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Classification of Karayaka and Bafra (Chios x Karayaka B_1) sheep according to body measurements by different clustering methods*

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Summary: This study has been carried out to classify Karayaka and Bafra (Chios x Karayaka B_1) sheep according to body measurements by k-Means within nonhierarchical clustering methods and single linkage, average linkage and complete linkage within hierarchical clustering methods. *In this research,* age-adjusted data of body measurements of 223 Karayaka and 462 Bafra sheep in various ages breed in Gökhöyük Agricultural Enterprise that belongs to General Directorate of Agricultural Enterprises were used. At the end of the study, it was detected that it was obtained the best parameter value when Bafra sheep were divided into 7 clusters and Karayaka into 3 according to k-Means method, and in hierarchical clustering methods, it was obtained different clusters according to various levels of similarity and distance. These results put forward that according to classifications made by different clustering methods, Bafra has a more heterogeneous structure than Karayaka in terms of body measurements.

Key words: Body measurements, clustering analysis, k-means, sheep

Farklı kümeleme yöntemleri ile Karayaka ve Bafra (Sakız x Karayaka G_1) koyunlarının vücut ölçülerine göre sınıflandırılması

Özet: Bu çalışma, Karayaka ve Bafra (Sakız x Karayaka G_1) koyunlarının vücut ölçüleri yönünden aşamalı olmayan kümeleme yöntemlerinden k-Ortalamalar yöntemi ve aşamalı kümeleme yöntemlerinden Tek Bağlantı, Ortalama Bağlantı ve Tam Bağlantı yöntemleri ile sınıflandırılması amaçlanmıştır. Araştırmada, Tarım İşletmeleri Genel Müdürlüğü'ne bağlı Gökhöyük Tarım İşletmesi'nde yetiştirilen 223 Karayaka ve 462 Bafra koyununun vücut ölçülerine ait yaşa göre düzeltilmiş verileri kullanılmıştır. Araştırma sonucunda, k-Ortalamalar yöntemine göre Karayaka koyunlarının 3, Bafra'nın ise 7 kümeye ayrıldığında en iyi parametre değerine ulaşıldığı, aşamalı kümeleme yöntemlerinde ise çeşitli benzerlik ve uzaklık düzeyine göre farklı küme sayıları elde edildiği saptanmıştır. Bu bulgular, farklı kümeleme yöntemleri ile yapılan sınıflandırmalarda Bafra genotipinin Karayaka'ya göre beden ölçüleri bakımından daha heterojen bir yapıda olduğunu ortaya koymuştur.

Anahtar sözcükler: k-ortalamalar, koyun, kümeleme analizi, vücut ölçüleri

Introduction

Body measurements, which give significant information on morphologic structure and development ability of animals, are the most influential factors on determining animals that are appropriate for the desired efficiency, and on determination of whether the establishment is in development or recession. Especially, to provide increase in meat productivity which is closely related with the body size of the animal, it is aimed to bring up animals which are portly and have a long, wide and deep body (9, 27). In addition, Akçapınar and Özbeyaz (1) state that live weight and body measurements, which are main determinants on the development of various tissues and organs in animal body, are directly influential on doing the selection of breeding and the determination of appropriate breed.

Increasing the amount and quality in the production process made in livestock becomes possible with providing new breeds or with studies regarding the improvement_of genetic structure besides maintenance and administration techniques. The improvement of genetic structure is achieved with the application of pure-breeding, and crossbreeding systems which aim to turn low productive breeds into high productive ones (8). Karayaka sheep, a thin-tailed domestic breed, is brought up meticulously by public especially around Tokat and in the coastline of Eastern Black Sea Region, but it is not on the desired level in terms of features having economic value such as live weight, reproductive and milk yield (6, 7). For this reason, the improvement of a new sheep type, which is appropriate for environmental conditions and have highly productive, instead of Karayaka in these

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regions, and accordingly providing more attention of public in sheep farming is emphasized (5), and Bafra (Chios x Karayaka B_1) sheep (6, 7) is obtained with the crossbreeding of Karayaka and Chios, which has a high milk yield and reproductive, which gets its origin from Chios Island and is brought up in the coastline from Antalya to Istanbul.

