Eth. J. Anim. Prod. 5(1)- 2005: 13-31

Phenotypic Characterization of Goat Types in Northwestern Ethiopia

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Abstract

In this study goat types of Benshangul were characterized using multivariate analytical techniques and farmers identification criteria. Phenotypic measurements using FAO standard descriptor list, adopted by FARM Africa, were used on 2076 goats selected through stratified multistage random sampling.

Morphologically five different goat types, namely Felata, Arab, Gumuz, Oromo and Agew were identified. The dominant goat types found in semi-arid part were Felata, Arab and Gumuz goats. Agew and Oromo goat types were found in sub-humid parts of the region. The reported trypanotolerant attribute of Felata, Arab and Gumuz goat types might be the reason for their abundance in the region. Felata, Arab and Gumuz goats are used for milk production. The Oromo and Agew goats weigh on average 41.5 kg and 42.3 kg, respectively. They are used for meat production. The Arab and Gumuz goat types are considered as a dual-purpose type. In order to complete and confirm this phenotypic characterization, genetic and molecular breed characterizations are recommended.

Keywords: indigenous goats, breed types, Benishangul, phenotypic characterization, multivariate analysis.

Introduction

Ethiopia is endowed with varied ecological zones and possesses diverse animal genetic resources. There is a long history of trade with Arab countries across the Red Sea, with Sudan in the West and Kenya and Somalia in the southern and southeast. The waves of trade and physical movement of people and animals must have influenced the genetic make up of domestic livestock, including goats (Workneh, 1992). Goat might have gone through a continuous change in genetic structure through natural selection. Therefore, it is necessary to characterize and identify individuals, families, groups, types and

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breeds of animals and environments to which such species or breed populations are adapted or known to be adapted.

Goat types of Ethiopia were characterized using their physical feature and 14 different goat types were identified of which some have been reasonably documented (FARM-Africa, 1996). The Northwestern Ethiopia goat types were characterized as Northwestern lowland goat types (Nigatu, 1994). According to the 1997 annual report of the Benshangul-Gumuz Region Agricultural Bureau, taking advantage of extensive area of bushes and woodlands, which accounts for 60 percent of the total area and their capacity to live in harsh environments, different types of goats form an integral part of the farming systems in the northwestern parts of the country. In addition to the above the 1994 annual report of the Benishangul Bureau of Agriculture has reported that the Region also has other breed types. Therefore, this study was designed to characterize major breed types of goats in Benshangul-Gumuz Region, northwestern Ethiopia.

Materials and Methods

Study area

This study covered the whole of the Benshangul-Gumuz Regional State, which is located in the northwestern Ethiopia, bounded by Sudan in the west, Amhara Region in the north and northeast, Oromia in the east and southeast and Gambela in the south. According to the 1995 annual report of the Benshangul-Gumuz Region Agricultural Bureau, the Region covers a total area of 250,000 km^2 and is located between geographical coordinates 9^0 30'N to 11^0 39'N latitude and 34^0 20'E to 36^0 30'E longitude. The region is divided into 3 administrative zones and 2 special woredas (districts). The 3 zones are further divided into 18 woredas to form a total of 20 woredas. Each woreda is further classified into Kebeles (lowest administrative unit of Ethiopia) and form a total of 633 Kebeles. The region has 8 major ethnic groups and 3 farming system namely Sedentary, Agro-pastoral and Nomadic.

Sampling method

The study considered the whole 20 woredas within 3 zones and 2 special woredas. Out of a total of 633 Kebeles about 10 percent of them were sampled. The Kebele within the stratum constitutes the first unit and the farmer within the Kebele the second unit. The Kebeles were selected in such a way that they were equally distributed among the woredas.

In the first stage, woredas were considered on the basis of identified ethnic groups and geographic locations and secondly Kebeles were taken into account. Further stratification within some woredas based on the production system was found to be important as if farmers could provide at least 30 adult non-pregnant female goats. Thus, the sampling method used was stratified multistage random sampling (Gomez and Gomez, 1976). Once Kebeles were selected, they were checked with local authorities and agricultural extension staff for their goat type and number that resulted to 59 Kebeles to be used for sampling. Four out of the 63 Kebeles were excluded due to few goat populations available.

