



## Principal component analysis of linear type traits to explain body conformation in Murrah buffaloes

S P DAHIYA<sup>1</sup>✉, MANOJ KUMAR<sup>1</sup>, SANDEEP DHILLOD<sup>2</sup> and POONAM RATWAN<sup>3</sup>

Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana 125 004 India

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### ABSTRACT

Linear type traits are important in terms of reflecting breed standards and in giving information about the developmental ability of the animals. For data analysis, principal component analysis (PCA) is most important technique when variables are correlated. The aim of present study was to make linear type traits unrelated and reduce their number to the extent which could be used in explaining body conformation in Murrah buffaloes. Measurements were recorded on a total of 81 adult Murrah buffaloes maintained at Buffalo Farm, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar for 11 linear type traits (top wedge angle, rump slope, rump width, hip bone distance, navel flap length, brisket distance, height at wither, body length, skin thickness at neck region, skin thickness at ribs region and skin thickness at rump region). Phenotypic correlations were calculated for considered traits and significant positive correlations varied from 0.26 to 0.67 in the present study. All 11 linear type traits were subjected to varimax rotated PCA with Kaiser Normalization to explain body conformation of Murrah buffaloes. Principal component analysis resulted into four components which described 69.522% of total variation and out of this, first component explained 28.678% variation. The communality ranged from 0.882 (rump slope) to 0.390 (navel flap length) and unique factors ranged from 0.118 to 0.610 for 11 different linear type traits. It was concluded that PCA was effective to reduce the number of variables required to explain the body conformation in Murrah buffaloes.

**Keywords:** Body conformation, Linear type traits, Murrah, Principal component analysis

Buffaloes, with a population of 109.85 million contribute around 20.45% to the total livestock population in India (Livestock Census, 2019). Genetic resources of buffalo in India are represented by 17 well-defined breeds namely, Murrah, Nili Ravi, Jaffarabadi, Bhadawari, Mehsana, Banni, Surti, Marathwadi, Pandharpuri, Nagpuri, Toda, Chilika, Kalahandi, Luit (Swamp), Bargur, Chhattisgarhi and Gojri (NBAGR, 2020). Murrah is the world famous dairy breed of buffalo having its native tract in Rohtak, Hisar and Jind districts of Haryana but graded Murrah buffaloes are found all over the country due to their higher milk production potential as well as adaptation to wide environmental conditions without affecting their production, reproduction and growth performance.

Principal component analysis (PCA) is a mathematical technique that converts a number of correlated variables into uncorrelated variables called principal components (Lukibisi *et al.* 2008, Rao 1964, Hotelling 1933, Pearson 1901). Principal component analysis technique was

invented by two scientists Pearson (1901) and Hotelling (1933). First time PCA was applied in ecology under the name factor analysis by Goodall (1954). Naes *et al.* (1996) reported that PCA is most well-known and basic method to interpret large data matrices, prediction of quality parameters of food samples and analyzing relationships among data matrices. The variance-covariance structure of a set of variables can be described through principal component analysis using linear combinations of these variables, whose general objectives are data reduction and interpretation (Liu *et al.* 2016). According to Johnson and Wichern (2007), data reduction and interpretation are the general objectives of principal component analysis. The factor extracted from PCA analysis can be used in breeding programs with sufficient reduction in number of first lactation traits to be recorded for explanation of maximum variability for prediction of lifetime performance traits (Ratwan *et al.* 2017). Principal component analysis technique was applied by several workers (Pundir *et al.* 2011, Vohra *et al.* 2015 and Vohra *et al.* 2017) for analysis of morphometric traits to describe the body conformation of cattle and buffaloes. The present study was conducted to make linear traits unrelated and reduce their number to the extent which could be used in explaining body conformation in Murrah buffaloes maintained at organized farm.

