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*Research article*

# Pelage coloration and hair structure of the grey wolf (*Canis lupus*) in Turkey

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**Abstract:** Pelage coloration and hair structure are reported for 32 grey wolf, *Canis lupus*, specimens collected between 2015 and 2020 from different regions of Turkey. The specimens were divided into three age groups; pups, juveniles and adults. Three pups have smoky grey dorsal pelage coloration. The dorsal pelage of juvenile and adult specimens, though slightly different, has a dense black colour that stretches in a narrow strip from the neck and shoulders to the tail. The flanks are slightly reddish-greyish yellow. The underside is a very pale yellowish dirty white. Hairs on the proximal dorsal tail and on the tail tip are longer than on the rest of the tail. The tips of these hairs are black, their bases are whitish and the mid-shafts are buffy. Bases, shafts and tips of guard hairs were examined and it was determined that they are of the "irregular wavy crenated" type in general structure.

**Keywords:** Pelage coloration, hair structure, scale patterns, grey wolf, Turkey.

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## Introduction

Mammalian fur has been important throughout human history. Both herbivorous and carnivorous mammals are hunted for their fur. Mammalian fur exploited in this way varies regionally according to its variety of colours and quality. Hair structural characteristics differ between species, so that, for example, hair morphology is widely used in the elucidation of some crimes (Huffman & Wallace, 2012). In faecal analyses prey species can be determined by considering hair morphology. In addition, it is seen that fur coloration and hair structure are important characteristics in taxonomic and systematic studies. The grey wolf, *Canis lupus*, has an extensive geographical distribution from North America and throughout much of Eurasia, and it occupies a wide range of habitats from deserts to the Arctic (Mech & Boitani, 2003). Given that the grey wolf is adapted locally to widely varying climatic conditions and habitats, the coloration and insulative properties of the pelage vary considerably. There are several detailed descriptions of grey wolf pelage coloration from different parts of its Old World distribution. Miller (1912) described the pelage coloration of *Canis lupus lupus* from Europe as generally yellowish brown or buff on the upper parts, tail and outer surfaces of the legs, darker along the back, posterior head and ears, and pale buff or buffy white underparts, while Ognev (1962) described the dorsal pelage coloration of Russian wolves in summer as light greyish rusty with black hair tips, and the ventral fur coloration was whitish pale yellowish brown.

Harrison and Bates (1991) and Ferguson (2002) recognised two putative subspecies of grey wolf in the Middle East and Arabia; *C. l. pallipes* extends as far as the Indian subcontinent, and *C. l. arabs* is restricted to the Arabian Peninsula. They described their very variable pelage colorations.

Turan (1984) pointed out that in Turkish wolves the general colour was dark on the dorsum, mostly dirty yellow on the abdomen and interior of the legs, with a black line running along the anterior of the forelegs. He

noted that the tail was darker and the tip was black; in winter the guard hairs were longer with thin grey or grizzled underfur. There is a V-shaped dark area on the withers. However, this is not a detailed description of the pelage coloration of the grey wolf in Turkey and takes no account of age and seasonal differences. The general structure of Turkish wolf hair was determined as "wavy crenated" type (Albayrak & Çoban, 1997).

The aim of this study is to describe the coloration of the fur and structure of guard and contour hairs of the grey wolf in Turkey based on specimens of different ages collected from across the country.

## Materials and Methods

This study was based on a sample of 32 specimens (21 adults, 6 juveniles, 5 puppies), which was collected from various localities in Turkey between 2015 and 2020.

In this study wolwes which killed by road accident or found in field already dead used. No wolves have been killed for this study. Samples were examined taking into account specimen age and sex, and fur coloration was assessed in relation to geographical location. Fur colour comparisons were based on fur samples from the Central Anatolia Region, which have sufficient seasonal samples. Pelage coloration was recorded according to the colour definitions of Ridgway (1886). Guard and contour hair samples were taken dorsally close to the neck in order to examine hair structure. After shaking for 90 seconds in a solution with a 5:95 ratio of glacial acetic acid to 70% ethanol, the hair samples were washed with distilled water and dried at 29 °C for about 24 hours in an oven (Benedict, 1957). Hair samples were examined with a Zeiss digital imaging system microscope to examine their general structure. Photographs of scale patterns of the samples were taken with a JSM-5600 scanning electron microscope (SEM) in the Kırıkkale University, Centre of Scientific and Technological Research and Application (KÜBTUAM) (Hayat, 1972) and evaluated using Teerink (1991). In order to examine their cross-sectional structure under the light microscope, guard and contour hair samples were embedded in paraffin (Thermo Histostar Histocentre), and transverse and longitudinal sections 4-8 μ thick were made with a fully automatic rotary microtome (Leica-Rm 2255).

