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Morphometric Comparison of Three Short-Beak Pigeon Breeds from The Aegean Region (Turkey) By Discriminant Analysis

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ABSTRACT

Hünkâri, Manisa Azman and Denizli Azman are local short-beak pigeon breeds originating from the Aegean region of Turkey. Although these three pigeon breeds are similar to each other, they differ from each other in some traits. This study was planned to reveal the possible differences among these three short-beaked breeds by using discriminant analysis with the help of some morphological characters. In order to compare these three breeds, the Edremit Kelebek pigeon, which differs significantly from these breeds, was used. For this purpose, live weight and beak, body, wing, tail and tarsus lengths were analyzed. Except for the length of the tarsus, all the characteristics differed between the breeds. Considering the proportional difference between the sexes (by female), the Denizli Azman differs from the other two short-beak breeds in terms of traits except for live weight. The Edremit Kelebek pigeon differs from the other three breeds except for body weight and tarsal traits. In the classification made by canonical discriminant functions, the rate of correct classification is 51% in Hünkâri, 59% in Manisa Azman, 87% in Denizli Azman. The whole Edremit Kelebek is correctly classified. In the component graph, Hünkâri and Manisa Azman are overlapping, while Denizli Azman is classified a little far from these two breeds. Edremit Kelebek, on the other hand, is classified far away from these three breeds. In terms of the traits used, it is seen that the Hünkâri and Manisa Azman cannot be separated from each other biologically. The Hünkâri and Manisa Azman breeds are probably genetically related to the Denizli Azman. However, it is believed that the Denizli Azman may have little or no gene flow with the Hünkâri and Manisa Azman.

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Introduction

Domestic pigeons (*Columbia livia domestica*) differ significantly from wild rock pigeons (*Columbia livia*) in terms of color, size, markings, and flight performance. According to Vogel et al. (1998), there are approximately 800 recognized breeds of domestic pigeons. Although some pigeons are bred for their flight performance, such as speed, altitude, tumble, roll, and diving, others are bred for their distinctive features, such as form, color, pattern, head, and beak structure, and are used as fancy show exhibition pigeons.

The Hünkâri pigeon, which originated from West Anatolia, was bred in palaces during the Ottoman Empire. Towards the end of the 19th century, European authors wrote about the Hünkâri pigeon and the short-beak pigeons from Anatolia in several books (Fulton, 1876; Lyell, 1881; Starr, 1886; Bungartz, 1890; Twombly, 1900). Breeders in Europe and America have developed this Anatolian-origin breed, resulting in a larger body and shorter beak. The Hünkâri pigeon is a well-known breed worldwide. It is important to note that this new breed, known as the Oriental Frill, differs significantly from the Hünkâri, which is the focus of this article. The Hünkâri pigeons (HU) are primarily bred in the Manisa and İzmir regions of Turkey. They were registered as a Turkish genetic source by the Ministry of Agriculture and Forestry in 2020. Türkeş and Gündüz (2021) wrote a comprehensive article on the origin of the Hünkâri pigeon.

There are two different breeds of domestic pigeons called Azman that are bred in the same geographical area. The first is the Manisa Azman (MA), which is very similar to the Hünkâri, and the other is the Denizli Azman (DA) (Gündüz, n.d.). Although there are similarities among these three short-beak breeds in terms of size and form, there are fundamental differences in terms of color pattern, breast, head, and foot ornaments. In the HU pigeon, there are white/cream-colored spots on the ends of the primary and tail feathers, called “pare” in Turkish. HU pigeons are divided into color and pattern classes according to the patterns formed by the spread of this spot to other body feathers (Türkeş and Gündüz, 2021). On the other hand, there

is no spot in MA pigeon. Both pigeons have feathered feet and frills. The crest is always present in HU and has a pointed structure, but it may or may not be present in MA. In DA there is no spot, no frill, no foot feather, and no pattern. There are three different patterns in DA in terms of color, solid white, colored tail (Turkish name; kesme), and colored shield and tail (Turkish name; ciba) (Damgacı, 2020).

Two of these three pigeon breeds, MA and DA, are not known outside the breeders in this region. Savaş and Erdem (2021) reported that confusion among pigeon breeders about the names used to describe the breeds led to crossbreeding of similar breeds. For this reason, breeders reported that these local breeds were crossed with other short-beak breeds and these breeds deteriorated with the migration of the region (Damgacı, 2020). The Edremit Kelebek (EK) pigeon is quite different from these three short-beak breeds in terms of both flight characteristics and appearance (Erdem et al., 2018). It is mainly bred in the Edremit district of Balıkesir province, but it is also common in the Marmara and Aegean regions. EK, which has a thin and long body, feathered feet, and a relatively long beak, belongs to the breeds of pigeons with flying performance as a diver and spinner (aerobatic pigeon breed) on the beak-tail axis. These pigeons have many colors. Both crested and crestless can be found. The crest structure is in the form of a crown.

