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Studies on the Hair Characteristics of European Hare, *Lepus europaeus* (Lagomorpha: Leporidae) in Turkey

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Abstract.- This study analysed some quantitative and qualitative hair characteristics in 35 brown hare, *Lepus europaeus*, from three different geographic/climatic regions in Turkey to find phenotypic variations and characteristics of hairs of this species, which has commercial fur. Analyzed quantitaive traits included fiber diameter (FD), fiber lengths of hauter (H) and barbe (B), fiber tenacity (T), and elongation (EL). The effects of geography and sex on the mentioned traits were assessed via the Least squares method. It was determined that the traits of FD, H, B, T, and EL were not significantly affected by geographic area or sex. The interaction between geography and sex was found to be insignificant for all traits. Significant phenotypic correlations were found between T and EL (–0.52, P = 0.0048). The structure of the hair scale type was found "mosaic" at the proximal of the shaft, "elongate petal" at the distal of the shaft, "streaked" at the proximal of the shield, and "regular wave" at the distal of the shield. Quantitative hair characteristics and hair scale patterns of the brown hares were determined to be conservative, in spite of the variations in fur colours.

Key words: *Lepus europaeus*, hair characteristics, phenotype, European hare.

INTRODUCTION

Hares (*Lepus* spp.) are placental mammals belonging to the family Leporidae, included in the order Lagomorphs. The family Leporidae is represented by extant 11 genera in the world. The genus *Lepus* includes hares and jackrabbits. Due to their exemplary ability of adaptation and some specialized physiological characteristics, members of this genus are spread on all continents except for Antartica (Hirakawa, 2001; Wilson and Reeder, 2005; Chapman and Flux, 2008; Mengoni, 2011; Ristić *et al*., 2012). These species have a wide spectrum of phenotypic variations. Additionally, hare fur are valuable commercially and their hairs are used as a disgnostic tool in ecology, wildlife biology, and nature management (Hausman, 1920a; Nowak, 1999; Teerink, 2003).

The genus *Lepus* has 32 species in the world. One of these species, brown hare (*Lepus europaeus* Pallas, 1778), showing the most widespread across the world, is the single hare species distributed in Turkey (Sert *et al*., 2005; Kasapidis *et al*., 2005; Chapman and Flux, 2008; Demirbaş, 2010; Demirbaş *et al*., 2013). A recent phylogenetic study suggests that brown hare (*Lepus europaeus*) originated in Anatolia (Mamuris *et al*., 2010). Turkish brown hares have high genetical and morphological variations because Anatolia has been a host for hares of north latitudes during the latest Pleistocene and early Holocene, owing to its suitable climatic conditions and biogeographic location (Kasapidis *et al*., 2005, Sert *et al*., 2005, 2009; Demirbaş *et al*., 2012).

Much research has been carried out in Turkey on the quantitative and microscopic analysis of hair of various domestic and wild mammals (Öztürk and Goncagül, 1995; Albayrak and Çoban, 1997; Bilgen *et al*., 2008; Erat and Arıkan, 2012), but not on brown hares. Sert *et al.* (2005) and Demirbaş *et al.* (2010) gave the records about fur colour of the Turkish brown hare. However, little is known about Turkish brown hares in terms of phenotypic traits and geographical variations, which are often described as insufficent. Such phenotypic features of *L. europaeus* in Turkey are given for the first time in this study. The hypotheses of this study were: (1) that quantitative hair characteristics and hair scale patterns of the Turkish brown hares were conservative within Turkey, in spite of the variations in fur colours; (2) that the interactions between geography and sex for *L. europaeus*

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populations in Turkey were insignificant for all the hair traits measured for this species; (3) that a negative phenotypic correlation between the hair traits of Turkish brown hare was between T and EL. I tested these hypotheses using hair samples collected from 35 adult *L. europaeus* from three different geographic/climatic regions in Turkey, allowing assessment of their hair characteristics.

