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Original article

The effect of non genetic factors on litter weight at birth and weaning in Dalland pig breed of Zimbabwe

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A B S T R A C T

Non-genetic factors influencing litter weight at birth and weaning were evaluated using the Dalland pig breed of Zimbabwe. The objective of the present study was to establish the non genetic factors which affect average litter weight at birth (ALBWT) and weaning (ALWWT) in Dalland pig breed of Zimbabwe. Mixed classification models containing effects of sire, ages at first service, gestation length, teat number, litter size at birth, litter size at weaning and year of birth and weaning were used for identification of non genetic factors. The ALBWT and ALWWT data were analyzed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS), 1996 to establish the significance of the non genetic factors. The mean litter weight at birth and weaning were 12.53±0.13 and 24.22±0.07, respectively. Sire line and age at first service had significant effects ($p<0.05$) on both ALBWT and ALWWT. Litter size at birth and year of birth had significant effects ($p<0.05$) on average litter weight at birth, while teat number influenced average litter weight at weaning. Two way factor interactions for age at first service *teat number and age at first service* sire line had a significant effect ($p<0.05$) on average litter weight at weaning. The lowest average litter weight both at birth and weaning were observed when the litter size was largest, 15.63±0.17 and 24.64±0.25, respectively. The inconsistency of literature results on the influence of non genetic factors on average litter weight at birth and weaning in pig production within specific sow units and environment indicates the importance of estimation of environmental factors for different pig production entities is necessary. The study alludes to the complexity of the non genetic factors influencing the average litter at birth and weaning in pig production, hence the need to correct for such non genetic factors for accurate estimation of genetic parameters..

1. Introduction

Birth and weaning weight are traits of economic importance which should be given prominence in pig breeding programmes or enterprise, as the two main traits affecting the profit function in a pig farm. However these traits are controlled by two different sets of factors; those of inherited nature and the environment. Elsewhere, numerous studies on the effects of non-genetic factors on pig productivity have been carried out (Dufour and Fahmy, 1975; Campbell and Dunkin, 1982; Omtvedt et al., 1986;Yen et al., 1987; Kumar et al., 2009) and the knowledge of the extent of their effects on birth and weaning weight enable development of effective management systems for increased pig production.

Body weight at birth is the most commonly measured trait in newborn animals and has long been recognized as a major determinant of post-natal well-being, with both light and extremely heavy animals being considered at greater risk of mortality and morbidity. Size at birth is an indicator of fetal growth, which is regulated by genetic, epigenetic, and environmental factors which affect placental growth and functionality and ultimately the maternal uterine environment (Ashworth , 2013). It is an important trait in pig production which impacts piglets growth ability, with low birth weight begin life smaller, gain less during all phases of production and they are lighter at the end of fattening period (Vaclavkova et al., 2012). Milligan et al., (2002) and Quiniou et al., (2002) observed that piglet birth weight was an important factor that affected piglet preweaning survival and litter uniformity. Elsewhere, piglet birth weight was associated with litter size and parity (Quesnel et al., 2008; Wientjes et al., 2012), but there may be other factors involved. 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 single largest influence on the survival of piglets in the first few days of life is their birth weight.

Litter weight at weaning weight is the most important economic trait determining economic returns from any pig production enterprise and provide a good example of a trait subject to both genetic and environmental variation (Chimonyo et al., 2008). Whilst genetics is a major influence on average litter weight at weaning, there are also a large number of environmental, nutritional and management factors that impinge on weaning weight of litter mates. Average litter weight at weaning would reflect mothering ability of sow as well as the inherent growth potential of individuals piglets. Although some attempt has been made to assess non genetic factors affecting average litter weight at birth and weaning in pig breeds in Zimbabwe (Bellis, 1982; Shoniwa et al., 1995; Mungate et al., 1999; Mpofu and Makuza, 2003; Chimonyo et al., 2008), no such studies have been undertaken in the Dallant pig breed of Zimbabwe. To fulfill this purpose a study was therefore planned to assess various non genetic factors that affect average litter birth and weaning weights in the Dallant pig breed of Zimbabwe.