Discriminant analysis is a multivariate analysis method used to reveal the differences between two or more groups. This method relies on functions constructed from arguments that make the best distinction for groups. This study was planned to reveal the possible differences between the three short-beak breeds of the Turkish Aegean region, with the help of some morphological traits, using discriminant analysis.

Material and Method

In this study, data from the short-beak Hünkâri (HU), Manisa Azman (MA), Denizli Azman (DA) breeds, which are mainly bred in Manisa and Denizli, and the long-beak Edremit Kelebek (EK) pigeon were used for comparison with these breeds (Figure 1 and Figure 2). These data consist of live weight (LW) and some morphological measurements [beak length (BEA), body length (BOD), wingspan (WIN), tail length (TAI), tarsus length (TAR)] in the registration application reports that have been prepared (Resmi Gazete, 2012 and 2020) or will be prepared within the framework of registration of domestic animal breeds and lines (Figure 3). In this context, data from 55 female and 45 male pigeons of the HU breed, 48 female and 52 male pigeons of the MA breed, 50 female and 50 male pigeons of the DA breed, and 36 female and 47 male pigeons of the EK breed were used.

Using the analysis of variance method, LW and morphometric traits were initially analyzed using a linear statistical model that included the fixed effects of breed, sex, and their interaction. The Tukey test was used for post-hoc analyses (SAS, 2002). A multivariate analysis was also performed, taking into account all the traits. For this purpose, the widely used discriminant analysis in the SAS (2002) package software was used. The purpose of discriminant analysis is to determine the proportional contribution of each trait to the canonical functions that explain the nature of the relationships between traits. Discriminant functions (multiple regression equation) were used to identify different breeds for live weight and morphological traits. The success of the functions in identifying breeds was determined by the proportion of pigeons correctly classified from the sample.

To quantify the difference between breeds through multivariate analysis, Mahalanobis distance (MD) or generalized distance was used and visualized with a dendrogram. MD measures the distance between two points in a space defined by interrelated variables and generalizes the distance between the means of the distributions. This distance is expressed as the standard deviation between the means. The distance between two distributions is measured by the number of standard deviations separating them.

Results

Table 1 shows the significance levels for breed, sex, and their interactions. The main effects are significant ($P \leq 0.0034$), except for TAR ($P=0.0604$). Breed and sex interaction were found to be significant for LW, WIN, and TAI ($P \leq 0.0446$).

Table 2 presents the least square means of the examined traits according to breeds. While HU, DA, and EK have similar LW values the LW value of MA is significantly lower than that of other breeds ($P \leq 0.05$). HU and MA have similar values in terms of BEA, BOD, and TAI. The means of WIN differ significantly among all breeds ($P \leq 0.05$). HU, MA, and EK pigeons have similar means in terms of TAR. When evaluating the breeds for the proportional difference between sexes (PDS), LW shows the greatest difference between sexes among all breeds. The order of these ratios varies by breed in terms of morphological traits. Therefore, no particular trend can be observed among the breeds. On the other hand, with some exceptions, the PDS shows the greatest difference between EK and other breeds, while the least difference is observed between HU and MA, except for BOD and TAR. Interestingly, in terms of BOD, PDS seems to be the same between MA and EK.

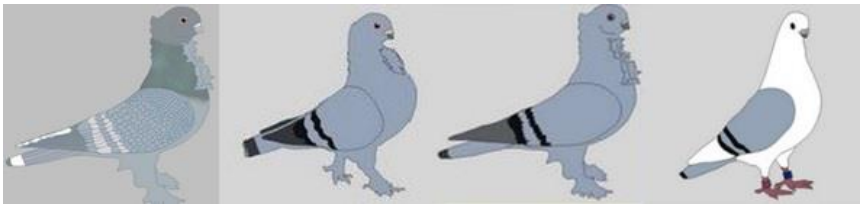

Figure 1. From left to right, representative drawings of Manisa Hünkâri, Manisa Azman, crested Manisa Azman, Denizli Azman