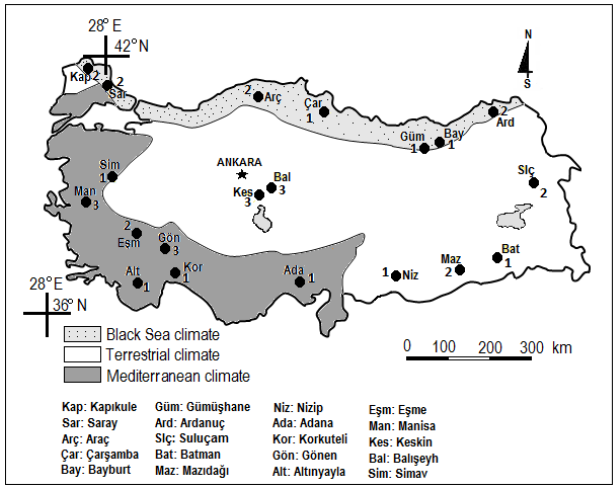

Fig 1. The map shows different climatic regions in Turkey (Black dots indicate localities of samples and figures indicate the number of individuals sampled at the location).

MATERIALS AND METHODS

Study area

Environmental conditions in Turkey are characterized by Black Sea climate, terrestrial climate and Mediterranean climate (Fig. 1). Black sea climate is a rainy, humid and temperate in the north of Turkey, especially in the northern part of the North Anatolian Mountains. The Black Sea coast receives the greatest amount of rainfall. The eastern part of that receives 2.200 millimeters annually and is the only region of Turkey that receives rainfall throughout the year. Terrestrial climate predominates in Central Anatolia, Eastern Anatolia, Southeastern Anatolia and inner part of Thrace. Terrestrial climate is arid and hot in summers, and cold and snowy in winters in the central part of Turkey; hot and dry in the southeastern parts; cold and dry in winters in east. Mediterranean climate which is hot and dry in summers and wet and warm in winters in west and southwestern Anatolia. Annual precipitation in those areas varies from 580 to 1.300 millimeters, depending on location (Sensoy *et al*., 2012) (Fig. 1).

Data collection

This study was carried out with permissions taken from of the General Directorate of Nature Conservation and National Parks of the Ministry of Forestry and Waterworks on 30.06.2008. During autumn hunts (October-December) of 2008 to 2012 years, hares were collected at 20 sampling sites within three Turkish population, separated by geography and climatic conditions. In this study were examined hairs of 11 adults specimens (5 ♀♀, 6 ♂♂) from Black Sea region, hairs of 12 adults specimens (5 ♀♀, 7 ♂♂) from inner parts of Anatolia (Central Anatolia, Eastern Anatolia, Southeastern Anatolia) and hairs of 12 adult specimens (6 ♀♀, 6 ♂♂) from Mediterranean region (Fig. 1). The age determination was identified according to the "Stroh sign" located at the tip of the ulna bone (Stroh, 1931).

Hair samples for quantitative analysis were taken by a scissor from costal area of each hare. Analysis of hair traits were performed in Lalahan Livestock Central Research Institute. For the hair analysis, Erat and Arıkan (2012) was followed. For fiber diameter (FD) analyses, an Uster OFDA 100 instrument was used; whereas for fiber length analysis, an Uster AL 100 instrument was used. Two values for fiber length were calculated: hauteur (H) and barbe (B). H is the length value based on the number of fibers; B is the length value based on the weights and the volumes of fibers. For the tenacity (T) and elongation (EL) analyses, a FAFEGRAPH HR + ME single fiber tensile tester instrument was used. T is a force necessary to produce a rupture for an individual hair; EL is the elongation at break.

The guard hairs for morphological analysis were taken from the shoulder blades dorsally and prepared according to Hayat (1972). Hair specimens were placed in acetone for 30 min, in an acetone-distilled water solution (1:1) for 15 min, and finally in distilled water for 10 min. Hairs were photographed at 500× and 1000× magnification

with a JSM 5600 scanning electron microscope (SEM). The determination of hair scale patterns was defined according to Teerink (2003).