2. Materials and methods

Data comprised of 393 sow records on average litter at birth and weaning from a commercial pig production farm at Stapleford in Harare, Zimbabwe were used for this study. The farm is located in agro-ecological region 2 classified as intensive farming area. The records were collected from 2009 through to 2013. The pigs were fed a local formulated ration with protein source of soybean grown on the farm. Breeding was all year round, piglets were weighed on weekly basis and weaned at 28days.

2.1. Litter weight at birth

Data on average litter weight at birth as influenced by random of sire line, gestation length, age at first service, litter size at birth, month and year of birth were analyzed using the General Linear Model (ProcGLM) procedure of SAS (1996). The model used was :

$Y_{ijklmno} = \mu + B_i + D_j + M_k + P_l + N_m + O_n + e_{ijklmno}$

Where Yijklmno= the observation of the ijklth average litter weight at birth;

μ = overall mean;

Bi= fixed effects of sire line the ith sire line(i=20, 35, 40, 80);

Dj= fixed effect of gestation length the jth sow (j = 109, 110, 111, … and 118);

Mk = fixed effect of age at first service the kth sow (k = 210, 220, 230, … and 250);

Pl = fixed effect of litter size at birth the lth sow (l= 1, 2);

Nm= fixed effect of month of birth the mth sow (m= Jan-Marc, Apri-Jun, Jul-Sept, Oct- Dec);

On = fixed effect of year of birth the nth sow (n= 2007, 2008, …….and 2013);

eijklmno= random error effect.

2.2. Litter weight at weaning

Data on average litter weight at weaning as influenced by sire line, gestation length, age at first service, litter size at birth, month and year of birth were analyzed using the General Linear Model (Proc GLM) procedure of SAS (1996). The model used was :

$Y_{ijklmno} = \mu + B_i + D_j + M_k + P_l + N_m + O_n + D_{jk} + D_{ji} + e_{ijklmno}$

Where Yijklmno= the observation of the ijklth average litter weight at weaning;

μ = overall mean;

Bi= fixed effects of sire line the ith sire line(i=20, 35, 40, 80);

Dj= fixed effect of age at first service the jth sow (j = 210, 220, 230, … and 250);

Mk = fixed effect of teat number the kth sow (k= 8, 11, 12, 13, 14, 15, 16);

Pl = fixed effect of litter size at birth the lth sow (l= 1, 2);

Nm= fixed effect of litter size at weaning the lth sow (l= 1, 2);

On = fixed effect of year of weaning to estrus interval the nth sow (n=8, 12, 16);

Djk= interaction between age at first service and teat number;

Dji= interaction between age at first service and sire effect;

eijklmno= random error effect.