It is benefited from various statistical methods in detecting the levels of similarity and/or distance in terms of investigated traits of breeds being relatives of each other like Bafra and Karayaka sheep besides other breeds. Clustering analysis, which is an important topic of multivariable analysis, comes forward within these methods. Clustering analysis, which is used in many researches in livestock, is a frequently applied method in the classification of sheep (13, 24, 25), cattle (20, 23) and other animal species (10, 11, 22) according to various features.

This research has been carried out for the purpose of classifying Karayaka and Bafra sheep with different clustering methods by using their body measurements.

Materials and Methods

In this research, body measurements (at the end of shearing season) of 223 Karayaka and 462 Bafra sheep, in different ages, obtained from Gökhöyük Agricultural Enterprise that belongs to General Directorate of Agricultural Enterprises were used. These body measurements are also the material of the research carried out by Atasoy et al. (6). Body measurements consisting of wither height (WH), chest depth (CD), chest width (CW), chest girth (CG), body length (BL), head length (HL), head width (HW), ridge length (RL) were determined with measuring stick and measuring tape.

In the research, it was benefited from clustering analysis for the classification of Karayaka and Bafra sheep in terms of their body measurements. In clustering analysis, which is used for determining real types or breeds, facilitating the model adjustment, forecasting for the groups, testing of hypothesis, clarifying the data structure, degrading the data and determination of contradictory values (26), distance measurements such as Minkowski, Euclidean, Chebychev, Manhattan City-Block, Mahalanobis, Hotelling T^2 and Canberra, and similarity measurements like cosine and Pearson correlation coefficient are used to calculate the distance among the units. According to Özdamar (21), Euclidean distance is one of the most commonly used distance measurements, and it is accepted as the most consistent method in the calculation of distances among units and variables. Euclidean distance is found with the formula below; i,j being the rows of data matrix and p being the number of variable:

$$d(x_i, x_j) = \left[\sum_{k=1}^{p} (x_{ik} - x_{jk})^2 \right]^{\frac{1}{2}} \qquad (1)$$

Although it is made different classifications in the literature (15, 17, 18), clustering analysis methods are separated into two main classes as hierarchical and nonhierarchical clustering methods according to the approaches in determining the clusters. In hierarchical clustering methods, pair in the number of n(n-1)/2 related to n unit is connected to each other hierarchically by means of forming dendrogram (tree graphic) considering the levels of similarity and distance between each other (4, 21). In nonhierarchical clustering methods, in order to form the desired number of clusters, it is aimed to find a parameter and form the cluster structure by analyzing the event on one level instead of connection levels of subclusters to each other hierarchically (16).

Various hierarchical clustering methods have been improved according to different handling of distance or similarity matrix in the connection of units, forming the cluster, into each other. The most common ones of these can be listed as Single Linkage, Average Linkage, Complete Linkage, Median Linkage, Centroid Linkage and Ward Method (4, 12, 15). k-Means, Medoid and Fuzzy clustering methods are the most commonly used nonhierarchical clustering methods in recent years (21).

In Single Linkage Cluster method, the closest two units are found by using distance matrix, and the first core cluster is formed. After that, another two close units or another unit close to this core group are found and the cluster is enlarged. In Average Linkage method, average distance from the units of a cluster to the units of another one is used as the clustering criteria. Complete Linkage method, contrary to Single Linkage method, is formed as a result of the integration of units, having the most distant adjacent feature, with each other. If the i. and j. units are clustered, the relation of this cluster with k. unit in distance and similarity measurements is found as (21);

$$d_{k(i,j)} = \max(d_{ki}, d_{kj}) \qquad s_{k(i,j)} = \min(s_{ki}, s_{kj}) \qquad (2)$$

In k-Means method, which is the most commonly used one within nonhierarchical clustering methods, units are divided to k cluster which makes the sum of squares within clusters (W) minimum. That means, if X_1, $X_2, \ldots, X_n$ observation vectors with p variable are thought as a point in multi-variable X space, and when a_{1n}, $a_{2n}, \ldots, a_{kn}$ are chosen as cluster centers for each group in the same space, units are classified in the closest cluster as required in the formula below (26).

$$Wn = \frac{1}{n} \sum_{i=1} \min_{1 \le j \le k} \left\| x_i - a_{jn} \right\|^2 \qquad (3)$$

