

Türkiye's indigenous genetic resource: Muradiye Kelebek pigeon

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ABSTRACT

The current study was carried out to determine the morphological characteristics of the Muradiye kelebek pigeon, which has been reared for many years by breeders in the Muradiye region. The ages of pigeons were classified into two groups: 12-24 months (age group I) and 25-36 months (age group II). The male pigeons had a significantly higher trunk length ($P<0.001$), head width ($P<0.05$), beak length ($P<0.001$), beak depth ($P<0.05$), thoracic perimeter ($P<0.001$), and tarsus diameter ($P<0.001$) compared to the female pigeons. The body weight ($P<0.001$), chest width ($P<0.05$), and thoracic perimeter ($P<0.01$) values of age group II were higher than those of age group I. It was determined that most of the pigeons were grayish blue-eyed (69.90%) and non-crested (76.72%). It was determined that the head structure of the Muradiye kelebek pigeon was similar to the Edremit kelebek, Muradiye donek, Bursa oynarı, Thrace roller, and Alabadem pigeon genotypes. The spotted plumage color of the Muradiye butterfly pigeon and the other three genotypes (jackal plumage in the Thrace roller, speckled plumage in the Edremit kelebek pigeon, and red/black galaca in the Muradiye donek pigeon) may be a common trait. Since these genotypes share some phenotypic characteristics, the phylogenetic relationships between the Muradiye butterfly pigeon and the other five pigeon genotypes (Edremit kelebek, Muradiye donek, Alabadem, Bursa oynarı, and Thrace roller) should be determined by molecular studies.

Introduction

Domestic pigeon genotypes were domesticated from the rock pigeon (*Columba livia*) in the Mediterranean region. Pigeons are classified into seven species and approximately 350 breeds. They are grown for meat production, ornamental features, vocalization traits, aerial display, and racing performance (1, 18, 21). The geography of Anatolia, the cradle of many civilizations, has a historical and geographical structure that includes many indigenous genetic resources. One of these genetic resources is the pigeon, which has been traditionally bred in these lands for centuries. Türkiye has a large number of pigeon breeds as indigenous genetic resources. Although pigeon breeds are classified according to their body structure, body shape, color and pattern of plumage pigmentation, feather placement and structure, and number of wing and tail feathers in other parts of the world, they are classified according to their flight display characteristics in Türkiye (21-23).

Pigeon breeds in Türkiye have been classified into nine main groups as diver (dalıcı) (Azman, Bango, Baska, Dewlap, Dolapci, Domino, Donek, Kelebek, Misiri, Oynak, Spotted Kelebek, Şarabi, and Yoz), tumbler (taklacı) (Alabadem, Anatolian, Gogsu ak, İç ağı, Ketme, Kizilbas, Taklambac), roller (makaracı) (Bursa roller, Cakal, Corum, Smyrna roller, Mulakat, Oriental roller, and Thrace roller), spinner (dolap dönücü) (Telkuyruk and Trabzon), fleet flyer (filo uçucusu) (Abu abse, Amberi, Bagdat, Bastankara, Bayramli, Buludi, Burmalı, Cici, Damascene, Gullu, Halebi, Scandaroon, Ispir, Karakuyruk, Kespri, Kullu, Msawad, Shicki, Shafari, and Sirtikizil), high flyer (yüksek uçucu) (Katal, Van highflier, and Yasmakli), racing/homer (postacı) (Homer racing), ornamental/show (form/süs) (Gumuskuyruk, Hunkari, Karakan, Selcuklu, and Tavuskuyruk), and singer (ötücü) (Ankut trumpeter, Turkish whisperer, Demkesh, and Kumru trumpeter). Among the listed genotypes, the Dolapci, Donek, Kelebek, and Oynak pigeons can be

further classified as the spinner, and the Alabadem, Gogsu ak, İç ağı, Ketme, Kizilbas, and Taklambac pigeons are also known as show birds (23).