Present address: <sup>1</sup>Livestock Farm Complex, LUVAS;  
<sup>2</sup>Department of Livestock Production Management, LUVAS;  
<sup>3</sup>Department of Animal Genetics and Breeding, LUVAS, Hisar 125004. ✉Corresponding author e-mail: dahiya642000@yahoo.com

## MATERIALS AND METHODS

**Data and farm management:** The data were recorded for 11 linear type traits on 81 lactating Murrah buffaloes maintained at Buffalo Farm, Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar. The farm is located under Trans-Gangetic plains at an altitude of 215 m above the mean sea level. Buffaloes were kept under loose housing system and their nutritional requirements were met through a balanced ration based on the requirements of the animals. Milking of buffaloes was done twice daily.

**Traits:** The traits recorded were top wedge angle (measured as the angle between the hip bones from the point at wither), rump slope (angle of the rump structure from hips to pin bone), rump width (distance between the most posterior point of pin bones), hip bone distance (distance between two hip bones measured with the help of measuring tape), navel flap length (measured from attachment to the body), brisket distance (measured as the distance between forelegs), wither height (measured when the animal was in standing position evenly on the ground with normal posture), body length (taken as the distance from the point of shoulder to the point of pin bone) and skin thickness (recorded at three sites with the help of vernier caliper over the side skin of the buffalo's neck region, ribs and rump region). The linear distance traits were measured with the help of measuring scale and tape while the top wedge angle and rump slope were measured with the help of an instrument made with protector and wooden sticks.

**Statistical analyses:** Phenotypic correlations were calculated among linear type traits using standard formula (Snedecor and Cochran, 1989). Principal component analysis (PCA) was carried out using Statistical Package for the Social Sciences (SPSS, 2001). Bartlett (1950) test was performed firstly to check whether the dataset of 81 animals with 11 traits could be factored or not as suggested by Maxwell (1959). For rotation of principal components, we have used Varimax rotation through transformation of components to approximate a simple structure. Kaiser-Meyer-Olkin (KMO) test of sampling adequacy was computed to find the validity of data set at 1% level of significance.

## RESULTS AND DISCUSSION

In the present study, means of linear type traits were  $46.9 \pm 0.5$  degree,  $13.0 \pm 0.6$  degree,  $17.7 \pm 0.3$  cm,  $47.0 \pm 0.4$  cm,  $1.8 \pm 0.1$  cm,  $24.3 \pm 0.5$  cm,  $138.5 \pm 0.4$  cm,  $148.9 \pm 0.8$  cm,  $6.7 \pm 0.1$  cm,  $9.0 \pm 0.2$  cm and  $11.3 \pm 0.2$  cm for top wedge angle, rump slope, pin bone distance, hip bone distance, navel flap length, brisket distance, height at wither, body length, skin thickness at neck region, skin thickness at ribs region, and skin thickness at rump region, respectively in Murrah buffaloes. Mean height at wither in Murrah buffaloes in present study was comparable with those observed by Kocaman *et al.* (2017) in dairy Anatolian water buffaloes (137.10 cm) as well as by Ahmad *et al.* (2013) in

