LIFE SCIENCE REVIEW

p-ISSN 3117-3535
e-ISSN 3117-3543

Original Research Article

Journal homepage: https://lsr.crcjournals.org/

Check for updates

Exploring Biometric Traits in Osmanabadi Goats: A Principal Component Analysis Approach

Nagendra A. Mule*, Chauhan D. S., and Tamboli N. M.

Department of Animal Husbandry and Dairy Science, College of Agriculture, Latur, Vasantrao Naik Marathwada Agriculture University, Parbhani (M. S.), India

07 April 2025: Received | 12 May 2025: Revised | 04 June 2025: Accepted | 13 July 2025: Available Online

*Corresponding Author: **Nagendra A. Mule** | Email Address: **thenagendramule@gmail.com**

Citation: Nagendra A. Mule, Chauhan D. S., and Tamboli N. M. (2025). Exploring Biometric Traits in Osmanabadi Goats: A Principal Component Analysis Approach. ***Life Science Review***. **DOI: https://doi.org/10.51470/LSR.2025.09.02.01**

Abstract

The present investigation was conducted to obtain phenotypic correlations between different morphometric traits and body conformation of Osmanabadi goat using the Principal Component Analysis (PCA) method.A total 7 biometric traits were considered for the present study viz.,Wither Height (WH), Chest Girth (CG), Body Length (BL), Rump Height (RH), Horn Length (HL), Ear Length (EL) and Body weight (BW). The data of total 765 animals were collected.Two principal components were extracted from seven body measurements. The principal component analysis explained a cumulative variance of 71.1% across the extracted components. The largest portion of the variance (58.2%) was explained by the first principal component (PC1), with the second principal component (PC2) accounting for an additional 12.8%.PC1 was predominantly defined by wither height (WH), body weight (BW), chest girth (CG), body length (BL), ear length (EL), and rump height (RH), reflecting its strong association with general body conformation traits. In contrast, PC2 was primarily characterized by head length (HL), capturing a smaller but distinct proportion of variance. These findings indicate that key biometric traits such as wither height, chest girth, and body length exhibit strong mutual correlations and are closely associated with body weight. Thus, PCA effectively summarizes the underlying structure of biometric measurements, with PC1 serving as the major determinant of overall body conformation. The results suggest that the extracted components can be reliably utilized for evaluation and selection, particularly when grouping animals based on correlated morphological traits.

Keywords: *Osmanabadi goat, (PCA), biometric traits, variance, correlation*

1. Introduction

Goats are incredibly versatile animals, providing a range of valuable products including milk, meat, fiber, offspring, and manure. Osmanabadi goat breed ispopular, especially across the arid and semi-arid regions.Its presence is most dominant in the Marathwada region, specifically in districts like Dharashiv (Osmanabad), Latur (our current location), Parbhani, Beed, Nanded, Hingoli, Jalna, and Chatrapati Sambhajinagar. This breed's reach also extends to adjoining districts in Maharashtra, as well as into the neighbouring states of Andhra Pradesh, Telangana, and Karnataka. Growth and development are essential factors in the production of meat animals. To effectively evaluate growth, body weight and various body measurements serve as key indicators. In order to identify and categorize breeds, phenotypic traits are crucial. Goat meat production could be improved by using linear body measurements as selection criteria.[4]. The output of meat animals depends on growth and development. Body dimensions and weight are crucial metrics for characterizing growth. A person or a population can be fully described by body measurements in addition to weight [12].

The main goal of the interdependence technique principal component analysis (PCA) is to identify the fundamental structure among the variables being examined. In order to assess body forms that might be important for evolution and to better understand the complex growth process that takes place in an animal's body dimensions during its growing phase, PCA has been utilized.[13].Principal component analysis results have an impact on animal management, but they also aid in conservation and breeders' selection of various qualities. [17] Type and function are increasingly being used as more reliable indicators of an animal's utility than weight. The value of weight alone is constrained in the absence of some qualification and measurement of related kind and conformation. The nature and function of an animal may be better described by combining several linear measurements into indices. Principal component analysis (PCA) and other multivariate methods have been utilized to provide a more accurate anylysis of the biometric relationship across animal breeds. [9].

