

The morphological and morphometric characteristics of Alabadem pigeons

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Received: 13.05.2020 • Accepted/Published Online: 03.10.2020 • Final Version: 22.04.2021

Abstract: This study aimed to determine the morphological and morphometric characteristics of Alabadem pigeons, which are grown as ornamental pigeons in Edirne province, and to determine mutual traits with other indigenous pigeon breeds in Turkey by comparing with previous studies. Body weight ($P < 0.001$), head length ($P < 0.01$), head width ($P < 0.05$), beak length ($P < 0.001$), and tarsus diameter ($P < 0.05$) of age group III were higher than those of other age groups; however, the wingspan of age group II was greater than that of other age groups in Alabadem pigeon. Compared to other indigenous genotypes in Turkey, the Alabadem pigeon is a small-sized genotype. Alabadem pigeons were similar to Edremit butterfly pigeons and Thracian tumbler pigeons in terms of crested and black-eyed pigeons. On the other hand, the irregularly shaped mark (almond) on the head in Alabadem pigeons was similar to the wide-long irregular shaped mark on the neck of Edremit butterfly pigeons. Some basic plumage colors (black, yellow, and red) and intermediate colors (chickpea and scarlet) were identical to Alabadem pigeons and Thrace roller pigeons. Since Alabadem pigeons have many mutual characteristics with Edremit butterfly pigeons and Thracian roller pigeons, genetic studies may be recommended to determine the degree of relationship among these breeds.

Key words: Alabadem pigeon, morphological characteristics, Turkey

1. Introduction

The pigeon is a species that has attracted the attention of mankind because of its various characteristics (ornamental purpose, sporting activities, use of pigeons as carriers/messengers, or source of meat) throughout history. The pigeon can be described as a cosmopolitan bird and it can be found in every country except the north and south poles. It is known that there have been more than 800 varieties of domestic pigeons from past to present in history, that were shaped by artificial or natural selection [1,2]. Many studies prove that the genotypes of pigeons differ from their ancestors in terms of morphological, physiological, and behavioral characteristics [3–6]. As a result of the breeding of pigeon genotypes for different purposes, various plumage colors and patterns, feather ornaments, crest types, vocalizations, and flight displays have emerged. Pigeon genotypes have been classified by various researchers in different ways according to their morphological features, flight characteristics, or game behaviors [7–10]. While some genotypes are classified according to their appearance (fancy/ornamental), other genotypes are classified according to their performance and game behavior (rolling, diving, tumbling, spinning, and thracing) [11–14].

Ornamental pigeon genotypes are bred for their fancy appearance. Plumage colors, crest, structure of the feathers, beak and tail shape, foot feathers (trotter) are among the factors affecting appearance. The crest can be defined as the downward elongation of the feathers on the head or neck [8,15,16]. A four-crest pattern is defined in the studies (peak crest, shell crest, mane crest, hood crest). Foot feathering can be defined as the elongation of tarsometatarsus feathers down to the phalanges. The foot feathering of pigeons has been classified by researchers as scaled, muff, slipper, and grouse trotter [7,13], as well as standard, sauté, sword, and abundant trotter [11].

There are many indigenous pigeon genotypes in the world. The English Tumbler and English Carrier in England, Berlin Tumbler in Germany, Spanish Barb in Spain, Iranian Tumbler in Iran, and Syrian dewlap in Syria are some of the pigeon genotypes [17]. Each breed has a specific body structure, plumage colors, and game behaviors. The Alabadem pigeon is a genotype specific to Turkey. It has been localized in and around Edirne since the 1920s. The Alabadem pigeon has been bred for fancy/ornamental purposes by breeders. Although these pigeons were classified as thracers, over time, the ornamental

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features became more prominent than the performance features, due to their dance-like movements on the floor and pleasing colors. Alabadem pigeons are well known for their ability to fly for 1–5 h and to perform 3–5 rapid thrace movements on top of an aerial display. Thrace length and frequency should be considered as mediocre. The definition of Alabadem derives from a group of irregularly shaped feathers of the same color as the rest of the plumage color on the pigeon's head. Alabadem pigeons have an important place as an indigenous genetic resource in Turkey. Although there have been studies on Bursa oynarı, Edremit butterfly roller, Thrace roller, Ankara tumbler, Squadron flyer, Scandaroon, and Adana wattled pigeon genotypes, which are among the genetic resources of domestic pigeons [11,12,18–22], there has been no research on Alabadem pigeon genotype.

This study aimed to determine the morphological and morphometric characteristics of Alabadem pigeons, which are grown as ornamental pigeons in Edirne province, and to determine their mutual traits with other indigenous pigeon breeds in Turkey by comparing with previous studies.

2. Materials and methods

2.1. Birds

This research was conducted with approval from the Local Animal Ethics Committee of Animal Experiments of T.C. Namık Kemal University (number 2017/09). The research consisted of 100 pigeons (47 male and 53 female) from five different breeders (30, 25, 18, 15, and 12 pigeons per breeder, respectively). This research was performed in 2019 in the central district of Edirne province. The care and management procedures of pigeons were carried out according to a routine program applied at the enterprises. The age and sex of the pigeons were determined according to the records kept at the enterprises. The ages of pigeons were classified into four groups: 10–23 months of age (age group I), 24–35 months of age (age group II), 36–47 months of age (age group III), and 48 months of age and older (age group IV).

