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The taxonomic status and geographic distribution of the European hare (*Lepus europaeus* Pallas, 1778) in Turkey (Mammalia: Lagomorpha)

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Abstract: This study was based on 125 specimens of hares collected from 61 different localities in Turkey between 2006 and 2010. We present diagnostic characters, pelage coloration, external, cranial and phallic measurements, skull and phallus features, hair structure, and collection localities of hares from Turkey. Additionally, we analyze morphometric variations of 5 regional populations according to the physiography/orography of the study area. Among the morphometric variables, 10 characters (weight, tail length, basal length, condylobasal length, rostral breadth, height of braincase, foramen incisiva length, occipitonasal length, profile length, and mandible length) are found to be significantly different between the populations (ANOVA, $P < 0.01$). Principal component analysis of 22 morphometric measurements is performed, and 71.56% of total variance is explained through 5 principle components. The Thracian specimen is distinguished from other populations on the first 2 canonical discriminant functions and the cluster dendrogram. The hair structure, as examined by scanning electron microscope, is found to be flattened and imbricate. Our Anatolian specimens are discussed at the subspecies level, comparing them to the relevant literature, and it is concluded that *Lepus europaeus* in Anatolia is represented by only one subspecies, *Lepus europaeus syriacus*.

Key words: *Lepus europaeus*, morphology, morphometric analysis, taxonomy, Turkey

1. Introduction

The order Lagomorpha is represented by 13 genera and 93 species belonging to 3 families (Ochotonidae, Leporidae, and Prolagidae) in the world. The family Leporidae (hares, rabbits, and jackrabbits) is composed of 11 genera and 61 species. The genus *Lepus* L., 1758 is represented by 32 species in the world (Wilson and Reeder, 2005). One of these species, *Lepus europaeus* Pallas, 1778 (European or brown hare), is the most widespread and the best-known hare species in the Palearctic region (Robinson and Mathee, 2005; Chapman and Flux, 2008). *L. europaeus* was once regarded as a subspecies of *Lepus capensis* L., 1758 (Cape hare). It is now considered that *L. capensis* and *L. europaeus* are not conspecific and they are treated as separate species today (Flux and Angermann, 1990; Nowak, 1999; Mitchell-Jones et al., 1999; Wilson and Reeder, 2005). *L. europaeus* is distributed from western Europe (except large parts of the Iberian Peninsula) to the west Siberian lowlands, northern Israel, northern Syria, northern Iraq, and western Iran (Wilson and Reeder, 2005), but the taxonomic status of hares in Turkey is uncertain. The taxonomic distinction between *L. europaeus* and *L. capensis* has not yet been completely resolved. Similarity in morphological, ecological, and molecular peculiarities makes systematic and taxonomic examinations of European hares (*L. europaeus*) and Cape hares (*L. capensis*) from the southern Palearctic region difficult (Petter, 1961; Yom Tov, 1967; Corbet, 1978; Ben Slimen et al., 2008).

Although the Turkish hare is considered to be *L. europaeus* by some authors (Steiner and Vauk, 1966; Ererçin, 1977; Turan, 1984; Mitchell-Jones et al., 1999; Yiğit et al., 2001, 2002; Kasapidis et al., 2005), others considered it to be *L. capensis* (Kumerlove, 1975; Doğramacı, 1989; Harrison and Bates, 1991; Çanakçıoğlu and Mol, 1996; Kurtonur et al., 1996). Within Turkey, Steiner and Vauk (1966) recorded *L. europaeus* from Konya; Kumerlove (1975) *L. capensis* from Birecik, Ceylanpınar, Urfa, and Viranşehir; and Sert et al. (2005) *L. europaeus* from Elmalı, Bucak, Manavgat, Cevizli, Taşeli Platosu, Kozaklı, Gaziantep, Şanlıurfa, Elazığ, and Mt. Kaçkar. Gramov and Erbajeva (1995) recorded *L. europaeus* as distributed in Asia Minor. Kryštufek and Vohralik (2001, 2009) and Smith and Johnston (2008) stated that *L. europaeus* was widespread in Turkey. There is also uncertainty at the level of subspecies; Ognev (1940) included NE Anatolia in the

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geographical distribution of the subspecies *Lepus europaeus cyrensis* Satunin, 1905, while Ellerman and Morrison Scott (1951) stated that *Lepus e. syriacus* Ehrenberg, 1833 occurs in Anatolia.

In Turkey, Oğurlu (1997) described only some ecological characteristics of brown hares in the woodland of Eskişehir-Çatalca. Sert et al. (2005, 2009), Ben Slimen (2006, 2008), and Stamatis et al. (2008) examined genetic diversity of Anatolian hares by analyzing allozymes, microsatellites, and mtDNA. Demirbaş et al. (2010) and Tez et al. (2012) also studied some cytogenetical and morphological features of hares in Turkey. Initial studies of hares from Turkey suggested that there was only one species present, namely the brown hare, *Lepus europaeus*; however, those studies were restricted in sample sizes and geographical samples. Additionally, there are insufficient morphometric data on *L. europaeus* in Turkey. Such morphological characteristics of *L. europaeus* in Turkey, as well as the morphometric differences, using multivariate analysis are given for the first time in this study. The aim of this study was to contribute to knowledge of the geographical distribution and to determine the morphometric variations of *Lepus europaeus* in Turkey.

2. Materials and methods

A total of 122 hares were collected via hunting by hunters from 61 different localities in Turkey between 2006 and 2010. One additional specimen was examined in the mammalian collection at Dicle University. Two leverets caught in Kırıkkale Province were released after being examined (Figure 1; Table 1).

Pelage coloration, hair structure, and features of the skull and phallus of all specimens were recorded. The specimens were divided into 3 age groups (leveret, juvenile, and adult) according to the criteria reported by Stroh (1931), Suchentrunk et al. (2000), and Bray et al. (2002). Only the adult group was used for comparison and evaluation. The skins of the specimens were prepared as conventional museum study skins (Mursaloğlu, 1965) in the field after taking 4 standard measurements and weight. External, cranial, and phallic measurements of the specimens were taken using a tape measure and a dial caliper to an accuracy of 0.05 mm according to Angermann (1968), Nagorsen (1985), and Harrison and Bates (1991) (Figure 2).