PCA is a tool for simplifying complex datasets. Imagine you have a dataset with many different variables—too many to easily analyze.It works by creating a new, smaller set of variables called principal components. These new variables are designed to capture the greatest variance, or spread, in the original data. The first PCcontribute the most variance, the second contribute the next most, and so on. A scree plot is a common visualization that shows you how much variance each component explains. Mathematically, Principal Component Analysis (PCA) is grounded in the derivation of eigenvalues and eigenvectors from the covariance matrix of the dataset. The eigenvalues quantify the extent of variance accounted for by each principal component, whereas the associated eigenvectors specify their orientation within the multidimensional space. Consequently, PCA functions as a robust methodology for reducing the complexity of high-dimensional data by highlighting the most influential sources of variation and minimizing redundancy.

This study, "Principal Component Analysis of Biometric Traits in Osmanabadi Goats," aims to simplify and understand the physical characteristics of Osmanabadi goats. The research will first determine the relationships between various body measurements, like body length and chest girth, through phenotypic correlation. Following this, it seeks to identify which of these measurements are most crucial for representing the goat's overall body conformation. Finally, the study will use Principal Component Analysis (PCA) to combine these key traits into a few composite variables, creating a more efficient and powerful way to describe the goat's body dimensions and conformation.

2. Materials and Methods

2.1 Study Area

The origin of Osmanabadi goats is Latur and Dharashiv (Osmanabad) districts of Marathwada region in Maharashtra. Goats across different blocks were observed to be managed under varying husbandry practices, which in turn influenced their production performance. They are primarily raised for meat production, with milk serving as a secondary output of economic importance.Hence Latur and Ausa blocks from Latur district and Tuljapur and Dharashiv blocks from Dharashiv district had been purposively selected for the study. The villages in the block were randomly selected.

2.2 Description of Data

The present investigation was carried out on Osmanabadi goats, wherein morphometric traits were recorded for 765 adult animals during the period 2024–2025. The traits measured included Horn Length (HL), Face Length (FL), Ear Length (EL), Height at Withers (HW), Body Length (BL), Chest Girth (CG), Tail Length (TL), and Body Weight (BW). Body measurements were obtained using a measuring tape, while body weight was recorded with the aid of a spring balance.

2.3 Statistical Analysis

Pearson's correlation coefficient (*r*) was employed to quantify the degree of linear association among the measured traits, thereby providing an estimate of the extent to which two characters vary concurrently. To assess sampling adequacy, the Kaiser–Meyer–Olkin (KMO) test was applied, while Bartlett's Test of Sphericity was conducted to evaluate the appropriateness of the data for factor analysis. Principal Component Analysis (PCA) was subsequently utilized as a multivariate technique that transforms a set of correlated variables into a reduced set of orthogonal (uncorrelated) variables, termed principal components (PC1, PC2, ..., PCm). Each component represents a linear combination of the original variables and accounts for a specific proportion of the total variance, with the first principal component explaining the maximum possible variance, followed by successive components capturing the remaining variance under the constraint of orthogonality [2,8]. It is defined as

$$PC1 = b_{11}X_1 + b_{12}X_2 + \cdots + b_{1m}X_i = X_{b1};$$
$$PC2 = b_{21}X_1 + b_{22}X_2 + \cdots + b_{2m}X_i = X_{b2};$$
$$PCm = b_{m1}X_1 + b_{m2}X_2 + \cdots + b_{im}X_i = X_{bi};$$

Where,
bi refer to the coefficients, i = 1 to m
xi refer to the variables, i = 1 to m

PC1's coefficients were chosen to increase its variance as much as feasible. The coefficients for PC2 were set to maximize the variance of the combined variable, with the restriction that scores on PCI and PC2 (whose variance has already been maximized) must be uncorrelated.Eigenvalues were computed for each computed. Eigenvalues represent the total amount of variance in each variable that can be explained by a given principal component. Eigenvalues represent the sum of squared component loadings across all variables for each extracted component. In determining the optimal number of components, two selection criteria were employed, ensuring that the retained components were fewer than the total number of measured variables.