2.2. Morphological characteristics

To determine the morphological characteristics of pigeons, head type, head mark, eye color, plumage color (body color), the number of wing and tail feathers, wing and tail marks, presence or absence of trotter (foot feathers) were recorded. These traits were defined according to the common declarations of breeders. The wing feathers were counted in the order of the primary-axial and secondary (p-a-s) feathers [11,20].

2.3. Morphometric characteristics

Body weight, body length, trunk length, wingspan and length, thoracic perimeter, tail length, chest width and

depth, head length and width, beak length and depth, chest width and depth, and tarsus diameter were obtained in Alabadem pigeons. Throughout the research, all weighing and body measurements were determined by the same researcher. The body weights of the birds were taken with a precision scale of 0.01 g. In morphological characteristics, a metal ruler was used to determine body length, 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 (Figure 1) [11].

2.4. Statistical analysis

GLM (general linear model) was used to identify the differences between age and sex groups. When a significant difference was found among groups for post hoc multiple comparisons, Tukey's test was used. Statistical analyses were performed using SPSS (IBM Corp., Armonk, NY, USA) for Windows. A value of $P < 0.05$ was considered statistically significant.

3. Results

3.1. Morphological characteristics

According to our observations and breeder declarations, the head structure of the Alabadem pigeon was determined as medium-sized and round-shaped with a light forehead. The Alabadem pigeon has crescent-like collared upright feathers extending from ear to ear, which distinguishes the pigeon breed from other genotypes. This feather structure on the head is defined as a peak crest (Figure 2). The eye color of the pigeons is usually black (76%); it was found to be greyish blue in some birds (24%) (Table 1). In this pigeon genotype, there was an irregularly shaped mark on the upper part of the head. The color of the head mark was identical to the plumage color, which was referred to by breeders as almond. If this mark is limited to a region with an irregular round shape on the top of the head, that was referred to as imprint almond ('kondurma badem' in Turkish) (Figure 3). If it covers a large part of the head and extends to the beak, it was called bolted almond ('sürme badem' in Turkish) (Figure 4).

Three basic plumage colors and three intermediate plumage colors were identified in this pigeon genotype. Black (plumage color and head mark color were black, which was called 'bursali' in Turkish) (15%) (Figure 5a), red (plumage color and head mark color were red, which was called 'mercan' in Turkish) (6%) (Figure 5b), and yellow (plumage color and head mark color were yellow, which was called 'kanarya akbaş' in Turkish) (10%) (Figure 5c). It was found that the first 5 or 7 of the wing primary feathers were white in all pigeons with basic plumage colors (black, red, and yellow) (Figures 5a, 5b, and 5c). In addition to these three basic plumage colors, there were

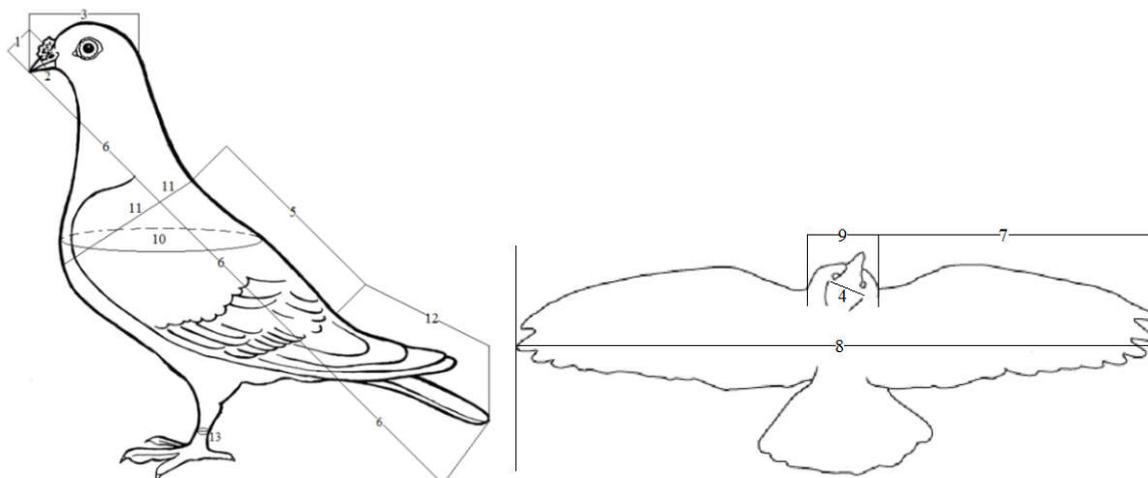


Figure 1. Morphometric body measurement regions [11]. (1 – beak length; 2 – beak depth; 3 – head length; 4 – head width; 5 – trunk length; 6 – body length; 7 – wing length; 8 – wingspan; 9 – chest width; 10 – thoracic perimeter; 11 – chest depth; 12 – tail length; 13 – tarsus diameter).