Abbreviations used for characteristics measured were as follows: W, weight; TBL, total body length; TL, tail length; HFL, hind foot length; EL, ear length; ZL, zygomatic length; ZB, zygomatic breadth; CBL, condylobasal length; ONL occipitonasal length; BL, basal length; NL, nasal length; NB, nasal breadth; PFL, profile length; RB, rostral breadth; MAB, meatus acusticus breadth; HBC, height of braincase; BBC, breadth of braincase; DL, diastema length; PL, palatal length; FIL, foramen incisiva length; BTB, breadth of tympanic bulla; MAL, mandible length; MAH, mandible height; UML, upper molar length; LML, lower molar length (Figure 2).

Intersexual differences in external and cranial measurements, and weights within age groups, were investigated using specimens of known sex by the t-test. However, no statistical differences were found in these

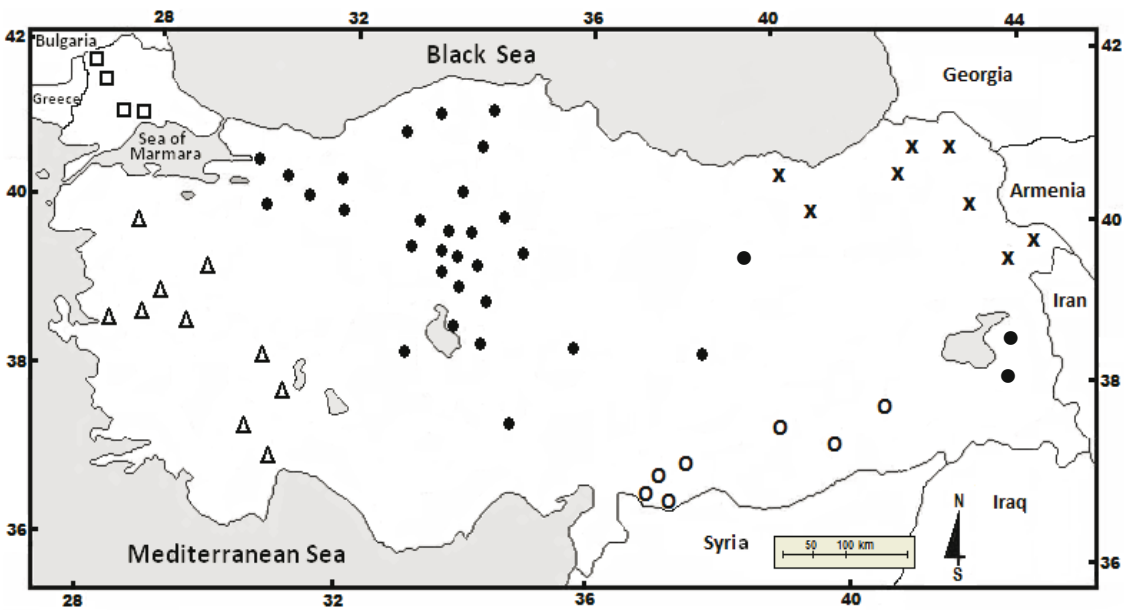

Figure 1. Collection localities for Turkish hares and 5 regional populations according to physiography/orography of the study area (□: Thracian population, Δ: Southwest Anatolian population, ●: Central and East-Central Anatolian population, ○: Southeast Anatolian population, ×: Northeast Anatolian population).

Table 1. Specimens examined (n = 125) and localities.

Locality	No. of samples	Locality	No. of samples
Kırıkkale (39°49′N, 33°30′E)	3 ♂♂, 3 ♀♀, 4 ??	Seben (40°24′N, 31°34′E)	1 ♀
Keskin (39°40′N, 33°36′E)	1 ♂, 5 ♀♀, 1 ?	Göynük (40°24′N, 30°46′E)	2 ♂♂
Bahşılı (39°48′N, 33°26′E)	5 ♂♂, 1 ♀, 1 ?	Taraklı (40°23′N, 30°29′E)	1 ?
Yahşihan (39°51′N, 33°27′E)	1 ♂, 2 ♀♀	Ovacık (41°04′N, 32°54′E)	1 ♀
Balışeyh (39°55′N, 33°42′E)	4 ♂♂, 3 ♀♀, 2 ??	Araç (41°01′N, 34°02′E)	1 ♂
Delice (39°56′N, 34°02′E)	2 ♀♀, 1 ♂	Taşköprü (41°30′N, 34°12′E)	1 ?
Nallıhan (40°11′N, 31°21′)	1 ?	Tosya (41°01′N, 34°02′E)	2 ♂♂
Şereflikoçhisar (38°56′N, 33°33′E)	3 ??	Aralık (39°52′N, 44°29′E)	1 ♂, 1 ♀
Kalecik (40°05′N, 33°24′E)	1 ♀	Suluçam (39°41′N, 43°48′E)	1 ♂
Elmadağ (39°54′N, 33°14′E)	1 ♂, 1 ♀	Kars (40°35′N, 43°04′E)	1 ♂
Şabanözü (40°27′N, 33°16′E)	2 ♀♀	Maçka (40°49′N, 39°37′E)	2 ♂♂, 1 ?
Sungurlu (40°09′N, 34°22′E)	1 ♂	Bayburt (40°15′N, 40°13′E)	1 ?
Yerköy (39°38′N, 34°28′E)	2 ♂♂	Kemah (39°36′N, 39°02′E)	1 ?
Mucur (39°03′N, 34°22′E)	1 ♂, 2 ♀♀	Ardanuç (41°07′N, 42°03′E)	1 ♂, 1 ♀
Ortaköy (38°41′N, 33°20′E)	1 ?	Demirkent (40°53′N, 41°44′E)	1 ♂, 1 ♀
Develi (38°23′N, 35°29′E)	1 ♂	Ardahan (41°06′N, 42°42′E)	1 ♂
Çamardı (37°50′N, 34°59′E)	1 ♂	Kilis (36°43′N, 37°07′E)	1 ♂
Cihanbeyli (38°59′N, 32°52′E)	1 ♂	Elbeyli (36°40′N, 37°27′E)	4 ♂♂, 2 ??
Arguvan (38°47′N, 38°19′E)	1 ♂, 1 ♀	Nizip (37°01′N, 37°48′E)	1 ♂
Tekirdağ (40°59′N, 27°31′E)	1 ♂	Şahinbey (36°54′N, 37°12′E)	1 ♂, 2 ??
Çorlu (41°10′N, 27°48′E)	1 ♂	Dinar (38°04′N, 30°10′E)	1 ♂
Havsa (41°32′N, 26°47′E)	1 ♂	Gönen (37°57′N, 30°30′E)	2 ♀♀, 2 ??
Kapıkule (41°41′N, 26°27′E)	3 ♂♂	Burdur (37°43′N, 30°17′E)	1 ♂, 1 ?
Balıkesir (39°38′N, 27°52′E)	1 ♂, 1 ♀	Korkuteli (37°04′N, 30°12′E)	1 ♀
İzmir (38°25′N, 27°07′E)	2 ??	Mazıdağı (34°29′N, 40°29′E)	1 ♂, 1 ♀
Manisa (38°27′N, 27°25′E)	1 ♂	Gölcük (40°42′N, 29°50′E)	2 ♂♂
Akhisar (38°55′N, 27°50′E)	1 ?	Beşiri (37°50′N, 41°26′E)	1 ♂
Kula (38°32′N, 28°38′E)	1 ♀	Karacadağ (38°17′N, 38°43′E)	1 ?
Eşme (38°24′N, 28°58′E)	1 ?	Van (38°29′N, 43°22′E)	1 ♂
Simav (39°05′N 28°58′E)	1 ♀	Gürpınar (38°19′N, 43°24′E)	1 ♂
Söğüt (40°00′N, 30°11′E)	1 ♂		

