sow (SOWBRD), parity, season of farrowing (SOF) and year of farrowing (YOF). The season was classified into four categories namely, cold dry (May, June, July), and hot dry (August, September, October), post rain season (Late February, March, April), and hot wet season (November, December, January and early February). Data were analyzed using the general linear models (GLM) of SAS (1999).

The model employed was: $Y_{ijklmn} = \mu + P_i + M_j + D_k + S_i + Y_m + b_1 (AAFS) + E_{ijklmn}$.

Where,

Y_{ijklmn} = NBA and ABWT

μ = overall mean

P_i = the fixed effects of the ith parity

M_j = the fixed effects of the jth season of farrowing

D_k = the fixed effects of the kth breed of sow

S_i = the fixed effects of the ith breed of boar

Y_m = the fixed effects of the mth year of farrowing

b_1 (AAFS) = age at first service as a covariate

Eijklmn = the random error

3. Results and discussion

3.1. Summary statistics

Table 1 shows the number of observations, raw means and standard deviations for age at first service, number of live births, average birth weight and farrowing interval. The minimum and maximum values for NBA were 3 and 16, respectively. The maximum ABWT was almost twice the minimum value.

Table 1
Summary Statistics of variables under study.

Variable	N	Mean	SD	Minimum	Maximum
Age at first service (days)	1166	151	18.6	125	193
Number of live births	1156	10.9	3.02	3	16
Average birth weight (kg)	1166	1.56	0.21	0.99	1.98
Farrowing interval (days)	1023	1.58	11.24	125	189

N is number of records, SD is standard deviation.

3.2. Effects of breed and parity of sow on NBA and ABWT

Figure 1 shows a significant ($p<0.05$) parity by breed of sow (SOWBRD) interaction effect on NBA. For gilts and parity 1 sows, their NBA was not significantly different among the breeds under study. From parity 2 onwards, the landrace breed (R) exhibited consistently higher NBA compared to the other breeds. The landrace breed reached its peak NBA in the sixth parity and started to decline thereafter. Even beyond parity six, the landrace breed still exhibited a consistently higher NBA compared to Large white (L) and Duroc (D). Duroc sows were inconsistent in the NBA across all parities, exhibiting high fluctuations. The Large white breed reached its peak NBA in the third parity and started to decline thereafter.

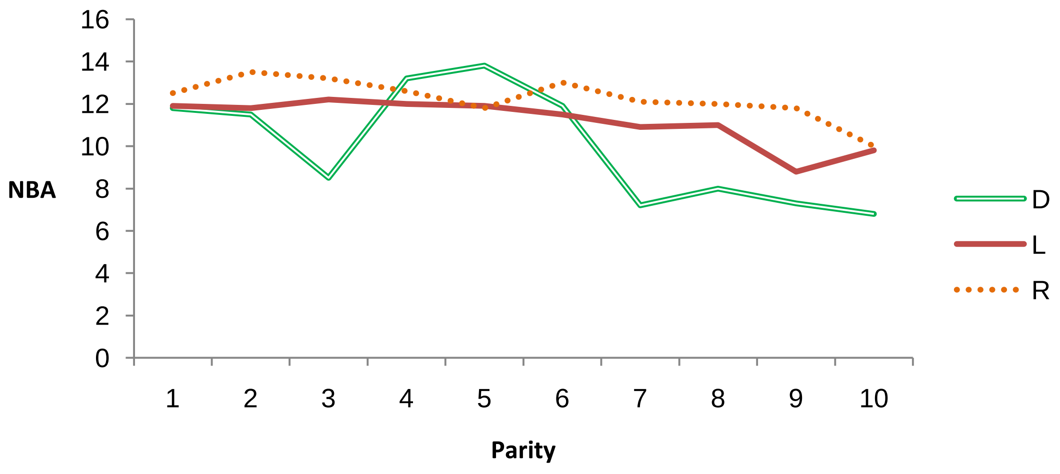

Fig. 1. Number of piglets born alive (NBA) in Large White(L), Landrace(R) and Duroc(D) sows.

Figure 2 shows significant ($p<0.05$) parity by breed of sow (SOWBRD) interaction effects on ABWT. For gilts and parity 1 sows, the Large White breed exhibited a significantly higher ABWT than Duroc and Landrace. The Landrace breed had a consistently lower ABWT than the other two breeds throughout the 10 parities. Duroc and large white breeds performance for ABWT from parity 2 onwards was not significantly different.