Figure 2. Peak crest.

four intermediate colors: citrin ('sarı ali' in Turkish), ashy ('küllü' in Turkish), chickpea ('nohudi' in Turkish), and scarlet ('yuva ali' in Turkish). Some birds had marks on the wing primary and secondary feathers that were called aleph ('elif, kalem' in Turkish) and they were visible along the wing (Figures 6a, 6b, 6c, and 6d). Pigeons can be identified by breeders depending on the plumage color and the color of the alephs. Light-cream plumage color and yellow/pale orange alephs on the wings were called citrin ('sarı ali' in Turkish) (15%) (Figure 6a), grayish-brown plumage color and red/crimson alephs on the wings were called ashy ('küllü' in Turkish) (7%) (Figure 6b), gray plumage color and black alephs on the wings were called chickpea ('nohudi' in Turkish) (25%) (Figure 6c), blue/dark blue plumage color and black alephs on the wings were called scarlet ('yuva ali' in Turkish) (22%) (Table 1) (Figure 6d).

In the present study, Alabadem pigeons were divided into two groups: 9-1-10 (58%) and 8-1-10 (42%) according to the number of primary-axial-secondary wing feathers. Three groups were determined according to the number of white feathers on the wing. The percentages of these groups were 28% (5 white feathers), 41% (6 white feathers), and 31% (7 white feathers), respectively. Additionally, Alabadem pigeons were divided into two groups, 12 (63%)

and 14 (37%) according to the number of tail feathers (Table 1). It was determined that all Alabadem pigeons examined in the study were free from trotter (Figure 7).

3.2. Morphometric characteristics

The body weight of male pigeons was significantly higher than that of female pigeons ($P < 0.001$). Also, this trait was significantly affected by age ($P < 0.001$). Age group III was heavier than other age groups ($P < 0.001$). Body length ($P < 0.05$), wingspan ($P < 0.001$), thoracic perimeter ($P < 0.001$), chest depth ($P < 0.05$), beak depth ($P < 0.001$), and tarsus diameter ($P < 0.05$) were higher in male pigeons than in female pigeons. Body weight ($P < 0.001$), wingspan ($P < 0.001$), head length ($P < 0.01$), head width ($P < 0.05$), beak length ($P < 0.001$), and tarsus diameter ($P < 0.05$) were significantly influenced by age group. Although body weight, wingspan, and tarsus diameter were significantly affected by sex and age, trunk length, wing length, tail length, and chest width were not affected by any variation factors (Table 2).

4. Discussion

4.1. Morphological characteristics

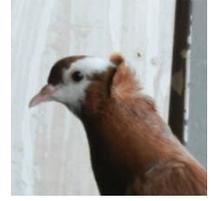
The head structure of this genotype (round-shaped) was different from some pigeon genotypes (Ankara tumbler/oval-shaped, Scandaroon pigeons/long and narrow) and similar to other pigeon genotypes (Bursa oynarı pigeons, Edremit butterfly pigeons, and Thrace roller pigeons/round-shaped) grown in Turkey [11,12,18,21,22]. As seen from previous studies, breeders prefer the shape rather than the size in defining the head structure. In phylogenetic studies, the comparative analysis of the skull structure of birds with various measurement and computer rendering methods has been carried out to reveal kinship between

Table 1. Morphological characteristics of Alabadem pigeons (%).

Morphological characteristics	Ratio (%)
Plumage color	
Black (Bursalı)	15
Red (Mercan)	6
Yellow (Kanarya akbaş)	10
Chickpea (Nohudi)	25
Scarlet (Yuva alı)	22
Citrin (Sarı alı)	15
Ashy (Küllü)	7
Eye color	
Black	76
Greyish blue	24
Number of wing feather	
9-1-10	58
8-1-10	42
Number of white feather on the wing	
5	28
6	41
7	31
Number of tail feather	
12	63
14	37

bird species and breeds. It was stated that there may be a relationship among races with similar skull shapes in these studies [5,23,24]. In the present study, it was determined that the head shape of Alabadem pigeons resembles Bursa oynarı, Thrace roller, and Edremit butterfly pigeons. All Alabadem pigeons examined in this study have a peak crest. In bird species, the crest structure plays an important role in attracting the attention of their mates during mating in nature [25]. Erdem et al. [18] reported that the Edremit butterfly pigeon had two varieties, known as crested (46%) and uncrested (54%). Besides, Soysal [21] stated that some Thrace roller pigeons were crested, and he described that it was in the form of a neat circle behind the head. Alabadem pigeons were similar to Thrace roller pigeons and Edremit pigeons in terms of having a crest. Some researchers stated that the EphB2 mutation is responsible for different crest phenotypes [13,16,17], hence a relationship may be found between Alabadem pigeons, Thrace roller pigeons, and Edremit butterfly pigeons.