1. Eigenvalues greater than 1: One criterion was choosing the components that have eigenvalues greater than 1.

2. Scree Plot: The scree plot was employed to identify the optimal number of components to retain in the analysis. In this method, the eigenvalues obtained from the initial solution were plotted against the corresponding component numbers. Components located along the steep slope of the curve, up to the point of inflection (commonly referred to as the “elbow”), were considered for extraction, as they represent substantial contributions to the explained variance. In contrast, components lying beyond the elbow, along the shallow slope of the plot, account for minimal variance and were therefore regarded as less meaningful to the overall solution.

3. Results and Discussion

3.1 Correlation matrix for body biometric traits

The seven body biometric traits recorded for Osmanabadi goat was subjected for correlation coefficient analysis.

The correlation coefficients amongst all combination of morphometric traits were presented in Table 3.1 It is evident from the table that correlation coefficient estimated ranged between 0.15 (RH and HL) and 0.96 (BW and WH). The highest correlation observed was between BW and WH (0.96) followed by BW and CG (0.85), CG and WH (0.85), WH and EL (0.60), WH and BL (0.57), CG and EL (0.56) and BW and BL (0.56). The lowest correlation coefficient found between RH and HL (0.15) followed by BL and HL (0.17). This indicate that there is very strong positive linear relationship (close to 1) between body weight, wither height and chest girth which suggest that as one of these biometric trait increases, the others tend to increase significantly as well. Moderate positive correlation coefficients (around 0.5 to 0.7) were estimated between BW with BL (0.56), RH (0.54), EL (0.56) and CG with BL (0.49), RH (0.48), EL (0.49) and WH with BL (0.57), RH (0.55), EL (0.60). All correlation coefficient involving HL viz., HL with BW (0.33), CG (0.26), WH (0.30), BL (0.17), RH (0.15), EL (0.25) had weaker positive relationship (around 0.1 to 0.3) suggesting that these traits are largely independent to each other.

Consistent with these findings, the range of correlation coefficients among various body traits has been reported- 0.32 to 0.86 in Assam hill goat [5], 0.82 to 0.97 and 0.76 to 0.91 in West African Dwarf goats male and female, respectively and 0.83 to 0.91 and 0.66 to 0.94 in Red Sokoto Goats male and female, respectively (Okpeku*et al.,* 2011), -0.02 to 0.83 in Katjang does in Indonesia [10].

The values of coefficients (r) of present study areconcur withvalues reported i.e. BW-CG (0.84), BW-WH (0.72) and BW-BL (0.68) for 36 months of age.[11], BW and withers height (WH) in bucks (r = 0.97) and between BW and heart girth (HG) in does (r = 0.91)[9].The values of 64phenotypic correlation coefficients among different morphological traits in the Udaypuri goats reported were highest between BL and CG (0.90), BW and WH (0.60) and lowest between BW and TL (0.58) where all coefficients were significant [14],BW exhibited stronger correlations with BL (0.86), HG (0.79), RL (0.70), SPW (0.57), and PG (0.53), whereas the lowest connection was observed with SH (-0.32).[5]. Body weight(BW) was correlated to other traits in females except for rump height(RH). All the traits in males were correlated to BW, except that withers height (WH) and sternum height (SH) were negatively correlated.[7]

However, the findings differ with those of Tyasi and Tada (2023) reported coefficients between BW with RH (0.80), BL (0.91), and HG (0.84) in South African Kalahari Red goats. The difference may be due to variation in the breed.