variables ($P > 0.05$), and so data were combined from both sexes in subsequent analyses.

Skulls were prepared following Mursaloğlu (1965). Diagnostic characters of the species were recorded according to Ognev (1940) and Harrison and Bates (1991). Guard hairs from each specimen were taken from between the shoulder blades dorsally and prepared according to Hayat (1972). The tip, middle, and basal parts of the hairs were photographed at 1000× magnifications with a JSM 5600 scanning electron microscope. The hair scale forms were defined according to Benedict (1957).

Using the data of the characteristics emphasized in this study, an analysis of variance (ANOVA) one-way test was performed to examine the differences between the groups. As a post hoc test, Tukey's test was used. Additionally, the differences between the means of groups except the Thracian group, having only one specimen, were analyzed by multivariate ANOVA (MANOVA).

A factor analysis was performed taking all the characteristics measured (except for W, TBL, and TL values, for which data were missing) into account. It was observed that the preconditions of Bartlett's sphericity

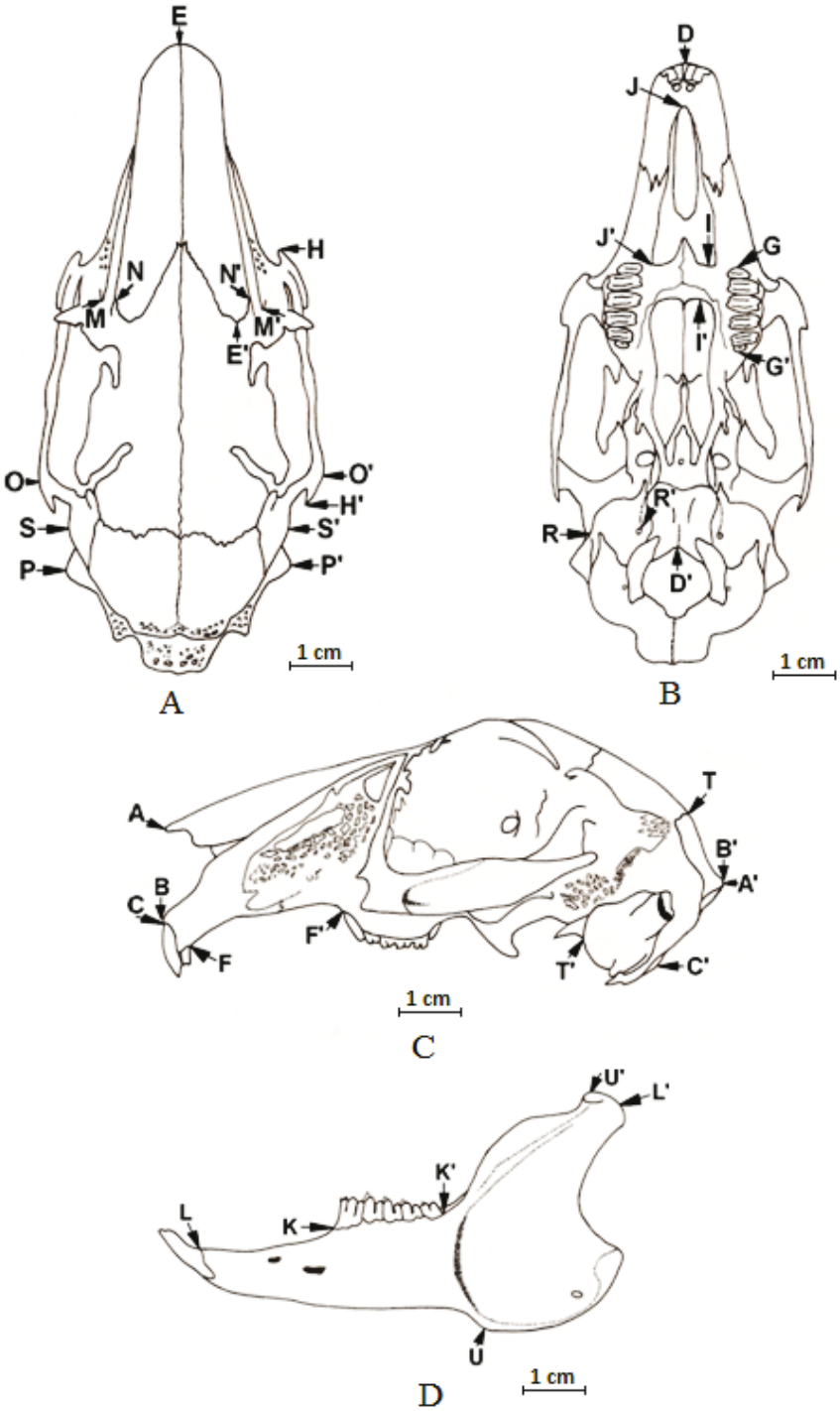

Figure 2. Characters measured on the skull and the mandible of Turkish hares (*L. europaeus*). A) dorsal view of skull, B) ventral view of skull, C) lateral view of skull, D) lateral view of the mandible. (A-A'): ONL, (B-B'): PFL, (C-C'): CBL, (D-D'): BL, (E-E'): NL, (F-F'): DL, (G-G'): UML, (H-H'): ZL, (I-I'): PL, (J-J'): FIL, (K-K'): LML, (L-L'): MAL, (M-M'): RB, (N-N'): NB, (O-O'): ZB, (P-P'): MAB, (R-R'): BTB, (S-S'): BBC, (T-T'): HBC (U-U'): MAH.

test, which is a prerequisite for factor analysis, were met ($P < 0.01$). In the principal component analysis (PCA), variance maximizing (varimax) rotation was used. By using discriminant analysis (Fisher's linear discriminant functions) according to 5 populations, it was ensured that specimens were correctly classified into their original groupings. Additionally, cluster analysis was performed on specimens and the results were shown by dendrogram. The statistical analysis were conducted using Minitab Version 16.1.0 (2010), PASW Statistics 18 (2010), and PAST Version 2.17c (Hammer et al., 2001).

Specimens were deposited in the mammal collection at the Department of Biology of Kırıkkale University in Kırıkkale.

3. Results

A total of 125 hares obtained from different localities in Turkey were examined (Figure 1). It was found that all of our samples were *Lepus europaeus*.

Lepus europaeus Pallas, 1778, European brown hare

1778. *Lepus europaeus* Pallas, 1778. Nova Spec. Quad. Glir. Ord., p. 30.

Type locality: Poland

Diagnostic characters: General pelage color of adult specimens varied from yellowish light brown to grayish brown. Hind foot length was 135.0–160.0, occipitonasal length was 87.7–104.0, condylobasal length was 79.5–93.0, zygomatic breadth was 42.0–48.8, upper molar length was 11.8–17.0, lower molar length was 14.0–18.9, mandible length was 64.7–75.0, phallic length was 29.5–35.0, and phallic breadth was 5.3–6.2 mm (Table 2).

Phallus characters: The phallus had a segmented look after the distal part. The urethral opening located ventrally in the phallus was rhomboidal in shape (Figure 3). There was no variation between regional groups with respect to phallus characteristics.