The traditional structure of pigeon breeding in Türkiye has been transferred to future generations by experienced breeders for centuries. People breeding pigeons for many years and transferring their experience to each other are called pigeon fanciers ('*meraklı*' in Turkish). Although morphological studies have been carried out on some of these breeds (Alabadem, Ankara taklacısı, Filo uçucu güvercini, Muradiye donek, Bursa oynarı, Edremit kelebek güvercini, and Trakya makaracısı), there is still limited data on other breeds (Konya Selçuklu taklambaç), and no research has yet been carried out on Domino, Oynak, Çorum, and Manisa azmanı (1, 2, 6, 8, 9, 15, 16). Furthermore, some of these genotypes are registered as indigenous breeds (Alabadem, Bursa oynarı, Edremit kelebek, Manisa hünkârı, Muğla dalıcı güvercini, and Thrace roller) (11-14). Kelebek pigeons are bred in various regions of Türkiye and called "*Saya*" in İzmir, Manisa, Bursa, and Balıkesir provinces (22). Kelebek pigeons show morphological differences according to the regions where they are raised. The Edremit kelebek pigeon has black, blue, red or yellow marks that cover a long and wide area on the back of the neck. In addition, purple or black feathers can be found in their tail feathers (9). Kelebek pigeons are members of the diver-spinner group (23). Although they are primarily performance birds, they are also known for their variety of colors and ornamental features. Erdem et al. (9) stated that the name "*kelebek*" in Turkish (meaning 'butterfly') was given because their wings flutter during flight resembled that of a butterfly. The difference between the Muradiye kelebek pigeon and the Edremit kelebek pigeon is related to their flight styles. The Muradiye kelebek pigeon soars in groups in which many pigeons gather together (shoal-shaped high fly), and they descend perpendicularly to the ground during landing. Due to these differences, breeders in the Muradiye region insist that the Muradiye kelebek pigeon be considered a distinct breed from the other butterfly pigeons. Therefore, this study aimed to determine the morphological and morphometric characteristics of the Muradiye kelebek pigeon as one of the indigenous animal genetic resources of Türkiye, which has been reared for many years by breeders in the Muradiye region.

Materials and Methods

Birds: This study was conducted in Muradiye town in Susurluk county, Balıkesir. This town is located at 40°02'32" N 28°05'34" E. It is approximately 23 km from Susurluk county in the southern part of Marmara region. The study consisted of 73 pigeons (35 male and 38 female) from six different breeders (13, 14, 12, 15, 9, and 10

pigeons per breeder, respectively). The management, care, and nutrition of the pigeons were undertaken according to a routine program under the conditions provided by the breeders. The sex and age of the pigeons were determined according to the breeder's records. The ages of pigeons were classified into two groups: 12-24 months (age group I) and 25-36 months (age group II). This study was carried out with the approval of Tekirdağ Namık Kemal University Animal Experiments Local Ethics Board (2017/09).

Morphological characteristics: Each pigeon was morphologically examined in detail concerning their plumage color, head type, eye color, head crest, presence or absence of head and body marks, wing and tail marks, and presence of muffs. Wing feathers are enumerated as primary, axillary, and secondary (p-a-s). Plumage color is traditionally entitled with body plumage color, head, wing, and tail marks in Türkiye. The plumage color names of the pigeons were recorded after consultation with local breeders. In light of this information and after much deliberation, we decided to classify the pigeons into two basic groups in terms of their plumage color. If the color of the feathers covering the whole body was uniform, it was classified as a basic plumage color, and if it was covered with feathers of two or more different colors, it was classified as an intermediate plumage color (8, 15, 16).

Morphometric characteristics: Body weight, body length, trunk length, head length, head width, beak length, beak depth, chest depth, chest width, thoracic perimeter, wing length, wing span, tail length, and tarsus diameter were individually obtained for each pigeon. The body weights of the pigeons were measured with a precision digital scale sensitive to 0.01 g (Vibra AJ-1200, Shinko Denshi Co. Ltd.). A metal ruler was used to determine body length, and a measuring tape was used to determine trunk length, wingspan, wing length, thoracic perimeter, and tail length. A digital caliper was used to determine the head length and head width, beak length and depth, chest width and depth, and tarsus diameter (500-155-30, Mitutoyo Co.Ltd.). Individual body weight and body measurements were undertaken by the same researcher in all the pigeons (Figure 1) (1, 8, 15, 16).