## Results

In our wolf sample there is individual variation in pelage coloration in different regions of the body. Although there is a similarity of coloration between adult and young specimens, the backs of adult specimens have a blackish tone, resulting from black hair tips, which run as a narrow strip from the shoulder to the tail. The upper flanks are light reddish, pale greyish yellow, which extends to the palmar and the plantar pads, including the exterior of the legs. This coloration continues from the forehead to the rhinarium, mixed with light blackish grey. An amorphous, very light yellowish grey is dominant around the eyes and towards the anterior edges of the mouth. The backs of the ears vary from reddish dirty yellow to yellowish slightly reddish grey. The outer edges of the ears are covered with slightly yellowish grey tinged with light reddish long hairs. Generally, the inner surface of the ears varies from the dorsal coloration and is greyish white, contrasting with the sometimes relatively long reddish-yellow hairs at the edges. The underside is light pale yellowish dirty white, which continues from under the chin to the edges of the muzzle anteriorly and continues posteriorly to the tail with a notably yellowish tint. The tail edges have a black tone that fades slightly to grey, which gradually darkens towards the tip (Figure 1). This fur color releated to summer varies to somewhat ligter towards winter.

Fur coloration of three puppies taken from Antalya and Yozgat provinces is smoky grey and it differs from that of juveniles and adults.

Hairs located on the dorsum, as well as on the dorsal tail and tail tip are longer than elsewhere on the body. These longer hairs have a black tip, a whitish base and are buff in the middle (Figure 2). SEM photographs of the different parts of the guard hairs in *Canis lupus* show that the cuticle layers are relatively wide basally, narrow gradually moving along the shaft and then widen again at the tip. The general structure of our specimens was of the "irregular wavy crenated" type (Figure 3-4).