Determining the cluster number at the end of hierarchical clustering methods is one of the most important processes of analysis. Although square root of the half of n numbered units that will be clustered ($k=\sqrt{n/2}$) is seen as a practical way that can be made use of in deciding the cluster number (k), it does not give good results if the sample size is large (14). Another method for determining the cluster number is suggested by Marriot (18). In this method, W, being the total matrix of in-group squares, cluster number (k) giving the smallest M value in the equation of $M = k^2|W|$ is handled as the appropriate cluster number. In hierarchical clustering methods, dendrograms, which are obtained at the end of analysis, are also analyzed for determining the cluster number. On the other hand, Tatlıdil (26) states that although some methods mentioned above are benefited in determining the cluster number, the most influential factor on that topic is the knowledge of researcher and whether the analysis results are significant or not. In nonhierarchical clustering methods, the most preferred method in determining the cluster number is to apply discriminant analysis to new data structure by using the cluster membership scores (codes) regarding which cluster the units belong to in clustering formed by increasing the cluster number consecutively one by one as k=2,3,4,…, and to find Wilk's Lamda value. Here, the cluster number, which belongs to Wilk Lamda value having the highest significance, is accepted as the appropriate fragmentation (21).

In this research, the effect of age on body measurements of Karayaka and Bafra genotypes was detected with Least Squares method (2), and it was adjusted according to age. Independent samples t test was used in the comparison of unadjusted (raw) and adjusted (according to age) body measurements according to genotypes. In the research, by using the adjusted values, k-Means method was applied within nonhierarchical clustering methods in the classification of Karayaka and Bafra sheep according to body measurements. Mahalanobis distance, which is the generalized version of Euclidean distance, was used as the distance criteria. Discriminant analysis was applied to data obtained for each cluster number in determining the cluster number, and Wilk's Lamda values regarding discriminant functions and the correct classification percentages were found. At the end of the analysis, the significance of the difference among clusters obtained for each genotype was tested with variance analysis (ANOVA). Duncan test was used in the paired comparison of groups related to each body measurement belonging to genotypes. Also, for the classification of Bafra and Karayaka sheep (by using Euclidean as the distance measurement, Pearson correlation coefficient as the similarity measurement), Single Linkage, Average Linkage, and Complete Linkage were applied, and the obtained results were compared. It was benefited from SPSS 14.01 program in the analysis of data.

Results

Since the effect of age was found significant on investigated body measurements of Karayaka and Bafra genotypes, adjustment was made according to age, and unadjusted (raw) and adjusted (Least Squares) mean values with the effect ration of age were given in table 1. It was detected that unadjusted and adjusted body measurements means belonging to sheep show significant differences according to genotypes (P<.001). Bafra genotype was found superior in terms of wither height, chest depth, body length, chest girth, ridge length,

Table 1. Unadjusted (raw) and adjusted mean values (cm) with effect rations of age on body measurements of Karayaka and Bafra sheep
Tablo 1. Karayaka ve Bafra koyunlarının vücut ölçüleri üzerinde yaşın etki payı ile ham ve düzeltilmiş ortalama değerleri

Variables	Age: / Genotypes	1 (n_1=87, n_2=45) e.r.	2 (n_1=12, n_2=140) e.r.	3 (n_1=44, n_2=152) e.r.	4 (n_1=61, n_2=82) e.r.	5 and+ (n_1=19, n_2=43) e.r.	Unadjusted Mean $\overline{X} \pm S_{\overline{X}}$	Adjusted Mean $\overline{X} \pm S_{\overline{X}}$	P
WH	Karayaka	-4.425	-.175	1.530	1.493	1.575	57.53±.27	58.43±.25	***
	Bafra	-.901	-.205	.092	.725	.287	68.47±.15	68.43±.17	
CD	Karayaka	-2.739	-.340	.918	.823	1.340	29.85±.16	30.42±.13	***
	Bafra	-1.995	-.974	.208	.881	1.882	32.50±.11	32.60±.12	
CW	Karayaka	-1.830	-.433	.601	.805	.856	22.61±.13	22.93±.13	***
	Bafra	-2.242	-1.065	.327	.851	2.128	21.60±.12	21.69±.13	
CG	Karayaka	-6.378	-.373	1.021	1.991	3.741	92.76±.39	94.21±.37	***
	Bafra	-6.619	-2.748	.824	2.703	5.837	100.24±.30	100.42±.30	
BL	Karayaka	-.742	-.834	.010	.433	1.131	58.38±.19	58.50±.25	***
	Bafra	-1.069	-.894	.023	.513	1.429	70.64±.15	70.78±.17	
HL	Karayaka	-1.101	-.231	.231	.522	.581	22.11±.10	22.31±.12	***
	Bafra	-.082	-.196	-.067	.038	.306	20.63±.05	20.68±.06	
HW	Karayaka	-.654	-.580	.360	.390	.482	12.35±.06	12.41±.07	***
	Bafra	.052	-.220	-.034	.015	.186	11.02±.03	11.07±.04	
RL	Karayaka	-.377	-.184	-.783	-.347	1.688	61.84±.20	62.10±.26	***
	Bafra	-1.289	-.753	-.309	.874	1.475	75.30±.18	75.47±.21	

