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Principal component analysis of morphometric and growth traits in crossbred piglets

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ABSTRACT

This investigation was undertaken to derive fewer independent common factors through principal component analysis to characterize 75% Landrace crossbreds. Records of 26 body measurements and weights at 4, 6 and 8 week from 279 crossbred (75% Landrace × 25% Bareilly local) piglets, born between September 2017 and April 2018 were used. Principal component analysis was done using PROC PRINCOMP Module of SAS 9.3 software. High correlation coefficients were observed among most of the morphometric and growth traits. Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's Test of Sphericity and communality at different ages were calculated. Three PCs were extracted at 4 week, two at 6 week and two at 8 week. These PCs accounted for 73.7, 73.76 and 75.45% variance, respectively of total variance. PC1 was represented by high loading of body length, heart girth and height at back at 4 week; and body length, heart girth and body weight at 6 and 8 week. PC2 had high loading for height at foreleg, height at shoulder, chest width and inner orbital width at 4 week; and height at foreleg, height at shoulder and snout circumference at 6 and 8 week. PC3 was characterized by snout circumference and ear length. PC1 seemed to explain the body of pig, i.e. general size; whereas PC2 seemed to represent the front view of the pig. Accounted PCs at different stage may be exploited in breeding and selection programmes to acquire highly coordinated animal bodies using fewer measurements.

Keywords: Crossbred pig, Growth traits, Morphometric traits, Principal component analysis

Linear body measurements are used to characterize different breeds of livestock and to indicate origin and relationship or shape and size of an individual. For body conformation and market value weight of farm animals, a number of linear body measurements have been reported to play an important role in their predictions. In livestock breeding programs, animals are chosen according to breeding objectives based on several correlated traits. Some traits are highly correlated and may either give positive or negative result when taken simultaneously. Analysis of variance and correlations are widely used to characterise phenotypic and genetic relationships among body measurements of animals. But when a large number of measurements are available, it is natural to enquire whether they could be replaced by fewer measurements without significant loss of information. Some traits may be redundant because they are highly correlated with each other during genetic evaluations. Furthermore, simultaneous analysis of correlated traits does not improve accuracy but requires increased recording and analytical work. The principal component analysis is a multivariate methodology that can be used with success when characteristics are correlated. Principal component analysis (PCA) can explain relationships in a better way. 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. Tolenkhomba *et al.* (2013) in Mizo local pigs and Okoro *et al.* (2015) in crossbred pigs of Nigeria used principal component analysis to study the morphometric traits. Information on interdependence among pre- and post-weaning body measurements to reduce dimension of explanatory data set are very scanty in Indian crossbred pigs. The present investigation was therefore undertaken in 75% Landrace crossbreds aimed at documenting interdependence among pre-weaning and post-weaning traits with a view to reduce number of traits for genetic and breeding purpose using principal component analysis.

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 279 crossbred (75% Landrace × 25% Bareilly local) piglets, born between September 2017 and April 2018 were covered. Records of body measurements and growth traits were collected from 279 piglets at pre-weaning (4 week), weaning (6 week) and

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Table 1. Principal components (PCs), eigenvalues, percentage of variance and cumulative percentages of variance described by components of morphometric and growth traits at 4, 6 and 8 week