Table 3.1 Pearson correlation coefficient matrix between seven morphometric variables

Traits	BW	CG	WH	BL	RH	EL	HL
BW	1	0.85	0.96	0.56	0.54	0.56	0.33
CG	0.85	1	0.85	0.49	0.48	0.49	0.26
WH	0.96	0.85	1	0.57	0.55	0.60	0.30
BL	0.56	0.49	0.57	1	0.32	0.34	0.17
RH	0.54	0.48	0.55	0.32	1	0.33	0.15
EL	0.56	0.49	0.60	0.34	0.33	1	0.25
HL	0.33	0.26	0.30	0.17	0.15	0.25	1

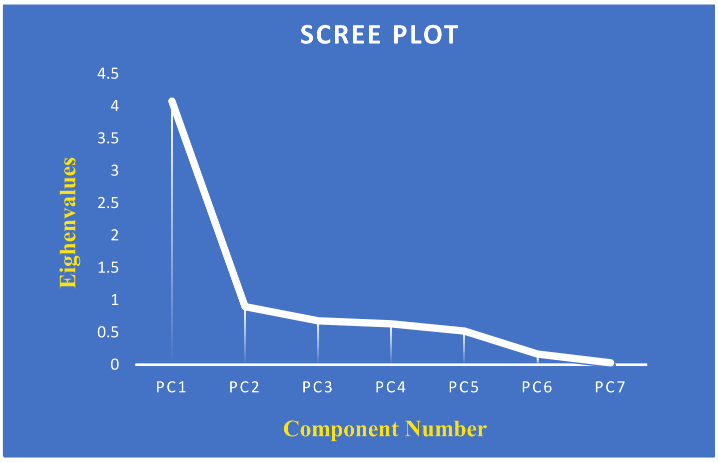

Fig 3.1

Table 3.2 KMO and Bartlett's test in Osmanabadi Goat

KMO and Bartlett's Test		Osmanabadi goat
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.850
Bartlett's Test of Sphericity	Approx. Chi-Square	4203.319
	df	21
	Sig.	.000

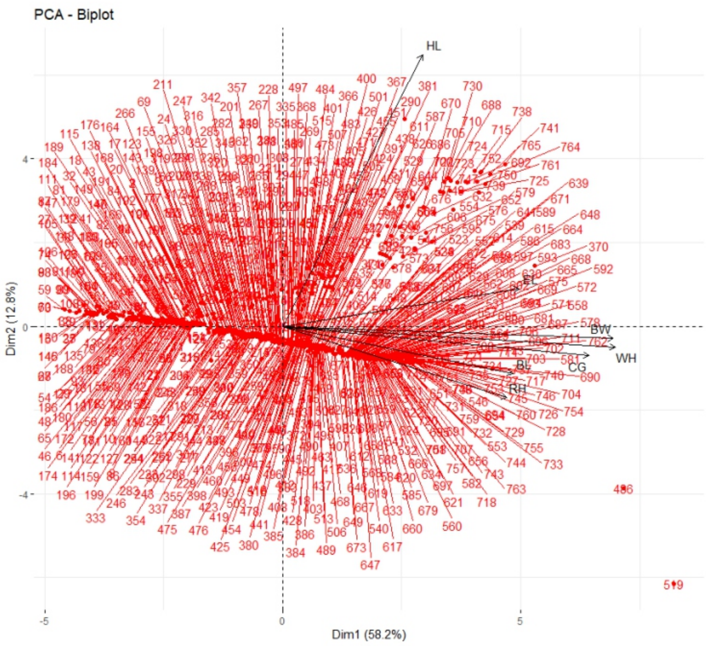

Fig 3.2

Table 3.3 Communalities in Osmanabadi Goat

Communalities		
Traits	**Initial**	**Extraction**
BW	1.000	.905
CG	1.000	.787
WH	1.000	.921
BL	1.000	.462
RH	1.000	**.471**
EL	1.000	.478
HL	1.000	**.95**

3.2 Principal Component Analysis

The results of KMO sampling adequacy and Bartlett's Test of Sphericity estimated for Osmanabadi goatpresented in Table 3.2.