In the present study, the eye color of the Alabadem pigeon was determined to be mostly black (76%). When we examine the other studies, it is reported that the

**Figure 3.** Imprint almond.**Figure 4.** Bolted almond.

goshawk color is very common in Ankara tumblers (51.76%), followed by pomegranate color (18.59%) [9]; amber (26.62%) is common in the squadron flyer pigeons, followed by yellow (23.02%) [20]. Dusty rose is very common in Bursa oynarı (67.44%), followed by white (23.26%) [10]. In another genotype, Edremit butterfly roller pigeons had black and goshawk eye colors [18]. Research conducted on the Thracian rollers found pigeons with black, pearl, yellow, and red eyes. Also, it has been emphasized that pigeons with red or yellow eyes may appear as a result of cross-breeding [21]. The presence of black-eyed pigeons could be considered a mutual trait among the Alabadem pigeons, Edremit butterfly pigeons, and Thrace roller pigeons.

Alabadem pigeons had a mark on the upper part of the head (almond). It was reported that the similarity of this mark was found in white Edremit butterfly pigeons, which could be black (20%), yellow (23%), brownish-red (13%), or blue (4%) in the form of the wide-long irregularly shaped band extending behind the neck to the upper body [18]. This situation is completely different for the Bursa oynarı pigeon breed. In this genotype, the head marks are named according to the distribution of white feathers on the head in black plumage color pigeons; most of the pigeons are called markless (69.77%) with ring-shaped whiteness around the eye. This whiteness merges white stripes extending from the bottom of the two eyes and converging at the root of the beak [10]. The irregularly shaped mark (almond) on the head in Alabadem pigeons resembles a wide-long irregularly shaped mark of the Edremit butterfly pigeons on the neck.

The variation of plumage colors in birds has attracted the attention of researchers for many years. Some researchers explained this situation with apostatic selection, which is cryptic camouflage against avian predators [26,27]. Galeotti et al. [28] emphasized that habitat and climatic changes played a major role in plumage color variation. Undoubtedly, the variation of coloration in domestic pigeons has emerged with genetic mutations and artificial selection. While the basic plumage color in the rock pigeon blue-gray in general plumage color with two black wing alephs and a greenish-purplish sheen around the neck and upper breast, the ancestor of

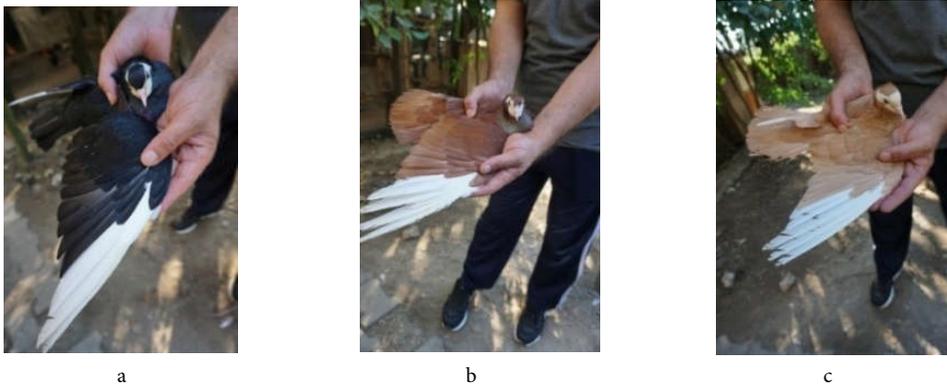


Figure 5. Basic plumage colors of Alabadem pigeons. a) Black, b) Red, c) Yellow.

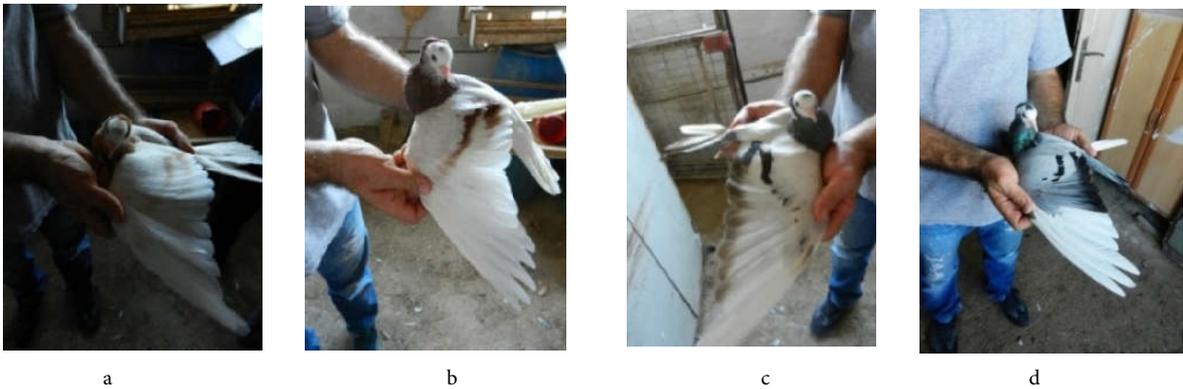


Figure 6. Intermediate plumage colors of Alabadem pigeons. a) Citrin, b) Ashy, c) Chickpea, d) Scarlet.