Statistical analysis: The general linear model (GLM) was used to identify the differences between the age and sex groups. If GLM showed an acceptable level of significance ($P<0.05$), Tukey's test was applied for post-hoc comparisons. Statistical analyses were performed using SPSS software version 22 for Windows. Data were presented as means \pm standard error. A value of $P<0.05$ was considered statistically significant (7, 20).

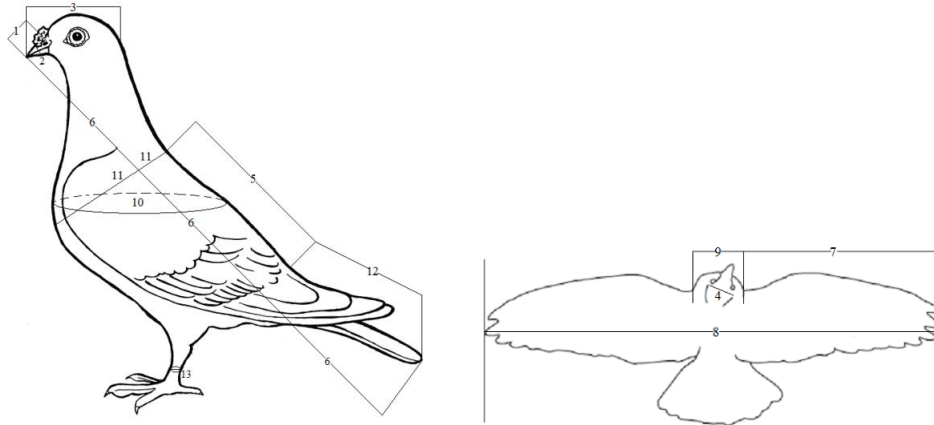


Figure 1. Morphometric body measurement regions (1, 8).

(1 - Beak length; 2 - Beak depth; 3 - Head length; 4 - Head width; 5 - Trunk length; 6 - Body length; 7 - Wing length; 8 - Wing span; 9 - Chest width; 10 - Thoracic perimeter; 11 - Chest depth; 12 - Tail length; and 13 - Tarsus diameter).

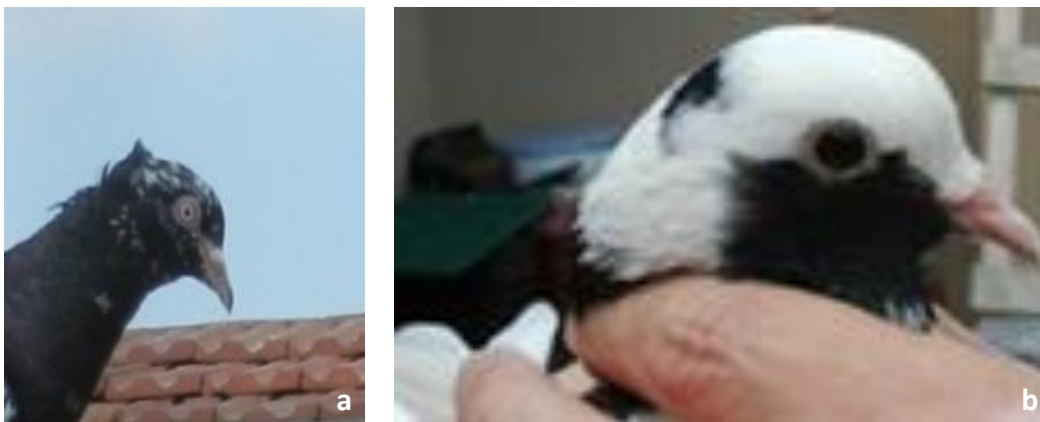


Figure 2. Eye colors of Muradiye kelebek pigeons. a. grayish blue and b. black.