3. Results and discussion

3.1. Average litter weight at birth

The descriptive statistics, analysis of variance and the least squares means± SE for average litter weight at birth and weaning weight are shown in Table 1, 2 and 3, respectively. There were significant differences in average litter weight at birth weight, due to sire line, age at first service, litter size and year of birth. The total number of piglets born alive at birth increased with as gestation length increased and were greater with sire line 80 and sire line 20 having the lowest average litter weight at birth (Table 4). This is partly in agreement with Ferrel (1993) who observed that the primary contributor of differences in foetal growth is foetal genotypes which consisted of contributions from both the sire and dam, hence influencing piglets birth weight. Therefore it be reasonably suggested that piglets birth weight is largely the expression of genetic differences between sires, and then some of the other environmental common to litter mates is really genetic in origin but depends on the genotype of the dam rather than on the genotype of the offspring. However, in pigs litter mates are subjected to similar environmental conditions during their intra-uterine life, which might well make the dam more important than the sire in affecting birth weights even though both sire and dam contribute equally to the unborn piglets. It is assumed that with the sire hold constant within year, was but slightly more than the eliminated by year alone, and it appeared certain that the sire had some effect on the birth weight of the offspring. While a pig's potential for growth is ultimately determined by its genotype (Schinkel,1999) the influence of non genetic factors may not be ruled out. The single largest influence on the survival of piglets in the first few days of life is their birth weight. Fetal growth and birth weight are regulated by genotype of the fetus in addition to maternal genotype, maternal nutrition and the external environment. Growth is accomplished by cellular hyperplasia early in life and cellular hypertrophy thereafter (Lawrence and Flower, 2002). However, quantitative and qualitative aspects of postnatal nutrition have a major effect on muscle development through their effect on growth rate and body composition. The genotype of both mother and foetuses play a vital role in determining birth weight, while the consequent litter weights basically depend on the foetuses' genotype and the suckled milk from the dam (Abdel-Azeem, 2006). However, the genotype of both mother and foetuses play a vital role in determining birth weight, while the consequent litter weights basically depend on the foetuses' genotype and the suckled milk from the dam (Abdel-Azeem, 2006).

Litter size at birth was highly significant ($p<0.01$) which is in agreement with Rashwan et al. (1995) who reported that differences in litter size at birth could be due to differences in ovulation rate, and pre-implantation viability as well as maternal effects determined by the number of matured, fertilized and established ova. As litter size increases, there is decrease in birth mass of individual offspring (Donald and Russel 1970; Mc Donald et al., 1981). The litter size had the greatest influence on birth (Ruttle, 1967) and higher litter size was connected with lower birth weights average (Wolf et al., 2008). An increase in litter size will decrease the average piglet birth weight, leading to an increase in pre-weaning mortality (Hermesch et al., 2001; Knol et al., 2002). The number of piglet born alive and average piglet weight at birth are antagonistic traits, the weighting of both traits in the total merit index should be done cautiously in order not to overemphasize birth weight traits and unintentionally decrease litter size by selecting heavier piglets from smaller litter (Suarez et al., 2004). Birth weight was significantly affected by type of birth and generally birth weight decreased with increase in litter size. Robinson et al (1977) reported that for lambs in utero, as the number of foetuses increases, the number of caruncles attached to each foetus decreases, thus reducing the feed supply to the foetus and hence reduction in the birth weight of the lambs. In goat and sheep, a positive correlation was found between birth weight and the weight of cotyledons (Alexander, 1964; Alkass et al., 1999; Osgerby et al., 2003; Madibela, 2004; Oramari et al., 2011). Also, it has been reported that the number of cotyledons per foetus varies between and within breed, litter size, sex and environmental conditions (Alexander, 1964). Therefore, the survival of a newborn is affected by sufficiency of placenta (Mellor and Stafford, 2004). The differences in foetal mass because of differences in litter size appear as early as the first month of pregnancy (Hulet et al., 1969; Dingwal et al., 1981). The larger the litter size at birth will compromise the average litter birth weight. Low birth weight than optimum is the main factor that determine the pre weaning losses of piglets and large birth have been associated with difficult birth. Low birth weight results from intrauterine growth retardation during gestation (Vaclavkove et al., 2012), and the reason cited has been that small piglets form a lower total number of skeletal muscle fibres during prenatal development compared with their larger littermates (Gondret et al., 2006). Elsewhere, Quiniou et al. (2002) observed that the average piglet body weight may decrease and the percentage of piglets with low birth weight may increase with increasing litter size. The same author showed that during lactation heavier piglets grow faster than lighter piglets. These authors assumed that heavier piglets have a greater ability to occupy the best performing teats, to stimulate and to drain them, thereby, to induce a larger milk flow. Low birth weight have been associated with the effect known as intrauterine crowding, which, together with genetic and epigenetic factors, influences angiogenesis, growth, and vascularization of the placenta. The sire line had a significant ($p<0.05$) effects on average litter weight at birth which is partly in agreement with Stoner et al., (1985) who observed that birth weight losses were greater in lean sire line than the obese line. Concluded that the obese line piglets appeared to have greater piglet fat stores at birth in common and other literature supports this as a factor in preweaning survival (Mersmann, 1974). Numerous studies indicate that one of the primary factors influencing preweaning survival is low birth weight (Tuchscherer et al., 2000; Milligan et al., 2002), which brings us back to uterine capacity, because birth weights are established during gestation. Beyond birth weights, piglets from different breeds or lines of pigs differ widely in pre- weaning survival.