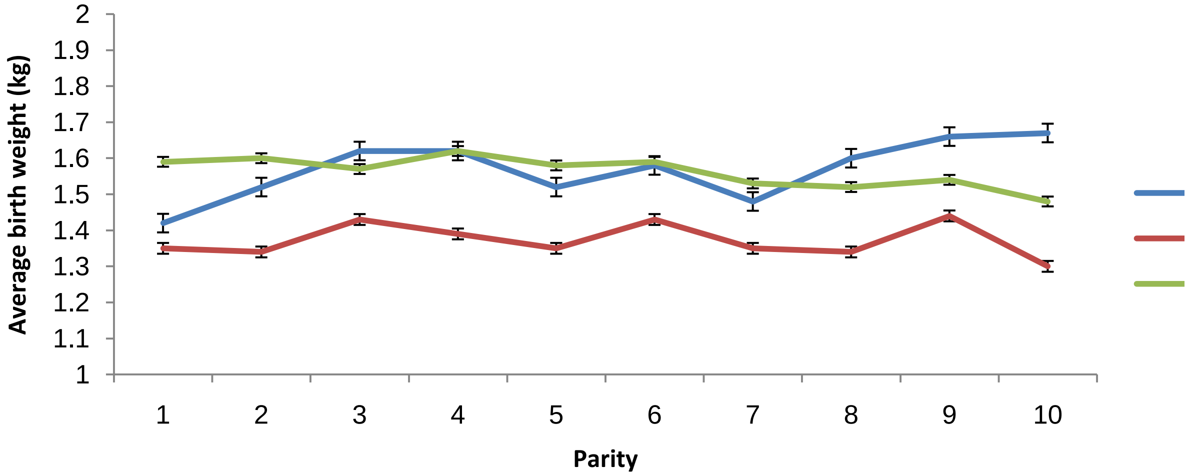

Fig. 2. Influence of breed and parity of sow on Average birth weight (ABWT).

3.3. Effects of season of farrowing and breed of boar on NBA and ABWT

Table 2 shows the effect of breed of boar (BOB) on NBA. Landrace and Large White boars gave the same NBA, which were, however, significantly higher than for Duroc boars. Duroc boars gave rise to piglets of the highest ABWT, followed by the Large White breed. The Landrace breed gave the least ABWT values.

Table 2
Effects of Breed of Boar on NBA and ABWT.

Breed	N	NBA	SEM	ABWT	SEM
Duroc	170	10.4a	0.262	1.64c	0.0132
Large white	473	11.1b	0.142	1.58b	0.0101
Landrace	523	11.0b	0.123	1.51a	0.00875

abc Values with different superscripts within column are significantly different ($p<0.05$).

The highest values for NBA were observed for farrowings in the hot dry season and the lowest were observed in the hot wet season as shown in Table 3.The cold dry season and the post rain gave the same NBA values. The highest ABWT values were observed in the hot wet season and the lowest in the hot dry season. Post rain farrowings gave rise to above average performances in both traits.

Table 3
Effects of season of farrowing on NBA and ABWT values.

Season	NBA	SEM	ABWT	SEM
Hot wet	10.0a	0.24	1.57c	0.020
Post rain	11.3bc	0.26	1.55bc	0.021
Cold dry	11.1b	0.25	1.52ab	0.021
Hot dry	11.6c	0.26	1.51a	0.021

abc Values with different superscripts within column are significantly different ($p<0.05$).

4. Discussion

The average NBA of 10.9 observed is higher than values reported by Mungate et al (1999), who were working with crossbred animals. The average birth weight of 1.56 is in agreement with what was reported by several authors (Maburutse 1992; Mungate et al 1999). The NBA and ABWT values reported are however higher than those reported for the indigenous Mukota breed of Zimbabwe (Ndiweni et al 1995; Ncube et al 2003; Chimonyo 2005).