Pelage color: Dorsal color of adult specimens varied from a light pale yellowish brown to a much darker yellowish brown, tinged slightly with black. In other specimens, except for the yellowish Kilis-Elbeyli specimens, the hind quarter part of the dorsum was gray. The inner lower edges of the ears, including the pale blackish or pale brownish strip, were dirty-white tinged slightly yellow or whitish light yellow. The dorsal surface of the tail varied between blackish brown and black. Ventral color, which was a band in the lower part of the neck ranging in size from small to large, was white with a mark of pale rust or yellow. The distinctive line between the dorsal and the ventral pelage was a faint, thin line.

Pelage color showed a little difference between age groups and sexes. Furthermore, winter pelage differed slightly from summer pelage. A prominent pure white mark was located on the middle of the crown behind the eyes on all leverets as well as on most juvenile and some adult specimens. This white mark was not present on older specimens.

Hair scale structure: The structure of the hair scales in the samples analyzed from 5 regional groups was flattened-imbricate (Figure 4).

Cranial features: In adults, the skull was slender and the braincase descended through an angle of 45° in the vertical plane, passing from the dorsal supraorbital bone. Therefore, the back part of the skull appeared slightly deflected downwards when viewed laterally. The nasal bones were relatively broad. The interorbital region was broad and flat and the postorbital region was narrow. The supraorbital bone in the upper orbital cavity formed an auricular shape with a broad curve. The zygomatic arches were thin and relatively broad. The foramen incisivum was massive and broadened in the posterior part. The palatine was partially narrowed between the posterior ends of P^4, with the beginning of P^2 between foramen incisivum and mesopterygoid space. The mesopterygoid space was very large. The tympanic bullae were small and the processes of the auditory canals were distinctly long and broad. The mandible was a massive and plate-like posterior part.

Measurements: External and cranial measurements and weights of adult specimens are given in Table 2. According to results of variance analysis in terms of the W, TL, BL, CBL, RB, HBC, FIL, ONL, PFL, and MAH characteristics, the differences between the means of groups were found to be statistically significant ($P < 0.01$; Table 2). The ages, measurements, and weights of the leverets are presented in Table 3.

In factor analysis, the Kaiser–Meyer–Olkin measure of sampling adequacy showed a high level of sampling adequacy with the value of 0.816. PCA extracted 5 principal components (PCs) that explained 71.56% of the total variance (Table 4). The first component explained 44.22% of total variance, the second 9.26%, the third 7.73%, the fourth 5.68%, and the fifth 4.66%. The highest contribution to PC1 was found in the characteristics of BL, CBL, NL, DL, ZL, FIL, ONL, PFL, LML, and MAL with values above 0.600, while 5 characteristics (RB, ZB, MAB, HBC, and BBC) contributed to PC2, 3 characteristics (HFL, UML, and MAH) to PC3, 2 characteristics (NB and BTB) to PC4, and 2 characteristics (EL and PL) to PC5. For this reason, it was considered to be suitable to name Factor I as "Cranial lengths factor", Factor II as "Cranial breadths factor", Factor III as "HFL&MAH factor", Factor IV as "NB&BTB factor", and Factor V as "EL&PL factor".

Discriminant function analysis (DFA) showed that of the 54 specimens from all groups, 48 (88.9%) were classified correctly. The first 2 canonical discriminant functions that explained 84.5% of the variance markedly separated the Thracian specimen from the other populations (Figure 5).