Nilli Ravi buffaloes ( $140.2 \pm 7.2$  cm) maintained at commercial dairy herds in peri-urban areas of the Lahore city. Dhillod *et al.* (2017) also observed  $135.78 \pm 0.46$  cm height at wither in Murrah buffaloes and Nivsarkar *et al.* (2000) reported the same trait as 134.2 cm in Nilli Ravi buffaloes. Average height at wither was  $128.66 \pm 0.32$  cm as reported by Vohra *et al.* (2015) in lesser known Gojri buffaloes. Vohra *et al.* (2017) in Chhattisgarhi buffaloes reported comparatively lesser ( $123.48 \pm 0.40$  cm) height at wither than the present study. Mean body length in Murrah buffaloes was found to be  $148.9 \pm 0.8$  cm in present study which was comparable with the findings of Dhillod *et al.* (2017) in Murrah buffaloes ( $152.23 \pm 0.83$  cm), Kocaman *et al.* (2017) in Anatolian water buffaloes (146.10 cm) and Ahmad *et al.* (2013) in Nilli Ravi buffaloes ( $147.3 \pm 7.2$  cm). Average body length of  $133.33 \pm 0.35$  cm was reported by Vohra *et al.* (2015) in Gojri buffaloes and  $120.57 \pm 0.50$  cm was reported by Vohra *et al.* (2017) in Chhattisgarhi buffaloes while Melo *et al.* (2018) observed 143.07 cm body length in crossbred Murrah buffaloes. In Azikheli buffaloes, Khan *et al.* (2013) observed body length of 140 cm. On contrary, longer average body length (156 cm) was reported by Mirza *et al.* (2015) in the Nilli Ravi buffaloes of Pakistan. Mean hip bone distance in Murrah buffaloes was found to be  $47.0 \pm 0.4$  cm in present study. Bedoya and Hernandez (2013) reported 44 cm average hip bone distance in Murrah buffaloes at Colombia and the same trait as reported by Vohra *et al.* (2017) in Chhattisgarhi buffaloes was  $46.62 \pm 0.24$  cm. Melo *et al.* (2018) reported comparatively less hip bone distance as 39.9 cm in crossbred Murrah buffaloes. On the contrary, Dhillod *et al.* (2017) observed higher ( $62.24 \pm 0.48$  cm) hip bone distance in Murrah buffaloes, Kocaman *et al.* (2017) reported 57.30 cm hip bone distance in Anatolian water buffaloes, Ahmad *et al.* (2013) observed the same as  $56.9 \pm 4.5$  cm in Nilli Ravi buffaloes maintained at commercial dairy herds in peri-urban areas of Lahore city. Vohra *et al.* (2015) also observed higher ( $53.58 \pm 0.24$  cm) hip bone distance in Gojri buffaloes. Mean pin bone distance in Murrah buffaloes in the present study was in concordance with the findings of Kocaman *et al.* (2017) in Anatolian water buffaloes (20.9 cm) and Vohra *et al.* (2017) in Chhattisgarhi buffaloes ( $18.89 \pm 0.22$  cm). Contrarily, more average pin bone distance was reported by Ahmad *et al.* (2013) in Nilli Ravi buffaloes ( $30.2 \pm 3.7$  cm), Vohra *et al.* (2015) in Gojri buffaloes ( $24.29 \pm 0.29$  cm) and Melo *et al.* (2018) in crossbred Murrah buffaloes (25.38 cm).

Phenotypic correlations were calculated among different linear type traits which were found to be correlated positively as well as negatively. Highly significant ( $P > 0.01$ ) positive correlations were found among traits, viz. top wedge angle, rump width with hip bone distance, height at wither and body length; hip bone distance with brisket distance, height at wither, body length; navel flap length with ribs skin thickness; height at wither with body length; navel flap length with ribs skin thickness, rump skin thickness and ribs skin thickness had maximum positive

Table 1. Total variance explained by different components in Murrah buffaloes.

| Component | Initial Eigen values |               |              | Extraction sums of squared loadings |               |              | Rotation sums of squared loadings |
|-----------|----------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|
|           | Total                | % of Variance | Cumulative % | Total                               | % of Variance | Cumulative % |                                   |
| 1         | 3.155                | 28.678        | 28.678       | 3.155                               | 28.678        | 28.678       | 2.635                             |
| 2         | 2.235                | 20.314        | 48.992       | 2.235                               | 20.314        | 48.992       | 2.426                             |
| 3         | 1.197                | 10.881        | 59.873       | 1.197                               | 10.881        | 59.873       | 1.388                             |
| 4         | 1.061                | 9.650         | 69.522       | 1.061                               | 9.650         | 69.522       | 1.199                             |
| 5         | 0.827                | 7.520         | 77.043       |                                     |               |              |                                   |
| 6         | 0.609                | 5.536         | 82.579       |                                     |               |              |                                   |
| 7         | 0.535                | 4.866         | 87.445       |                                     |               |              |                                   |
| 8         | 0.463                | 4.211         | 91.656       |                                     |               |              |                                   |
| 9         | 0.372                | 3.384         | 95.041       |                                     |               |              |                                   |
| 10        | 0.295                | 2.684         | 97.725       |                                     |               |              |                                   |
| 11        | 0.250                | 2.275         | 100.000      |                                     |               |              |                                   |