The observation that parity, breed of boar, season of farrowing and breed of sow were significant sources of variation on NBA agrees with literature (Boland 1983; Marrow et al 1989; Whittemore 1993). The findings that the Large White, Landrace and Duroc sows reach their peak between the third and sixth parity also is in agreement with literature (Whittemore 1993; Mungate et al 1999; Chimonyo 2005). Ovulation rates are expected to be higher for multiparous sows than for primiparous gilts. In other words, the number of follicles and fertile ova increases as the sow grows (Whittemore 1993). Observations in this study would encourage culling at parity 6 or 7. The reduced NBA values beyond parity 6 could be attributed to high incidences of mummified fetuses, stillbirths and dystocia as reported by Mungate et al (1999). Sows in this study gave the highest NBA values when they occupied the parity region 2 to 6, than when in earlier or later parities. It is now known that sows are most productive when they occupy this parity region. Before parity 3 sows are still growing and are not yet fully developed for the vagaries of reproduction. The gilts and young sows produce fewer fertile ova compared to mature sows. The low ABWT in gilts as compared to later parities also agrees with findings by Mungate et al (1999) and Chimonyo (2005). Gilts are still physiologically immature and partition nutrients between their own growth requirements and those of the fetuses, resulting in lower birth weights. In addition, the limited uterine capacity for gilts tends to limit weight of fetuses. The decline in ABWT for later parity sows is because older sows tend to undergo a physiological deterioration and hence may fail to fully utilize their feed resources, in providing nutrients to the feotus in- utero.

The significant effect of breed of boar on both NBA and ABWT was as expected (Whittemore 1993). Large White and Landrace boars produced significantly higher NBA than Duroc boars. Pigs sired by Duroc were, however, heavier than the other breeds. These observations demonstrated the negative correlation between the traits NBA and ABWT (Serres 1992). More piglets per litter imply an increased competition for nutrients in-utero which then leads to a decline in the average birth weight of piglets born (English et al 1988). According to Whittemore (1993), the number of live births per litter is usually a function of embryo loss/survival than number of ova shed. The high ABWT observed when NBA is low is indicative of a low uterine capacity of the modern day breeds to support the high genetic potential for growth. Hence the negative correlation between ABWT and NBA is more environmental than it is genetic.

The highest NBA observed during hot dry season (August, September, October and early November) agree with Mungate et al (1999) who reported that the number of live births under the Zimbabwean conditions is high in the hot dry season. The findings that the hot wet season had the lowest number of live births could be due to the fact that mating of sows would have been in the hot dry season. At this time of the year breeding animals suffer most from heat stress leading to low sperm count, reduced libido, increased foetal resorption due to stress, and silent heat. From mating up to farrowing which then takes place in the hot wet season, the conditions will still be unfavorable as the pregnant and lactating sows experience reduced appetite due to high ambient temperatures. This reduces the availability of nutrients to support pregnancy. This agrees with Brooks (1991) who reported that under hot seasonal conditions, pregnant and lactating sows experience reduced feed intake leading to reduced litter sizes at farrowing. Reduced appetite in pregnancy leads to increased mobilization of body reserves which ultimately may lead to poor condition at farrowing and lactation leading to reduced NBA and numbers weaned, among many other adverse effects. The seasons with the highest litter size also turned to have the least number of live piglets at birth.

5. Conclusions and recommendations

Performance of breeding sows in Zimbabwe is dependent on Breed type, season and parity. Sows are most productive when they occupy parity region 2 to 6. Breed effects on NBA and ABWT are also parity dependent. Landrace sows give the highest NBA and maintain this performance to the 6th parity, whilst Large White sows produce litters with consistently high ABWT to the 6th parity. The Duroc breed appears to be the most superior for ABWT at all parities. These observations support the current position that there is no one breed that is most ideal for all conditions. There is need to exploit breed complementarities by adopting breeding plans that make use of as much genetic material available as is possible. It is recommended that Large White and Landrace be crossed to form hybrid dam lines which can be crossed to Duroc boars terminal sires. Such a cross exploits the strength of Landrace in NBA and Large white in ABWT as well as the Duroc in both ABWT and carcass traits. The dam line is also expected to exhibit longevity in the breeding herd at least for the two traits NBA and ABWT. For the purposes of adjusting for effect of season of farrowing in breeding value estimations for NBA and ABWT the post rain season would be the most ideal base level to adjust all other records. The hot dry season appeared to adversely affect reproductive performance. This could be due to reduced fertility as well as reduced nutrient availability due to high heat stress that also affect feed intake. Boar fertility could be enhanced by sprinkling the boars with cold water. Wet feeding could be encouraged to improve on feed intake in sows.

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