Table 2. Descriptive statistics of morphometric measurements (mm) with weights (g). 1= Thracian population, 2= Southwest Anatolian population, 3= Central and East-Central Anatolian population, 4= Northeast Anatolian population, 5= Southeast Anatolian population. g = group, n = sample size, m = mean, l = letter, sd = standard deviation, r = range. Different letters indicate statistically significant differences between the means. *: Group consists of only one sample.

Variable	g	n	m	l	sd	r	Variable	g	n	m	l	sd	r
W	1	2	4025.0	A	35.4	4000.0–4050.0	CBL	1	3	89.68	A	1.16	88.35–90.50
	2	6	3617	AB	331	3200–4000		2	13	86.58	AB	3.18	81.50–91.70
	3	12	3173	AB	419	2550–4050		3	43	84.41	B	3.01	79.50–93.00
	4	6	2967	B	472	2300–3500		4	4	82.06	B	2.03	80.00–84.85
	5	4	3075	AB	320	2800–3400		5	10	84.39	AB	2.57	81.00–89.00
TBL	1	2	657.50	A	3.54	655.00–660.00	NL	1	2	43.28	A	4.00	40.45–46.10
	2	5	598.0	A	23.9	560.0–620.0		2	12	43.95	A	2.34	40.75–49.30
	3	10	612.0	A	46.4	500.0–670.0		3	42	42.72	A	2.70	36.50–47.50
	4	5	582.0	A	44.9	520.0–630.0		4	5	41.78	A	1.53	39.75–44.00
	5	4	596. 3	A	31.5	560.0–625.0		5	8	41.53	A	2.08	38.85–45.85
TL	1	2	97.50	AB	3.54	95.00–100.00	RB	1	2	25.65	AB	0.91	25.00–26.30
	2	5	100.00	AB	9.35	90.00–110.00		2	13	26.38	A	1.04	24.50–28.50
	3	11	100.45	A	8.20	90.00–110.00		3	41	25.53	AB	1.43	23.00–28.85
	4	5	87.00	B	7.58	75.00–95.00		4	5	26.10	A	1.69	23.95–27.90
	5	4	103.75	A	2.50	100.00–105.00		5	8	23.82	B	1.65	20.70–26.80
HFL	1	3	155.00	A	5.00	150.00–160.00	NB	1	3	22.51	A	0.72	22.00–23.35
	2	14	139.00	B	3.33	135.00–145.00		2	12	22.07	A	0.96	20.30–23.50
	3	44	141.41	B	4.59	135.00–155.00		3	44	20.97	A	1.84	15.85–23.90
	4	6	149.50	A	6.89	142.00–160.00		4	5	22.24	A	1.71	20.10–23.90
	5	9	141.11	B	4.17	135.00–150.00		5	10	22.13	A	2.31	20.00–27.45
EL	1	4	105.00	A	8.16	95.00–115.00	DL	1	2	27.55	A	0.14	27.45–27.65
	2	14	109.64	A	4.99	100.00–120.00		2	13	27.94	A	1.68	24.40–30.50
	3	44	109.55	A	5.52	95.00–120.00		3	42	27.61	A	1.72	24.75–32.00
	4	6	111.17	A	5.12	102.00–115.00		4	4	26.81	A	0.81	25.95–27.60
	5	8	113.13	A	4.58	105.00–120.00		5	8	26.087	A	0.71	25.00–27.00
BL	1	2	81.88	A	2.30	80.25–83.50	UML	1	3	15.90	A	0.95	15.30–17.00
	2	13	78.742	AB	3.11	73.30–84.00		2	13	15.47	A	0.61	14.50–16.60
	3	40	76.935	ABC	3.05	71.00–83.00		3	45	14.78	A	0.87	11.85–16.60
	4	4	74.662	BC	1.98	72.20–76.85		4	5	14.80	A	1.00	13.15–15.70
	5	7	74.800	C	2.27	71.20–77.70		5	10	14.56	A	0.49	13.50–15.10
ZL	1	2	37.60	A	1.63	36.45–38.75	BBC	1	1	36.80		*	36.80–36.80
	2	12	37.53	A	1.23	36.00–39.55		2	13	32.48	A	1.06	30.80–33.90
	3	40	37.29	A	1.50	33.60–40.50		3	40	32.29	A	1.04	29.85–34.15
	4	4	38.18	A	1.61	35.90–39.45		4	4	31.50	A	1.21	30.35–33.20
	5	7	36.99	A	1.18	35.25–38.70		5	7	31.65	A	0.74	30.70–32.70
ZB	1	3	46.65	A	0.93	45.80–47.65	ONL	1	4	100.47	A	1.37	99.50–102.50
	2	12	45.76	A	1.25	44.45–48.85		2	13	97.20	AB	3.72	93.30–104.00
	3	42	44.93	A	1.62	42.00–48.85		3	42	94.56	B	3.87	87.70–102.20
	4	4	44.14	A	2.00	42.20–46.90		4	5	94.46	AB	2.79	91.00–97.40
	5	9	44.20	A	1.72	42.85–48.30		5	10	93.84	B	2.56	90.20–98.40

Table 2. (continued).

