

Hierarchical cluster analysis of yearling body weight and linear body measurements of sheep of Northern Nigeria and their crosses

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Abstract

This study was conducted at the Sheep Project Unit of Small Ruminant Research Programme (SRRP) of National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria. Balami, Uda and Yankasa breeds (sheep of Northern Nigeria) were crossed. A total of 65 Yankasa, 23 Uda and 16 Balami ewes were served by 4 Yankasa, 3 Uda and 3 Balami rams. The diallel breeding pattern produced 192 lambs. However, only the 65 yearling that survived up to 12 months of age (yearling) were used for this study. The yearling body weight and linear body measurement data were analysed using General Linear Model (GLM) procedures of SAS with model that incorporated lamb genotype as fixed effects. Pair-wise difference was used to separate the mean (SAS, 2003). Distances were used to construct dendrogram using the Unweighted Pairs Group Method Analysis implemented in R 2.13.0 package. TREE procedure that prints the dendrogram based on the distances between the clusters was introduced in PROC CLUSTER procedure. Yearling genotype affected body weight and all the linear body measurements considered in this study ($P < 0.05$). The pure Balami yearling (BL X BL) had the highest birth weight at 12 months of age (29.10 ± 4.02 kg). Clumping structure of yearling body weight among sheep of Northern Nigeria and their crosses were grouped into two clusters at distance 2.656. Pure Balami (BL X BL) formed the first cluster while the rest of the genotypes belong to the second cluster. The second cluster was further divided into two sub-groups at 0.796. The first sub-group had yearlings from pure Uda (UD X UD), Uda ram and Yankasa ewe (UD X YK), Uda ram and Balami ewe (UD X BL), Balami ram and Uda ewe (BL X UD) and Yankasa ram and Uda ewe (YK X UD) at 0.514. Similar clumping structures with two clusters share among the nine genotypes at varied distances were recorded for all the linear body measurements studied. Patterns of similarities were established for yearling body weight and linear body measurements among sheep of Northern Nigeria and their crosses. Improvement plans for yearling growth traits of sheep in Nigeria should consider the genotypes with divergent genetic distances as sires and dams. This will ensure the best exploration of positive heterosis.

Keywords: Hierarchical cluster, body weight and linear body measurements, sheep

Introduction

Differences among breeds substantially exceed those within breed, suggesting that genetic variation among breeds is a major component of the readily accessible livestock diversity (Adebambo, 2003). Delgado *et al.* (2001) stated that knowledge of variation in the morphological and morphometric traits is the first step in characterization of local genetic resources. Weight at one year (yearling weight) of ram

and ewe lambs is an important trait in the selection of replacement breeding rams and ewes at the National Animal Production Research Institute, Shika, Zaria. Some of the factors that affect birth weight and weaning weight of sheep also affect sheep weight after weaning (Taiwo, 1979).

Cluster analysis is a very useful data reduction technique for identifying latent patterns by suggesting useful groupings (clusters) of objects that are not discernible

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through other multivariate techniques (Hair *et al.*, 2010). Hierarchical agglomerative cluster analysis begins by calculating a matrix of distances among items in the data matrix. Clustering begins by finding the two groups that are most similar, based on the distance matrix, and merging them into a single group. This procedure of combining two groups and merging their characteristics is repeated until all the samples have been joined into a single large cluster. A variety of distance metrics can be used to calculate similarity. For data that show linear relationships, Euclidean distance is a useful measure of distance (Holland, 2006).

This method of grouping objects on the basis of the similarity of their distances can be used to classify livestock breeds. Evaluation of growth performance of all the possible genotypes obtainable from sheep breeds in Nigeria will require classification of the genotypes into groups. The patterns of similarities among the groups will guide sheep breeders on the combinations of genotypes that will yield the best positive

heterosis for desired traits. This study was therefore aimed at generating and classification of Northern Nigerian sheep breeds and their crosses at yearling through the use of hierarchical cluster analysis.

Materials and methods

This study was conducted at the Sheep Project Unit of Small Ruminant Research Programme (SRRP) of National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria. The Institute is located in Northern Guinea Savannah zone of Nigeria on latitude 11°12'16.78''N and longitude 7°33'39.18''E. Balami, Uda and Yankasa breeds (sheep of Northern Nigeria) were crossed using diallel breeding pattern. A total of 65 Yankasa, 23 Uda and 16 Balami ewes were served by 4 Yankasa, 3 Uda and 3 Balami rams. One hundred and ninety-two lambs were produced. However, only the 65 yearling that survived up to 12 months of age (yearling) were used for this study. The breeding pattern is as shown in Table 1.