KMO Measure of Sampling Adequacy for the biometric data of Osmanabadi goats was 0.850, indicating that the data was adequate for factor analysis and that the intercorrelations among variables were suitable for the application of Principal Component Analysis (PCA).

In the current study, a total of 765 observations were recorded for each of the seven biometric traits subjected to PCA. The significance of the correlation matrix was further evaluated using Bartlett's Test of Sphericity, which yielded a chi-square value of 4203.319 and was highly significant (P < 0.01). This result confirmed the rejection of the null hypothesis that the correlation matrix is an identity matrix, thereby validating the suitability of the dataset for factor extraction.

The communalities extracted for Osmanabadi goat body measurements are presented in Table 3.3. Traits with higher communalities (> 0.50) indicated that a substantial proportion of their variability was explained by the extracted components, thereby reflecting their importance in assessing growth performance. The communalities obtained for the seven variables were: body weight (0.90), chest girth (0.78), wither height (0.92), body length (0.46), rump height (0.47), ear length (0.47), and horn length (0.95).

The literature referred indicated that the communality ranged from 0.80 (BW) to 0.46 (BL) in Zulu sheep [6], 0.44 (WH) to 0.81 (CG) in Katjang does[10], 0.71 to 0.95 in Assam Hill goats [5] for body biometric traits were concur with values estimated in present study. In Pakistani goats,[3] reported very high communalities ranging between 0.928 to 0.999 and in West African Dwarf and Red Sokoto Goats [9] reported the communalities ranged from 0.91-0.99 and 0.86- 0.99, respectively.

Table 3.4 summarizes the variance accounted for by the initial eigenvalues, the extracted components, and the rotated components for Osmanabadi goats. The initial eigenvalues denote the fraction of the total variance in the original variables captured by each component.The first component accounted for the highest variance, with an eigenvalue of 4.077, while the seventh component explained the least, with an eigenvalue of 0.029. Since a total of seven variables were included in the analysis, seven components were extracted in the initial solution. In line with the principles of factor analysis, the sum of the eigenvalues equals the total number of components extracted, which, in this case, is seven.The percentage of variance indicates the proportion of the total variance in all variables that is attributed to each component. As indicated in Table 3.4, the first component explained 58.2% of the variance, and each subsequent component accounted for progressively smaller amounts of variance, with the final component explaining only 0.4%. The cumulative percentage represents the cumulative total of variance explained, summing the percentages from the first component through to the last, which ultimately reaches 100%. This cumulative approach allows for a comprehensive understanding of the distribution of variance across the components.

In the study, the two principal components extracted for Osmanabadi goats explained a cumulative variance of 71.1% (Table 4.4). PC1 alone accounted for 58.2% of the total variation.

Table 3.4 Total variance explained by different components in Osmanabadi goat

Total Variance Explained							
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of variance	Cumulative%	Total	% of variance	Cumulative %	Total
1	4.077	58.2	58.2	4.077	58.2	58.2	2.565
2	0.898	12.8	71.1	0.898	12.8	71.1	0.442
3	0.677	9.7	80.7				
4	0.632	9.0	89.8				
5	0.521	7.4	97.2				
6	0.166	2.4	99.6				
7	0.029	0.4	100				

Table 3.5 Extracted principal component matrix

Component Matrix		
	PC1	PC2
BW	**0.471**	-0.041
CG	**0.437**	-0.101
WH	**0.474**	-0.073
BL	**0.328**	-0.162
RH	**0.32**	-0.247
EL	**0.337**	0.129
HL	0.199	**0.937**