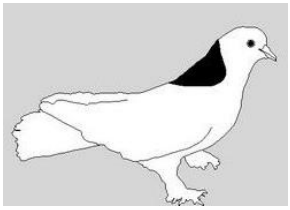

Figure 2. Representative drawings of Edremit Kelebek

Figure 3. Beak length, body length, wingspan, tail length, and tarsus length measurements, respectively

Table 1. P values of the effects in the statistical model of analysis of variance regarding live weight and morphological traits

Trait	Breed	Sex	Breed x Sex
Live Weight	0.0007	<0.0001	0.0187
Beak Length	<0.0001	0.0034	0.5865
Body Length	<0.0001	<0.0001	0.0964
Wingspan	<0.0001	<0.0001	0.0446
Tail Length	<0.0001	<0.0001	0.0135
Tarsus Length	0.0604	0.0025	0.2799

Table 2. Least square means ($\bar{x}$), standard error (SE) and the proportional difference between sexes (by female) (PDS, %) of live weight and morphological traits by breed

Traits	Hünkâri			Manisa Azman			Denizli Azman			Edremit Kelebek		
	$\bar{x}$	SE	PDS	$\bar{x}$	SE	PDS	$\bar{x}$	SE	PDS	$\bar{x}$	SE	PDS
LW, g	320.1^{a}	2.59	4.9	307.3^{b}	2.58	5.1	315.7^{a}	2.58	2.7	320.5^{a}	2.87	10.7
BEA, mm	15.2^{b}	0.10	2.0	15.3^{b}	0.10	2.6	13.3^{a}	0.10	3.8	23.5^{c}	0.11	0.4
BOD, mm	314.2^{b}	0.98	1.5	312.9^{b}	0.98	2.5	318.2^{a}	0.98	0.8	355.2^{c}	1.09	2.5
WIN, mm	612.4^{b}	1.62	2.4	606.2^{c}	1.61	2.1	619.4^{a}	1.61	0.7	655.9^{d}	1.78	7.0
TAI, mm	115.8^{b}	0.61	3.0	115.4^{b}	0.61	3.4	117.7^{a}	0.61	0.0	132.8^{c}	0.67	4.2
TAR, mm	26.7^{b}	0.29	3.1	26.9^{b}	0.29	6.1	27.7^{a}	0.29	4.4	26.7^{b}	0.32	1.1

LW: Live weight; BEA: Beak length, BOD: Body length, WIN: Wingspan, TAI: Tail length, TAR: Tarsus length (TAR). The difference between the means indicated by different letters in the row is statistically significant. (P<0.05)

Multivariate statistics and approximate F values of the statistical significance of canonical correlations between traits and breeds are summarized in Table 3. It is seen that all statistics are significant (P<0.0001).

The first component's eigenvalue resulting from the canonical discriminant analysis is 16.79, explaining 97.2% of the total variance (Table 4). The second and third components explain a relatively low share of variance (2.56% and 0.21%, respectively), with the third component having practically no meaning.

The canonical discriminant functions of the breeds are given in Table 5. It is seen that the coefficients of the functions are similar, except for EK.

Table 6 shows the classification of each pigeon breed based on the canonical discriminant functions. The ratio of correctly classified HU is 51%, while the remaining were classified as DA (10%) and MA (39%). Of the MAs, 59% were classified correctly, 4% were classified as DA, and 37% as HU. 87% of DAs were correctly classified, with 8% of them being classified as HU and 5% as MA. As expected, all EKs were correctly classified.

The graph in Figure 4 supports the classifications summarized in Table 6. HU and MAs have overlapping values, while DAs diverge slightly but form a cluster with HU and MAs. EKs, on the other hand, are located far away in the two-dimensional graphic. These findings are supported by the dendrogram in Figure 5, created using the MD. As a matter of fact, although HU and MA are very similar (MD=0.30), DA differs slightly (MD=5.31 with HU; MD=6.05 with MA). The MD of EK is 83.35 with MA, 86.27 with HU, and 120.36 with DA.

Discussion

The Hünkâri, Manisa Azman, and Denizli Azman breeds are defined as qualitatively different breeds originating from a close and limited geography. They share a common trait of having shorter beaks compared to the natural length of the pigeon species. In contrast, the Edremit Kelebek breed, which has a relatively longer beak, was used for comparison. The study found significant effects of breed and sex on the traits. Table 1 shows that the traits LW, WIN, and TAI were significantly affected by the interaction between breed and sex (Table 1). The pigeon breeds included in the study are ranked by LW values as follows: EK, HU, DA, and MA, from heaviest to lightest. Table 2 shows that these breeds are medium-small, with live weights ranging from 155 g for the short-beak Figurita to 1400 g for the Giant Runt (Parés-Casanova and Kabir, 2020).