Table 1: Diallel breeding pattern and the resulting lamb genotype

Sire breed	Dam breed	Lamb genotype
Yankasa	Yankasa	YK X YK
Uda	Uda	UD X UD
Balami	Balami	BL X BL
Yankasa	Uda	YK X UD
Yankasa	Balami	YK X BL
Uda	Yankasa	UD X YK
Uda	Balami	UD X BL
Balami	Yankasa	BL X YK
Balami	Uda	BL X UD

YK = Yankasa; UD = Uda; BL = Balami

Records taken included lamb's sire and dam, date of mating, date of birth, 360-Day weight (yearling weight). Body weights were recorded in kilogramme using Salter® scale. Data that were not collected at the desired date were adjusted using the following formula:

$$\text{Body weight at specific age} = \left(\frac{X_{ik} - X_{ij}}{Y_k - Y_j} \right) * (Y_L - Y_j) + X_{ij}$$

Assumptions made were: $j, k, L \neq 0$; j ,

$k, L > 1$; $k > j$; $L > j$ and $k \neq L$

Where:

X_{ik} = parameter measurement

(growth trait or linear body measurements) after the desired date;

X_{ij} = value of parameter measured (growth trait or linear body measurements) before the desired date;

Y_k = Date of record;

Y_j = Date of previous record; and

Y_L = Age of animal on the day of record.

Body linear measurements were recorded in centimetre using Tailor's measuring tape. The description of each of the linear body measurements were as stated below:

Neck length: The distance between the last atlas bone to the last cervical vertebra.

Back length: The distance from the last cervical vertebra anteriorly, the entire thoracic vertebra, sacral vertebra to sacro-coccygeal vertebra joints at the hip of the animal.

Height at wither: Measured from the tip of the scapula at the cervico-thoracic joint to the tip of the hoof.

Loin girth: Is the measure of the circumference at the loin, in a position anterior to the hind leg.

Chest girth: This was measured as the circumference posterior to the forelegs at right angles to the body axis.

Leg length: Leg length was measured from the hip of elbow joint to the tip of the hoof.

The yearling body weight and linear body measurement data were analysed using General Linear Model (GLM) procedures of SAS (SAS, 2003) using model that incorporated lamb genotype as fixed effects. Pair-wise difference was used to separate the mean (SAS, 2003). Distances were used to construct dendrogram using the Unweighted Pairs Group Method Analysis implemented in R 2.13.0 (R Development Core Team, 2015) package. TREE procedure that prints the dendrogram based on the distances

between the clusters was introduced in PROC CLUSTER procedure.

Results and discussion

Table 2 shows the effect of yearling genotypes on body weight and linear body measurements of sheep of Northern Nigeria and their crosses. Yearling genotype affected body weight and all the linear body measurements considered in this study ($P < 0.05$). The pure Balami yearling (BL X BL) had the highest BWT_12 (29.10 ± 4.02 kg). Yearling produced from Balami-sired mating with Yankasa ewe had the next heaviest weight (24.00 ± 2.84 kg). This was followed in the third ranking when Balami was used as the dam and Uda was used as the sire (20.50 ± 4.02 kg). The least overall BWT_12 was recorded when Yankasa was used as sire on Balami ewe (15.12 ± 4.02 kg). The BWT_12 recorded for $YK \times YK$ (14.79 ± 0.80 kg) was similar ($P > 0.05$) to what was obtained when Yankasa was used as sire on Balami ewe. The result indicating Balami as the heaviest yearling supports earlier reports by Adu and Ngere (1979); Oni (2002) and Yunusa *et al.* (2013).

The variability of neck length among sheep of Northern Nigeria and their crosses showed that pure Balami (BL X BL), UD X BL and BL X YK had longer neck ($P < 0.01$) than the other yearling genotypes. The longest back length was recorded by BL X YK (43.75 ± 2.95 cm) while the least value was that of YK X BL (32.25 ± 1.98 cm). Pure Balami yearling (BL X BL) stood highest with 78.90 ± 3.10 cm as height at wither. All the crosses however had higher height at wither than the pure Yankasa (YK X YK) and pure Uda (UD X UD); which had the lowest and similar values for height at wither (59.50 ± 1.15 cm and 59.30 ± 3.84 cm, respectively). The crosses produced by Balami sires (BL X YK and BL X UD) had the fattest (74.85 ± 4.75 cm and