Statistical analysis

The effects of geography and sex factors on the hair traits were analyzed using the Least squares method. The phenotypic correlations between the hair traits of the hares were also computed. The Generalised Linear Model (GLM) procedure of SAS (SAS Institute, Cary, NC, USA) were used to perform the statistical analysis.

RESULTS

Fur colorations of Turkish hares were relatively different for geographic regions. In the north-western Turkey, brownish yellow tinged gray or black fur colour type predominated, whereas in the central, eastern and southeastern Anatolia yellowish light brown tinged, slightly gray or black fur colour type was prominent. And in the Black Sea region hares possessed light brown tinged, slightly black fur colour types, and the furs of all samples were fairly soft.

Descriptive statistics of the hair traits, least squares means and standard errors of the main effects, and the significance levels of model terms for the hair traits, are given in Tables I, II and III, respectively. The FD, H, B, T, and EL values were not significantly affected by geography and sex (Tables II, III). Significant phenotypic correlations were found only between T and EL (–0.52, P = 0.0048) (Table IV).

Table I.- Traits of fiber diameter (FD), hauter (H), barbe (B), tenacity (T), and elongation (EL) in Turkish hare.

Variable	n	Mean±S.D.	(Range)
FD (µm)	35	14.79±1.10	(13.05-17.58)
H (mm)	35	19.46±1.80	(16.10-23.20)
B (mm)	35	21.06±2.20	(18.50-28.80)
T (g/den)	35	33.18±16.48	(8.45-119.00)
EL (%)	35	25.66±3.12	(13.68-31.46)

The guard hair type was GH2, in which the shield and shaft usually form an angle with each other. The structure of the hair scale type was found to be "mosaic" at the proximal of the shaft, "elongate petal" at the distal of the shaft, "streaked" at the proximal of the shield, and "regular wave" at the distal of the shield (Fig. 2). It was determined that there were not any variations in terms of hair morphology among the three analysed regions of Turkish hare populations.

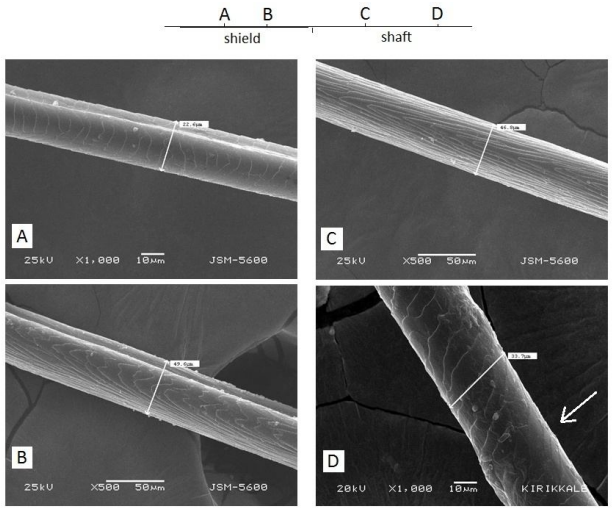

Fig. 2. Scale patterns of *Lepus europaeus* in Turkey (A, regular wave; B, streaked; C, elongate petal; D, mosaic).

DISCUSSION

The hair and mohair characteristics of some domestic mammals such as goats, cats, dogs, sheep and rabbits have been examined in detail by many researchers (Qi *et al*., 1994; Öztürk and Goncagül, 1995; Bunge *et al*., 1996; Herman *et al*., 1996; Sato *et al*., 2006; Rafat *et al*., 2007; Bilgen *et al*., 2008; Erat and Arıkan, 2012). The hair morphologies of various wild mammals (*i.e.*, order Logomorpha, Insectivora, Carnivora, Rodentia, and Chiroptera) have been also studied microscopically by some researchers (Hausman, 1920a,b, 1921; De Marinis and Angelli, 1993; De Marinis and Asprea, 2006; Sert, 2006). Albayrak and Çoban (1997) studied the hair morphology of some mammalian species in Turkey. However, there was no information for *Lepus* sp. Teerink (2003) proposed cross-section and cuticular scale pattern as discriminant characteristics. The researcher recorded hair characteristics

Table II.- Least squares means and standard errors for fiber diameter (FD), hauter (H), barbe (B), tenacity (T), and elongation (EL) in Turkish hare.