MAB	1	1	36.85		*	36.85–36.85	PFL	1	3	100.23	A	1.47	99.10–101.90
	2	11	36.75	A	1.48	34.30–38.55		2	14	96.90	AB	3.11	92.50–102.00
	3	38	36.35	A	1.43	33.15–39.00		3	37	95.26	AB	3.31	88.65–101.40
	4	5	37.01	A	1.73	34.60–39.40		4	5	96.02	AB	2.39	93.60–99.10
	5	7	35.67	A	0.87	34.30–36.90		5	7	93.40	B	2.04	90.35–97.00
HBC	1	2	27.70	AB	0.42	27.40–28.00	LML	1	2	17.47	A	0.81	16.90–18.05
	2	13	27.92	AB	1.24	26.50–30.15		2	13	17.20	A	0.90	15.40–18.90
	3	39	27.91	AB	1.77	24.05–31.75		3	42	16.45	A	1.03	14.00–18.90
	4	5	29.59	A	1.58	28.00–31.70		4	5	16.31	A	1.15	14.40–17.40
	5	7	26.84	B	1.83	24.10–29.05		5	8	16.33	A	0.68	15.40–17.25
PL	1	2	6.70	A	0.99	6.00–7.40	MAL	1	2	63.63	A	2.30	62.00–65.25
	2	13	6.11	A	0.77	4.40–7.30		2	13	63.21	A	2.26	58.60–67.10
	3	41	6.12	A	0.71	4.60–7.30		3	41	62.34	A	2.35	58.50–68.30
	4	4	5.75	A	0.35	5.40–6.10		4	4	62.57	A	2.57	59.80–65.40
	5	8	6.25	A	0.55	5.50–7.15		5	7	62.03	A	1.55	60.00–64.20
FIL	1	2	25.60	AB	0.56	25.20–26.00	MAH	1	2	39.10	AB	2.69	37.20–41.00
	2	13	25.66	A	1.60	23.15–28.55		2	13	38.92	AB	1.88	35.50–41.70
	3	42	25.39	AB	1.44	21.80–28.50		3	40	37.76	B	1.87	33.25–41.60
	4	4	24.85	AB	0.54	24.30–25.55		4	4	41.61	A	1.74	39.45–43.70
	5	8	23.56	B	0.74	22.55–24.90		5	7	39.0	AB	0.90	37.80–40.30
BTB	1	3	10.10	A	0.40	9.65–10.45							
	2	13	9.83	A	0.53	9.10–10.65							
	3	45	9.850	A	0.60	8.25–11.60							
	4	5	10.47	A	0.32	10.000–10.800							
	5	9	10.07	A	0.71	9.150–11.500							

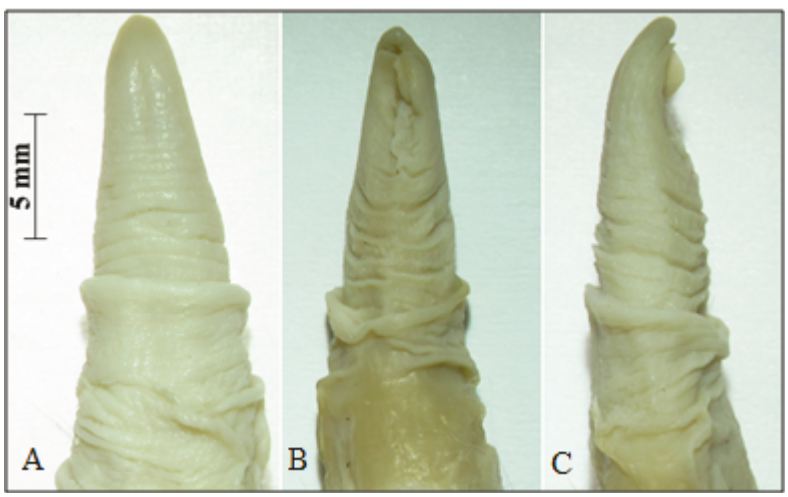

Figure 3. The phallus morphology of *Lepus europaeus* in Turkey: A) dorsal, B) ventral, C) lateral view.

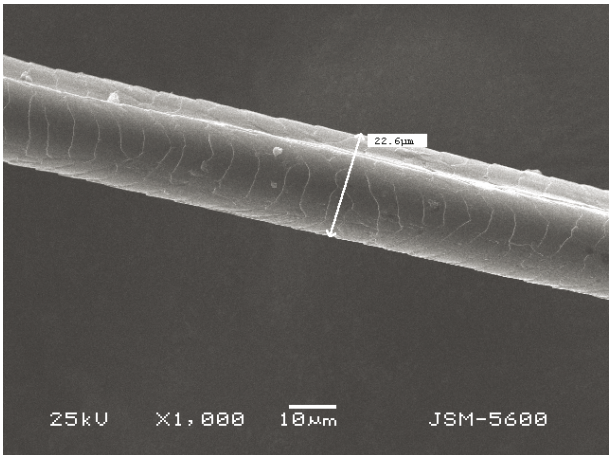

Figure 4. Hair scale structure of *L. europaeus* in Turkey.

Additionally, this specimen was clearly distinguished in the cluster dendrogram (Figure 6).

MANOVA results presented a statistically significant difference between the Central and East-Central Anatolian population and the Northeast Anatolian population ($P < 0.05$).

4. Discussion

The 2 species of the genus *Lepus* in the Palearctic region, *L. capensis* and *L. europaeus*, were distinguished from each other by Ellerman and Morrison-Scott (1951) using the occipitonasal length and bulla breadth. These authors reported that a short occipitonasal length (≤87 mm) was diagnostic for *L. capensis*, while an occipitonasal length of ≥88 mm was diagnostic for *L. europaeus*. They also stated that *L. arabicus* had an auditory bulla that is ≥16% of occipitonasal length, while *L. capensis* and *L. europaeus* had bullae ≤15% of occipitonasal length. In this study, all Turkish specimens were found to have an occipitonasal lengths of ≥88 mm and an auditory bulla ≤15% of the occipitonasal lengths. Therefore, we concluded that our specimens were *L. europaeus*.

To date, *Lepus europaeus* has been recorded from different parts of Turkey by Steiner and Vauk (1966), Sert et al. (2005), Sert (2006), and Tez et al. (2012). Sert et al. (2005) determined that the hares from the semiarid Şanlıurfa region, close to the Syrian border, had a distinct yellow pelage color, whereas all other Anatolian hares in their study represented more or less the European brown hare pelage type, with variably brownish colors interspersed with yellowish, black, and white elements, as well as grayish thighs. However, according to Sert et al. (2005), this distinct color difference was not in parallel with a pronounced genetic diversity. Sert et al. (2005) also reported that even though many alleles found in Anatolian hares were not found in European populations, their allozyme data indicated a close phylogenetic relationship between European and all Anatolian brown hares. Sert (2006) recorded that the variations of the fur color occurred by means of the narrowing and expansion of light and dark bands or the disappearance of some bands of hairs. In this study, apart from the yellowish hares collected from the semiarid Kilis-Elbeyli region, close to the Syrian border, all hares had the typical external appearance (i.e. brown type) of *L. europaeus*. However, morphometric measures of the yellowish Kilis-Elbeyli specimens were similar to those of the brown pelage type.