Figure 7. Foot plumage condition in Alabadem pigeons (free from trotter).

the pigeon (*Columba livia*), the varieties of plumage colors of pigeon genotypes have formed as a result of selection and mating for certain purposes [7]. According to the data obtained in this study, the plumage color of the Alabadem pigeons was determined as chickpea (25%), scarlet (22%), citrin (15%), black (15%), yellow (10%), red (6%), and ashy (7%). Balcı pointed out that the Bursa Oynarı pigeons had two main plumage colors, white (91.3%) and black (8.7%), with different neck colors (green, purple, and green-purple) [12]. In another study, it was reported that 29.32% of the pigeons in Scandaroon pigeons had a red plumage

color, followed by yellow (23.78%), black (20.13%), white (15.21%), and sky blue (11.56%) in Hatay [22]. In the study conducted with Thrace rollers, the main plumage colors were black, white, red, yellow, and blue, and intermediate colors, which were described by the breeders as olive, chickpea, and coyote. Erdem et al. [18] stated that the main plumage colors of Edremit butterfly pigeons were black-wired tail (some of the tail primaries are black and the rest of the plumage color is white) (28%), purple-wired tail (some of the tail primaries are purple/dark blue and the rest of the plumage color is white) (2%), and black (2%). In the same study, the presence of black spots on the white plumage color was referred to as *şes* in this genotype (7%). It has been reported as *keşbir* in Squadron flyer pigeons with different color distributions [20]. In this study, it was determined that Alabadem pigeons did not have these body marks (*şes*). Derelle et al. [16] stated that variations in regulatory regions of MC1R (the melanocortin 1 receptor gene) or in other genes were probably responsible for the color polymorphism of the white, blue alephs, spread, and ash-red colored feral pigeons. It was determined that the identical basic colors of Alabadem pigeons and Thrace roller pigeons were black, yellow, and red. Also,

Table 2. Morphometric characteristics of Alabadem pigeons ($\bar{X} \pm S_x$).

Variation Factors	n	Body weight (g)	Body Length (cm)	Trunk length (cm)	Wingspan (cm)	Wing length (cm)	Thoracic perimeter (cm)	Tail length (cm)
Sex		***	*	-	***	-	***	-
Male	47	332.97 ± 3.31	32.44 ± 0.54	11.01 ± 0.07	64.33 ± 0.28	29.87 ± 0.21	20.12 ± 0.13	12.71 ± 0.09
Female	53	310.71 ± 3.39	30.78 ± 0.61	10.77 ± 0.09	62.01 ± 0.24	29.47 ± 0.12	19.48 ± 0.12	12.73 ± 0.10
Age group		***	-	-	***	-	-	-
I	36	308.31 ± 3.56 ^c	30.84 ± 0.59	10.85 ± 0.12	61.81 ± 0.31 ^b	29.42 ± 0.15	19.81 ± 0.15	12.88 ± 0.13
II	10	309.50 ± 4.84 ^c	31.13 ± 1.01	10.75 ± 0.17	63.37 ± 0.55 ^a	30.50 ± 0.98	19.15 ± 0.15	12.57 ± 0.20
III	17	348.76 ± 1.69 ^a	31.65 ± 0.47	11.01 ± 0.13	63.21 ± 0.41 ^a	29.61 ± 0.16	19.86 ± 0.24	12.62 ± 0.20
IV	37	324.16 ± 4.60 ^b	32.34 ± 0.90	10.90 ± 0.09	64.24 ± 0.34 ^a	29.68 ± 0.12	19.89 ± 0.16	12.65 ± 0.09
Grand mean	100	321.17 ± 2.61	31.56 ± 0.41	10.89 ± 0.06	63.10 ± 0.21	29.65 ± 0.12	19.78 ± 0.09	12.72 ± 0.07
Variation Factors	n	Chest width (mm)	Chest depth (mm)	Head length (mm)	Head width (mm)	Beak length (mm)	Beak depth (mm)	Tarsus diameter (mm)
Sex		-	*	-	-	-	***	*
Male	47	52.16 ± 0.31	58.12 ± 0.63	50.51 ± 0.15	18.51 ± 0.14	18.16 ± 0.15	5.38 ± 0.06	3.59 ± 0.05
Female	53	51.30 ± 0.55	55.75 ± 0.68	50.48 ± 0.20	18.82 ± 0.16	17.92 ± 0.15	4.71 ± 0.07	3.42 ± 0.04
Age group		-	-	**	*	***	-	*
I	36	52.26 ± 0.45	55.45 ± 0.93	50.32 ± 0.25 ^b	18.36 ± 0.19 ^{bc}	17.70 ± 0.17 ^c	4.86 ± 0.12	3.54 ± 0.06 ^{ab}
II	10	52.35 ± 0.55	56.15 ± 1.60	50.12 ± 0.44 ^b	18.10 ± 0.33 ^c	17.18 ± 0.39 ^{cb}	4.86 ± 0.20	3.30 ± 0.06 ^c
III	17	51.92 ± 0.42	58.07 ± 0.69	51.46 ± 0.26 ^a	19.19 ± 0.26 ^a	18.74 ± 0.17 ^a	5.22 ± 0.11	3.69 ± 0.09 ^a
IV	37	50.89 ± 0.72	57.87 ± 0.72	50.32 ± 0.14 ^b	18.89 ± 0.15 ^{ab}	18.27 ± 0.16 ^{ab}	5.14 ± 0.07	3.43 ± 0.04 ^{bc}
Grand mean	100	51.70 ± 0.32	56.86 ± 0.48	50.49 ± 0.12	18.67 ± 0.11	18.03 ± 0.11	5.02 ± 0.06	3.50 ± 0.03