Effect	N	FD (µm)	H (mm)	B (mm)	T (g/den)	EL (%)
Region						
Black Sea	11	15.12±0.48	17.84±0.66	19.15±0.80	28.60±8.81	24.36±1.27
Inner Anatolia	12	14.26±0.30	19.36±0.52	22.45±0.75	35.10±8.56	22.10±1.86
Mediterranean	12	14.05±0.48	19.45±0.70	22.60±0.85	34.02±8.76	23.76±1.20
Sex						
Female	16	15.70±0.44	19.25±0.52	20.58±0.52	36.14±6.50	23.22±1.15
Male	19	15.95±0.38	19.05±0.46	22.12±0.70	30.15±7.42	25.08±1.24

Table III.- Significance levels of model terms for fiber diameter (FD), hauter (H), barbe (B), tenacity (T), and elongation (EL).

Effect	FD	H	B	T	EL
Region (R)	0.6824	0.2215	0.1125	0.7436	0.5916
Sex (S)	0.6343	0.8817	0.3179	0.3970	0.2532
R X S					0.1018

Table IV.- Phenotypic correlations between the hair traits of Turkish brown hare.

Trait	Fiber length (H)	Fiber length (B)	Fiber tenacity	Elongation
Fiber diameter	0.02	0.25	–0.22	0.12
Fiber length (H)		0.89	–0.24	0.21
Fiber length (B)			–0.35	0.20
Fiber tenacity				–0.52*

*P < 0.05

of west European mammals. The hair scale patterns of our specimens were similar to those of *L. europaeus* reported by Teerink (2003).

Hermann *et al.* (1996) recorded that fiber diameters ranged from 12.6 µm to 19.8 µm for Angora rabbits' fiber from different origins. The fiber diameter of the Turkish brown hares in this study falls within this range of variation for Angora rabbits. Öztürk and Goncagül (1995) and Bilgen *et al.* (2008) stated that the T and EL values of mohairs of Angora goats ranged from 8.7 g/den to 27.5 g/den and from 26.5% to 47.7%. These results suggested that the hairs of the Turkish brown hare were stronger and had lower elasticity in comparison to the mohair of Angora goats.

Teerink (2003) stated that *L. europaeus* had a thick hair medulla. It is considered that if hair is a thick medulla, elongation increases and tenacity reduces. Therefore, a negative phenotypic correlation between the hair traits of Turkish brown hare was between only T and EL.

Sert (2006) pointed out that there is a significant correlation between hair diameter of hares and rainfall. However, the researcher was not able to acquire a distinct grouping among measured values in hairs. The author also stated that micro measured values were more significant taxonomically. In this study, although the Black Sea region was the rainiest region included, this region's data did not differ from those of others in terms of fiber diameter.

Least squares means of fiber FD, H, B, T, and EL for two cat breeds in Turkey (Turkish Angora cats and Turkish Van cats) were reported earlier by Erat and Arıkan (2012). These authers found that the H (27.5 versus 20.1 mm), B (33.1 versus 23.4 mm), and EL (33.8% versus 24.0%) values were all greater (P<0.0001) for the Turkish Angora cats, while only the T value (12.1 versus 7.6 g/den) was greater (P = 0.0001) for the Turkish Van cats. As for sex, only the FD value (27.2 versus 21.9 µm) was greater (P = 0.0001) for the male cats. However, such quantitative hair characteristics of *L. europaeus* from Turkey are given for the first time in this study. The present study states that the FD, H, B, T, and EL traits for the Turkish brown hares are not significantly affected by geography and sex. These results may support that *L. europaeus*

populations in the all over Turkey have similar genetic structure, as mentioned earlier by Sert *et al*. (2005) and Demirbaş *et al*. (2013). It was revealed that the quantitative and morphological hair characteristics of brown hares in autumn season examined in this study were determined as conservative. It is supposed that these results will make a contribution to the phenotypic features and ecomorphology of Turkish hares.