correlation with rump skin thickness (0.67). Principal component analysis was applied to 11 body linear type traits of adult female Murrah buffaloes and Kaiser-Meyer-Olkin measure of sampling adequacy was obtained as 0.702 in present study. For rotation of principal components, we applied varimax rotation and Fernandez (2002) stated that varimax rotation was extensively used and accepted method of rotation. Kaiser-Meyer-Olkin (KMO) estimate of sampling adequacy which reveals fraction of variance in different morphometric traits caused by the causal components (Kaiser 1958) was applied for testing. Pundir *et al.* (2011) observed higher estimates (0.89) of sampling adequacy in Kankrej cattle. Vohra *et al.* (2015) and Vohra *et al.* (2017) observed KMO value as 0.74 in lesser known Gojri buffaloes and Chhattisgarhi buffaloes for body biometric traits. Overall significance of correlation matrix was tested by Bartlett's test of sphericity and it was found significant ( $P < 0.01$ ), depicting that correlation matrix was not an identity matrix. Kaiser Rule criterion (Johnson and Wichern 1982) led to extraction of four components out of total 11 principal components, retaining only the components that have eigenvalue greater than 1 (Table 1), usually principal components with eigenvalue greater than one are retained for further analysis. Scree plot also represent the various components and help in deciding the actual number of components to be included for analysis. Scree plot orders the eigenvalues from largest to smallest and ideal pattern of scree plot is steep curve, followed by a bend and then a straight line (Fig. 1). The extracted four components were able to explain 69.522% cumulative variance and first component accounted for maximum (28.678%) variation. Tolenthomba *et al.* (2013) used factor analysis and found six components which explained 69.77% variability in local cattle of Manipur which is almost similar to our finding. Yakubu *et al.* (2009) extracted two factors in the age group of 1.5 to 2.4 years which contributed to 85.37% of the total variation and in the age group of 2.5 to

3.6 years extracted four factors which accounted for 86.47% of the generalized variation by studying 14 morphometric traits of White Fulani cattle.

In present study, communality estimates ranged from 0.882 (rump slope) to 0.39 (naval flap length) and unique factors ranged from 0.118 to 0.610 for all the considered 11 linear type traits (Table 2). Vohra *et al.* (2015) reported that communality estimates ranged from 0.83 (distance between hip bone) to 0.44 (horn length) and unique factors ranged from 0.55 to 0.16 for 13 different biometric traits in lesser known Gojri buffaloes. Vohra *et al.* (2017) reported that communalities ranged from 0.92 (horn length) to 0.51 (rump length) and unique variance ranged from 0.08 to 0.49 for 18 different biometric traits in Chhattisgarhi buffaloes. Yakubu *et al.* (2009) observed communality estimates ranging from 0.95 (rump length) to 0.55 (head width) and 0.93 (heart girth) to 0.79 (rump height) in 1.5–2.4 years and 2.5–3.6 years old cattle, respectively. Shahin *et al.* (1993) in Egyptian buffalo bulls reported communality estimates varying from 0.96 (height at hips, height at wither) to 0.78 (rump width). It was evident that first component was represented by significant positive high loading of top

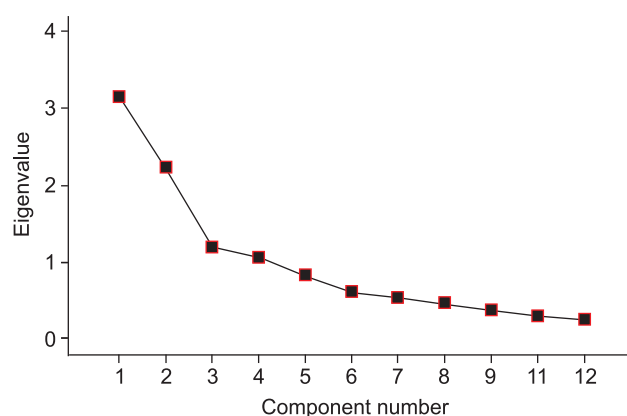


Fig. 1. Scree plot showing component number with eigenvalue.