****P<.001 n_1: number of Karayaka sheep n_2: number of Bafra sheep   e.r.: effect ration* and Karayaka in terms of chest width, head length, head width.

Statistics regarding the classification according to k-Means clustering method by using body measurements of Karayaka and Bafra sheep were shown in table 2. Wilk's Lamda value having the highest significance and the highest correct classification percentage in Karayaka sheep was calculated when the cluster number was 3 and 4. At the end of discriminant analysis applied by using cluster membership scores, correct classification percentages of 94.2% for 3 clusters and 93.3% for 4 clusters were obtained. In Bafra sheep, Wilk's Lamda value having the highest significance and the highest correct classification percentages were obtained for 7, 8 and 9 clusters (95.7% for 7 clusters, 90.9% for 8 and 91.1% for 9). Depending on these results, descriptive statistics regarding 7 clusters for Bafra and 3 clusters for Karayaka, being reached to the highest correct classification, and variance analysis results regarding the comparison of clusters were shown in table 3.

When the sheep numbers in clusters belonging to each genotype in table 3 were investigated, it was seen that 24.66% of sheep was grouped in 1st cluster, 39.91% in 2nd cluster, and 35.43% in 3rd cluster in Karayaka genotype. In Bafra genotype, while 19.48% of sheep was grouped in 1st cluster and 8.87% in 4th cluster, the number of individuals in other clusters was between these values. According to cluster means, in Karayaka sheep, the cluster having the lowest mean values regarding the body measurements in general sense was the 2nd cluster, the one having the highest means was the 3rd cluster. In Karayaka sheep, whereas chest depth, chest width and chest girth of sheep in 3rd cluster was higher than the other two clusters; wither height, body

Table 2. Clustering of Karayaka and Bafra sheep according to body measurements by k-Means method
Tablo 2. Karayaka ve Bafra koyunlarının beden ölçülerine göre k-Ortalamalar yöntemi ile kümelenmesi

Number of Cluster	Karayaka Correctly Classified Percentages	Karayaka Wilk's Lamda	Karayaka df	Karayaka p	Bafra Correctly Classified Percentages	Bafra Wilk's Lamda	Bafra df	Bafra P
2	90.3	.899	8	.010	84.1	.954	8	.013
3	*94.2*	*.764*	*16*	*.000*	88.2	.942	16	.010
4	*93.3*	*.617*	*24*	*.000*	87.7	.909	24	.026
5	80.1	.851	32	.173	83.3	.936	32	.736
6	81.5	.887	40	.279	83.9	.908	40	.471
7	76.3	.912	48	.377	*95.7*	*.691*	*48*	*.000*
8	-	-		-	*90.9*	*.706*	*56*	*.000*
9	-	-		-	*91.1*	*.764*	*64*	*.000*
10	-	-		-	87.1	.846	72	.020

Table 3. Cluster statistics obtained by k-Means method
Tablo 3. k-Ortalamalar yöntemi ile elde dilen kümelere ilişkin istatistikler