**Figure 1.** Pelage coloration of an adult grey wolf in a rural area near Çankırı Province

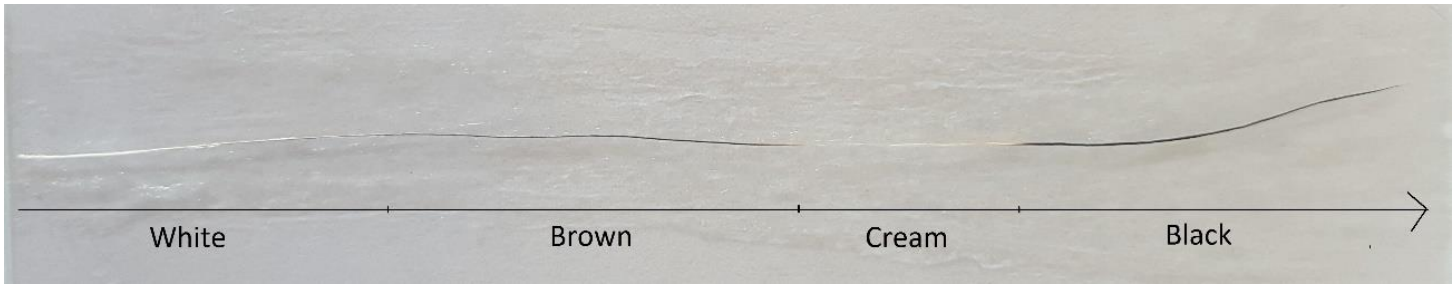


**Figure 2.** Guard hair coloration of the grey wolf, showing bands of different coloration from hair base to tip

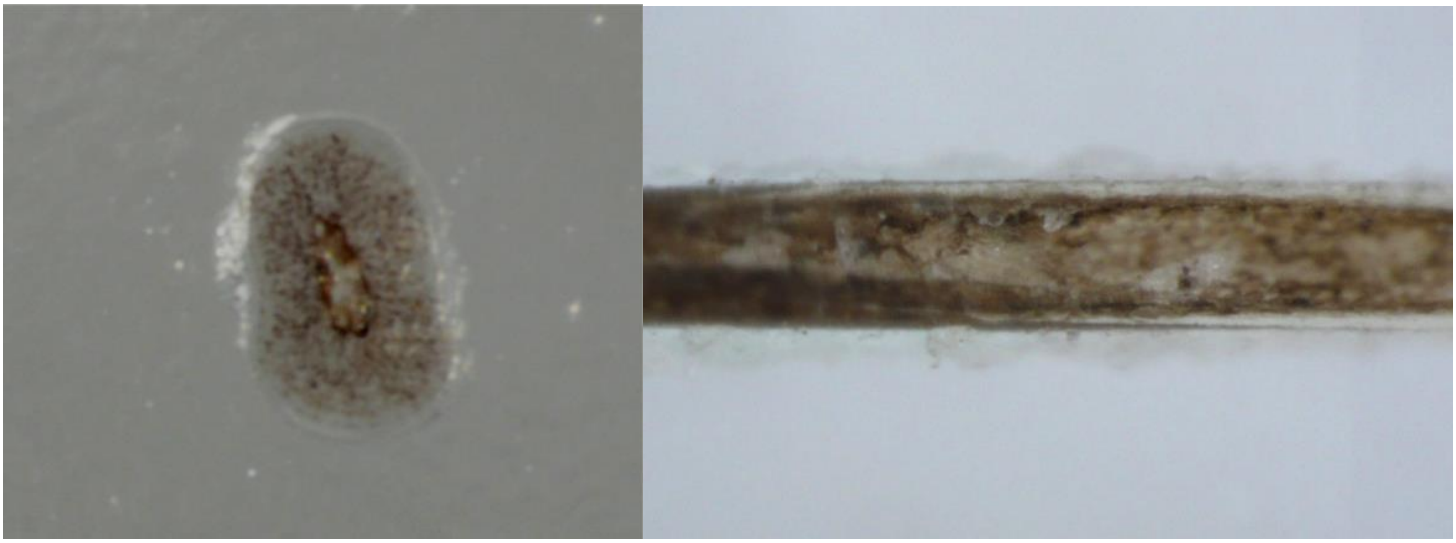

**Figure 3.** Transverse (top) and longitudinal (bottom) sections of a guard hair of *Canis lupus*

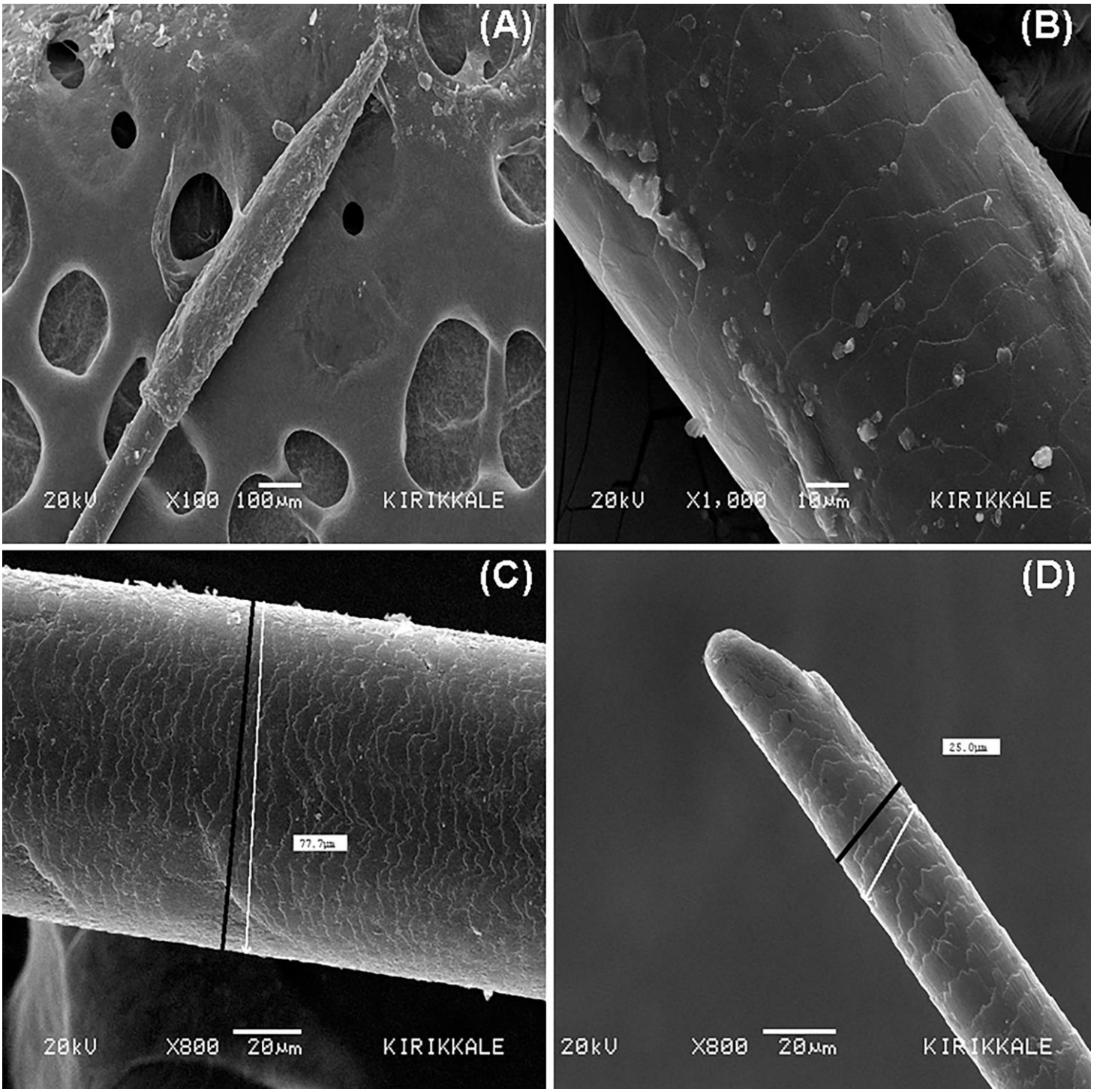


**Figure 4.** Structure of the root (A), cuticle morphology of the base (B), the mid-shaft (C) and the tip (D) of the guard hair of *Canis lupus*

**Discussion**

Fur coloration in grey wolves varies geographically, but there is also considerable individual and age variation. Miller (1912) noted in European specimens, belonging to the subspecies *Canis lupus lupus,* that the general coloration of the grey wolf's upper parts, tail and external parts of its legs are yellowish brown or buff, darker along the back, the posterior head and on the outer surfaces of the ears, lighter greyer on the shoulders as well as between the ears and eyes. The longer hairs on the back and sides of the body are black-tipped, forming dark shading over the middle back, especially at the tail base and behind the middle of the body. The tail tip is black and the rest of the tail resembles the back. The underparts and insides of the legs are pale buff or buffy white, and this coloration does not contrast strongly with the flanks, while the chin and underside of the jaws are usually grizzled and frequently margined in black. From the lower halves of the cheeks to the muzzle and lips the fur is dull whitish and quite similar to the throat coloration. The inner surfaces of the ears are light buff. *Canis lupus signatus* from the Iberian Peninsula is described by Miller (1912) as more tawny brown, particularly on the muzzle, and the white throat extends to the cheeks.