Table 2. Communalities and unique factor of various linear type traits in Murrah buffaloes.

| Biometry trait      | Communalities | Unique factor |
|---------------------|---------------|---------------|
| Top wedge angle     | 0.792         | 0.208         |
| Rump slope          | 0.882         | 0.118         |
| Rump width          | 0.699         | 0.301         |
| Hip bone distance   | 0.657         | 0.343         |
| Navel flap length   | 0.390         | 0.610         |
| Brisket distance    | 0.788         | 0.212         |
| Height at wither    | 0.597         | 0.403         |
| Body length         | 0.616         | 0.384         |
| Neck skin thickness | 0.703         | 0.297         |
| Ribs skin thickness | 0.737         | 0.263         |
| Rump skin thickness | 0.787         | 0.213         |

Table 3. Varimax rotated component matrix of different factors for linear type traits in Murrah buffaloes

| Trait               | Component |        |        |        |
|---------------------|-----------|--------|--------|--------|
|                     | 1         | 2      | 3      | 4      |
| Top wedge angle     | 0.864     | 0.122  | -0.169 | 0.04   |
| Rump slope          | 0.755     | 0.044  | 0.098  | 0.124  |
| Rump width          | 0.735     | 0.055  | 0.211  | -0.169 |
| Hip bone distance   | 0.734     | 0.111  | 0.27   | -0.181 |
| Navel flap length   | 0.08      | 0.883  | -0.029 | -0.03  |
| Brisket distance    | 0.148     | 0.843  | -0.011 | -0.06  |
| Height at wither    | 0.008     | 0.837  | -0.033 | 0.037  |
| Body length         | 0.058     | 0.428  | 0.226  | -0.39  |
| Neck skin thickness | 0.053     | 0.042  | 0.875  | -0.129 |
| Ribs skin thickness | 0.45      | -0.132 | 0.642  | 0.259  |
| Rump skin thickness | -0.045    | 0.011  | 0.036  | 0.937  |

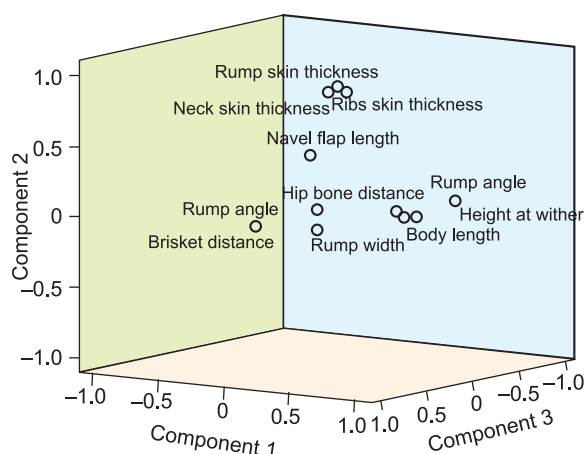


Fig. 2. Component plot in rotated space showing different linear type traits.

wedge angle, rump slope, rump width and hip bone distance (Table 3). First component seemed to be explaining the maximum of general body conformation in Murrah buffaloes. The second component explained 20.314% of total variance with high loading of navel flap length, brisket distance, height at wither and body length. Third component explained 10.881% of variance and had high component loadings for skin thickness at neck region and skin thickness

at ribs region. The fourth factor accounted for 9.65% of total variability with comparatively higher loading for skin thickness at rump region. The component plot of the three components in rotated space for different linear type traits is shown in Fig.2. Shahin *et al.* (1993) found that 88% general variation in body conformation can be accounted by synthetic variable principal components representing general size, body depth and height and head width in Egyptian buffalo bull.

In conclusion, results of principal components analysis suggested that use of four synthetic variables, i.e. extracted principal components provide a means of reduction in the number of linear type traits to be recorded in Murrah buffaloes which could be used in analysis of prediction equations in future to explain body conformation.

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