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74.35±9.35cm, respectively) and similar ($P>0.05$) loins which was followed by the value of loin girth recorded by pure Balami yearlings (68.40±2.87cm). The thinnest loin girth was recorded by YK X UD and UD X UD with 64.72±2.43cm and 62.73±3.47cm, respectively. The highest values for chest girth was recorded by BL X UD (66.95±7.75cm) and UD X BL (65.80±3.20cm) which had similar values ($P>0.05$). The least value of chest girth was recorded by YK X YK (57.56±1.10 cm). The legs of YK X BL (44.80±3.04 cm) and BL X YK (43.85±1.55 cm) were similar ($P>0.05$) and were also longer than those of other yearling genotypes. The shortest leg length was however recorded by YK X YK (39.18±0.66 cm).

The similarity obtained for linear body measurements among genotypes that had Balami as sire or dam laid credence to the fact that Balami sheep had higher genetic potential for growth traits more than other breeds of sheep in Nigeria. Iyiola-Tunji *et al.* (2013) had reported that breed of sire or dam affected average daily gain of lambs in

the same population. They concluded that Balami sheep (used as either sire or dam) expressed their superior genetic potential in terms of faster growth rate than Uda and Yankasa. Most of the lowest values for linear body measurements were recorded by crosses. For example, the shortest neck length was recorded by YK X BL (26.25±1.02cm) and BL X UD (26.20±0.60 cm). The lowest values of neck length obtained for YK X BL and BL X UD may be as a result of negative heterotic effect. For a polygenic character, heterosis is estimated as the amount by which the average performance of crossbreds exceeds the average of the two parental breeds (Dickerson, 1973). Amount of heterosis was expected to increase as the genetic divergence of the parents increased especially between Yankasa and Balami sheep. Cress (1966) explained that the negative heterotic contributions of some loci may cancel positive responses at other loci so that little deviations from the mid-parent mean results, even though the parental genotypes have a large degree of diversity.

Table 2: Effect of yearling genotypes on body weight and linear body measurements of sheep of Northern Nigeria and their crosses

Lamb genotype	N	Body weight (kg)	Neck length (cm)	Back length (cm)	Height at withers (cm)	Loin girth (cm)	Chest girth (cm)	Leg length (cm)
YK × YK	25	14.79±0.80 ^f	27.88±0.88 ^c	34.80±0.65 ^e	59.50±1.15 ^g	63.12±1.49 ^e	57.56±1.10 ^f	39.18±0.66 ^c
UD × UD	6	17.43±1.64 ^c	28.03±0.53 ^b	36.12±1.41 ^c	59.30±3.84 ^g	62.73±3.47 ^e	60.68±1.21 ^e	42.03±1.35 ^c
BL × BL	3	29.10±4.02 ^a	30.80±1.69 ^a	42.60±2.04 ^b	78.90±3.10 ^a	68.40±2.87 ^b	62.20±3.01 ^d	42.40±2.64 ^c
YK × UD	9	16.90±1.34 ^c	27.98±1.04 ^c	37.13±1.92 ^d	59.62±1.45 ^f	64.72±2.43 ^c	59.80±1.61 ^e	42.96±2.39 ^c
YK × BL	3	15.12±4.02 ^f	26.25±1.02 ^d	32.25±1.98 ^b	63.25±1.33 ^e	65.20±2.06 ^d	65.20±3.02 ^b	44.80±3.04 ^a
UD × YK	8	16.78±1.42 ^c	27.36±0.92 ^c	36.06±1.31 ^c	63.28±1.57 ^e	66.12±2.36 ^e	61.04±2.18 ^e	41.61±0.79 ^b
UD × BL	3	20.50±4.02 ^c	30.80±0.16 ^a	40.10±1.34 ^c	68.60±2.31 ^c	63.40±1.05 ^e	65.80±3.20 ^a	41.50±1.81 ^c
BL × YK	3	24.00±2.84 ^b	30.00±1.80 ^a	43.75±2.95 ^a	73.20±2.90 ^b	74.85±4.75 ^a	63.95±1.45 ^e	43.85±1.55 ^a
BL × UD	3	18.20±2.84 ^d	26.20±0.60 ^d	35.35±3.15 ^f	66.10±2.80 ^d	74.35±9.35 ^a	66.95±7.75 ^a	40.60±0.20 ^d
SEM		0.35	0.46	0.56	0.90	1.03	0.76	0.56

N- Number, SEM- Standard error of the mean

Figures 1 to 7 showed the clustering dendrogram obtained by different distances among genotypes of sheep using body weight, neck length, back length, height at wither, chest girth, loin girth and leg length, respectively at 360 days. Clumping structure of yearling body weight among sheep of Northern Nigeria and their crosses (Figure 1) was grouped into two clusters at

distance 2.656. Pure Balami (BL X BL) formed the first cluster while the rest of the genotypes belong to the second cluster. The second cluster was further divided into two sub-groups at 0.796. The first sub-group had UD X UD, UD X YK, UD X BL, BL X UD and YK X UD at 0.514. The pure Yankasa (YK X YK), YK X BL and BL X YK formed the second sub-group at 0.170.