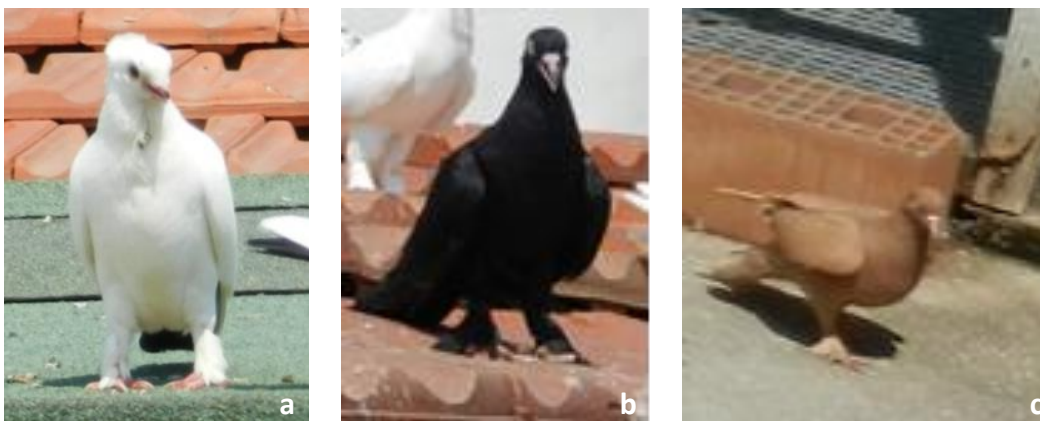


Figure 3. Basic plumage colors of the Muradiye kelebek pigeons. a. white, b. black, and c. sable.

Results

Morphological characteristics: The descriptions and percentages of morphological characteristics of the pigeons are shown in Table 1. Based on our observations and conservations with the breeders, the head structure of the pigeons was determined to be large-sized and round-shaped (Figure 2a). Some of the pigeons (23.28%) had a crest in the form of a peak (Figure 2a and Figure 5c). The

eye color of the pigeons was mostly grayish-blue (69.90%) (Figure 2a), followed by black (30.10%) (Figure 2b). Three basic plumage colors and eight intermediate plumage colors were identified in this pigeon genotype. Basic plumage colors were defined as white (*Ak*) (11.00%) (Figure 3a), black (*Arap*) (8.20%) (Figure 3b), and sable (*Samur*) (6.80%) (Figure 3c) (Table 1). In addition to these three basic plumage colors, there were eight intermediate

colors, including spotted (*Kaplan şeş*) (17.80%) (Figure 4a and Figure 4b), jackal (*Çakal*) (16.40%) (Figure 4c), black-tailed (*Kara kuyruk*) (13.70%) (Figure 5a), almond (*Bademli*) (6.85%) (Figure 5b), yellow-tailed (*Sarı kuyruk*) (6.80%) (Figure 5c), band-tailed (*Telli*) (5.50%) (Figure 6a), blue (*Mavi*) (4.20%) (Figure 6b), and black-headed (*Karabaş*) (2.75%) (Figure 6c).

The number of primary, axillary, and secondary wing primaries was determined as 10, 1, and 10, respectively in all the pigeons. The Muradiye kelebek pigeons were divided into four groups according to the number of tail primaries: 14 (24.70%), 15 (39.70%), 17 (19.20%), and 18 (16.40%) (Table 1). All the pigeons had feathers extending down from the metatarsus to cover certain digits, and they were therefore described as 'muffled' or 'feathered-legged' (*paçalı*) (Figures 4c, 5a, and 6a).

Morphometric characteristics: Body weight was significantly affected by sex. The body weight of the male pigeons was significantly higher than that of the female pigeons ($P<0.001$). Body weight was also significantly affected by age. Age group II was heavier than age group I ($P<0.001$). The male pigeons had a significantly higher trunk length ($P<0.001$), head width ($P<0.05$), beak length ($P<0.001$), beak depth ($P<0.05$), thoracic perimeter ($P<0.001$), and tarsus diameter ($P<0.001$) compared to the female pigeons. Age significantly affected body weight, chest width, and thoracic perimeter among the Muradiye kelebek pigeons. The body weight ($P<0.001$), chest width ($P<0.05$), and thoracic perimeter ($P<0.01$) of age group II were significantly higher than those of age group I (Table 2).



Figure 4. Intermediate plumage colors of the Muradiye kelebek pigeons. a. spotted, b. head-spotted, and c. blue-jackal.



Figure 5. Intermediate plumage colors of the Muradiye kelebek pigeons. a. black-tailed, b. almond, and c. yellow-tailed.



Figure 6. Intermediate plumage colors of the Muradiye kelebek pigeons. a. band-tailed, b. blue, and c. black-headed.

Table 1. Morphological characteristics of the Muradiye kelebek pigeons (%).

