BREED DIFFERENCES AND HETEROSIS IN TEAT NUMBER OF LANDRACE, LARGE WHITE AND THEIR F_1 CROSSES

Daryl C. Manalastas[1] and Orville L. Bondoc[1]

ABSTRACT

This study aimed to evaluate breed differences and heterosis in the number of teats from 5,788 performance-tested pigs (1,663 boars and 4,125 gilts) belonging to Landrace (LDR), Large White (LRW), F1 LDR x LRW crosses, and R1 LRW x LDR crosses produced from 2016 to 2018 in a local nucleus/ multiplier breeding farm. The average number of the left, right, and total teats was 6.72, 6.70, and 13.42, respectively. Teat number was positively correlated (*P*<0.01) with body length at the end of test (r = 0.06 to 0.09). Teat number was not affected (*P*>0.05) by gender and backfat thickness. Large White pigs had significantly (*P*<0.05) more total teats than Landrace pigs by 0.29 teat. The R1 LRW x LDR crossbred pigs had more (*P*<0.05) total teats than F1 LDR x LRW cross by 0.48 teat. Heterosis estimates in F_1 crosses were 1.04%, 0.45%, and 2.25% equivalent to additional 0.07 teat, 0.03 teat, and 0.30 teat for the number of the left, right and total teats, respectively. While teat number can be improved within a breed by selection, teat number may also be improved by heterosis resulting from the production of F_1 crosses.

Key words: teat numbers, heterosis, Landrace, Large White, F_1 crosses

INTRODUCTION

Teat number is an important fertility trait for pig production, reflecting the mothering ability of sows (Ding *et al*., 2009). Knowledge on the number of functional teats in the herd is also important in selection programs that aim to increase litter size (Chalkias *et al*., 2013). This is because when litter size increases, the number of teats must also increase to supply nutrition to all piglets (Rohrer and Nonneman, 2017). However, selection for large litters had also resulted indirectly in a decrease in birth weight of piglets and increased competition between littermates (Theil *et al*., 2014). The competition for teats leads to increased pre-weaning mortality due to crushing and starvation (Andersen *et al*., 2011). Litter sizes that exceed lactational capacity for many litters, will thus require artificial rearing and/or cross-fostering of young to increase survival.

Teat number can be increased in these breeds by genetic selection although heritability of teat number varies widely from 0.16 to 0.39 in the Landrace and Large White

[1]Animal Breeding Division, Institute of Animal Science, College of Agriculture and Food Science (CAFS), University of the Philippines Los Baños (email: olbondoc@up.edu.ph).

breeds (Borchers *et al*., 2002). The number of teats may also differ between breeds. For example, Kim *et al*. (2005) showed that the total teat number of Landrace and Yorkshire were 14.9 and 13.7, respectively. They also reported that gilts with 14 or more teats had higher litter size at birth and at 21-day weaning than gilts with 11 to 13 teats.

In the Philippines, the commercial swine growers who raise 35.8% of the 12.6 million pigs available nationwide (Philippine Statistics Authority, 2018) commonly produce market hogs from the cross between the Duroc (or Pietrain) terminal boars and the F_1 Landrace x Large White crossbred sows. While heterosis for litter size at birth in F_1 Landrace x Large White crossbred sows as reported by Bondoc *et al*. (2019) was 10.33% equivalent to additional 1.05 piglets, local studies on heterosis for teat number in F_1 Landrace x Large White crosses are not common.

In this regard, this study aims to evaluate breed differences for teat number between Landrace and Large White pigs, and heterosis resulting from their F_1 crosses in a local swine nucleus/multiplier breeding farm.

MATERIALS AND METHODS

The number of the left, right and total teats were recorded from 5,788 performance-tested pigs consisting of 1,663 boars and 4,125 gilts belonging to the Landrace (LDR), Large White (LRW), and their F_1 crosses (i.e., F1 LDR x LRW and its reciprocal cross – R1 LRW x LDR). The 3-year data from 2016 to 2018 were taken from the performance testing program of the International Farms Corporation (INFARMCO) swine breeding farm located at San Isidro, Cabuyao, Laguna, Philippines (approx. 14° 14’ 49.69” N, 121° 8’ 34.41” E).