The major feature of sub-group 1 of cluster 2 is that Uda (either as sire or dam) was part of the genotypes of yearling of that group.

Similar pattern was also observed in sub-group 2 of cluster 2; Yankasa (either as sire or dam) was common to the entire yearling in that group.

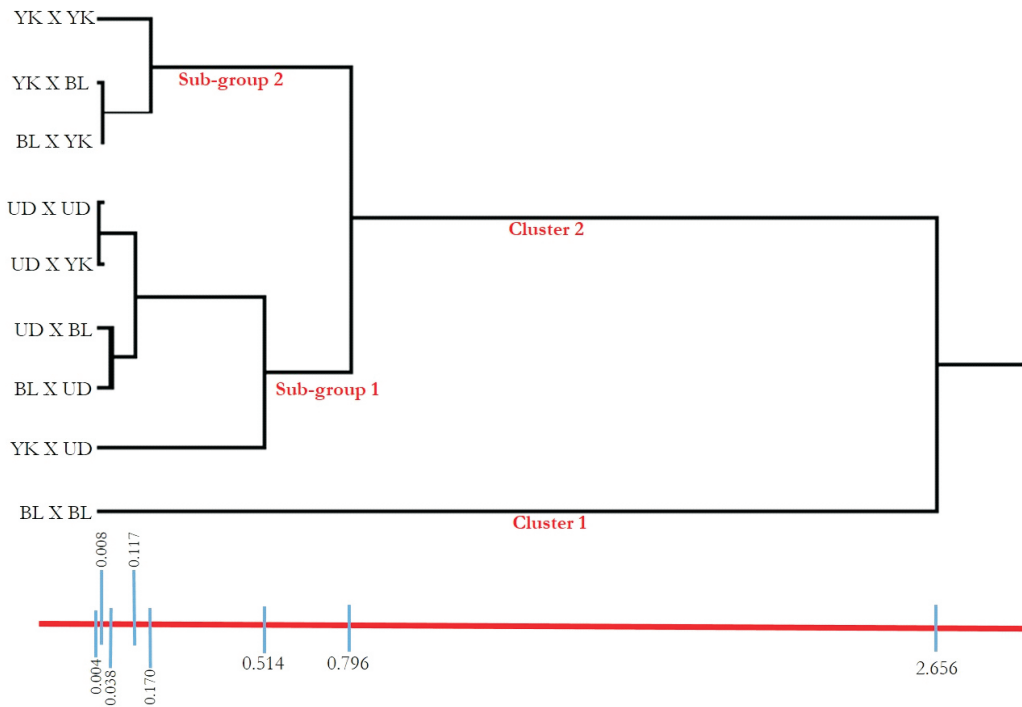


Figure 1: Dendrogram obtained by different distances among genotypes of sheep using body weight at 360 days

The Northern Nigerian sheep and their crosses were grouped into two clusters at distance 2.311 based on their neck length (Figure 2). Each of the two clusters was also divided into two sub-groups. Cluster 1 split into two at 0.974. The two sub-groups of cluster 1 were also further splits at 0.312. YK X YK and BL X YK (sub-group 1 of cluster 1) were more related on the basis of neck length than other genotypes that make up cluster 1. Three genotypes (YK X BL,

UD X YK and BL X UD) make up the sub-group 2 of cluster 1. However, UD X YK and BL X UD had closer relationship at distance 0.162 based on neck length. Cluster 2 was branched into two at 1.149. The three genotypes in sub-group 1 of cluster 2 had Uda sheep as either the sire or dam. UD X UD and YK X UD were more closely related than UD X BL. BL X BL however solely formed sub-group 2 of cluster 2.