Low average litter weight can lead to reduced litter viability. Therefore, particular nutritional privileges should be given to pregnant sows. Traditional measures to ameliorate birth associated negative effects should also focus on maternal dietary manipulation which may influence optimum birth weight (Assan, 2013). Nutritional programs designed to improve dam’s body condition during pregnancy will have a positive influence on birth weight of progeny. It is reasonable to suggest that improving the nutrition of sows during pregnancy increases birth weight and this leads to improved survival of their progeny. The importance of litter size at birth is an indication of a constant maternal environment effect and the smaller the litter tend to maintain their birth advantage up to weaning. Nutritional stress during pregnancy may limit the piglets expressing their full genetic potential for birth weight. Alterations to the composition of the diet consumed by pregnant females have been shown to increase average birth weight and reduce the incidence of runts (Ashworth, 2013).The number of fully formed piglets present at furrowing is influenced by the number of ova shed, the fertilization failure rate, the embryonic mortality rate, and the number of fetuses maintained by the uterus during gestation and uterine capacity (Bennett and Leymaster, 1989). While a pig's potential for growth is ultimately determined by its genotype (Schinkel,1999) many non genetic factors are at play. Fetal growth and birth weight are regulated by genotype of the fetus in addition to maternal genotype, maternal nutrition and the external environment. Growth is accomplished by cellular hyperplasia early in life and cellular hypertrophy thereafter (Lawrence and Flower, 2002). However, quantitative and qualitative aspects of postnatal nutrition have a major effect on muscle development through their effect on growth rate and body composition.

Age at first service which may represent the biological age of the sows had a significant ($p<0.05$) effect on average litter weight at birth. This might be explained by the fact that the biological age of the sow which may explain the state of sow physiological preparedness to carry a fetuses. The relative competition for nutrients between the still growing ewes and developing foetus may be the reason for depression in birth weight in livestock production in offspring born to younger mothers (Thiruvenkadan et al., 2011).

The year of birth had a significant ($p<0.01$) effect on average litter weight at birth, this might be explained by possibly due to differences in management within years. It is well established that year of birth causes variation on weight and performance of livestock due to climatic variations and management during pregnancy (Abegaz et al., 2005) Variation in nutrition and farm management from year to year might be responsible for increased variation in birth weight. The significant differences in average litter weight at birth in pigs born in different years may be attributed to differences in management such as selection of rams and exposure to environmental conditions, such as the ambient temperature and humidity. Seasonal influence on birth weight operates through its effect on the dam's uterine environment mostly in late gestation (Eltawil et al 1970). The year effect on average litter weight at birth encompasses factors which include feeding, management, humidity, temperature, disease control and management ability of the person responsible for data collection. The decreased feed intake , depressed thyroid activity and hence in metabolic rate of pregnant does during hot summer months affected litter weight and mean kit weight at birth negatively (Abdel-Azeem et al., 2007).