Genotypes	Clusters	n	%	WH	CD	CW	CG	BL	HL	HW	RL
Karayaka	1st	55	24.66	59.49a	30.53ab	22.62a	92.11a	60.35a	21.97	12.28	63.48a
	2nd	89	39.91	56.53b	29.72b	22.48a	91.57a	56.68b	22.28	12.35	59.84b
	3rd	79	35.43	59.81a	31.15c	23.66b	98.64b	59.27a	22.58	12.57	63.70a
	P			***	**	**	***	***	*>.05*	*>.05*	***
Bafra	1st	90	19.48	68.86a	32.79a	21.45a	99.15a	71.78a	20.44a	11.00a	73.40a
	2nd	73	15.80	68.58a	30.90b	19.98b	93.75b	70.95a	20.81a	10.98a	76.46b
	3rd	79	17.10	65.64b	31.81ab	21.96ad	101.85c	68.08b	20.50a	11.03a	74.13a
	4th	41	8.87	65.10b	30.48b	20.66ab	94.00b	67.59b	20.03a	10.60b	70.92c
	5th	63	13.64	70.40c	32.93a	20.87ab	99.22a	72.17ac	21.10ab	11.22a	80.35d
	6th	65	14.07	67.69a	34.77c	24.21c	108.83d	71.16a	20.63a	11.31a	73.98a
	7th	51	11.04	71.24c	34.41c	22.73d	105.93e	73.30c	21.27b	11.24a	79.26d
	P			***	***	***	***	***	**	*	***

[a,b,c,d,e]*Means for each genotype in same column followed by different letters differ significantly (*P<.05; **P<.01; ***P<.001)*

Table 4. Summary statistics regarding hierarchical clustering methods
Tablo 4. Aşamalı kümeleme yöntemlerine ilişkin özet istatistikler

Hierarchical Clustering Methods	Karayaka *50%	Karayaka 60%	Karayaka 70%	Karayaka 80%	Bafra 50%	Bafra 60%	Bafra 70%	Bafra 80%
	k	k	k	k	k	k	k	k
Single Linkage method	1	1	1	5	1	1	1	5
Average Linkage method	2	5	9	32	5	9	16	54
Complete Linkage method	3	11	22	55	7	17	44	102

**similarity levels k: cluster numbers*

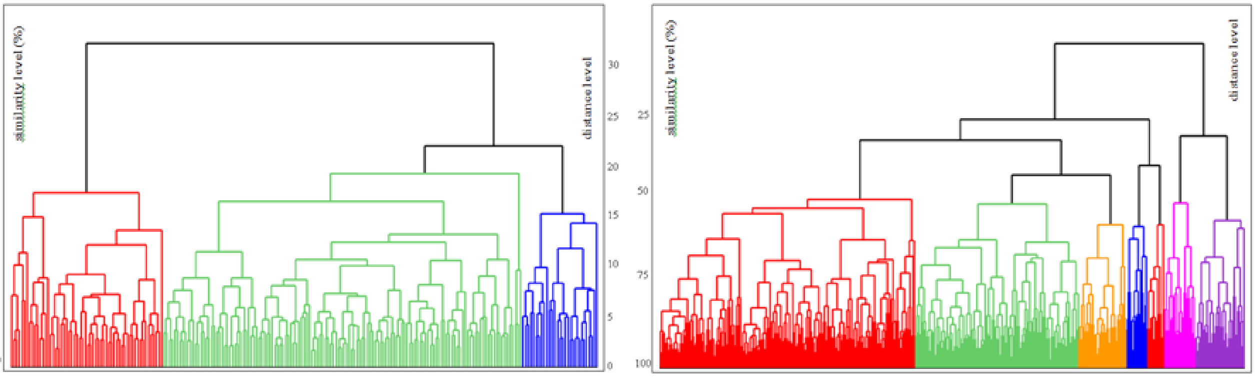

Figure 1. Dendrograms of Karayaka (left) and Bafra (right) sheep
Şekil 1. Karayaka (solda) ve Bafra (sağda) koyunlarına ait dendrogramlar

length and ridge length of sheep in 2nd cluster was lower than other clusters. In Bafra sheep, while wither height and body length in 3rd and 4th clusters were lower than others; chest depth, chest width and chest girth in 6th and 7th clusters, head length in 7th clusters, and ridge length in 5th and 7th clusters were higher than other ones.