Other performance-test data were also used including average daily gain, feed efficiency (for boars only), age, weight, and body length at the end of test. The target age of pigs at the start and the end of test for boars and gilts were 77 ± 3 d, 143 ± 3 d, 150 ± 3 d, respectively. The simple descriptive statistics for teat number and performance-test records are shown in Table 1.

Pearson product-moment correlation coefficients among the number of the left, right, and total teats and with performance-test records were initially determined using the CORR procedure of SAS (2009). Performance-test records found to be consistently and significantly correlated with teat number were included as covariates in the statistical model.

The general least squares procedures for unbalanced data were used to examine the principal sources of variation affecting each teat number. Statistical significance was set at $P<0.05$. The following statistical model was used to determine, using an F-test (SAS, 2009): $\mathbf{y_{ijkl} = \mu + Breed_i + Sex_j + BLength_k + e_{ijkl}}$ where y_{ijkl} is the dependent variable (i.e., number of the left, right, and total teats), μ is the overall mean, $Breed_i$ is the fixed effect for the ith breed (i.e., Landrace, Large White, F1 and R1 crossbreds), Sex_j is the fixed effect for the jth sex (i.e., boar and gilt), $BLength_k$ is the covariate effect of the kth body length (cm), and e_{ijkl} is the error term assumed to be normally distributed with the variance of errors as constant across observations.

Heterosis for the number of the left, right, and total teats were estimated as the mean crossbred deviation expressed in percentage of mid-parent performance, where crossbred average = $(\overline{F1} + \overline{R1}) \div 2$ and purebred average = $(\overline{LDR} + \overline{LRW}) \div 2$.

Table 1. Simple descriptive statistics for teat number and performance-test records (2016 - 2018).

	N	Average ± Std. Dev.	Range
Number of teats			
Left	5,788	6.72 ± 0.55	6 –10
Right	5,788	6.70 ± 0.55	5 – 9
Total	5,788	13.42 ± 0.88	12 – 17
Performance-test records			
Average daily gain for boars, kg/day*	1,663	0.835 ± 0.120	0.387 – 1.200
Average daily gain for gilts, kg/day**	4,125	0.601 ± 0.060	0.424 – 0.803
Feed efficiency for boars, g/g	1,663	2.680 ± 0.32	1.95 – 5.26
Backfat thickness at shoulder area, mm	5,787	16.36 ± 2.94	8 – 29
Backfat thickness at midback area, mm	5,787	12.69 ± 2.30	6 – 24
Backfat thickness at loin area, mm	5,787	15.83 ± 2.95	6 – 27
Average backfat thickness, mm	5,787	14.96 ± 2.41	7 – 25
Age at the end of test, days	5,787	155.57 ± 4.53	141 – 171
Weight at the end of test, kg	5,787	95.56 ± 10.11	62.5 – 129.0
Body length at the end of test, cm	5,778	112.90 ± 3.55	96 – 150

*Boar ADG was computed from the start until the end of test.

**Gilt ADG was computed from birth until the end of test.

Reciprocal or maternal effects for teat number were computed as the difference in average F1 and R1 performance. In this study, the advantage (in terms of more teat numbers) of using a Large White or Landrace sows in the production of F_1 crossbred pigs is equal to $\overline{F1} - \overline{R1}$ and $\overline{R1} - \overline{F1}$, respectively.

RESULTS AND DISCUSSION

The average teat number on the left and right sides were 6.72 ± 0.55 and 6.70 ± 0.55, respectively (Table 1), indicating symmetry since the number of left and right teats are not significantly different. In contrast, higher count for right teats than left teats have been reported for Jiaxing x Iberian crossbred pigs (Fernandez *et al*., 2004), White Duroc × Erhualian crossbred pigs (Ding *et al*., 2009), and ½ Landrace – ¼ Duroc – ¼ Yorkshire composite population (Rohrer and Nonneman, 2017).

In this study, the total teat number was 13.42 ± 0.88, ranging from 12 to 17 teats. By comparison, Borchers *et al*. (2002) reported a higher total teat number, ranging from 13.8 to 14.4 .8 in a mixed herd of Landrace, Large White, and Landrace x Large White crosses.