Morphological characteristics	Description	Ratio (%)
Presence or absence of crest		
Crested	Presence of a peak crest	23.28
Non-crested	Absence of crest	76.72
Eye color		
Grayish-blue	Grayish-blue eye	69.90
Black	Black eye	30.10
Basic Plumage Colors		
White (<i>Ak/düz beyaz</i>)	White plumage	11.00
Black (<i>Arap</i>)	Black plumage	8.20
Sable (<i>Samur</i>)	Dark yellow plumage	6.80
Intermediate Plumage Colors		
Spotted (<i>Kaplan seş, kaplama, or bovma</i>)	The plumage was dark in color, usually black, with irregular-shaped black spots	17.80
Jackal (<i>Çakal</i>)	White plumage, with blue, yellow, red, or black feathers covering both wings	16.40
Black-tailed (<i>Kara kuyruk</i>)	The plumage color was white, and the entire tail was covered by black feathers, with large irregular-shaped black patches of identical color to those on the body. These patches were found mainly on the nuchae, neck, and under the beak.	13.70
Almond (<i>Bademli</i>)	The plumage color was white, and there were large irregular-patches on the body and a mark on the upper part of the head, which were identical in color.	6.85
Yellow-tailed (<i>Sarıkuyruk</i>)	The plumage color was white, and the entire tail was covered by yellow feathers, with large irregular-shaped yellow patches of identical color to those appears on the body	6.80
Band-tailed (<i>Telli</i>)	The plumage was white, and the middle parts of the tail feathers were colored in the form of long longitudinal thin strips, with white edges	5.50
Blue (<i>Mavi</i>)	Except for the wingtips and tail, the feathers covering the majority of the body were azuré-colored	4.20
Black-headed (<i>Karabaş</i>)	White plumage color, head and tail feathers are black	2.75
Number of wing primaries	The number of primary, axillary, and secondary wing primaries	
10, 1, and 10		100
Number of tail primaries	The number of tail primaries	
14		24.70
15		39.70
17		19.20
18		16.40

Table 2. Morphometric characteristics of the Muradiye kelebek pigeon ($X \pm S_x$).

Variable	n	Body weight (g)	Body length (cm)	Trunk length (cm)	Head length (mm)	Head width (mm)	Beak length (mm)	Beak depth (mm)
Sex		***		***	-	*	***	*
Male	35	357.61±5.93	37.83±0.48	11.10±0.10	51.75±0.31	20.11±0.11	18.42±0.11	5.23±0.04
Female	38	320.06±4.76	36.69±0.43	9.91±0.13	51.36±0.32	19.65±0.17	17.53±0.16	5.04±0.06
Age group		***	-	-	-	-	-	-
I	42	325.52±4.70	37.44±0.36	10.39±0.16	51.69±0.31	19.74±0.15	18.03±0.14	5.16±0.05
II	31	355.06±7.03	36.96±0.60	10.60±0.13	51.34±0.33	20.05±0.15	17.86±0.18	5.09±0.05
Grand mean	73	338.06±4.35	37.24±0.32	10.48±0.11	51.54±0.22	19.87±0.10	17.96±0.11	5.13±0.04
Variable	n	Chest depth (mm)	Chest width (mm)	Thoracic perimeter (cm)	Wing length (cm)	Wing span (cm)	Tail length (cm)	Tarsus diameter (mm)
Sex		-	-	***	-	-	-	***
Male	35	58.96±0.94	54.49±0.57	19.69±0.15	30.61±0.21	64.92±0.84	13.92±0.15	3.77±0.07
Female	38	57.09±0.90	47.11±0.59	18.80±0.10	29.99±0.12	64.62±0.62	13.71±0.13	3.50±0.02
Age group		-	*	**	-	-	-	-
I	42	58.42±0.82	49.53±0.58	18.99±0.10	30.26±0.15	64.94±0.62	13.77±0.12	3.65±0.04
II	31	57.40±1.08	52.17±1.11	19.56±0.19	30.33±0.21	64.53±0.88	13.88±0.17	3.60±0.06
Grand mean	73	57.98±0.65	50.65±0.59	19.23±0.10	30.29±0.12	64.76±0.51	13.81±0.10	3.63±0.03