Cluster numbers, which were obtained with hierarchical clustering methods that were applied regarding the classification of Karayaka and Bafra sheep according to body measurements, were given in table 4 according to their different similarity levels. In each similarity level (50%, 60%, 70% and 80%), the highest cluster number was obtained with Complete Linkage method. In Single Linkage method, while cluster numbers of Karayaka and Bafra sheep were equal in four similarity levels, cluster number of Bafra sheep was higher in other two clustering methods. Cluster numbers which were obtained with Complete Linkage method in 50% similarity level were the same as k-Means method. Dendrograms, which were formed with Complete Linkage method for each genotype, were presented in figure 1.

Discussion and Conclusion

In this research, different cluster numbers were obtained on the same (or approximate) distance and similarity levels with hierarchical clustering methods that were applied for the purpose of classifying Karayaka and Bafra (Chios x Karayaka B_1) sheep according to body measurements. This situation may result from handling the distance or/and similarity matrix with different approaches in each method in the process of connecting the units, to be clustered, into each other (4, 12). In addition to this, if it cannot be made a desired level of classification with Single Linkage on the condition that distances among individuals are big, with Complete Linkage method on the condition that they are smaller than a certain value, Average Linkage method has been suggested as an alternative because of giving healthy results (26).

In the research, as a result of applying k-Means method within nonhierarchical clustering methods, it was detected that the best parameter value was obtained when Karayaka sheep was clustered to 3, and Bafra to 7, and cluster number was decided more easily than hierarchical clustering methods. According to Dogan (10), having stronger theoretical basis, being prior knowledge about cluster number or researcher's deciding the significant cluster number make nonhierarchical clustering methods (e.g k-Means) more preferable than hierarchical clustering methods. In the research, for Karayaka 3 and for Bafra 7 clusters, which were obtained on 50% similarity level with Complete Linkage method, were parallel with the results obtained with k-Means method. On the other hand, at the end of the hierarchical clustering methods that were applied, it was seen that the most appropriate cluster number (on 50% similarity level) was obtained from Complete Linkage method also in the evaluation made according to both dendograms and sum of squares within groups. These results, which were obtained from clustering analyses, put forward that Bafra sheep have a more heterogeneous structure than Karayaka sheep in terms of body features. Since Karayaka genotype is a pure breed and Bafra genotype is a crossbreed (Chios x Karayaka B_1) sheep, Bafra's being more heterogeneous in terms of body features is an expected result, because Bafra genotype's approximating as a purer breed to its father breed Chios by parting from Karayaka in terms of yield traits is a main aim of crossbreeding studies (8).

It has been also benefited from clustering analysis in studies regarding selection (3, 10, 19). Dogan (10) states that handling the features of individuals in selection methods one by one creates weakness, and this weakness can be overcome by evaluating the variables simultaneously in clustering methods. If it is considered that bringing up portly wide and deep animals having long bodies is aimed (9, 27) to provide increase in meat yield, it can be said that in this research 3rd cluster for Karayaka sheep, 6th and 7th clusters for Bafra sheep can be evaluated as the most productive groups.

In livestock, in the researches, in which clustering analysis is applied, studies regarding Karayaka and Bafra have not been carried out, and there is limited number of studies on the classification of other sheep breeds according to body measurements. Gürcan and Akpınar (13) investigated Deutsche and Karacabey Merino sheep with Single Linkage clustering method according to body measurements, and detected heterogeneity in low ages, homogeneity in sub-groups regarding other ages (>3) for each genotype. In the research carried out by Streitz et al. (25), it was stated that Mutton merino stock lambs group in four clusters according to body compositions. Salako (24) detected that Uda sheep, aged between 0 and 14 months, were separated into two clusters according to morphological features.

The results obtained in this research are seen important in terms of both the comparison of hierarchical clustering methods in themselves, and the hierarchical and nonhierarchical clustering methods. Besides, another point showing the importance of the research is that comparison of Karayaka and Bafra sheep according to body measurements gives information about the development of Bafra, because determining the distances and similarities of genotypes being relatives of each other, and detecting the increase and decrease levels regarding mentioned similarities and distances with studies that will be carried out in the future on the Karayaka, Bafra and Chios genotype, which have been used as father breed, are thought to contribute to both literature and related establishments.

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