Survey design

In each of the 59 selected Kebeles, scientific surveys by following sampling designs and suitable formats, descriptors and questionnaires for collecting all possible information for particular goat type residing in a defined area were used. A one-time visit survey (Workneh, 1992, Peacock, 1996) was employed in the Kebeles to the randomly selected goats for physical measurements. Key informant farmers were chosen and interviewed.

Identification of goat types

Physical measurements were taken on goats to assess breed types. Both continuous (5) and discrete (41) phenotypic breed descriptor variables (Nigatu, 1994; FARM-Africa, 1996) from 2076 goats of 59 sample sites were taken for the breed characterization (Table 1).

Stage of maturity of goats was determined at the stage where bone development was assumed to cease. This was done after identifying matured female goats through linear measurements of ear, horn, height at withers, heart girth and body weight of 100 goats of different age group from each goat type. Height at withers stops increasing at an increasing rate earlier than body weight and chest girth, which verifies the stage where the animal is mature (Figure 1) and further bone development stops (Makhenzie, 1976).

Females of greater than 14-19 month of estimated age as judged by their dentition classes (add a foot note explaining the dentition classes), with fully spread apart milk teeth or start to wear down and with erupted and growing first pair of incisors, were sampled for phenotypic characterization. As Nigatu (1994) reported earlier, such goats represents the center of population in the flock age structure.

Data analysis

Multivariate analysis was used to analyze the multiple measurements of subjects to reduce the data dimension and to assign observations to groups (Minitab, 1998).

Principal component analysis

Phenotypic measurements of both continuous and discrete variables from goats of 59 sample sites of 2076 goats each with 46 variables were taken. Principal Component (PC) analysis was used to explore the underlying data structure and form a smaller number of un-correlated components. Only the first five most important PCs were selected for further analysis and classification using Scree plot diagram of the Principal component analysis. The relative importance of the PC was observed from their eigenvalues and their contribution in explaining the overall variance. The eigenvector and loading value identifies how each variable influences its corresponding PC.

Clustering of observations

The procedure used for clustering of observation into groups was sequential, agglomerate, hierarchical and non-overlapping (SAHN) (Workneh, 1992; Alemayehu, 1993; Nigatu, 1994). Average linkage method was found to be appropriate for the data as it suits the clustering technique employed. The within-cluster sum of squares, average distance from centroid, maximum distance from centroid and the squared distance between clusters of goats was calculated to determine the clusters.

Discriminant analysis

Using discriminant analysis, the data were repeatedly analyzed to classify the observations into identified breed groups and identify misclassified goat types.

Results

Principal components (PC)

Based on their associated eigenvalue eight variables from PC one, six from PC two then five, four and three from PC three, four and five, respectively were selected (Table 2). This reduces the variables numbers from 46 to 26 and these were quite satisfactory for the analysis (Sneath and Sokal, 1973; Pimental, 1979). The first five PCs (Table 3) that display weight on the Scree plot profile (Figure 2) and explained 54 percent of the total variation were selected for classification.

PC one was most strongly influenced by ear length, convex head, pendulous ear form, bodies weight, height at withers, hairiness, brown and gray coat color. Principal component 2 was most strongly associated with coat pattern like short smooth hair and coarse hair. Chest length, slightly concave facial profile, presence of wattle and beard were also concerned by PC 2. Principal component 3 was closely related to horn orientation, which was upward and backward orientation with scurs horn shape. Principal component 4 was highly related with polledness, erect ear and straight horn shape. Principal component 5 was associated with lateral horn orientation, hair on toughs and white coat color (Table 3).

Cluster analysis

The amalgamation steps that run before identifying the final clustering showed that five clusters appeared to be more meaningful for the final partition. Because, the similarity level dropped from 59 of cluster six to 54 of cluster five. This 5% abrupt reduction of the similarity level compared to the one to two percent observed at other levels, decision was made to take this as the cut off point (Figure 3). At similarity level of 54 the 59 adult female goats was likely to be grouped into five distinct types of goats (Table 4). After considering the group standard error with in cluster similarity level reveals that cluster 5 representing Agew goat type was more similar than others (Table 5). The squared distance matrix (Table 6) explains that cluster 2 representing Felata goat is exceptionally different than the rest goat types.