3.2. Average litter weight at weaning

Sire line, age at first service and number of teats ($p < .01$) were significant sources of variation for litter weight at weaning. Litters weaned to sows with age at first service above 230 days were larger in size compared to those weaned to sows with age to first service below 230days. This is probably because older gilts have good mothering instincts and may produce more milk. However, (Magowan and McCann, 2009) observed that the number of pigs weaned per litter, the total weight of pigs weaned per litter and the average daily gain of piglets between birth and weaning did not differ between sire line breeds. Sire line breed had no significant effect on the coefficient of variation for wean weight of pigs. As was not expected the litter size at birth and weaning was non significant on litter weight at weaning. This was in contrary to previous observation that the larger the litter size the lesser the average litter weight at weaning due to competition for sow's milk. In rabbits litter weight at weaning was controlled by the number of kittens that survived to weaning (Risamet al., 2005). The genotype of both the mother and the fetus play a vital role in determining the birth weight, while the consequent litter weights at weaning basically depend, beside the piglets genotype, on the suckled milk from the dam. The importance of the random effect of sires lines within breeds on average litter at weaning suggest that selection of boars should be given a priority in any pig production system making it useful in the improvement of overall economic efficiency. In general crossbred litter showed higher litter weight at weaning than those of purebred litter (Abdel-Azeem et al., 2007). These results were in agreement with those reported by Seleem (2005). Weaning weight would reflect mothering ability of dam as well as the inherent growth potential, thereafter growth potential would predominate. Milk production of the sow is potentially a limiting resource in growth of piglets causing competition among piglets because the voluntary feed intake of piglets keeps increasing, whereas milk production of the sow reaches a rather constant level after 8 to 10d (Harrel et al., 1993). This may have a serious effect on sows with a larger litter size.

Table 1
Descriptive statistics of average litter weight at birth (ALBWT) and weaning (ALWWT) in Dalant pig breed of Zimbabwe.

Trait	N	Mean ±SE	CV%	R2	STD
ALBWT	393	12.53±0.13	20.79	0.93	2.61
ALWWT	393	24.22±0.07	6.06	0.83	1.47

CV%= Coefficient of variation, R2= Coefficient of determination, STD= Standard deviation.

Table 2
Analysis of variance (mean squares) for average litter weight at birth (ALBWT) in Dalant pig breed of Zimbabwe.

Source	Df	Type III SS	Mean Squares	P-value
Sire line	3	27.042082	6.760520	0.0261*
Gestation length	9	35.762636	3.973626	0.1014ns
Age at first service	4	31.973032	7.993258	0.0112*
Litter size at birth	2	1421.370939	710.685469	<0.0001**
Month of birth	3	11.370329	3.790110	0.1969ns
Year of birth	6	30.537848	5.089641	0.0520**

*(P< 0.05), **(P<0.01), ns=non significant.

Table 3
Analysis of variance for average litter weight at weaning (ALWWT) in Dalant pig breed of Zimbabwe.

Source	Df	Type III SS	Mean Squares	P-value
Sire line	3	6.5621777		0.0085**
Age at first service (AGEFS)	4	223.6812486	6.7782197	<0.0001**
Teat number (TTN)	4	14.5034780	3.6258695	<0.0001**
Litter size at birth	2	4.9294983	0.4481362	0.6246ns
Litter size at weaning	3	4.3975958	0.3997814	0.7118ns
Weaning to estrus interval	2	5.3614719	0.5361472	0.4649ns
AGEFS*TTN	6	47.9878378	7.9979730	<0.0001**
AGEFS*Sire	7	155.8700144	9.7418759	<0.0001**

*(P< 0.05), **(P<0.01), ns=non significant.

Table 4
Least squares means and standard errors for average litter weight at birth (ALBWT) and weaning (ALWWT) according to sire line, months, year, and gestation length, litter size at birth and weaning in Dalant pig breed of Zimbabwe.