The component matrix (Table 3.5) indicated that PC1 was characterized by high positive loadings for wither height (WH, 0.474), body weight (BW, 0.471), chest girth (CG, 0.437), body length (BL, 0.328), ear length (EL, 0.337), and rump height (RH, 0.320). Consequently, this component may be employed to evaluate and compare the body morphometrics of Osmanabadi goats, with particular emphasis on key traits such as wither height, chest girth, body length, rump height, and ear length. PC1 appears to represent overall body conformation or body condition, suggesting that animals could be effectively selected for improved body size and structure based on this component.Characterized by wither height (WH), body weight (BW), chest girth (CG), body length (BL), ear length (EL), and rump height (RH), the first principal component (PC1) accounted for the largest share of total variance (58.2 %) and reflects the overall body size of Osmanabadi goats, and is therefore referred to as the 'Body Size Factor'. Various other studies namely morphological structuring of Zulu sheep of South Africa [6] Assam hill goat [5] and Uda and Balami sheep of Nigeria [17]. reported that the first principal component (PC1) represent overall body size. Similar to the present finding of Osmanabadi goat**,** [5] extracted four PCsfor the Assam hill goat which contributed for 85.84per cent of the total variance. [9] extracted two factors for each sex in West African Dwarf goats accounted for

94.15 % (female) and 97.65 % (male) of total variance which were higher than current findings but PC1 in male had its loadings for HG, BL and HW similar to present results. In another study on Boer goat by [7] reported PC1 with 57.75 % variance having high loadings for WH, BL and HG which conform the present values. [15]reported that the first component accounted for 28.024 % of the total variance and was primarily associated with a significant positive loading for body height in Malabari goats, which contrasts with the findings of the present study.

The second component accounted 12.8 % of total variance with maximum loading of horn length (0.937). The second principal component derived in Osmanabadi goats can be used to distinguish the breed according to horn traits. This findings support the result of [9] as they extracted second component contributing 11.36 % and 6.46 % of total variance in female and male Red Sokoto goats respectively. [10] extracted three components from different body measurements of Katjang does and second components explained 13.71 % of total variance which concur to present values. The study by [15] on Malabari goats reported that the second principal component accounted for 15.09 % of the total variance, with body length exhibiting a high loading. In Thalli sheep [1] reported that second component had variance as 12.184 % and 9.7 % for male and female respectively. In another study on Rampur-Bushair sheep by Sankhyan*et al.* (2018) explained 14.26 % of total variance is contributed by PC2 in adult sheep. The higher % of variance of second component than present findings is observed in Assam hill goat (24.93 %) [5], Boer goat (20.56 %) [7] and lower % of variance was reported in Madgyal sheep (8.25 %) [16].

In the present study on Osmanabadi goats, two principal components were extracted from seven body measurements, together explaining 71.1 % of the total variance. The first principal component (PC1), which accounted for 58.2 % of the variance, was characterized by wither height (WH), body weight (BW), chest girth (CG), body length (BL), ear length (EL), and rump height (RH), representing the major contribution to overall variance. The second principal component (PC2), associated only with horn length (HL), explained a smaller proportion of the variance (12.8 %).

4. Conclusion

Biometric traits, including wither height, chest girth, and body length, exhibited strong and positive correlations both among themselves and with body weight. The significant correlations observed between these linear body measurements suggest a high degree of predictability among the traits, highlighting their interdependence. The principal component analysis (PCA) effectively captured the underlying structure of general body conformation, with the first principal component (PC1) accounting for the majority of the variation. PC1 exhibited high loadings for wither height, chest girth, and body length, suggesting that these morphometric traits are pivotal in explaining overall body conformation.

These findings underscore the importance of biometric traits in the selection of animals, particularly in the context of breeding programs. Furthermore, the factors extracted from the PCA provide a robust framework for evaluating and selecting animals based on a set of related morphological variables. This approach can be particularly valuable for enhancing selection efficiency, as it considers the interrelated nature of the traits under investigation.