P > 0.05; n.s.; *: P < 0.05; **: P < 0.01; ***: P < 0.001, ^{a-c}: means within a column with different letters are significantly different (P < 0.05)

the identical intermediate colors of Alabadem pigeons and Thrace roller pigeons were chickpea and citrin.

Two groups were determined as 9-1-10 (58%) and 8-1-10 (42%) according to the number of the wing primary-axial-secondary feathers (p-a-s) in Alabadem pigeons. The number of wing feathers (p-a-s) in Ankara tumbler pigeons varies between 9-1-10 (3.35 %) and 9-1-14 (10.05%). The highest rate was found to be 9-1-13 (50.84%) in a previous study [9]. Yıldırım et al. [22] stated that the number of wing primaries of the Scandaroon pigeons varied between 12 (89.26%) and 14 (3.20%). As a result of interviews with breeders during the research, they stated that the number of the wing primaries affects the rapid rise to the air, and the number of the wing secondaries affects the airborne time in pigeons. Although the number of wing primaries in Alabadem pigeons was similar to Ankara tumbler pigeons, it was lower than that of Scandaroon pigeons. According to these results, it is possible that Alabadem pigeons have rapid maneuverability and good tumbler ability like the tumbler pigeon genotype (Ankara tumbler pigeon), but they do not have the ability to fly for a long time like the squadron flyer pigeon genotype (Scandaroon pigeons). Three groups were determined according to the number

of white primaries on the wing in Alabadem pigeons. The percentages of these groups were 28% (5 white primaries), 41% (6 white primaries), and 38% (7 white primaries), respectively. White primaries on the wings of the Alabadem pigeons were also seen in Ankara tumbler pigeons, squadron flyer pigeons, and Thrace roller pigeons. This was referred to as grizzle wing ('kır kanat' in Turkish) in Ankara tumbler pigeons, shoving ('sokuşturmalı' in Turkish) in squadron flyer pigeons, and jackal ('çakal' in Turkish) in Thrace roller pigeons [11,20,21].

It was determined that the Alabadem pigeons were divided into two groups as 12 (63%) and 14 (37%) according to the number of tail primaries. The number of tail primaries was determined as 12, 13, and 14 (85.43%, 9.04%, and 5.53%, respectively) in Ankara tumbler pigeons [9]. In other studies, the number of tail primaries was reported as 10, 12, 13, 14 (2.56%, 87.18%, 8.97%, and 1.29%, respectively) in Squadron flyer pigeons, and it was reported as 14.63% and 14.59% in male and female crested Edremit butterfly pigeons, respectively [18,20]. In the study carried out in the Thrace roller pigeons, the number of tail primaries was reported to be 12–15 in males and 12–16 in females [21]. In the present study, Alabadem pigeons

were found to be free from trotter. A similar situation was observed in the studies of squadron flyer pigeons and Thrace roller pigeons [20,21]. On the other hand, all tumbler pigeons that were reared in Ankara province and butterfly rollers that were reared in Edremit province were found to have trotter [9,18]. It was determined that Alabadem pigeons are similar to Squadron flyer pigeons and Thrace roller pigeons due to their being free from trotter.

4.2. Morphometric characteristics

Body weight, thoracic perimeter, chest width, chest depth, head width, and tarsus diameter of Alabadem pigeons, which were obtained in the current study (321.17 g, 19.78 cm, 51.70 mm, 56.86 mm, 18.67 mm, and 3.50 mm) were lower than the study for squadron flyer pigeons (428.85 g, 22.11 cm, 56.02 mm, 65.03 mm, 21.60 mm, 4.36 mm) [20], Scandaroon pigeons (496.21 g, 31.75 cm, 55.75 mm, 68,99 mm, 27,93 mm) [22], Adana wattled pigeons (505.94 g, 25.65 cm, 62.66 mm, 23,81 mm, 5.77 mm) [19], but similar to the study of Ankara tumbler pigeons (321.62 g, 19.70 cm, 56.04 mm, 62.98 mm, 20.08 mm, 4.01 mm) [9]. Body weight, body length, wingspan, tail length, and chest width of Alabadem pigeons, which were obtained in this study, were lower than the Thrace roller pigeons (335.58 g, 34.42 cm, 67.32 cm, 12.72 cm, 51.70 mm) [21]. Body length (32.44 and 30.78 cm), wingspan (64.33 and 62.01 cm), and tail length (12.71 and 12.73 cm) values obtained from male and female Alabadem pigeons were lower than the body length (35.89 and 34.91 cm), wingspan (65.98 and 64.18 cm), and tail length (13.56 and 12.79 cm) values reported in male and female crested Edremit butterfly pigeons [18]. Genotypic differences are caused by variation in morphological characteristics among the indigenous genotypes. In Turkey, basic features required by breeders in roller pigeons are medium-sized body, short and nonblunt beak, trotter-free, and desired color of the eyes [21]. Also, the raising of the breed as a tumbler in the past and the purpose of raising it today for ornamental purposes and being subject to artificial selection for this purpose may have caused the body size to decrease. Forshaw and Cooper [29] stated that ornamental genotypes developed by pigeon breeders for appearances are often poor fliers and tend to be held in semiliberty or in full confinement. It is possible