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REFERENCES

ALBAYRAK, İ. AND ÇOBAN, N., 1997. Hair Morphology of Some Mammalian Species in Turkey. *Communications Fas. Des. Scien. De L univ. D-Ankara*, **15**: 21-39, (In Turkish, English summary).

BİLGEN, A., ANKARALI, B., AKMAN, N., AYTAÇ, M. AND EROL, H., 2008. Lahan Hayvancılık Merkez Araştırma Enstitüsü'nde Yetiştirilen Ankara Keçilerinde Bazı Tiftik Özellikleri ve Kırkım Sonu Canlı Ağırlığı. *Lalahan Hay. Arast. Enst. Derg*., **48**: 28-33, (In Turkish, English summary).

BUNGE, R., THOMAS, D.L., NASH, T.G. AND LUPTON, C.J., 1996. Performance of hair breeds and prolific wool breeds of sheep in Southern Illinois: wool production and fleece quality. *J. Anim. Sci*., **74**: 25-30.

CHAPMAN, J.A. AND FLUX, J.E.C., 2008. Introduction to the Lagomorpha. In: *Lagomorpha biology: Evolution, ecology, and conservation* (eds. P.C. Alves, N. Ferrand and K. Hackländer), Springer Press, Berlin, pp. 1-9.

DE MARINIS, A.M. AND ANGELLI, P., 1993. Guide to the microscope analysis of Italian mammals hairs: Insectivora, Rodentia and Lagomorpha. *Boll. Zool*., **60**: 225-232.

DE MARINIS, A.M. AND ASPREA, A., 2006. Hair identification key of wild and domestic ungulates from southern Europe. *Wildl. Biol*., **12**: 305-320.

DEMİRBAŞ, Y., AŞAN, N. AND ALBAYRAK, İ., 2010. Cytogenetic study on the European brown hare (*Lepus europaeus* Pallas, 1778) (Mammalia: Lagomorpha) in Turkey.*Turk. J. Biol*., **34**, 247-252.

DEMİRBAŞ, Y., 2010. *Türkiye Lepus Linnaeus, 1758 Cinsinin Taksonomik Durumu (Mammalia: Lagomorpha).* PhD thesis. University of Kırıkkale, Turkey.

DEMİRBAŞ, Y., ALBAYRAK, İ. AND SUCHENTRUNK, F., 2012. Population genetics of Turkish hares. *Proceedings* 4th W.L.C., July 23-27, Vienna, Austria, pp. 45.

DEMİRBAŞ, Y., ALBAYRAK, İ. AND YILMAZ, A., 2013. Studies of ecomorphological variations of the European hare (*Lepus europaeus*) in Turkey. *Arch. Biol. Sci., Belgrade*, **65**: 559-566.

ERAT, S. AND ARIKAN, Ş., 2012. The hair characteristics of Turkish Angora and Van cats. *Turk. J. Vet. Anim. Sci.*, **36**: 215-221.

HAUSMAN, L.A., 1920a. The Microscopic Identification of Commercial Fur Hairs. *Scient. Month.*, **10**: 70-78.

HAUSMAN, L.A., 1920b. Structural Characteristics of the Hair of Mammals. *Am. Nat*., **54**: 496-523.

HAUSMAN, L.A., 1921. Hair coralation in Animals. *Scient. Month.*, **12**: 215-222.

HAYAT, M.A., 1972. *Basic electron microscopy techniques*. Van Nostrand Reinhold Company, New York.

HERMANN, S., WORTMANN, G. AND WORTMANN, F.J., 1996. Characteristics of Angora rabbit fibre 1. The influence of fibre origin on fibre and medulla diameter in Angora wool. *World Rabbit Sci*., **4**: 149-153.

HIRAKAWA, H., 2001. Coprophagy in leporids and other mammalian herbivores. *Mammal Rev.*, **31**: 61–80.