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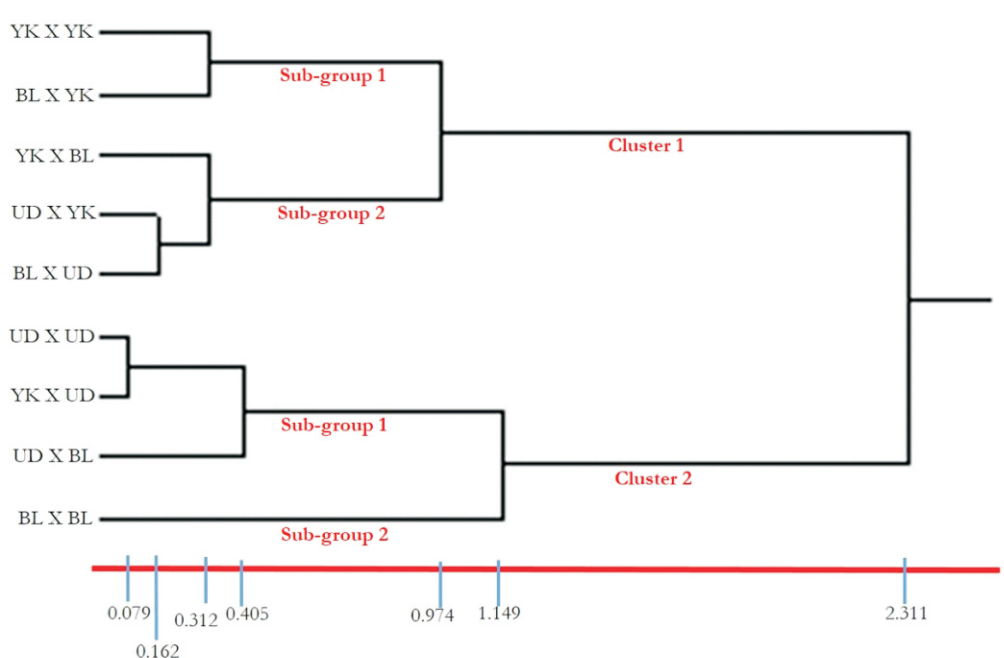


Figure 2: Dendrogram obtained by different distances among genotypes of sheep using neck length at 360 days

A somewhat complex relationship was illustrated among the 9 genotypes of yearlings of sheep of Northern Nigeria and their crosses on the basis of back length (Figure 3). The closest relationship was found between YK X YK at distance 0.016. The farthest relationship was however found at distance 2.477 between the leader of cluster 1 (YK X YK) and the joiner of cluster 2 (BL X BL). Cluster 1 was split into two splinter groups. BL X YK shared common features of back length with three other genotypes (YK X YK, UD X UD and BL X UD) at 0.246. Cluster 1 was split into two splinter groups. BL X YK shared common features of back length with three

other genotypes (YK X YK, UD X YK and BL X UD) at 0.246. YK X YK and UD X YK formed the splinter 2 in cluster 1 at 0.016. In splinter 1 of cluster 1, BL X UD shared common features with the two genotypes in splinter 2 at 0.085.

At distance 1.125, cluster 2 was divided into subgroup in which BL X BL separated from all other genotypes in that cluster (UD X UD, UD X BL, YK X UD and YK X BL). These other 4 genotypes in cluster 2 were also splintered into 2 groups. The closest relationship in cluster 2 on the basis of back length was found in splinter 2 (UD X UD and UD X BL) at 0.046. YK X UD however (in splinter 1) was related to the genotypes in splinter 2 at 0.246.