to say that the Alabadem pigeon is a small-sized breed compared to other indigenous breeds in Turkey.

Body weight, body length, wingspan, thoracic perimeter, chest depth, and beak depth were statically different between sex groups. These results were similar to results reported by other researchers, suggesting the existence of sexual dimorphism in pigeon breeds [9,10,30]. Body weight, head length, head width, beak length, and tarsus diameter of age group III were higher than those of other age groups; however, the wingspan of age group II was higher than that of other age groups. These findings proved that the body development of Alabadem pigeons continues for up to 47 months and the wingspan may change depending on training frequency.

5. Conclusion

Considering the findings in this study and compared with previous studies, the Alabadem pigeon is a small-sized genotype compared to other indigenous genotypes in Turkey. The body development of this genotype continues until the age of 47 months. The Alabadem pigeon resembles the Bursa oynarı pigeon, Edremit butterfly pigeon, and Thrace roller pigeon in terms of head structure. Alabadem pigeons were similar to Edremit butterfly pigeons and Thracian tumbler pigeons in terms of finding crested and black-eyed pigeons. On the other hand, the irregularly shaped mark (almond) on the head in Alabadem pigeons was similar to the wide-long irregularly shaped mark on the neck in Edremit Butterfly pigeons. Some basic plumage colors (black, yellow, and red) and intermediate colors (chickpea and scarlet) were identical in Alabadem pigeons and Thrace roller pigeons. Another identical trait between Alabadem pigeons and Thracian roller pigeons was the fact that both genotypes were free from trotter. Since the Alabadem pigeons have many mutual characteristics with Edremit butterfly pigeons and Thracian roller pigeons, genetic studies may be recommended to determine the degree of relationship among these breeds.

Acknowledgments/disclaimers/conflict of interest

This study was funded by Tekirdağ Namık Kemal University Scientific Research Project Coordination Unit (Project No: NKUBAP.10.GA.17.138).

References

1. Jerolmack C. Primary groups and cosmopolitan ties: The rooftop pigeon flyers of New York City. *Ethnography* 2009; 10 (4): 435-457. doi: 10.1177/1466138109346997
2. Vogel C, Gerlach H, Löffler M. Columbiformes. In: Harrison GJ, Richie B (editors). *Avian Medicine: Principles and Application*. Florida, FL, USA: Florida Wingers Publishing Inc.; 1994. pp.1200-1217.
3. Helms JA, Bruggmann SA. The Origins of species-specific facial morphology: the proof is in the Pigeon. *Integrative and Comparative Biology* 2007; 47 (3): 338-342. doi: 10.1093/icb/ icm051
4. Lapidra O, Sol O, Carromas S, Beaulieu JM. Behavioural changes and the adaptive diversification of pigeons and doves. *Proceeding of Royal Society* 2013; 280: 1-9. doi:10.1098/ rspb.2012.2893