Total teat number was highly correlated with the number of left teats (r = 0.81) and right teats (r = 0.81), see Table 2. The phenotypic correlation between the teats of the two sides was low (r = 0.30). A similar low-value (r = 0.42) was also found by Dall'Olio *et al*. (2018) in Italian Large White pigs.

Total teat number was lowly but significantly (P<0.01) related to average daily gain (ADG) of performance-tested gilts (r = 0.05), backfat thickness at the midback area (r = 0.03), and body length at the end of test (r = 0.09). This implies that pigs born with more teat number are likely to have higher backfat thickness at the midback area and higher ADG in gilts. Total teat number was not related (P>0.05) to ADG and feed efficiency of boars, and backfat thickness at the shoulder and loin area. Incidentally, teat number and vertebra number or carcass length – which both are both positively correlated to body length, are hypothesized to be controlled by common genes (Ding *et al*., 2009).

The number of right teats is most variable with a coefficient of variation of 8.18%, followed by left teats (8.08%) and total teats (6.55%), see Table 3. The total teat number was significantly (P<0.01) affected by breed and body length. Differences in teat number between boars and gilts were not significant (P>0.05). Teat number was not significantly affected (P>0.05) by backfat thickness measurements at the shoulder, midback, and loin.

In the comparisons between pure breeds, the total teat number was significantly (P<0.05) higher in Large White than in Landrace by 0.31 teat (Table 4). However, the number of right teats was significantly (P<0.05) higher in Landrace than in Large White by 0.9 teat. The number of left teats was not significantly different (P>0.05) between Landrace and Large White pigs. This implies that that teat numbers may be increased in pure breeds (especially in the Large White) through genetic selection. However, improvements in teat number due to additive gene effects are expected to be very small on a yearly basis. In the local nucleus breeding program, for example, a selection threshold of either 12 or 14 teats for both Landrace and Large White, that are regularly spaced, well-protruded and with normal and functional nipples may initially be targeted (Rohrer and Nonneman, 2017; Dall'Olio *et al*., 2018). Alternatively, marker-assisted selection may be used to expedite genetic progress

Table 2. Pearson correlation coefficients among teat number and performance-test records.

	No. of left teats	**No. of right teats**	**Total no. of teats**
Number of teats			
Left	–	0.30**	0.80**
Right	–	–	0.81**
Performance-test records			
Average daily gain for boars	ns	ns	ns
Average daily gain for gilts	ns	0.06**	0.05**
Feed efficiency (boars only)	ns	ns	ns
Backfat thickness (shoulder area)	ns	0.03*	ns
Backfat thickness (midback area)	ns	0.04**	0.03*
Backfat thickness (ham area)	ns	ns	ns
Average backfat thickness	ns	0.03*	ns
Body length at the end of test	0.06**	0.08**	0.09**

ns - correlation coefficient (r) is not significantly different from zero (P >0.05).
*correlation coefficient (r) is significantly different from zero (P<0.05).
**correlation coefficient (r) is significantly different from zero (P <0.01).

Table 3. Mean square F-tests for the effects of breed, sex, and the covariate effects of performance-test traits on teat number.

	No. of left teats	No. of right teats	Total no. of teats
Breed	ns	**	**
Sex	ns	ns	ns
Covariates			
Body length at the end of test	**	**	**
Average daily gain	*	ns	*
Feed efficiency (boars only)	*	*	**
Backfat thickness (shoulder area)	ns	ns	ns
Backfat thickness (midback area)	ns	ns	ns
Backfat thickness (ham area)	ns	ns	ns
Average backfat thickness	ns	ns	ns
Coefficient of variation, %	8.09	8.18	6.55

ns - no significant effect of independent variable (P>0.05).
*significant effect of independent variable (P<0.05).
**highly significant effect of independent variable (P<0.01).

Table 4. Number of teats (LSM ± SE) in different breed groups.