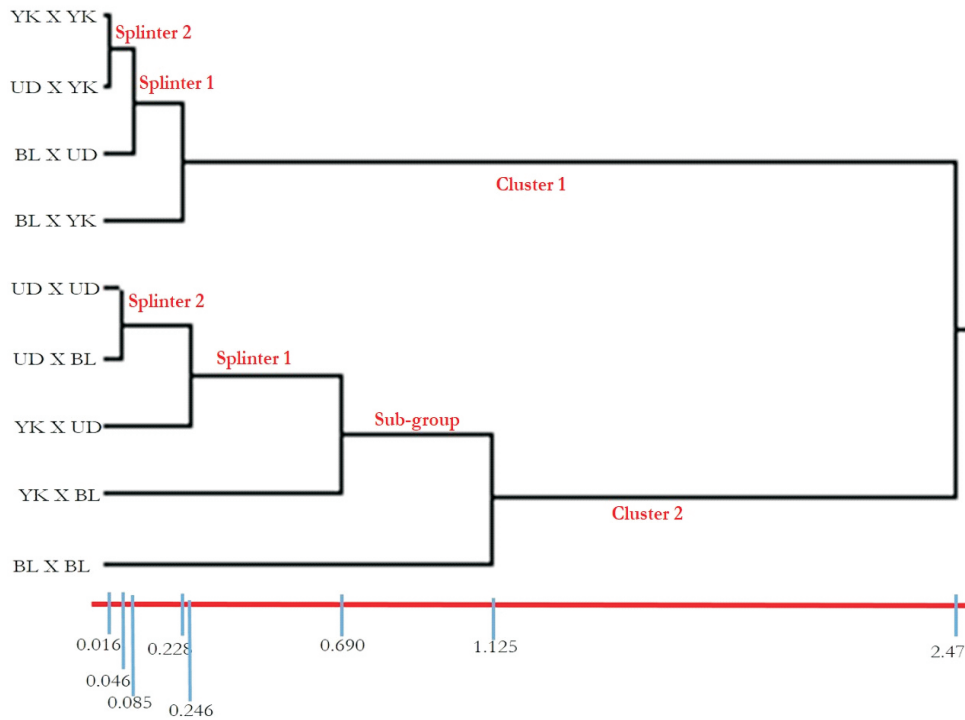


Figure 3: Dendrogram obtained by different distances among genotypes of sheep using back length at 360 days

The relationships among genotypes of sheep of Northern Nigeria and their crosses based on height at wither at 360 days was illustrated by formation of 2 clusters at 2.26 (Figure 4). Two subgroups were also formed from cluster 1 at 1.557. And each of the 2 subgroups in cluster 1 was also splintered into two splinter groups. The dams of the three genotypes in subgroup 1 of cluster 1 were Yankasa while the sires were each of the three breeds of sheep considered in this study. YK X YK and BL

X YK formed splinter 1 of subgroup 1 of cluster 1 at 0.073 and were both found to relate with UD X YK (splinter 2 of subgroup 1 of cluster 1) at 0.384. The closest relationship among yearling sheep of Northern Nigeria and their crosses on the basis of height at wither was found between UD X UD and UD X BL at 0.013 while the farthest relationship was found between BL X UD and the leader of cluster 1 (YK X YK) at 2.26. it is of note that BL X UD was solely formed in a distinct cluster (cluster 2) on the basis of height at wither.

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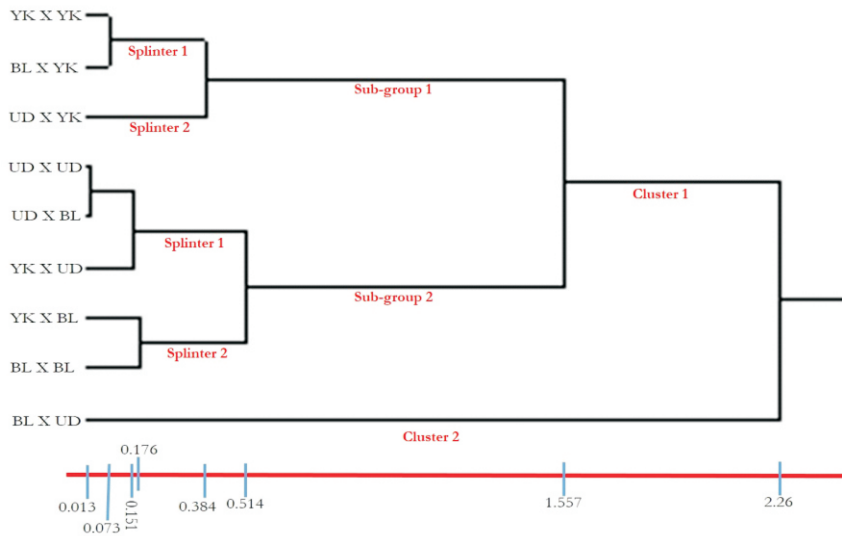


Figure 4: Dendrogram obtained by different distances among genotypes of sheep using height at wither at 360 days

Figure 5 showed the hierarchical clustering dendrogram obtained by different distances among genotypes of sheep using chest girth at 360 days. The Northern Nigerian sheep were grouped into two clusters at distance 2.399 on the basis of chest girth of sheep of Northern Nigeria. The first cluster formed pure BL $\times$ BL and YK $\times$ BL at 0.027. Cluster 2 was further divided into sub-group 1 and 2 at a distance of 1.358 with

sub-group 1, which formed UD $\times$ UD, UD $\times$ YK and YK $\times$ UD at 0.391 whereas sub-group 2 of cluster 2 formed YK $\times$ YK, BL $\times$ YK, UD $\times$ BL and BL $\times$ BL at 0.423. The major attribute of sub-group 1 of cluster 2 is that Uda (either as sire or dam) was part of the genotypes of yearlings of that group. Similarly, Balami was observed as (either as sire or dam), which was common to the entire yearling in sub-group 2 of cluster 2.