5. Young NM, Linde-Medina M, Fondon JW, Hallgrímsson B, Marcucio RS. Craniofacial diversification in the domestic pigeon and the evolution of the avian skull. *Nature Ecology and Evolution* 2017; 1: 0095 doi: 10.1038/s41559-017-0095
6. Domyan ET, Shapiro MD. Pigeonetics takes flight: evolution, development, and genetics of intraspecific variation. *Developmental Biology* 2017; 427 (2): 241-250. doi: 10.1016/j.ydbio.2016.11.008
7. Baptista L, Martínez gómez JE, Horblit HM. Darwin's pigeons and the evolution of the columbiformes: recapitulation of ancient genes. *Acta Zoológica Mexicana* 2009; 25 (3): 719-741. doi: 10.21829/azm.2009.253674
8. Hubbard JK, Uy JA, Hauber ME, Hoekstra HE, Safran RJ. Vertebrate pigmentation: from underlying genes to adaptive function. *Trends in Genetics* 2010; 26: 231-239. doi: 10.1016/j.tig.2010.02.002
9. Price TD. Domesticated birds as a model for the genetics of speciation by sexual selection. *Genetica* 2002; 116:311-327. doi: 10.1023/A:1021248913179
10. Manceau M, Domingues VS, Linnen CR, Rosenblum EB, Hoekstra HE. Convergence in pigmentation at multiple levels: mutations, genes and function. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 2010; 365:2439-2450. doi: 10.1098/rstb.2010.0104
11. Atasoy F, Erdem E, Hacan ÖG. Determination of morphological characteristics of tumbler pigeons in province of Ankara (*Columba livia domestica*). *Ankara Üniversitesi Veteriner Fakültesi Dergisi* 2013; 60: 135-143 (article in Turkish with an abstract in English). doi: 10.1501/Vetfak_0000002567
12. Balcı F, Ardıçlı S, Alpay F, Dinçel D, Soyudal B et al. The determination of some morphological characteristics of Bursa Oynarı pigeon breed. *Ankara Üniversitesi Veteriner Fakültesi Dergisi* 2016; 65: 349-355. doi: 10.1501/Vetfak_0000002867
13. Kabir MA. Head-Leg feathers in fancy pigeons of Bangladesh. *American Research Journal of Biological Sciences* 2015; 1 (1): 48-51.
14. Rosenblum EB, Parent CE, Brandt EE. The molecular basis of phenotypic convergence. *Annual Review of Ecology, Evolution, and Systematics* 2014; 45: 203-226. doi: 10.1146/annurev-ecolsys-120213-091851
15. Bartels T. Variations in the morphology, distribution, and arrangement of feathers in domesticated birds. *Journal of Experimental Zoology Part B, Molecular and Developmental Evolution* 2003; 298B: 91-108. doi: 10.1002/jez.b.28
16. Derelle R, Kondrashov FA, Arkhipov VY, Corbel H, Frantz A et al. Color differences among feral pigeons (*Columba livia*) are not attributable to sequence variation in the coding region of the melanocortin-1 receptor gene (MC1R). *Biomed Central Research Notes* 2013; 6: 310. doi: 10.1186/1756-0500-6-310
17. Shapiro MD, Kronenberg Z, Li C, Domyan ET, Pan H. et al. Genomic diversity and evolution of the head crest in the rock pigeon. *Science* 2013; 339 (6123): 1063-1067. doi:10.1126/science.1230422
18. Erdem H, Konyalı, C, Savaş T. Morphological characterization of Edremit Kelebek Roller Pigeons. *Çanakkale Onsekiz Mart Üniversitesi Dergisi* 2018; 6 (2): 93-100 (in Turkish with an abstract in English).
19. Özbaşer FT, Alaşahan S, Nariñç D, Gündüz Ö, Özkul BY. Live weight and some morphological characteristics of the Cins Pigeons. In: *Proceedings of the 3rd International Congress on Advances in Veterinary Science and Technics*. Belgrade, Serbia; 2018. pp.84-87.
20. Özbaşer FT, Atasoy F, Erdem E, Güngör İ. Some morphological characteristics of squadron flyer pigeons (*Columba livia domestica*). *Ankara Üniversitesi Veteriner Fakültesi Dergisi* 2016; 63: 171-177 (in Turkish with an abstract in English).
21. Soysal Mİ, Gürçan EK, Akar T, Alter K, Genç S. The determination of several morphological features of Thrace Roller Breeds in raised Thrace Region. *Tekirdağ Ziraat Fakültesi Dergisi* 2011; 8 (3): 61-68 (in Turkish with an abstract in English).
22. Yıldırım H, Doğan U, Cimrin T. Determination of the morphological characteristics of Scandaroon pigeon grown in the central of Hatay province (*Columba livia domestica*). *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics* 2018; 2: 368-375 (in Turkish with an abstract in English)
23. Bailleul AM, Horner JR. Comparative histology of some craniofacial sutures and skull-base synchondroses in non-avian dinosaurs and their extant phylogenetic bracket. *Journal of Anatomy* 2016; 229: 252-285. doi: 10.1111/joa.12471
24. Felice RN, Goswami A. Developmental origins of mosaic evolution in the avian cranium. *Proceedings of the National Academy of Sciences* 2018; 115 (3): 555-560. doi: 10.1073/pnas.1716437115
25. Kane SA, Van Beveren D, Dakin R. Biomechanics of the peafowl's crest reveals frequencies tuned to social displays. *Plos One* 2018; 13 (11): e0207247. doi: 10.1371/journal.pone.0207247
26. Baker RR, Parker GA. The evolution of bird coloration. *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences* 1979; 287: 63-130. doi:10.1098/rstb.1979.0053
27. Clarke B. The evidence for apostatic selection. *Heredity* 1969; 24: 347-352. doi: 10.1038/hdy.1969.52
28. Galeotti P, Rubolini D, Dunn PO, Fasola M. Colour polymorphism in birds: causes and functions. *Journal of Evolutionary Biology* 2003; 16 (4): 635-46. doi: 10.1046/j.1420-9101.2003.00569.x
29. Forshaw JM, Cooper W. *Pigeons and Doves in Australia*. Melbourne, Australia: CSIRO Publishing; 2015.
30. Johnston RF. Variation in size and shape in pigeons, *Columba livia*. *The Wilson Bulletin*, 1990; 102: 213-225.