Based on farmer's identification criteria (Table 7) five goat types were identified which differed in their phenotypic characteristics and production system they inhabit. The last cluster analysis identifies Cluster 1, the Arab goats (Figure 5). They are mainly characterized by straight head (53%) profile and smooth hair pattern (69%). Cluster 2, Felata goat's (Figure 6) convex facial profile (86%) and pendulous ear form (88%) differentiate it from other goat types. Oromo goat type (Figure 7) is characterized in cluster 3 and is identified by erect ear form (64%) and the presence of beard (59%). The fourth cluster is Gumuz goat (Figure 8), which differs from other goat types by erect ear form (57%) and short smooth hair (80%). The last cluster (Cluster 5, Agew goat (Figure 9)) is mainly characterized by a concave facial profile (75%) and plain coat pattern (68%) (Table 8, 9).

Discussion

A cluster with a small sum of squares is more compact than one with a large sum of squares with equal number of observations (Minitab, 1998). For unequal number of observations standard error was calculated and used for comparison (Rangaswamy, 1995; Minitab, 1998). Cluster 5 had the lowest standard error and was considered as highly compact while cluster 3, with the highest standard error (Table 5) exhibited the slackness of the cluster. The relatively large size of standard error (13.3) of the Oromo goats indicated higher heterogeneity within the breed type. Similarly, the intra-cluster similarity level of Oromo goat type with other clusters, as indicated by the squared distance matrix was lowest (Table 6). This indicated that Oromo goat share some phenotypic characters with other goat types.

The large standard error associated with the Gumuz goat population (Cluster 4) also indicates relatively large within-cluster variability compared to the other goat types. Furthermore, this cluster had the maximum distance (74.9) from the group centroid (Table 5). The average distance from centroid is maximum for cluster one (Arab) depicts that this cluster is more distinct than the other clusters. But the low standard error for the within cluster sum of square indicated that the similarity level within this cluster is higher than those with higher standard error.

Similarity level among Oromo, Arab and Gumuz clusters compared to the similarity noticed with Agew and Felata was lowest. They were not grouped into one cluster, as they were not similar at 54 percent similarity level and their geographical detachment (Metekel and part of Kamashi zones for Gumuz goats, Assosa and part of Kamashi for Arab and Oromo goats). Besides, the dominant production system for each goat type was different. Oromo goats were raised in sedentary agriculturalist areas of the sub-humid zones of the region; Gumuz goats were confined around the agro-pastoral area of dry to sub-humid zones and the Arabs dominated in sedentary to agro-pastoral areas.

The biometrics result of grouping was compared with the result obtained using subjective clustering technique of the farmer. According to farmer's identification criteria sites 25-29 (where Gumuz people dominate) and site 30 (where Mao and Como people dominate) were miss-classified as compared to the clustering technique. Looking at their phenotypic similarity, geographical area and proximity of the area to where Arab goats dominate, it

was decided to give the three local names of the aforementioned sites, as identified by the farmer (Arab, Gumuz and Oromo) in cluster 1, as Arab goat types. This result was subjected to subsequent discriminate analysis and proved that they are of the same group.

The name of each goat was given after the dominant tribe that generally owns the particular goat type. The indigenous goats were usually named after specific ethnic groups or geographic location. In addition to this the classification of the major types was largely based on morphological or physical characteristics (Mohammed *et al*, 1999). The name of the cluster representing different goat types followed the most common name used by the farmer to that group (Table 4).

The phenotypic similarity reveals the functional or adaptation similarity of types (Sneath and Sokal, 1973). Differences may be due to the different evolution paths of goats adapted to different ecology along with human interference in selection for breeding. In this study the Arab, Oromo and Gumuz goat types with less squared distance matrix (Table 6) compared to the rest of goats in Benshangul can be grouped in one main group. This grouping was relatively similar to the grouping made by Nigatu (1994) who described goats with such character as coastal goats under Small East African Family. The similarity among these three goat types could also be speculated from the functional and adaptations similarity (Table 8) in lowlands.

The largest distance between two clusters was observed when cluster 2, representing Felata goats, was compared with the remaining cluster (Table 6). The high variation was also observed on the Dendrogram (Figure 3). In view of the geographical location (the drier part of Benshangul-Gumuz region) and the production system within which it resides (mainly pastoral systems), Felata goat is separated from other goat types. This could be strengthened by an abrupt reduction of similarity level from 47 of cluster 2 to 9 of cluster 1 (Figure 3). Therefore, this breed could be grouped as one major group. In support of this Nigatu (1994) identified this type with the same phenotypic characteristics as the Nubian goat type.