Ognev (1962) recorded in Russian wolves that the general colour of the summer fur in old wolves is pale rusty-dark yellow grey (similar to pinkish cinnamon, but paler). This general coloration appeared darker owing to black hair tips, especially dorsally from the rhinarium up to about the eyes. The fur around the mouth and lower part of the chin is white, and the forehead, occiput the areas between the eyes and ears, and the fur around each eye are markedly rusty grey. Each eye is surrounded by pale rusty rings, the backs of the ears and upper neck are cinnamon-rusty dark yellow, the inner edges of the ears are pale blackish-brown rusty dark yellow, the insides of the ears are pale whitish, and the shoulders have more black-tipped hairs. Ognev (1962) described the bases of the hairs in the middle of the back as varying from pinkish cinnamon to light pinkish cinnamon, and the ends of these hairs are paler, ending with very long black tips. The tail fur coloration is dark yellow-straw, with extensively black-tipped hairs, notably in the basal third of the tail, while the middle part of the tail is pale dark yellowish-straw also with black tips. Ognev (1962) described the coloration of the flanks and outer sides of the paws as pale dark yellow with a pinkish cinnamon tone, the insides of the paws as white; longitudinal dark stripes with dark yellow background tones are especially conspicuous on the anterior parts of the forelimbs. Ognev (1962) described the fur as pure white on the chin and throat, with an indistinct wide whitish dark yellow band along its length, the belly is whitish pale dark yellow, and the groin is whitish. The guard hairs appear to be coarse on the back.