Principal Component	4 week			6 week			8 week		
	Eigen value	Proportion	Cumulative	Eigen value	Proportion	Cumulative	Eigen value	Proportion	Cumulative
PC1	15.669	60.26	60.26	17.403	66.93	66.93	17.816	68.52	68.52
PC2	2.256	8.68	68.94	1.774	6.82	73.76	1.800	6.92	75.45
PC3	1.236	4.76	73.70	0.862	3.31	77.07	0.945	3.63	79.08
PC4	0.769	2.96	76.65	0.725	2.79	79.86	0.625	2.41	81.49
PC5	0.763	2.94	79.59	0.653	2.51	82.37	0.557	2.14	83.63
PC6	0.716	2.75	82.34	0.560	2.15	84.53	0.500	1.92	85.55
PC7	0.515	1.98	84.32	0.483	1.86	86.39	0.462	1.78	87.33
PC8	0.496	1.91	86.23	0.413	1.59	87.98	0.369	1.42	88.75
PC9	0.457	1.76	87.99	0.407	1.57	89.54	0.351	1.35	90.10
PC10	0.416	1.60	89.59	0.372	1.43	90.97	0.299	1.15	91.25
PC11	0.374	1.44	91.02	0.338	1.3	92.27	0.287	1.10	92.35
PC12	0.313	1.20	92.23	0.297	1.14	93.42	0.269	1.03	93.39
PC13	0.284	1.09	93.32	0.268	1.03	94.45	0.235	0.90	94.29
PC14	0.254	0.98	94.29	0.219	0.84	95.29	0.218	0.84	95.13
PC15	0.250	0.96	95.25	0.203	0.78	96.07	0.202	0.78	95.91
PC16	0.220	0.85	96.10	0.178	0.68	96.75	0.186	0.71	96.62
PC17	0.199	0.77	96.87	0.163	0.63	97.38	0.155	0.60	97.22
PC18	0.165	0.63	97.50	0.133	0.51	97.89	0.138	0.53	97.75
PC19	0.148	0.57	98.07	0.121	0.47	98.36	0.120	0.46	98.21
PC20	0.126	0.49	98.56	0.094	0.36	98.72	0.113	0.43	98.64
PC21	0.107	0.41	98.97	0.086	0.33	99.05	0.098	0.38	99.02
PC22	0.077	0.30	99.26	0.070	0.27	99.32	0.087	0.33	99.35
PC23	0.074	0.28	99.55	0.062	0.24	99.56	0.065	0.25	99.60
PC24	0.061	0.23	99.78	0.051	0.2	99.76	0.046	0.18	99.78
PC25	0.050	0.19	99.97	0.043	0.17	99.92	0.041	0.16	99.94
PC26	0.007	0.03	100.00	0.020	0.08	100.00	0.016	0.06	100.00

post-weaning (8 week) stage. Each animal was gently restrained while data collection. Body weight was recorded in kilogram with the aid of an electronic weighing scale. The other conformation traits were measured in centimetres (cm) with measuring tape and mapping stick. Measurements were done by the same person to avoid between individual variations. Measured morphometric and growth traits were body weight, body length, height at withers, heart girth, ear length, ear width, head length, chest width, rump height, rump width, rump length, body depth, average daily gain, punch girth, height at shoulder, height at back, height at fore leg, height at hind leg, thigh length, thigh circumference, snout length, snout circumference, neck circumference, inner orbital width and tail length.

Statistical analysis: Principal component analysis for morphometric and growth traits was done using PROC PRINCOMP Module of SAS 9.3 software. 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 proportion of the total variance were computed. Eigen vectors and factor patterns were estimated. Loading of variables was determined.

RESULTS AND DISCUSSION

Phenotypic correlation: A total of 325 correlation coefficients were estimated at 4, 6 and 8 week. Among these, 319 at 4 week, 318 at 6 week and 311 at 8 week were significant and positive ranging from 0.19–0.99, 0.17–0.95 and 0.17–0.98, respectively. Oluwole *et al.* (2014) and Omitogun *et al.* (2016) reported positive and significant correlation coefficients among morphometric traits ranging from 0.68–0.86 at pre-weaning stage and 0.33–0.91 at post weaning stage, respectively in crossbred pigs of Nigeria. Banik *et al.* (2012) in Ghungroo pigs and Aro (2013) in a mixed population of Duroc and Large White pigs also reported high positive significant correlations among morphometric traits. In present investigation, most of the correlation coefficients had their standard errors low and within acceptable limit. Animals of actively growing stage up to 8 week may be a liable cause of high correlation among morphometric and growth traits. The positive and significant ($P<0.01$) correlations among morphometric and growth traits suggest high predictability of traits and appropriateness of PCA to classify the variables.

Appropriateness testing for PCA: Data inspection for

Table 2. Component matrix of different factors (morphometric and growth traits) at 4, 6 and 8 week