Agew goat similarity level was more compact than the rest goat types (Table 5). The similarity distance of this group with the other goat types was also higher, coming after Felata goat type (Table 6). In addition, its geographical location (sub-humid zones of Benshangul-Gumuz region) and the production

system it dominates (sedentary agriculturists) isolate this type from other goat types. The Agew goat that forms distinct phenotypic feature with that of Gumuz goats within the same locality forms another goat type in Benshangul. It is dominant in the sub-humid part of Metekel zones where sedentary agriculturist dominates. Nigatu (1994) characterized the same goat type with the same phenotypic feature and geographical area as Northwestern highland goat.

Conclusion

In Benshangul-Gumuz region, five goat types were identified based on the multivariate analytical technique and farmers identification criteria. These five types could be grouped into two major families on the basis of their phenotypic similarity level identified earlier (FARM-Africa, 1996):

Nubian family:

- Its typical Roman-nosed facial profile and lobbed ear form characterize this breed type. It is known for its good milking ability (FARM-Africa, 1996). Since the characteristics feature of Felata goat type, as reported by FARM-Africa (1996), is similar to the Nubian family and the squared distance matrix result of this finding separate it from other goat types of the region it is grouped under Nubian family.

Small East African family:

- This family includes the other four goat types of the region: Arab, Oromo, Gumuz and Agew goat types, with mainly concave and straight facial profile. It incorporates a large heterogeneous population of goats in the region.

This phenotypic characterization is only the beginning of breed evaluation studies, and hence it should be followed by molecular genetic studies to verify breed identities. Breed performance levels should also be evaluation under standardized on-station evaluation studies.

Acknowledgement

We would like to acknowledge the Benishangul Bureau of Agriculture for assisting data collection and the Ethiopian Science and Technology Commission for financial assistance. The valuable comments of Ato Alemayhu Reda, Ato Ephrem Getahun and Ato Gemechu Degefu are duly acknowledged.

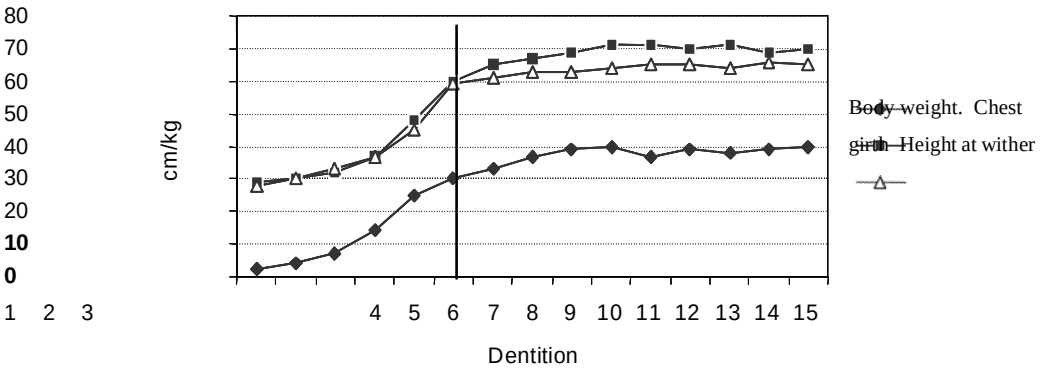

Figure 1. Some body measurements of goats based on their dentition for selected variables