Table 3. Statistics on the significance of canonical correlations between traits and breeds

Statistics	Value	Approximate F values	P
Wilks's Lambda	0.038	128.59	<0.0001
Pillai's Trace	1.287	46.98	<0.0001
Hotelling-Lawley Trace	17.275	357.03	<0.0001
Roy's Greatest Root	16.792	1049.50	<0.0001

Table 4. Statistics on canonical discriminant components of breeds and traits

Component	1	2	3
Eigenvalue	16.79	0.45	0.041
Explaining variance, %	97.20	2.56	0.21
Approximate F values	128.59	16.79	3.34
P	<0.0001	<0.0001	0.0104

Table 5. The canonical discriminant functions of the breeds

Trait	Hünkâri	Manisa Azman	Denizli Azman	Edremit Kelebek
Constant	-814.90	-811.02	-824.27	-1081.00
Live Weight	-0.38	-0.40	-0.40	-0.49
Beak Length	8.66	8.83	6.39	17.03
Body Length	16.59	16.74	17.47	18.52
Wingspan	16.44	16.28	16.63	17.16
Tail Length	5.12	5.36	5.17	8.42
Tarsus Length	1.31	1.37	1.57	0.83

Table 6. Classification of individuals according to breeds through discriminant functions, %

Breed	Hünkâri	Manisa Azman	Denizli Azman	Edremit Kelebek
Hünkâri	51	39	10	0
Manisa Azman	37	59	4	0
Denizli Azman	8	5	87	0
Edremit Kelebek	0	0	0	100

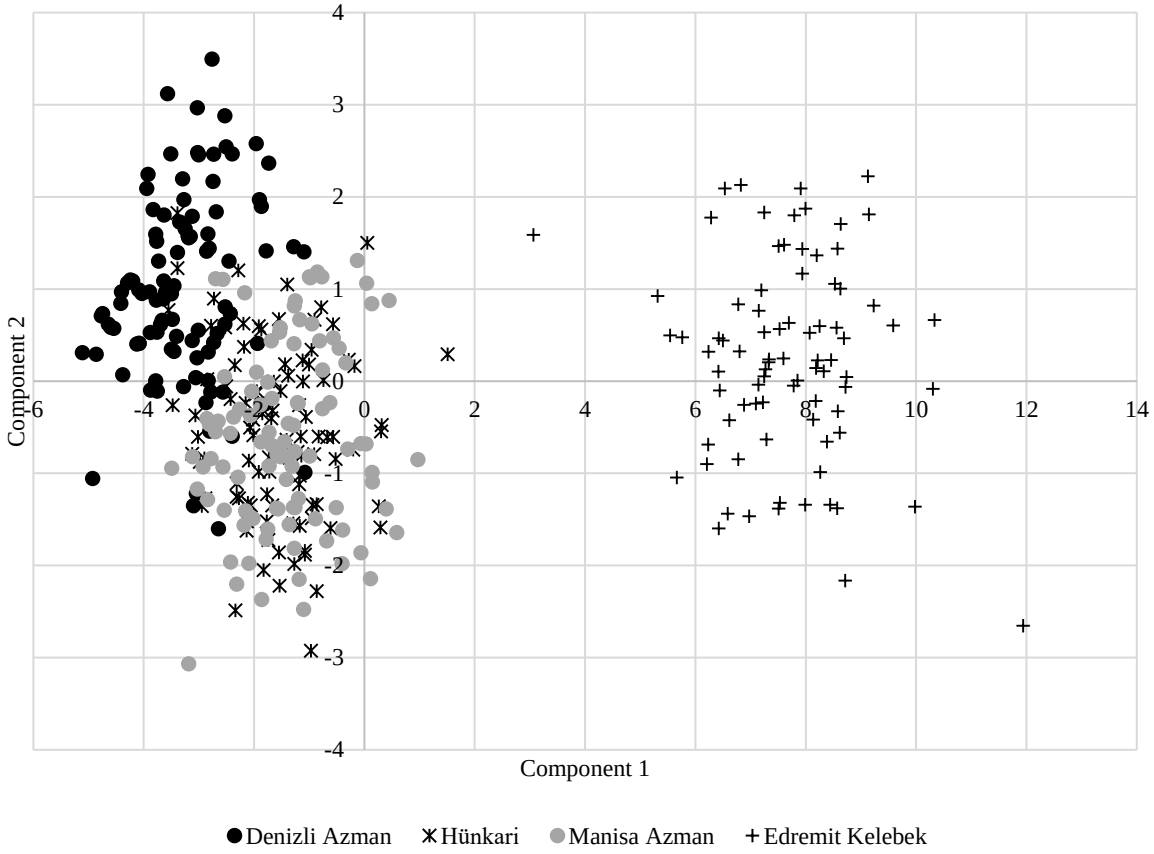

Figure 4. Distribution according to the discriminant components of each bird within the breed