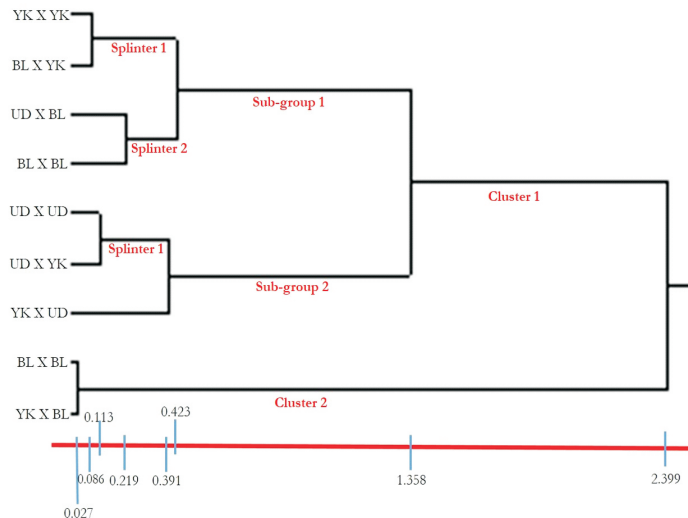


Figure 5: Dendrogram obtained by different distances among genotypes of sheep using chest girth at 360 days

Figure 6 showed the clustering dendrogram obtained by different distances among genotypes of sheep using loin girth at 360 days. The Northern Nigerian sheep were grouped into two clusters at distance 2.352 on the basis of loin girth of sheep of Northern Nigeria. The first cluster was further divided into 2 sub-group at a distance of 1.282 with the first sub-group,

which had BL × BL, YK × UD and UD × BL at 0.766 while sub-group two formed UD × UD, YK × BL, UD × YK and BL × UD at a genetic distance of 0.293. The second cluster formed the pure yankasa (YK × YK) and BL × YK. The major attribute of sub-group 2 of cluster 1 is that Uda (either as sire or dam) was part of the genotypes of yearlings of that group.

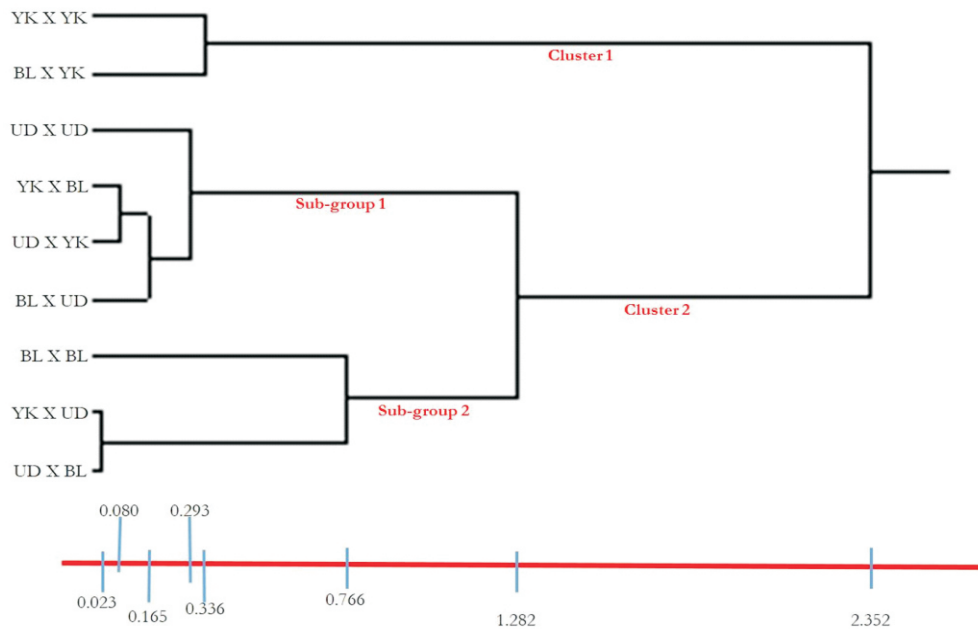


Figure 6: Dendrogram obtained by different distances among genotypes of sheep using loin girth at 360 days