References

1. Akbar M.A, Javed K, Faraz A, Waheed A. (2021). Principal Component Analysis of Morphometric Traits Explain the Morphological Structure of Thalli Sheep. Pak Zool, 1-6.

2. Everitt, B. S., S. Landau and M. Leese (2001). Cluster analysis. 4th edn., Arnold Publisher, London.

3. Eyduran, E., A., Waheed, M. M., Tariq, F. Iqbal, and S. Ahmad, (2013) Prediction of live weight from morphological characteristics of commercial goat in Pakistan using factor and principal component scores in multiple linear regression. *Journal of Animal and Plant Sciences*. 23(6): 1532-1540

4. Hamayun Khan, Fida Muhammad, Gul Nawaz, Rahimullah, Muhammad Zubair and Riaz Ahmad (2006). Relationship of body weight with linear body measurements in goats. *Journal of Animal and Veterinary Advances* 5(6): 452-455, 2006.

5. Khargharia G., G. Kadirvel, S. Kumar, S. Doley, P. K. Bharati and M. Das (2015). Principal component analysis of morphological traits of Assam hill goat in eastern Himalayan India. *The Journal of Animal & Plant Sciences*, 25(5): 2015, Page: 1251-1258ISSN: 1018-7081.

6. Mavule, B. S., V. Muchenje, C. C., Bezuidenhout, and N. W. Kunene (2013) Morphological structure of Zulu sheep based on principal component analysis of body measurements. Small Ruminant Research. 111(1-3) :23-30.

7. Mokoena, K. &Tyasi, T.L.,(2021). Morphological structure of South African Boer goats explained by Principal Component Analysis. *Veterinaria*. 70(3), 325-334.

8. Mulyono, R. H., A. Gunawan and C. Sumantri (2009). Characteristics of size and shape of body dimension of Madura and Rote (Indonesia) Fat- Tailed sheep using Principal component analysis. The 1st International Seminar on Animal Industry. Pp 253-258.

9. Okpeku M., A. Yakubu, S. Peters, M. Ozoje, C. Ikeobi, O. Adebambo and I. Imumorin (2011) Application of multivariate principal component analysis to morphological characterization of indigeneous goats in Southern Nigeria. *Acta AgriculturaeSlovenica*98(2): 101-109

10. Putra WPB, Ilham F. (2019). Principal component analysis of body measurements and body indices and their correlation with body weight in Katjang does of Indonesia. *J Dairy Vet Anim Res*, 8(3), 124–34.

11. Raskar B. R., D S Chauhan and P.S. Singerwad (2018). Morphological characterization of Osmanabadi goats in its breeding tract. VOL. VII, Special volume ICAAASTSD-2018.

12. Salako, A. E. (2006a). Application of morphological indices in the assessment of type and Function in sheep. *Int. J. Morph*. 24:8- 13.

13. Salako, A. E. (2006b). Principal component factor analysis of the morphostructure of the immature Uda sheep. *Inter. J. Morph*. 24: 571-574.

14. Singh C. V., O. Sarma, R. S. Barwal (2024). Principal Component Analysis of Morphological Traits in Udaipuri Goats in Uttarakhand, India. Annual Research & Review in Biology39(7):12-20 June 202):4 39(712-20).

15. Valsalan J., T. Sadan & T. Venketachalapathy1 (2020). Multivariate principal component analysis to evaluate growth performances in Malabari goats of India. Tropical Animal Health and Production (2020) 52:2451–2460.

16. Yadav D. K., R. Arora, A. Jain (2016). Principal component analysis of body measurements based morphological structure of Madgyal sheep. *Indian Journal of Animal Sciences* 86(5): 568–571, May 2016.

17. Yunusa, A. J., A. E. Salako and O. A. Oladejo (2013). Morphometric characterization ofNigerian indigenous sheep using multifactorial discriminant analysis. *International J.Biodiv. Conserv*. 5 (10): 661-665.