∴ P > 0.05; *; P < 0.05; **; P < 0.01; ***; P < 0.001^{a-c}

Discussion and Conclusion

Morphological characteristics: As we mentioned in our previous research, pigeons' head structure are described according to their shape (8). However, we observed that when describing the head structure of the Muradiye kelebek pigeon, breeders considered not only the shape but also the size. We determined that in artificial selection, breeders insisted that the head type of this genotype should be round. In recent years, there have been a growing number of studies on skull structure and beak development in birds (3-5, 10, 17). Bright et al. (4) drew attention to the variation in head and beak structures in birds, and stated that their beak morphology could evolve in harmony with their cranial morphology. We consider that head development is related to beak development in pigeons, and it can show changes due to genetic and environmental factors. In our study, the head structure of the Muradiye kelebek pigeon was defined as round-shaped, which is similar to the Edremit kelebek, Muradiye donek, Bursa oynarı, Thrace roller, and Alabadem pigeon genotypes (round-shaped) (2, 8, 9, 16, 19). Studies on skull shape in birds have shown that there may be kinship among genotypes with similar head shapes (3, 10, 24). Since these genotypes have mutual traits in terms of the head structure, molecular studies can be performed to

determine the phylogenetic relationships between the Muradiye kelebek pigeon and the other five pigeon genotypes (Edremit kelebek, Muradiye donek, Alabadem, Bursa oynarı, and Thrace roller).

We determined two eye colors among the Muradiye kelebek pigeons: grayish-blue (69.90%) and black (30.10%). In the Muradiye donek pigeons, black, blue, and white eye colors were determined at the rates of 60%, 25%, and 15%, respectively. It was determined that the eye colors of the Bursa oynarı pigeon were dusty-rose (67.44%), white (23.26%), or dark dusty-rose (9.3%). In another study, it was determined that the eye color of the Alabadem pigeon was mostly black (76%), but some pigeons had grayish blue eyes (24%) (2, 8, 16). Soysal et al. (19) classified the eye color of the male Thrace roller pigeon as white (80%), dusty-rose (13%), and black (7%), and that of the female pigeon as white (58%), dusty-rose (24%), dark dusty-rose (5%), and black (7%). Edremit kelebek pigeons with black and greyish blue eyes were also described (9).

Most of the pigeons examined in the current study were non-crested (76.72%). In pigeons with a crest, this structure was described as peak-crest (23.28%) (19). The Muradiye donek pigeon was defined as non-crested (16). In previous studies, while some Edremit kelebek pigeons

were described as crested (46%), others were non-crested (54%). Similar to the Edremit kelebek pigeon, there were crested and non-crested pigeons for the Thrace roller breed (9, 19). Soysal et al. (19) described the crest structure of the Thrace roller pigeon as a straight and intact circle on the backside of the head. On the other hand, in the Edremit kelebek pigeon, this structure is not very large and consists of feathers turning upwards from the nape, and it is emphasized that the tips of the feathers forming the crest structure are in line with the highest point of the head (9). When we examined the crest shapes of the pigeons, we observed that the crest shape of the Muradiye kelebek pigeon was more similar to the Edremit kelebek pigeon than the Thrace roller pigeon. Özbaşer et al. (16) reported that according to their plumage colors, the Muradiye donek pigeons were divided into three groups as black galaca (70%), red galaca (16%), and blue galaca (14%). On the other hand, the body color was uniform in the Bursa oynarı pigeon. Since the latter is more uniform in terms of color (white, black, and white wing-white tail), so the pigeons of this breed can be named according to the distribution of the white feathers on the head (markless, browed, piebald, mottled, scarfed, and speckling) (2). In the Thrace roller pigeon, the basic plumage colors were black (*arap or mürakat*), white, red (*pal*), yellow (*kanarya*), and blue (*zavrak or küllü*), while intermediate colors described by breeders were olive-colored (*zeytini, kara pal or kara küllü*), chickpea (*nohudi or açık küllü*), and jackal (*çakal*) (19). For the Alabadem pigeon, three basic plumage colors (black, 15%; red, 6%; and yellow, 10%) and three intermediate plumage colors (citrine, 15%; ashy, 7%; chickpea, 25%; and scarlet, 22%) were identified. The Alabadem pigeon has an irregularly shaped mark on the upper part of the head, and the color of this mark is the same as the body plumage color (8).