Figure 7 showed the hierarchical clustering dendrogram obtained by different distances among genotypes of sheep using leg length at 360 days. The Northern Nigerian sheep were grouped into two clusters at distance 2.371 on the basis of leg length of sheep of Northern Nigeria. Cluster 1 was divided into 2 sub-group 1 and 2 at genetic distance 1.336. The sub-group 1 of cluster 1 formed BL × BL, YK × UD and YK × BL at 0.466

while the sub-group 2 of cluster 2 formed UD × UD, UD × YK and UD × BL at 0.261. Cluster 1 was also divided into 2 sub-group 1 and 2 at 0.519 with sub-group 1 of cluster 2, which formed BL × YK and BL × UD at 0.102 while sub-group 2 of cluster 2 formed the pure YK × YK. The main characteristic of sub-group 2 of cluster 1 is that Uda (either as sire or dam) was part of the genotypes of yearlings of that group.

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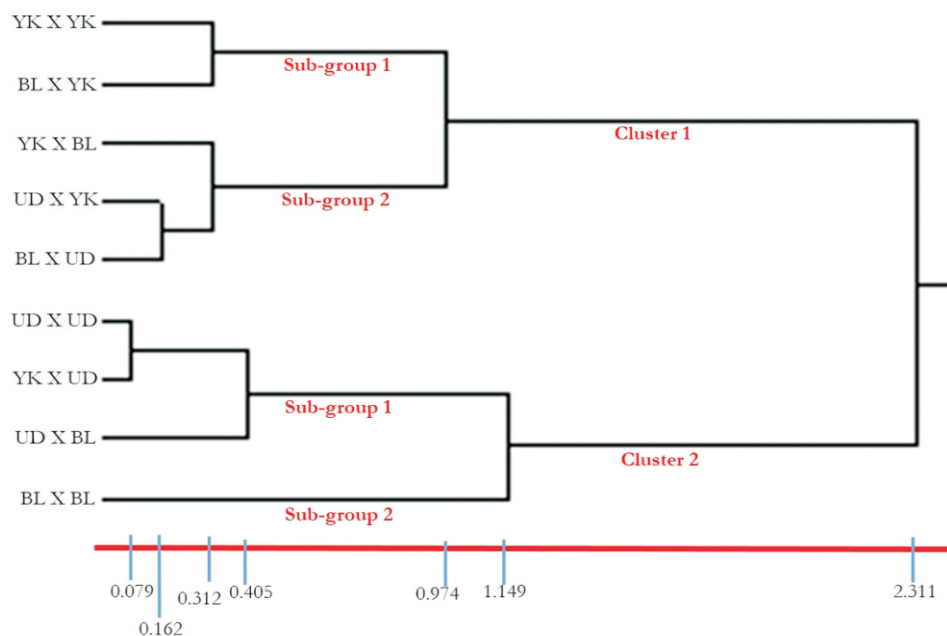


Figure 7: Dendrogram obtained by different distances among genotypes of sheep using leg length at 360 days

The results of hierarchical clustering are usually presented in a dendrogram. Two main clusters were formed for all the traits considered in this study. However, divergent relationships were formed at closer distances among some genotypes than the others. Johnson and Wichern (2008) list four different measure of association (similarity) that are used with continuous variables in cluster analysis. The most commonly used among the four is Euclidean distance which plot the observations in two dimensions. It simply measure the distances between the pairs of points as the square root of the sum of the squared differences between the measurements for each variable.

One of the reasons for estimating genetic distance is to evaluate the expected heterosis when breeds of the same species are crossed. Genotypes whose genetic distances are farther being expected to

express more heterotic effects. Pure Balami sheep in this study had the farthest genetic distance of 2.636, based on body weight, with all the other genotypes considered. This was in agreement with Yunusa *et al.* (2013) who reported that there is room for improvement of the indigenous breeds of sheep especially between Southern and Northern breeds. Somewhat different patterns of association were illustrated for linear body measurements of sheep genotypes in this study (Figures 2 to 7). The physiological vitality of an organism is evident in its speediness of growth, its height and general strength that is certainly allied with the amount of difference in the gametes by whose unification of the organism was formed (Lawrence and Fowler, 2002). The patterns of association (similarities) recorded through cluster analysis on body weight and linear body measurements of sheep of Northern

Nigeria in this study depicts the patterns of variations of the traits as described earlier by Adu and Ngere (1979) for sheep breeds in Nigeria.

Conclusion and recommendations

Patterns of similarities were established for yearling body weight and linear body measurements among sheep of Northern Nigeria and their crosses. Improvement plans for yearling growth traits of sheep in Nigeria should consider the genotypes with divergent genetic distances as sires and dams. This will ensure the best exploration of positive heterosis.

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