KASAPIDIS, P., SUCHENTRUNK, F., MAGOULAS, A. AND KOTOULAS, G., 2005. The shaping of mitochondrial DNA phylogeographic patterns of the Brown hare (*Lepus europaeus*) under the combined influence of Late Pleistocene climatic fluctuations and anthropogenic translocations. *Mol. Phylogenet. Evol.*, **34**: 55-66.

MAMURIS, Z., MOUTOU, K.A., STAMATIS, C., SARAFIDOU, T. AND SUCHENTRUNK, F., 2010. Y DNA and Mitochondrial lineages in European and Asian populations of the brown hare (*Lepus europaeus*). *Mammal. Biol.*, **75**: 233-242.

MENGONI, C., 2011. *Phylogeny and genetic diversity of Italian species of hares (genus* Lepus*).* Ph.D. thesis. University of Bologna, Italy.

NOWAK, R.M., 1999. *Walker's Mammals of the World*. The Johns Hopkins University Press, Baltimore and London.

ÖZTÜRK, A. AND GONCAGÜL, T., 1995. Muhtelif yaşlardaki Ankara keçilerinde tiftik verimi ve tiftik özellikleri. *Lalahan Hay. Arast. Enst. Derg.*, **35**: 67-78, (In Turkish, English summury).

QI, K., LUPTON, C.J., PFEIFFER, F.A. AND MINIKHIEM, D.L., 1994. Evaluation of the Optic Fibre Diameter Analyser (OFDA) for measuring fiber diameter parameters of sheep and goats. *J. Anim. Sci.*, **72**: 1675-

1679.

RAFAT, S.A., DE ROCHAMBEAU, H., BRIMS, M., THEBAULT, R.G., DERETZ, S., BONNET, M. AND ALLAIN, D., 2007. Characteristics of Angora rabbit fiber using optical fiber diameter analyzer. *J. Anim. Sci.*, **85**: 3116-3122.

RISTIĆ, Z.A., MARKOVIĆ, V., BAROVIĆ, V. AND VASILJEVIĆ, D.A., 2012. Loss calculation model of brown hare (*Lepus europaeus* Pall) and its application in the hunting grounds of Vojvodina region (north Serbia). *Pakistan J. Zool.*, **44**: 1-5.

SATO, H., MATSUDA, H., KUBOTA, S. AND KAWANO, K., 2006. Statistical comparison of dog and cat guard hairs using numerical morphology. *Forensic Sci. Int*., **158**: 94-103.

SENSOY, S., DEMİRCAN, M., ULUPINAR, Y. AND BALTA, İ., 2012. Climate of Turkey. *http://www.mgm.gov.tr/files/en-US/climateofturkey.pdf*, accessed on 22.06.2012.

SERT, H., SUCHENTRUNK, F. AND ERDOĞAN, A., 2005. Genetic diversity within Anatolian brown hares (*Lepus europaeus* Pallas, 1778) and differentiation among Anatolian and European populations. *Mammal. Biol.*, **70**: 171-186.

SERT, H., 2006. *Akdeniz ve Güneydoğu Anadolu Bölgesi ile Orta, Avrupa, Ortadoğu ve Güney Afrika Yaban Tavşanı Populasyonlarında Ekomorfolojik ve Moleküler Varyasyonlar (Lagomorpha: Lepus).* Ph.D. thesis. University of Akdeniz, Turkey.

SERT, H., BEN SLIMEN, H., ERDOĞAN, A. AND SUCHENTRUNK, F., 2009. Mitochondrial HVI sequence variation in Anatolian hares (*Lepus europaeus* Pallas, 1778). *Mammal. Biol.*, **74**: 286-297.

STROH, G., 1931. Zwei sichere Altersmerkmale beim Hasen. *Berl. Tierarztl. Wschr*., **12**: 180-181.

TEERINK, B.J., 2003. *Hair of West-European mammals*. Cambridge University Press, Cambridge.

WILSON, D.E. AND REEDER, D.M., 2005. *Mammals species of the World: A taxonomic and geographic reference*. John Hopkins University Press, Baltimore.

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