Ognev (1962) found that the summer fur is greyer and dirtier than that of old wolves; rusty dark yellow tones are not more distinctive and the hairs with dark tips are more obvious. The scapular region and backs of the ears are rusty dark yellow, which appear more marked and bright. Ognev (1962) reported that winter fur is of variable coloration, with guard hairs thicker and longer in the middle of the back.

Ognev (1962) noted that young puppies with a body length of 650 mm as have a general straw-grey-brown coloration, which is markedly lighter than that of adults. The small pointed ears have rusty backs, blackish tips and are straw white on the inside, while the neck, back, paws and short tail are covered with matt straw-grey fur, and the middle of the back is light rusty. Long, blackish guard hairs with brown tips (more than 56 mm long) are especially evident on the flanks and shoulders, while soles of the paws are straw yellow; there are black tones apparent on the tibiae, the chest and abdomen are pale greyish brown, the claws were horny black, and the whiskers are blackish brown.

In wolves from Russia the summer fur was a mixture of black hair tips, which were all black on the dorsum in particular, and a light grey and reddish-earth, and the underside is pale-ochre with a whitish tinge. In the winter the fur was more richly grey. The length of the dorsal guard hairs was 60-70 mm in the summer and 85 mm in the winter (Ognev, 1962).

For wolves from the Middle East and the Arabian Peninsula Harrison and Bates (1991) reported very high individual variation in pelage coloration, with most being bright and variegated. According to Harrison and Bates (1991), the overall tone is pale whitish yellow, which darkened progressively towards the spinal crest, and turned into a creamy pale white tone on the sides of the neck, cheeks, underside and backs of the thighs, whereas the dorsal muzzle, top of the head and backs of the ears are rufous brown, and the cheeks and brow are speckled with black, with cream spots above the eyes and on the cheeks. The insides of the ears and legs are whitish, the paws are

dorsally creamy white, and the spinal crest contrasts markedly with the paler flanks. The brownish underfur is hardly noticeable and the guard hairs banded black and creamy white. The tail is strongly streaked with black dorsally and at the tip, and the hair bases are pale cream-buff. Ferguson (2002) described differences in coloration between *C. l. pallipes* and *C. l. arabs* in Israel. *C. l. pallipes* has greyish-brown upper parts and is sometimes blackish on the back. The muzzle, cheeks and throat are white; darker animals have a distinct white cheek spot, and the backs of the ears are light rufous. There is a blackish streak on the outer foreleg (incorrectly described as the tarsus) and the tail has a black tip (Ferguson, 2002). In contrast *C. l. arabs* is described as paler with shorter fur than *C. l. pallipes* (Ferguson, 2002).

In our samples dorsal pelage coloration is very light blackish grey and ventrally it is very pale yellow dirty white. The pelage coloration of our sample of wolves is slightly different from that reported in the literature elsehwere in Eurasia, and this may reflect the polymorphism of the grey wolf over wide geographical regions, with paler coloration at lower latitudes and in more arid habitats, and darker coloration at higher latitudes in forests. The general dorsal coloration of three puppies is smoky grey. The coloration of speciments from the Central Anatolian Region showed seasonal variation; spring and summer fur coloration differs from that of winter specimens which are a lighter tone.

According to illustration of Teerink (2003) guard hairs of our specimens as having a scale position was "transversal", according to the longitudinal direction of the hair; the shape of the scales was "irregular wave"; and the edge structure of the scales was "rippled". However, it is concluded from this study that the scale-edge structure is wavier and crenated. According to Benedict (1957), who studied bats, the scale structure was of the "imbricate", "flattened" type. In previous studies the cuticular structure of wolf guard hairs was described as "wavy crenated" type (Albayrak & Çoban, 1997) and "flattened imbricate and irregular crenate coronal" (Baydemir et al., 2011). Thus, our result concerning hair structure type (irregular wavy crenated) is in agreement with that of Albayrak and Çoban (1997).

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**Conflicts of Interest**

No potential conflict of interest was reported by the authors.

**Ethical approval**

No need to ethical approval for this study.

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