In the current study, a similar mark was observed on the upper part of the head among the Muradiye kelebek pigeons with an almond-colored body plumage (Figure 5b). The main plumage colors of the Edremit kelebek pigeon were reported to be black-tailed (28%), purple-tailed (2%), black-neck (20%), yellow-neck (23%), red-neck (13%), black (2%), and tiger (*şes*) (7%) (9). We consider that the spotted (*kaplan-şes*) plumage color of the Muradiye kelebek pigeons, jackal (*çakal*) plumage color of the Thrace rollers, the speckled (*şes* or tiger) plumage of the Edremit kelebek pigeons, and the red and black feather colors on the wings of the Muradiye donek pigeons (*siyah galaca* or *kırmızı galaca*) may be the common traits of these four pigeon genotypes (9, 16, 19). In previous studies, interindividual variation in terms of body color is less seen in the Thrace roller and Bursa oynarı pigeons than in other indigenous genotypes (2, 19), suggesting that these genotypes may be more uniform than the other genotypes. In the current study, it was determined that the

number of primary, axillary, and secondary wing primaries was 10, 1, and 10, respectively in all the Muradiye kelebek pigeons.

The number of wing primaries (p-a-s) of the Alabadem pigeons varies between 8-1-10 (42%) and 9-1-10 (58%) (8). In a study on the Muradiye butterfly pigeon, the pigeons were divided into three groups as 10-1-12 (25%), 10-1-10 (48%), and 10-1-9 (27%) according to the number of their wing primaries (16). In the Muradiye kelebek pigeons, we identified four groups according to the number of tail primaries (14, 24.70%; 15, 39.70%; 17, 19.20%; and 18, 16.40%). In previous studies, the number of tail primaries were reported as 14 (75%) and 13 (25%) for the male and female Muradiye donek pigeons, and 12-15 and 12-16, respectively for the Thrace roller pigeons. The Alabadem pigeon was reported to have 12 (63%) or 14 (37%) tail primaries. In another study, which was carried out on the non-crested Edremit kelebek pigeon, the number of tail primaries was 14.81 and 14.70 in the male and female pigeons, respectively (8, 9, 16, 19).

In our study, we observed that the legs of all the Muradiye kelebek pigeons were covered with feathers, called 'muffles'. Similarly, the Edremit kelebek pigeon has muffles. On the other hand, the Muradiye donek, Thrace roller, and Alabadem pigeons were found to be free from muffles (8, 9, 16, 19). In a study conducted on the Thrace roller pigeon, it was reported that breeders preferred a breed-specific eye color, medium-sized body, pearl-colored short beak, and non-muffled pattern in animals kept for breeding (19). This situation is completely different in pigeon genotypes with muffles. For the Edremit kelebek genotype, breeders prefer to breed pigeons with muffles in addition to proper eye color and body traits (9). In our field studies, we observed that artificial selection was applied to pigeons concerning some characteristics (eye color, beak color, plumage color, body traits, and the presence or absence of muffles) by breeders, and this led to morphological variation in these pigeons.

Morphometric characteristics: The beak length, thoracic perimeter, and wing span values determined for the Muradiye kelebek pigeons in age group II (17.86 mm, 19.56 cm, and 64.53 cm, respectively) were lower than those obtained from the Muradiye donek pigeons in age group II (19.25 mm, 19.65 cm, and 68.30 cm, respectively). However, the Muradiye kelebek pigeons had higher body weight, body length, head width, and chest depth values (335.06 g, 36.96 cm, 20.05 mm, and 57.40 mm, respectively) than the Muradiye donek pigeons (318.71 g, 35.03 cm, 18.23 mm, and 57.31 mm, respectively) (16). It was found that the Muradiye kelebek pigeons from age group I had a significantly lower body weight (325.52 g) and beak length (18.03 mm), and

significantly higher body length (37.44 cm), chest depth (58.42 mm), and wingspan (64.94 cm) values compared to the 17-26-month-old Bursa Oynarı pigeons (341.95 g, 26.70 cm, 26.00 mm, 56.00 mm, and 59.07 cm, respectively) (2).