	No. of left teats	No. of right teats	Total no. of teats
Landrace (LDR)	6.71 ± 0.01[b]	6.73 ± 0.01[a]	13.15 ± 0.21[c]
Large White (LRW)	6.70 ± 0.01[b]	6.64 ± 0.01[b]	13.44 ± 0.02[b]
F1 LDR x LRW cross	6.60 ± 0.13[b]	6.55 ± 0.13[b]	13.35 ± 0.02[c]
R1 LRW x LDR cross	6.95 ± 0.14[a]	6.88 ± 0.14[a]	13.83 ± 0.23[a]

Means within a column without common letter superscripts are significantly different (P<0.05).

for teat number. Recent genome-wide association analyses already identified the vertnin (VRTN) mutant allele to be associated with an increase in teat count by 0.35 in ½ Landrace – ¼ Duroc – ¼ Yorkshire composite population (Rohrer and Nonneman, 2017) and in Italian Large White pigs (Dall'Olio *et al*., 2018).

In comparisons between the F_1 crossbred pigs, the R1 LRW x LDR cross had significantly (P<0.05) more left, right, and total teats than the F1 LDR x LRW cross by 0.35, 0.33, and 0.52 teat, respectively.

The number of the left, right, and total teat were higher in F_1 Landrace x Large White crossbred pigs compared to the average of purebred pigs by 0.07, 0.03, and 0.28 teat, respectively (Table 5). This resulted in heterosis estimates of 1.04%, 0.45%, and 2.22% for the left, right, and total teats, respectively. The heterosis estimate for total teat number suggests that teat number may also be affected by non-additive genes (dominance, overdominance, and epistasis), equivalent to an additional 0.30 teat in the F_1 crossbred progeny. In contrast, when divergent parental pure breeds are used, negative heterosis (based on F_1 crossbred performance) was reported by Ding *et al*. (2009) in China for White

Table 5. Estimates of heterosis for teat number.

	No. of left teats	No. of right teats	Total no. of teats
Pure breeds			
Landrace (LDR)	6.71	6.73	13.15
Large White (LRW)	6.70	6.64	13.44
Average	6.71	6.69	13.30
Crossbreeds			
F1 LDR x LRW cross	6.60	6.55	13.35
R1 LRW x LDR cross	6.95	6.88	13.83
Average	6.78	6.72	3.59
Heterosis, %	1.04	0.45	2.22
Maternal effect using Large White dam	-0.35	-0.33	-0.48
Maternal effect using Landrace dam	+0.35	+0.33	+0.48
Improvement due to heterosis (including reciprocal or maternal effects)			
F_1 cross	0.07	0.03	0.30
F1 LDR x LRW cross	-0.28	-0.30	-0.19
R1 LRW x LDR cross	+0.42	+0.36	+0.78
Predicted crossbred performance			
F_1 cross	6.78	6.72	13.59
F1 LDR x LRW cross	6.43	6.39	13.11
R1 LRW x LDR cross	7.13	7.05	14.07

Maternal and reciprocal effects were computed as FT minus RT and RT minus FT, respectively.

Duroc (European) x Erhualian (Chinese) crosses (i.e., –1.53% heterosis or –0.25 teat) and by Fernandez *et al*. (2004) in Spain for Jiaxiang (Chinese) x Iberian (European) crosses (i.e., –3.20% heterosis or –0.48 teat).

Moreover, the maternal (reciprocal) effects to increase the number of teats were higher for F_1 crossbred pigs with Landrace dams. The F_1 crossbred pigs with Landrace dams are predicted to have 0.70 left teat, 0.66 right teat, and 0.96 total teat more than crossbred pigs having Large White dams. This implies that Large White sows should be preferred over Landrace sows in the production of F_1 Large White x Landrace crossbred gilts by the local nucleus/multiplier farms.

In conclusion, Large White pigs had more total teats than Landrace pigs, although differences in teat number between boars and gilts were not significant. Teat number was higher in F_1 crossbred pigs compared to the average of purebred pigs. While the teat number may be increased in the Landrace and Large White breeds by selection based on breeding values (additive genetic values), this study shows that higher teat numbers may also be expected in F_1 Landrace x Large White crossbred pigs, due to both heterosis and reciprocal effects (non-additive genetic values). The associations of teat number with the number of live piglets born and birth weight, and whether an increase in the number of teats will result in increased total milk production should be further investigated.

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