Variable	4 week				6 week			8 week		
	PC1	PC2	PC3	Communality	PC1	PC2	Communality	PC1	PC2	Communality
Body length	0.229	–0.132	–0.009	0.87	0.227	0.15	0.92	0.225	0.014	0.92
Tail length	0.173	0.043	0.262	0.53	0.175	–0.16	0.62	0.156	0.254	0.55
Heart girth	0.232	–0.175	–0.074	0.93	0.226	–0.20	0.94	0.228	–0.087	0.95
Punch girth	0.218	–0.197	–0.059	0.86	0.218	0.04	0.92	0.219	–0.107	0.90
Height at wither	0.228	0.056	–0.083	0.88	0.216	–0.32	0.88	0.217	–0.002	0.88
Height at shoulder	0.154	–0.411	–0.184	0.82	0.201	0.65	0.90	0.187	–0.260	0.75
Height at foreleg	0.139	0.456	0.253	0.80	0.072	0.05	0.76	0.039	0.647	0.61
Chest width	0.156	0.320	–0.320	0.66	0.193	0.07	0.69	0.199	–0.045	0.74
Height at back	0.233	0.048	–0.006	0.91	0.223	0.16	0.91	0.223	0.063	0.91
Height at hind leg	0.205	0.094	0.005	0.76	0.187	0.10	0.75	0.204	0.092	0.78
Rump height	0.222	0.075	0.070	0.87	0.216	0.08	0.88	0.212	0.100	0.87
Rump length	0.200	0.109	0.168	0.71	0.209	0.22	0.80	0.210	0.071	0.84
Rump width	0.192	0.112	0.130	0.71	0.193	–0.04	0.77	0.189	0.140	0.72
Thigh length	0.214	0.089	–0.179	0.78	0.216	–0.12	0.84	0.218	–0.016	0.87
Thigh circumference	0.201	–0.113	–0.221	0.73	0.211	–0.12	0.81	0.215	–0.090	0.84
Neck circumference	0.218	–0.218	–0.040	0.85	0.218	0.22	0.88	0.219	–0.058	0.88
Ear length	0.159	0.028	0.432	0.56	0.162	–0.05	0.59	0.160	0.214	0.61
Ear width	0.152	–0.217	0.078	0.51	0.174	–0.11	0.61	0.132	–0.045	0.44
Body depth at front	0.214	0.099	–0.139	0.88	0.213	–0.10	0.96	0.220	–0.097	0.97
Body depth at back	0.225	0.088	–0.029	0.91	0.217	0.02	0.97	0.220	–0.107	0.97
Head length	0.193	0.031	0.115	0.65	0.187	0.11	0.67	0.190	0.062	0.69
Snout length	0.141	0.231	0.068	0.51	0.151	0.33	0.49	0.176	–0.102	0.60
Snout circumference	0.128	–0.200	0.507	0.49	0.127	0.05	0.49	0.118	0.438	0.48
Inner orbital width	0.140	0.339	–0.286	0.56	0.174	–0.03	0.57	0.191	0.047	0.68
Body weight	0.228	–0.146	–0.067	0.99	0.224	–0.22	0.93	0.226	–0.032	0.94
Average daily gain	0.225	–0.154	–0.089	0.99	0.187	0.15	0.81	0.189	–0.302	0.83

adequacy in sampling for PCA at different ages was performed using Kaiser-Meyer-Olkin measure of sampling adequacy (0.95 to 0.97) and Bertlett's test of sphericity (χ^2=8966.05–9994.48, P<0.01). The results of this study were in agreement with Yakubu *et al*. (2009) in Fulani cattle, Pundir *et al.* (2011) in Kankrej cows, Yunusa *et al.* (2013) in Balami and Uda sheep and Khargharia *et al.* (2015) in Assam hill goat wherein they reported range of 0.22 to 0.98 for Kaiser-Meyer-Olicn measure of sampling adequacy and 169.1 to 5182.01 for Bartlett's Test of Sphericity. The communality in present investigation ranged from 0.44 (ear width at 8 week) to 0.99 (body weight, average daily gain at 4 week) at different ages. The results were similar to findings of Yakubu *et al.* (2009) in Fulani cattle, Pundir *et al.* (2011) in Kankrej cows, Yunusa *et al.* (2013) in Balami and Uda sheep, Tolenkhomba *et al.* (2013) in Mizo local pigs and Okoro *et al.* (2015) in crossbred pigs of Nigeria. Their values of communality ranged from 0.32 to 0.93. The estimate of sampling adequacy Kaiser-Meyer-Olkin (KMO) revealed the proposition of the use in morphometric and growth traits caused by the underlying factors. Significant chi squares value in Bartlett's Test of Sphericity provided enough support for the validity of PCA. High communality value for most of the traits is an indication that most variances are shared between the variables permitting the use of PCA to classify them. Communalities of different morphometric and growth traits at 4, 6 and 8 week are given in Table 2.