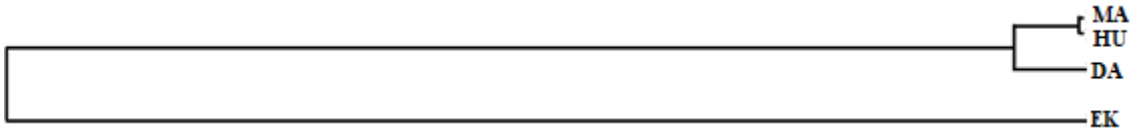

Figure 5. Dendrogram of breeds created according to Mahalanobis distance. HU: Hünkâri, MA: Manisa Azman, DA: Denizli Azman, EK: Edremit Kelebek

Based on the analysis of beak lengths among breeds, it was found that the DA breed has a 13% shorter beak compared to HU and MA. Notably, the beak of the DA breed is 17% shorter than that of the MA breed when considering body size. Conversely, the beak of the EK breed is relatively long compared to its body size when compared to other pigeon breeds (Parvez et al., 2016; Parés-Casanova and Kabir, 2020). Although the DA breed has a shorter beak than other breeds, its body length is longer than that of HU and MA. The EK breed is significantly longer than the short-beaked breeds. When evaluating LW and BSB together, it can be said that the short-beaked breeds have a more compact body, which is more pronounced in HU. In terms of WIN, all breeds differ significantly, and the EK breed has a larger WIN than the others. Breeders primarily select these birds based on their flight performance, which likely explains the significant difference in EKs. In all three short-beak breeds, the primary selection criteria are their physical traits. However, it is noted that the flight performance of DAs is also good (Damgacı, 2020). It can be inferred that the same applies to the TAI trait. Notably, aerobatic pigeon breeds have longer tail feathers than other breeds. The reported ratios of tail lengths to live weight (mm/g) of aerobatic Turkish pigeon breeds are approximately 4%, according to several studies (Soysal et al., 2011; Atasoy et al., 2013; Balcı et al., 2018; Özçelik, 2019; Özbaşer et al., 2021; Erdem et al., 2019; Erdem et al., 2021). In contrast, this value ranges from 2.7% to 2.9% in pigeons bred for flight performance (Özbaşer et al., 2016; Özbaşer et al., 2018). The prevalence of the same rate in DA, HU, and MA, which are distinguished by their physical traits, is 3.7%, 3.6%, and 3.8%, respectively. When comparing the breeds included in this study with other breeds in terms of tarsus length, it is evident that they are high-body breeds (Parés-Casanova and Kabir, 2020).

Table 3 shows that all statistics are significant, indicating that the data do not deviate from the multivariate normal. Empirical data often fail to meet the prerequisites for discriminant analysis, as stated in the literature (Feilmeier et al., 1981). However, empirical studies have shown that variables that do not meet the normality condition do not significantly affect the results of linear discriminant analysis. For instance, Gilbert (1968) demonstrated that linear discriminant analysis on multinomial distributions, particularly binomial, gives good results, as do methods adapted to these distributions. The author concluded that linear discriminant analysis can

be safely used in the analysis of data that are approximately normally distributed.

The first component of the canonic discriminant explains almost all of the variance (Table 4). The relative position of individuals within the two-dimensional graphic, created by utilizing the first and second components of the analysis based on the discussed traits, clearly displays the breed's relative positions to each other at a macro level (refer to Figure 4). Accordingly, the short-beak pigeons that were the subject of the research were grouped. Especially HU and MA individuals form a single cluster. As can be seen from the dendrogram created with the help of the Mahalanobis distance of the breeds in Figure 5, HU and MA cannot be separated from each other in terms of the traits discussed.

Conclusion

Furthermore, as stated in the introduction, there are variations in color and pattern. However, upon evaluating the results of this study as a whole, it is evident that Hünkâri and Manisa Azman cannot be distinguished from each other biologically based on the traits used. It is likely that there is a genetic exchange between these two breeds. It is also possible that the HU and MA breeds are genetically related to Denizli Azman. However, it is believed that gene flow between DA and HU/MA may be minimal or nonexistent.

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