Yom-Tov (1967) reported that morphometric measurements vary regionally, with pelage color matching soil color. In this study, MANOVA results of populations from different geographical regions in Turkey presented a significant difference only between the Central and East-Central Anatolian population and the Northeast Anatolian population with respect to morphometric measurements. The findings of the present study regarding the pelage color were in line with those of Yom-Tov (1967). Sert et al. (2005) reported that genetic diversity was the highest in Anatolian hares, moderate in brown hares from the southern and southeastern Balkans, and the lowest in Central European populations. However, Sert et al. (2005) stated that genetic differentiation among Anatolian populations was low and there was an increase in genetic diversity only among some population pairs that were distributed distantly from each other. Similarly, we also determined that there were moderate morphometric and morphological divergences among populations from different biogeographical regions of Turkey. In DFA, the Thracian specimen was found to be the most distinct. Additionally, Northeast Anatolian specimens were relatively different from others (Figure 5). For a clearer assessment of these discriminations, more samples from the Turkish Thrace region are needed. As mentioned by Harris and Steudel (1997), morphological differences might be determined by ecological adaptations to different environments. Our results support the findings of Suchentrunk et al. (2000), who suggested that the

Table 3. Five morphometric measurements (mm) and weights (g) of leverets.

Age (days)	Skull length	Skull width	Hind foot length	Ear length	Weight
5	46.3	30.0	58.0	45	130
7	48.5	31.0	60.0	46	145

Table 4. Total variance explained (first 5 principal components explain 71.56% of total variance).

Component	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	9.728	44.217	44.217
2	2.038	9.262	53.479
3	1.701	7.731	61.210
4	1.251	5.685	66.895
5	1.026	4.665	71.560

Extraction method: principal component analysis.

external characteristics of Israeli hares were correlated with ecogenetic rather than phylogenetic factors.

Sert et al. (2009) reported that Anatolia's topography, with its many mountain ranges, has no significant impact on gene exchange between hare populations, and Southeast Anatolian hares with yellowish pelages are phylogenetically closely related to all other studied Anatolian hares (with brownish pelages). They also recorded that because of a lack of samples from Central and North Anatolia, the phylogenetic relationships of Anatolian hares have not been completely explained. Demirbaş et al. (2010) stated that the karyotype of Turkish brown hares conforms to the conservative karyotype for the genus, except for the differences owing to differential amounts of heterochromatin occurring in Turkish specimens.

To date, pelage colors and external and cranial measurements of subspecies of *L. europaeus* have been recorded from many countries by various authors (Miller, 1912; Ognev, 1940; Ellerman and Morrison-Scott, 1951; Lewis et al., 1967; Palacios, 1983; Harrison and Bates, 1991) (Table 5).

Miller (1912) and Ognev (1940) reported that *Lepus europaeus europaeus* exists in Central Europe with a yellow or creamy-buff pelage color and *Lepus europaeus transsylvanicus* occurs in the Balkans with a grayish-brown pelage color. The pelage color of our Thracian specimens was not similar to those of *L. e. europaeus* and *L. e. transsylvanicus*. Furthermore, our Thracian specimens had smaller upper and lower molar row lengths than those of the European subspecies. Ognev (1940) included Northeast Anatolia in the distribution area of *Lepus europaeus cyrensis* with a reddish-gray pelage color and Caucasia in the distribution area of *L. e. caucasicus* with a yellowish-gray tinged with brown. Although measurements of our Northeast and East Anatolia specimens were similar to

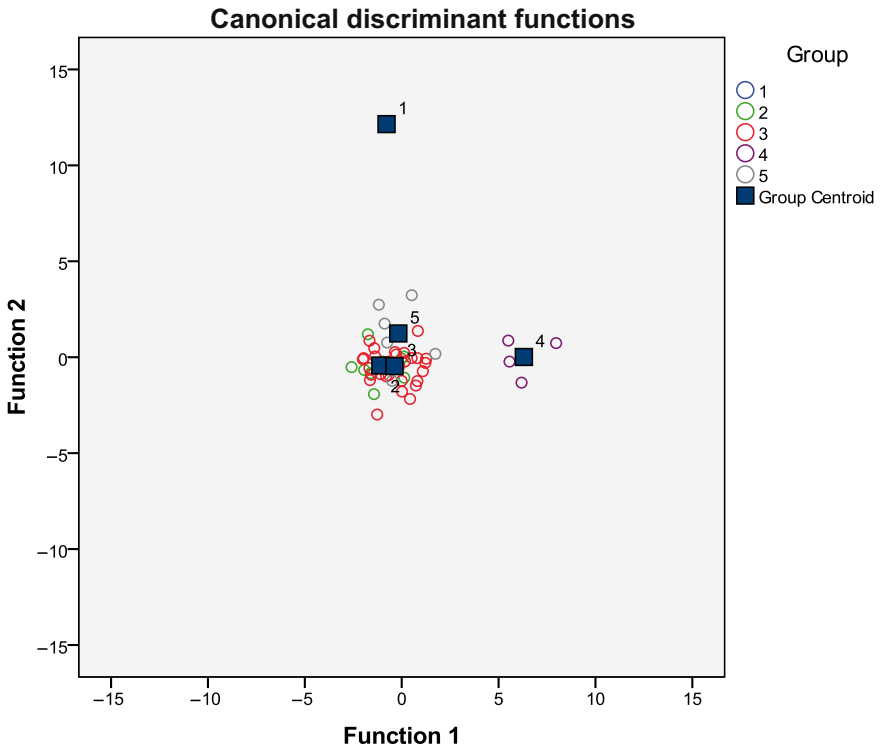

Figure 5. The group centroids obtained from discriminant functions: 1 = Thracian specimen, 2 = Southwest Anatolian population, 3 = Central and East-Central Anatolian population, 4 = Northeast Anatolian population, 5 = Southeast Anatolian population.