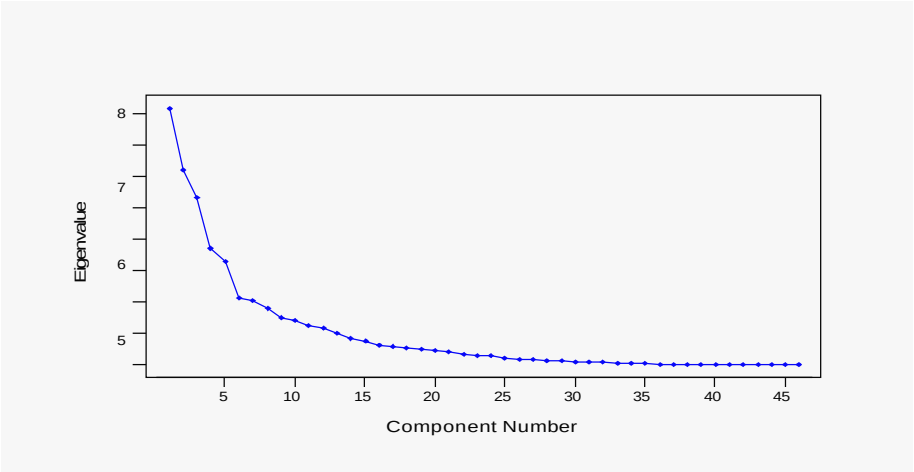

Figure 2. Screen plot of eigenvalue to component number

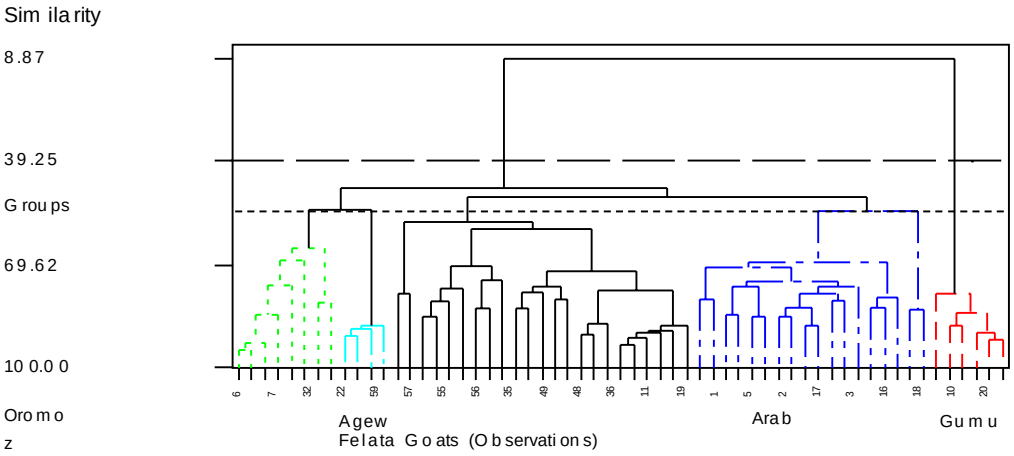

Figure 3. Dendrogram based on average linkage method

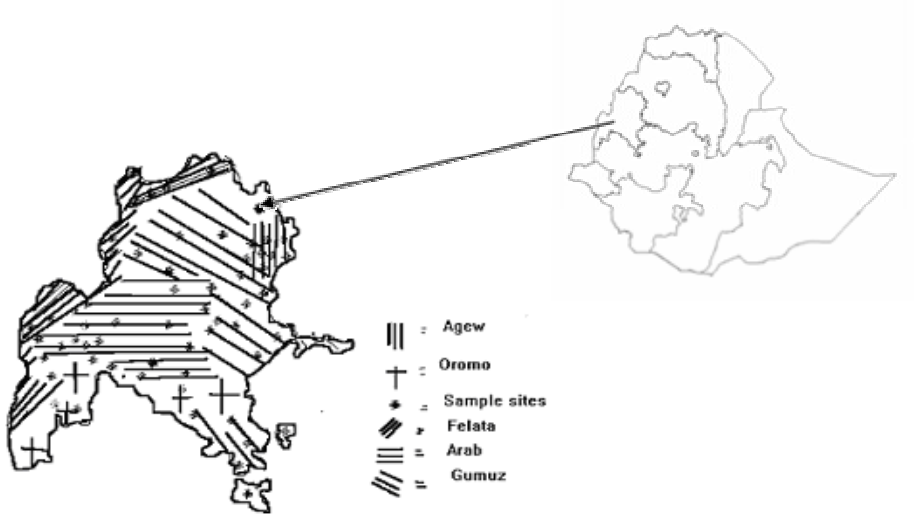

Figure 4. Benshangul Gumuz National regional state, sample sites and distribution of goat types in the region. (Source of the map, Benshangul-Gumuz Agriculture Bureau, 2001)

Figure 5. Arab female goat

Figure 6. Felata female goat

Figure 7. Oromo female goat

Figure 8. Gumuz female goat

Figure 9. Agew female goat

Table 1. Five standard principal component scores representing 58.3 percent of the variance from the original 46 goat characteristics