Principal component analysis (*PCA*): Principal components (PCs), eigenvalues, percentage of variance and cumulative percentages of variance; described by components of morphometric and growth traits at 4, 6 and 8 week are presented in Table 1. In our investigation, three PCs were extracted at 4 week, two at 6 week and two at 8 week using Kaiser Rule criterion (Kaiser 1960) to determine the number of components, i.e. retaining only the components that have eigenvalue greater than 1.

These PCs accounted for 73.7, 73.76 and 75.45% variance, respectively of total variance. Okoro *et al.* (2015) in crossbred pigs of Nigeria extracted two factors of 6 body confirmation traits at pre-weaning stage which accounted for 91.63% of total-variation. They however extracted only one factor at post-weaning stage explaining 73.63% of the total variation. Sadek *et al.* (2006) extracted three factors of 14 different traits in Arabian mares and stallions separately explaining 66 and 67% of total variation. Two factors of 14 morphostructural traits in White Fulani cattle extracted by Yakubu *et al.* (2009) accounted for 85.37% of total variation. Pundir *et al.* (2011) extracted three factors of 18 body biometric traits which accounted for 66.02% of total variation. Two factors were extracted by Yunusa *et al.* (2013) from 17 different biometric traits in Uda and Balami sheep which accounted for 57.4 and 66.9%, respectively of total variation. A single factor of 5 body measurements was extracted by Tolenkhomba *et al.* (2013) at birth, 4 week,

weaning, 14 week and 18 week which accounted 60.41, 69.79, 67.49, 81.85 and 87.73% of total variance in Mizo local pigs. Khargharia *et al.* (2015) extracted four factors of 13 body biometric traits which accounted for 85.84% of total variation in Assam hill goat.

PC1 in present study accounted for 60.26% of the variation at 4 week. It was represented by high loading of body length, heart girth and height at back. Yakubu *et al.* (2009) in Fulani cattle, Pundir *et al.* (2011) in Kankrej cows, Yunusa *et al.* (2013) in Balami and Uda sheep, Tolenkhomba *et al.* (2013) in Mizo local pigs, Okoro *et al.* (2015) in crossbred pigs of Nigeria and Khargharia *et al.* (2015) in Assam hill goat also reported that the first factor explained maximum variation. PC2 explained 8.68% variation at 4 week. It had high loading for height at foreleg, height at shoulder, chest width and inner orbital width. PC 3 accounted for 4.76% of total variation at 4 week. It was characterized by snout circumference and ear length. Proportion of variance, explained by PC2 and PC3 also differed in previous literature. Sadek *et al.* (2006) reported that the second factor explained 15 and 17% of total variation in Arabian mares and stallions, respectively. Yakubu *et al.* (2009) observed 6.38 and 7.68% of total variation for PC2. Pundir *et al.* (2011) reported 19.68% of total variation for PC2. Yunusa *et al.* (2013) reported that the second factor explained 9.35 to 12.1% variation. Okoro *et al.* (2015) observed that the second factor explained 19.29% of total variation at pre-weaning stage. Sadek *et al.* (2006) and Pundir *et al.* (2011) reported PC3 explained 12 and 7.44% of total variation respectively.

PC1 in present study accounted for 66.93 and 68.52% of the variation at 6 and 8 week, respectively. It was represented by high loading of body length, heart girth and body weight. PC2 explained 6.82 and 6.92% variation at 6 and 8 week, respectively. It had high loading for height at foreleg, height at shoulder and snout circumference. The results indicated that PC1 seemed to explain the body of pig, i.e. general size; whereas PC2 seemed to represent the front view of the pig. Component matrix of different factors (morphometric and growth traits) at 4, 6 and 8 week are presented in Table 2.

In conclusion, high correlation coefficients were observed among most of the morphometric and growth traits ranging from 0.70–0.99. MSA, Bertlett's test of sphericity and communalities of different morphometric and growth traits at 4, 6 and 8 week revealed appropriateness of variables for PCA. 3 PCs at 4 week, 2 PCs at 6 week and 2 PCs at 8 week had more than 1 eigen values and explained 74%, 74% and 75% of total variance. PC1 was represented by heart girth and body length, PC2 by height at shoulder and height at foreleg and PC3 by snout circumference. Accounted PCs at different stage may be exploited in breeding and selection programmes to acquire highly coordinated animal bodies using fewer measurements.

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