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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(1): 31-33

www.thepharmajournal.com
Received: 16-11-2019
Accepted: 20-12-2019

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Principal component analysis of litter traits in crossbred piglets

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Abstract
This investigation was undertaken to derive fewer independent reproductive traits through principal component analysis. Accordingly, records of 2 litter traits at birth, 4, 6 and 8 week from 42 crossbred (75% Landrace X 25% Bareilly local) pigs, farrowed between September 2017 and April 2018 were used in the present investigation. Principal component analysis was done using PROC PRINCOMP Module of SAS 9.3 software. High correlation coefficients were observed among most of the litter traits. Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's Test of Sphericity and communality were calculated. A single principal component (PC) was extracted for litter traits. It accounted for 82.24% of total variance. PC1 was represented by litter size at 4, 6 and 8 week. This factor seemed to be representing the overall performance of the litter. Accounted PC may be exploited in breeding and selection program for reproductive traits.

Keywords: Crossbred pig, Litter size, Litter weight, Principal component analysis

1. Introduction
Commercial pig farming for meat production is one of the best and profitable businesses in India. Pigs as compared to other livestock species contribute faster economic return to the farmers. They are one of the most prolific and fast growing livestock that can convert food waste to valuable products. They have several advantages over other species of farm animals including high prolificacy. Pig production is relatively inexpensive due to fast growth rate, high production potential, highly efficient carcass yield and high adaptability to varied environmental conditions. Pig is an appropriate animal model in research and is useful to understand disease progression and therapeutic drug development (Bassols *et al.*, 2014) [9].
Pig, being a highly prolific mammal, could be one of the best species to study the genetic complexity of lowly heritable reproductive traits. Reproductive performance in commercial pig production systems is usually quantified by numerous economically important production traits. Litter traits in pig mainly include number of total number of piglets born, piglets born alive, litter size at different age and litter weight of piglets at different age. Litter size is an important trait in pig genetic improvement programs and responded successfully to selection (Sorensen *et al.* 2000; Noguera *et al.* 2002) [11, 10]. Several correlated reproductive traits are used in livestock breeding programs for the selection of animals. Some traits are highly correlated and may either give positive or negative result when taken simultaneously. Some traits may be redundant because they are highly correlated with each other during genetic evaluations. The principal component analysis (PCA) is a multivariate methodology that can be used with success when characteristics are correlated. It eliminates redundant traits, transforms original group of variables into another group i.e. principal components, which are linear combination of original variables and has been used to elucidate the structural relationships among different traits. The present investigation was therefore undertaken in 75% Landrace crossbreds aimed at documenting interdependence among reproductive traits using principal component analysis.

2. Materials and Methods
The present study was conducted at Swine Production Farm, Livestock Production and Management Section, ICAR- Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh, India; a unit of ICAR- All India Coordinated Research Project on Pigs. A total of 42 crossbred (75% Landrace X 25% Bareilly local) pigs, farrowed between September 2017 and April 2018

were covered in the present investigation. Records of 2 litter traits i.e. size and weight were collected from 42 pigs. Litter weight was recorded in kilogram with the aid of an electronic weighing scale and litter size was measured in number.

2.1 Statistical analysis
Principal component analysis for litter traits was done using PROC PRINCOMP Module of SAS 9.3 software. Means, standard errors and coefficients of variation of the litter traits were calculated. Pearson's coefficients of correlation (r) were computed to determine the degree of associations among the linear measurements. Appropriateness testing for PCA was done using PROC FACTOR Module of SAS 9.3 software. Data were inspected for adequacy in sampling using Kaiser-Meyer-Olkin (KMO) test. Bartlett's Test of Sphericity was performed to test the validity of the factor analysis of the data sets. The communalities of variables employed in PCA were determined. Eigen values and the proportion of the total variance were computed. Eigen vectors and factor patterns were estimated. The loading of variables was determined.
Principal component analysis transforms the variables in a multivariate data set x_1, x_2,—, x_p, into new variables, y_1, y_2—, y_p, which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$y_1 = a_{11} x_1 + a_{12} x_2 + \text{—} + a_1 p_{xp}$$
$$y_2 = a_{21} x_1 + a_{22} x_2 + \text{—} + a_2 p_{xp}$$
$$y_p = a_{p1} x_1 + a_{p2} x_2 + \text{—} + a_{pp} x_p$$

with the coefficients being chosen so that y_1, y_2—, y_p account for decreasing proportions of the total variance of the original variables, x_1, x_2,—, x_p.