Variable	PC1	PC2	PC3	PC4	PC5
Ear length	-0.261	0.035	-0.046	-0.144	-0.153
Horn Length	0.030	-0.076	-0.007	-0.071	-0.099
Chest length	-0.195	0.222	0.082	-0.121	-0.083
Body weight	0.218	0.147	0.074	-0.098	0.008
Height at withers	-0.204	0.216	0.101	-0.091	-0.077
Head profile					
Straight	0.175	0.130	-0.256	-0.062	0.190
Convex	-0.329	0.040	0.038	-0.022	-0.057
Slt. Convx	-0.141	0.028	-0.035	-0.193	0.011
Slt. Concave	0.178	-0.279	-0.035	-0.053	-0.125
Concave	0.149	0.056	0.266	0.190	-0.003
Ear form					
Erect ear	0.210	-0.048	0.225	-0.247	-0.018
Horizontal	0.169	0.001	-0.258	0.263	0.080
Pendulous	-0.330	0.041	0.028	-0.013	-0.054

Table 1. Continued

Variable	PC1	PC2	PC3	PC4	PC5
Horn shape					
Polled	0.110	-0.094	0.076	-0.340	-0.081
Scurs	0.038	0.200	-0.241	-0.050	-0.260
Straight	-0.052	0.253	0.047	0.282	0.185
Curved	-0.033	-0.189	-0.115	-0.067	0.112
Spiral	0.042	-0.230	0.025	-0.211	-0.228
Horn orientation					
Lateral	0.146	0.083	-0.205	-0.124	0.266
Upward	-0.142	0.056	-0.248	0.146	-0.176
Backward	-0.010	-0.054	0.353	0.122	0.031
Polled	0.091	-0.087	0.011	-0.392	-0.070
Coat pattern					
Plain cot	0.111	-0.001	0.171	0.163	-0.104
Patchy	-0.111	0.006	-0.168	-0.135	0.123
Spotted	-0.001	-0.016	-0.012	-0.098	-0.061
Hair type					
Short smooth	0.051	-0.227	-0.017	0.136	-0.227
Coarse	-0.051	0.227	0.017	-0.136	0.227
Presence					
Hair on tough	0.076	0.076	0.248	0.044	-0.244
Hair on abdomen	-0.070	0.128	0.145	0.156	-0.186
Hairy	-0.094	0.013	0.132	0.069	-0.186
Ruff	0.110	0.011	0.167	-0.104	-0.041
Wattle	0.071	0.304	0.126	-0.076	-0.069
Beard	0.152	0.220	0.092	0.017	0.195
Coat color					
White	0.191	0.075	-0.056	0.131	-0.239
Black	0.172	0.090	-0.120	-0.004	-0.231
Fawn	-0.133	-0.060	0.094	0.111	0.112
Red	-0.059	0.166	0.067	-0.210	0.136
Brown	-0.247	-0.121	0.093	0.012	0.098
Gray	-0.194	-0.219	-0.061	-0.003	0.105
Roan	-0.037	0.229	-0.108	-0.087	-0.245
White & black	0.193	-0.015	0.015	0.027	0.024
White & fawn	0.024	-0.225	-0.000	0.023	0.169
Black & red	0.070	0.031	0.255	-0.066	0.135
Black & fawn	0.065	0.088	0.189	-0.113	0.164
White, black & brown	0.105	0.250	-0.205	-0.079	-0.088
Other	0.076	0.030	-0.019	0.182	-0.008

Table 2. Eigenvalues, proportion of variability and the cumulative variability explained by the first five principal components

Principals	PC 1	PC 2	PC 3	PC 4	PC 5
Eigenvalues	8.2737	6.1966	5.3145	3.7099	3.3000
Proportion	0.180	0.135	0.116	0.081	0.072
Cumulative	0.180	0.315	0.430	0.511	0.583

Table 3. Principal components and their corresponding contributing variables

PC 1	PC 2	PC 3	PC 4	PC 5
Ear length	Short Smooth hair	Upward horn orientation	Polledness	Lateral horn orientation
Convex head	Coarse hair	Backward horn orientation	Erect ear form	Hair on toughs
Pendulous ear form	Chest length	Scurs horn shape.	Straight horn shape	White coat color.
Body weight	Slightly concave facial profile	Concave facial profile	Horizontally lobed ear form	
Height at withers	Presence of wattle	Straight head		
Hairiness	Presence of beard.			
Brown coat color				