Source	N	ALBWT	ALWWT
Sire line			
20	112	13.96±1.03a	23.90±1.03a
35	154	11.96±1.03b	24.36±1.03b
40	198	12.33±1.03bc	23.92±1.03a
80	125	12.98±1.03c	24.63±1.03b
Months			
January - March	89	12.98±0.87a	24.10±0.11a
April- June	124	12.74±0.87a	24.23±0.11a
July - September	83	12.47±0.87a	24.17±0.11a
October- December	93	12.61±0.87a	26.34±0.11a

Year			
2007	61	13.02±0.90a	25.09±0.52a
2008	70	14.81±1.15b	25.54±0.65ab
2009	80	15.47±1.15b	25.10±0.65b
2010	32	12.40±0.45b	24.18±0.26c
2011	54	13.25±0.33a	24.18±0.19c
2012	201	12.40±0.18c	24.17±0.10c
2013	88	12.59±0.27c	24.21±0.16c
Gestation Length (days)			
109	52	10.94±0.87a	24.04±1.30a
110	67	11.51±0.42 a	24.10±0.63a
111	89	11.85±0.31b	24.89±0.46b
112	63	11.84±0.24bc	24.65±0.35b
113	99	11.86±0.22cd	24.74±0.32b
114	128	11.83±0.22d	24.81±0.32b
115	65	11.96±0.24d	25.01±0.34c
116	120	11.85±0.35d	25.12±0.51c
117	86	10.74±0.84a	25.52±0.25c
118	90	11.35±0.52b	26.59±0.77d
Age at first service			
210	44	12.44±0.39a	23.66±0.22a
220	147	13.09±0.21a	24.45±0.12b
230	157	12.10±0.21a	26.22±0.11c
240	33	12.53±0.44a	26.04±0.25c
250	12	11.77±0.74a	26.23±0.42c
Litter size at birth			
6	24	7.12±0.33a	26.67±0.21a
12	280	12.01±0.10b	24.14±0.31ab
18	89	15.63±0.17c	24.64±0.25b
Weaning to estrus interval			
8	56	12.99±0.72a	24.87±0.40a
12	78	12.53±0.14a	24.78±0.08a
16	34	1161±0.47a	24.15±0.26a
Litter size at weaning			
5	15	-	23.83±0.38a
10	164	-	23.01±0.11a
15	194	-	22.38±0.10b
20	56	-	22.79±0.33b
Teat number			
8	86	-	23.89±1.83a
11	57	-	24.50±1.63b
12	71	-	24.67±0.58b
13	102	-	24.78±0.49b
14	39	-	24.53±0.46b
15	89	-	25.84±0.59c
16	92	-	25.52±0.68c

Means with different superscripts in the same column differ significantly ($p<0.05$).

4. Conclusion

Average litter weight at birth and weaning in Dalland pigs breed are important indicators of potential growth of piglets and is affected by various non-genetic factor, and the birth size depends on their interaction, hence the importance of proven sires. In conclusion, sire line, age at first service, litter size at birth and year of birth were found to be significant ($p<0.05$) sources of variation for average litter weight at birth, while age at first service and teat number had a significant ($p<0.05$) effects on average litter weight. The results obtained show that non genetic factors influence average litter weight at birth and weaning of piglets as much as genetic factors, with better weaning weights being observed when the sows has more teat numbers and delay in date of first service. The following deductions could be made, gestation length and month of birth had no significant effect on the average litter weight at birth. Precisely targeted nutritional interventions during sow pregnancy could reduce the incidence of low average litter weight at birth. Estimation of reliable estimates of genetic parameters for average litter at birth and weaning in pig production need to take into account the adjustment of performance data for environmental factors hence this will increase the accuracy of selection of breeding animals. An understanding of non genetic factors which affect these traits in pig production will influence the breeding and management programs to minimize influences which reduce production efficiency. The significant influences of non genetic factors on average litter weight at weaning can be explained in part by differences in the number of sow teats which has a bearing on the competition for milk between litter mates. In pigs the antagonistic relationship between litter size at birth and piglets average litter at birth was confirmed, subsequently it may be reasonably to conclude that inclusion of birth weight as a selection criteria in pig production may be recommended.

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