3. Results and Discussion
The various attributes of the litter traits have been presented have been presented in table 1**.** As per the findings, the average litter size decreased to 6.71 at 8 week of observation from that at the time of the birth (7.76). However, contrary to the litter size trait, the litter weight at 8 week was higher from rest of the observations. Moreover, the coefficient of variation for different litter traits ranged from 30.47% (litter weight at birth) to 38.64% (litter weight at 8 week). Average litter size and weight at birth (7.76 and 8kg), 4 (6.81 and 42.23kg), 6 (6.74 and 60.71kg) and 8 (6.71 and 77.21kg) week in our investigation was similar to that reported by Chhabra *et al.* (1996) [2], Song *et al.* (2003) [7] and Reddy *et al.* (2012) [2, 7, 6] in crossbred pigs. However, Phookan (2002) [5], Ajayi and Akinokun (2013) [1] and Oluwole *et al.* (2014) [5, 1, 4] observed contrasting results where they found low litter size and weight at different ages in indigenous pigs.

Table 1: Mean, standard error (SE), coefficient of variation (CV) and communality of different litter traits (n=42)

S. No.	Trait	Mean ± SE	CV%	Communality
1	Litter Size at birth	7.76±0.39	32.42	0.90
2	Litter Size at 4 week	6.81±0.40	38.00	0.99
3	Litter Size at 6 week	6.74±0.40	38.23	1.00
4	Litter Size at 8 week	6.71±0.39	37.98	1.00
5	Litter weight at birth(kg)	8.00±0.38	30.47	0.91
6	Litter weight at 4 week(kg)	42.23±2.31	35.40	0.98
7	Litter weight at 6 week(kg)	60.71±3.18	33.94	0.99
8	Litter weight at 8 week(kg)	77.21±4.60	38.64	0.96

3.1 Correlation coefficients among litter traits
The correlation coefficients among litter traits with their standard errors are given in table 2. Pearson's correlation analysis was done to evaluate the correlations among litter traits. A total of 28 correlations (in all combinations) were estimated and all correlation coefficients found significant. The correlation coefficients ranged from 0.48 to 0.99. Litter size at 4 week had a higher correlation with litter size at 6 (0.99) and 8 (0.99) week. Variables that were highly correlated with litter weight at 6 week included litter weight at 4 (0.97) and 8 (0.95) week. Low correlation coefficient was observed between litter size at birth and litter weight at 4 (0.61), 6 (0.58) and 8 (0.48) week. Litter weight at birth was poorly correlated with litter weight at 8 week (0.57). Most of the correlation coefficients had their standard errors low and within acceptable limit. High correlation coefficients were observed from 0.48 to 0.99 among litter traits in present investigation suggesting high predictability of traits and appropriateness of PCA to classify the litter traits.

Table 2: Coefficients of correlation (below diagonal) among litter traits with their standard errors (above diagonal)

	LS0	LS4	LS6	LS8	LW0	LW4	LW6	LW8
LS0	1.00	0.10	0.10	0.10	0.07	0.13	0.13	0.14
LS4	0.77	1.00	0.02	0.02	0.09	0.08	0.09	0.12
LS6	0.77	0.99	1.00	0.01	0.10	0.08	0.09	0.11
LS8	0.76	0.99	1.00	1.00	0.10	0.08	0.09	0.12
LW0	0.90	0.81	0.80	0.79	1.00	0.10	0.11	0.13
LW4	0.61	0.88	0.87	0.87	0.76	1.00	0.04	0.08
LW6	0.58	0.82	0.83	0.83	0.70	0.97	1.00	0.05
LW8	0.48	0.69	0.69	0.69	0.57	0.87	0.95	1.00