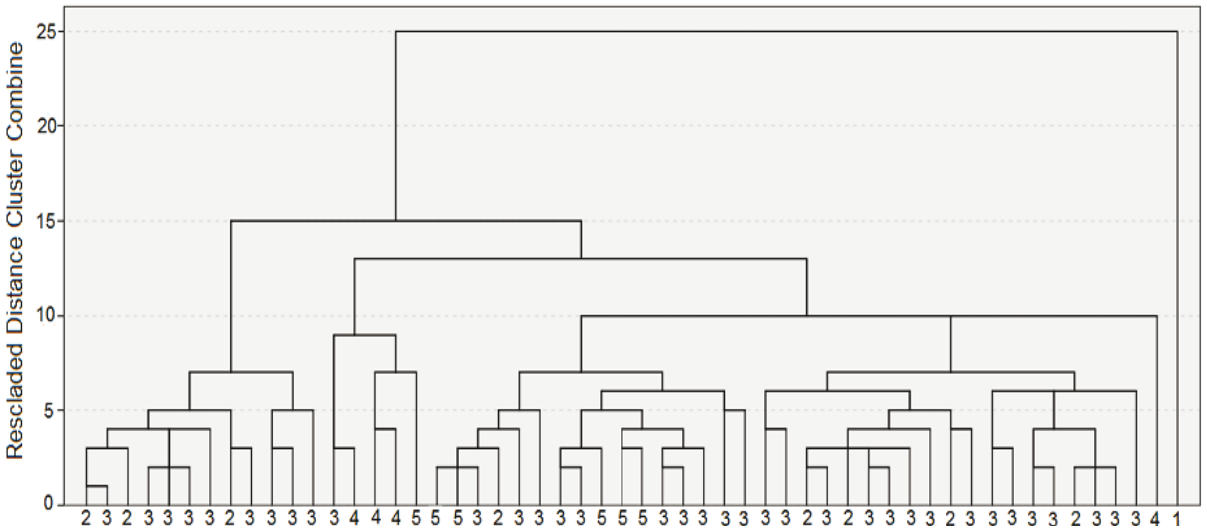

Figure 6. The dendrogram obtained by results of cluster analysis. Figures indicate the groups: 1 = Thracian specimen 2 = Southwest Anatolian population, 3 = Central and East-Central Anatolian population, 4 = Northeast Anatolian population, 5 = Southeast Anatolian population.

Table 5. Measurements of some external and cranial characters (mm) of *Lepus europaeus* specimens from Turkey in comparison with those from Central Europe, the Balkans, Caucasia, Northwest Iran, Syria, Lebanon, and North Israel.

Characters	A (Central Europe)	B (Central Europe)	C (Balkans)	D (Balkans)	E (Caucasia)	F (Caucasia and Northwest Iran)	G (Syria, Lebanon, and North Israel)	H (Turkey)
TBL	–	–	–	–	–	–	557 (498–620)	603 (500–670)
TL	–	–	–		–	–	76.7 (63–86)	97.4 (75–110)
HFL	140	140	147 (123–160)		151 (140–167)	130–150	129.9 (108–141)	141.9 (135–160)
EL	–	–	–		108 (104–115)	110–115	111.2 (101–126)	109.2 (95–120)
ONL	94–102.2	97.7 (89–99)	94.4 (89.3–101)	97.6–105	99.2 (92–105)	93–97	91.5 (83.7–98.0)	95.3 (87.7–104)
CBL	85.5–92.2	86.4 (84–87.7)	83.6 (78.2–89)	86.4–92.2	88.2 (83–94.2)	81–86	80.6 (74.5–87.8)	84.8 (75.5–93)
ZL	45.2–50.2	46.1 (44–48)	46.1 (43.2–48.2)	46.4–48.6	46.6 (43.6–49.2)	43.5–48	43.2 (37.9–46.2)	45 (42–48.8)
BBC	31–34.6	–	–	33.4–34.2	–	–	30.9 (27.3–32.1)	32.2 (29.8–36.8)
NL	42.2–46.2	44.4 (44–47)	43.1 (37.2–46.5)	45.4–46.2	45.7 (41.1–48.8)	41–47	–	42.7 (36.5–49.3)
NB	20.6–24.6	16.9 (16–17)	18.6 (16.8–21.1)	22.2–23.8	19.4 (16.3–22.2)	–	–	21.2 (15.8–23.9)
UML	17.2–19.2	17.4 (17–17.6)	16.9 (15.8–18.1)	17.0–18.4	16.9 (15.2–18.9)	15.3–17.2	15.4 (13.7–16.8)	14.9 (11.8–17)
LML	18.6–20.2	–	–	18.4–19.6	–	–	16.2 (14.0–17.8)	16.5 (14–18.9)

A: Miller (1912) *Lepus europaeus europaeus* Pallas (1778), B: Ognev (1940) *Lepus europaeus europaeus* Pallas (1778), C: Ognev (1940) *Lepus europaeus transsylvanicus* Matchie (1901), D: Miller (1912) *Lepus europaeus transsylvanicus* Matchie (1901), E: Ognev (1940) *Lepus europaeus caucasicus* Ognev (1929), F: Ognev (1940) *Lepus europaeus cyrensis* Satunin (1905), G: Harrison and Bates (1991) *Lepus europaeus syriacus* Ehrenberg (1833), H: this study.

the measurements of the 2 subspecies, the pelage color of our specimens was different. Ellerman and Morrison-Scott (1951) recorded the subspecies *Lepus europaeus syriacus* in Anatolia. According to Lewis et al. (1967) and Harrison and Bates (1991), the subspecies *syriacus*, with pelage color varying from light yellowish-brown to grayish-brown, exists in Syria and Lebanon. In the present study, comparing the morphometric data and pelage color of our specimens with those of the subspecies *europaeus*, *transsylvanicus*, *cyrensis*, *caucasicus*, and *syriacus*, it was concluded that they fall within the range of variation of *L. e. syriacus*. The skull characteristics of our specimens were also similar to those of *syriacus*. However, although being similar to *L. e. syriacus* with respect to pelage color, morphometric measurements, and skull characteristics, the Thracian specimens could not be evaluated statistically under the subspecies rank. Therefore, we decided that the Anatolian hares belonged to the subspecies *L. e. syriacus*.

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