Table 4. Classification of sample sites into the five homogeneous clusters

Cluster	Number of sites in a cluster	Site Number	Given name	Local name
1	23	1, 2, 5, 3, 11, 10, 13, 12, 14, 15, 16, 17, 18, 19, 20, 21, 25, 26, 27, 28, 29, 30, 33	Arab	Arab/ Gumuz/ Oromo
2	6	4, 8, 9, 31, 38, 40	Felata	Felata
3	8	6, 7, 22, 32, 55, 56, 57, 59	Oromo	Oromo
4	18	23, 24, 34, 37, 39, 41, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53, 54, 58	Gumuz	Arab/ Gumuz
5	4	35, 36, 48, 49	Agew	Agew

Table 5. Clusters, within cluster sums of squares and average and maximum distances from centroids

Clusters	Nº	Within cluster sum of squares	Standard error	Average distance from centroid	Maximum distance from centroid
1	23	45793.391	9.5	43.235	65.881
2	6	2463.833	9.1	19.679	30.357
3	8	9937.375	13.3	33.768	47.898
4	18	29654.667	9.8	38.385	74.870
5	4	696.750	7.6	13.127	14.784

Nº = Number of observations

Table 6. Squared distances between clusters

Cluster	Arab	Felata	Oromo	Gumuz	Agew
Arab	0.00				
Felata	5213.99	0.00			
Oromo	83.58	5214.03	0.00		
Gumuz	122.10	5361.56	79.37	0.00	
Agew	259.36	5578.09	144.30	163.01	0.00

Table 7. Goats as identified by farmers and their major identification criteria

Goat type	Ear form	Facial Profile	Height at withers	Ethnic group	Place of origin	General body size	Belly Condition
Agew			*	*	*		
Oromo					*		
Arab				*	*	*	
Felata	*	*					
Gumuz			*	*		*	*

* Indicate the farmer's major identification criteria

Table. 8. Habitat and physical attributes of the five goat types

Goat types	Climate of Habitat	Attributes		
		Physical (Percent of types)	Functional	Others
Feleta	Semi arid	Head: Convex facial profile (86%), pendulous ear (88%), Horn: Straight (39%) or curved (31%), back ward (45%), up ward (43%), Coat: patchy pattern (69%) Hair: smooth (58%) or coarse (62%) Wattle: present (30%) Beard: present (30%)	Milk	*Trypanotolerant
Arab	Semi arid	Head: Straight (53%) or straight concave (29%), Ear: horizontal and lobbed, Horn: straight (36%) or curved (31%) or spiral (23%) oriented up ward (40%) or back ward (34%) Coat: patchy pattern (56%), hairs smooth (69%), white (14%) or black (11%). Beard: present (42%) Wattle: present (30%)	Meat and milk	
Oromo	Sub humid	Head: straight (53%), curved (26%) Ear: Erect (64 %) Horn: straight (40%), back ward (47%), Coat: patchy (54%) Hair: short smooth (53%), coarse (47%), white and black (23%) or roam (11%) Beard: present (59%) Wattle: (56%)	Meat	
Gumuz	Semi arid	Head: concave (51%) Ear: Erect (57%), Horn: spiral (41%), curved (33%), back ward (47%), up ward (28%) Coat: patchy (49%) or plain (47%) Hair: short smooth (80%), white and black or gray (22%)	Meat and milk	*Trypanotolerant
Agew	Sub humid	Head: concave facial profile (75%) Ear: horizontal (56%) erect (58%) coat: plain (68%) Hair: smooth (61%) white (20%) or fawn (18%) or combination of white and black 18%)	Meat	

*The trypanotolerant attribute of the breed types is not proven, but goat owners it is true.

Table 9. Average linear body measurements of the five goat types (N= 2076)

Name of the goat types	Ear length (cm)	Horn length (cm)	Chest girth (cm)	Body weight (kg)	Height at wither (cm)
Arab	13.4	10.7	70.9	37.9	68.2
Felata	23.8	10.6	81.6	27.8	78.4
Oromo	13.5	10.8	73.6	41.5	70.5
Gumuz	13.3	12.1	69.7	37.8	67.2
Agew	11.0	10.3	74.0	42.3	71.0

Table 10. Sex composition of adult goats in study flocks by breed type (%)

Goat types	Number	Percentage			
		Among males		Out of total	
		Intact	Castrated	Male	Female
Agew	583	56	44	37	61
Feleta	714	73	27	26	74
Arab	3199	67	32	28	71
Oromo	505	56	39	34	66
Gumuz	1963	68	32	31	69

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