All correlation coefficients significant at $P \leq 0.01$

3.2 Appropriateness testing of PCA for litter traits
Data were inspected for adequacy in sampling for PCA using Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) from the diagonals of partial correlations. The value of MSA was high for litter traits ranging from 0.71 to 0.86 with an average of 0.78. Kaiser (1960) [8] recommended the acceptable value of 0.5 for sample adequacy. The overall significance of correlation matrices was also tested by Bartlett's Test of Sphericity. The chi square value (801.48) was significant at $p < 0.0001$. Bartlett's measure tests the null hypothesis that the original correlation matrix is an identity matrix. The highly significant chi-square values observed for litter traits indicated that the factor analysis was appropriate. Variance of a variable which was partitioned into a common portion 'communality' is shared with some or all other variables. The communality ranged from 0.9 (litter size at birth) to 1 (litter size at 6 and 8 week). It was an indication that most of the variances are shared between the variables permitting the use of PCA to classify them. Communalities of litter traits are given in table 1**.** Kaiser-Meyer-Olkin measure of sampling adequacy (0.78), Bartlett's Test of Sphericity (λ^2=801.48) and communality (0.9-1) revealed that data were appropriate for PCA.

3.3 Principal component analysis (PCA) for litter traits
Principal components (PCs), Eigenvalues, percentage of variance and cumulative percentages of variance; described by components of litter traits are presented in table 3. Principal component analysis of 8 litter traits was conducted which generated 8 principal components. Using the criterion

of the scree plot (Cattell, 1966) [3]; inflection was identified, which occurred after the first principal components in this study (Figure 1). Another method was used to reinforce the criterion based on variance (Kaiser, 1960) [8], whereby eigenvalues > 1 were considered. Based on these criterions, it was possible to explain 82.24% of the total variance by the first component, as observed in table 3. Principal components (PCs), Eigenvalues, percentage of variance and cumulative percentages of variance; described by components of litter traits are presented in table 4. The first principal component (PC1) accounted for 82.24% of the total variation with positive coefficients for all litter traits. The highest discrimination was represented by litter size at 4 (13.30%), 6 (13.29%) and 8 week (13.28%). The component matrix of different factors for litter traits is presented in table 4. This factor seemed to be representing the overall performance of the litter.

Table 3: Principal components (PCs), eigenvalues, percentage of variance and cumulative percentages of variance described by components of litter traits

PCs	Eigenvalue	Proportion (%)	Cumulative (%)
PC1	6.579	82.24	82.24
PC2	0.861	10.76	93.00
PC3	0.378	4.72	97.72
PC4	0.132	1.65	99.37
PC5	0.033	0.41	99.78
PC6	0.013	0.16	99.94

Table 4: Component matrix of different factors for litter traits

S. No.	Trait	PC1	%
1	Litter Size at birth	0.314	11.12
2	Litter Size at 4 week	0.375	13.30
3	Litter Size at 6 week	0.375	13.29
4	Litter Size at 8 week	0.375	13.28
5	Litter weight at birth	0.338	11.99
6	Litter weight at 4 week	0.368	13.03
7	Litter weight at 6 week	0.359	12.71
8	Litter weight at 8 week	0.318	11.28

4. Conclusion

In the present investigation, 2 litter traits of 42 pigs were recorded at birth, pre-weaning (4 week), weaning (6 week) and post-weaning (8 week) stage. Analysis exploring relationships and dependencies of litter traits were conducted using principal component analysis. The litter traits measured were litter size and litter weight. The average litter size at birth, 4, 6 and 8 week was 7.76, 6.81, 6.74 and 6.71, respectively. Litter weight at birth, 4, 6 and 8 week averaged 8, 42.23, 60.71 and 77.21 kg, respectively. The coefficients of variation for different litter traits ranged from 30.47% (litter weight at birth) to 38.64% (litter weight at 8 week). The results revealed that Landrace crossbreds at IVRI had better litter performance as compared to indigenous pigs. A total of 28 correlations (in all combinations) were estimated among litter traits. All correlation coefficients were significant. The correlation coefficient ranged from 0.48 to 0.99. Kaiser-Meyer-Olkin measure of sampling adequacy (0.78), Bartlett's Test of Sphericity (λ^2=801.48) and communality (0.9-1) revealed that data were appropriate for PCA. A single PC was extracted for litter traits with an Eigen value greater than 1. It accounted for 82.24% of total variance. PC1 was characterized by litter size at 4, 6 and 8 week. This factor seemed to be representing the overall performance of the litter.

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