In the current study, the values obtained for body weight, body length, head length, head width, beak length, chest depth, thoracic perimeter, wing span, and tarsus diameter from the Muradiye kelebek pigeons in age group II (355.06 g, 36.96 cm, 51.34 mm, 20.05 mm, 17.86 mm, 57.40 mm, 19.56 cm, 64.53 cm, and 3.60 mm, respectively) were higher than those obtained from the Alabadem pigeons of the same age range (309.50 g, 31.13 cm, 50.12 mm, 18.10 mm, 17.18 mm, 56.15 mm, 19.15 cm, 63.37 cm, and 3.30 mm, respectively) (8). The body weight and body length values obtained from the male (357.61 g and 37.83 cm, respectively) and female (320.06 and 36.69 cm, respectively) Muradiye kelebek pigeons were higher than those obtained for the same characteristics for the uncrested male (339.25 g and 36.04 cm, respectively) and female (310.50 g and 35.21 cm, respectively) Edremit kelebek pigeons (9). Shapiro et al. (18) emphasized that some morphological traits show similar patterns of variation in different breeds depending on genetic factors. They also noted the presence of variations in plumage color in the early stages of domestication, followed by plumage and structural (skeletal and soft tissue) characteristics, and finally behavioral changes. There were also variations among our indigenous pigeon genotypes in terms of structural characteristics due to domestication and artificial selection. The body weight, trunk length, head width, beak length, beak depth, thoracic perimeter, and tarsus diameter were significantly affected by sex. The male pigeons had significantly higher values for these traits than the female pigeons. These results are in line with previous studies that found statistically significant differences between the sexes in terms of body weight, head width, beak length, beak depth, thoracic perimeter, and tarsus diameter in the Alabadem and Muradiye donek pigeons (8, 16). In this study, the differences in body weight between the two age groups among the Muradiye kelebek pigeons suggest that growth continued after 24 months of age. In addition, the increase in the width and perimeter of the chest structure with age indicates that its volumetric development continues after 24 months. In bird species, the chest plays an important role in flight because it contains the heart, lungs, some parts of the air sacs, and large veins. We consider that breast development may occur more or less depending on the frequency of training, and this may play a role in the bird's performance. Erdem et al. (8) emphasized that the development of the Alabadem pigeon continued until the age of 47 months. However, to determine at what age growth and development are

completed in indigenous pigeon genotypes, it is necessary to investigate their body weight and body characteristics during the entire growth period.

It is clear that there are morphological and morphometric variations among the indigenous pigeon genotypes in Türkiye. Although these differences show disparities according to the geographical regions in Türkiye, they are mostly related to the desire of breeders to obtain pigeon genotypes with different morphological and aerial-display characteristics. In terms of the head structure, we consider that the Muradiye kelebek pigeon shares some features with the Edremit kelebek, Muradiye donek, Alabadem, Bursa oynarı, and Thrace roller pigeons. The spotted (*kaplan-şeyş*) plumage color of the Muradiye butterfly pigeon and the other three genotypes, the jackal (*çakal*) plumage color of the Thrace roller, the speckled (*kaplan-şeyş*) plumage color of the Edremit kelebek pigeon, and the red/black galaca (*kırmızı/siyah galaca*) plumage color of the Muradiye donek pigeon may be the common traits of these pigeons. In terms of morphometric characteristics, the Muradiye kelebek pigeon can be evaluated somewhere between the Bursa oynarı and Alabadem pigeons. This genotype showed values close to the Muradiye donek pigeon. It was also determined that the Muradiye kelebek pigeon had higher body weight and length values than the Edremit kelebek pigeon. Since these genotypes share some phenotypic characteristics, the phylogenetic relationships between the Muradiye butterfly pigeon and the other five pigeon genotypes (Edremit kelebek pigeon, Muradiye donek, Alabadem, Bursa oynarı, and Thrace roller) should be determined by molecular studies.

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Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contributions

EE, FTÖ, EKG and MİS conceived and planned the experiments. EE and FTÖ carried out the experiments. EKG and MİS contributed to the interpretation of the results. EE took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

This study was approved by the Local Ethics Board for Animal Experiments of Tekirdağ Namık Kemal University, Türkiye (2017/09).

Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

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