

On tooth anomalies and the loss of *Canis lupus* (Mammalia: Carnivora) in Turkey*

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Abstract: Because of their feeding habits, which are affected by their ranking in the last steps of the food chain, the teeth of carnivores are subjected to great forces during the breaking up and chewing of food when they are hunting. In this sense, missing teeth and tooth anomalies are common in carnivores. This research was based on an examination of the properties of the tooth structures of 25 wolf specimens collected in Turkey between 2014 and 2018. In this study, the excess and missing teeth, tooth fracture, and root anomalies in the lower and upper jaw of the head skeletons from an adult age group were examined in detail. Some anomalies, defined as the supernumerary tooth, additional roots, and fusion roots, were found in 4 skulls; tooth loss was found in 6 skulls; tooth fractures were found in 7 skulls; and tooth remains were found in 4 skulls. Fusion roots, supernumerary teeth, and additional roots were among the important variations in dentition. Tooth loss, fractures, and remains, and dental anomalies were determined in approximately 56% of the specimens in this study. It can be conclusively stated that dental anomalies were frequently encountered in wolves in the Palearctic Region.

Key words: Dentition, tooth anomalies, gray wolf, Turkey

1. Introduction

Wolves, which are found in almost every region of Turkey, generally live on a diet of deer, roe deer, wild boar, hares, foxes, hedgehogs, mice, frogs, and lizards. It has been reported that wolves have attacked livestock and have killed stray horses, cattle, and other smaller animals. It has been recorded that wolves, hunting in packs, prefer sick, weak, young, and injured animals. Wolves sometimes eat animal tissue, horn, bone, and in summer, they eat fruit, such as watermelons, grapes, and melons (Huş, 1967).

It has been said that the feeding habits of carnivores cause deviations in their tooth structure, such as root anomalies, supernumerary, or missing teeth. It has been stated that dental wear, especially in old individuals, could indicate that the teeth had completely lost their function (Vila et al., 1992). It was noted that in the adult female wolf, a tooth can sometimes be removed from the root without a new tooth coming in and the alveoli of the tooth was then filled with porous bone tissue (Vila et al., 1992).

In male wolves in the eastern part of the former Soviet Union, I²I² was observed as an analog anomaly, and a bilateral absence of M₃ was found only in specimens from the south of Poland (Vila et al., 1992). The bilateral skewness of P³ was recorded in only 3 wolves in the Lublin Bay Area (Buchalczyk et al., 1981).

As an assumption, it was suggested that the greatest pressure on the wolves' teeth was applied to the premolars and a high degree of symmetrical alveolar ossification might be caused by intense pressure applied by hard materials throughout their lives (Vila et al., 1992). The survival of wolves, in the event of losing their first premolar and last molar teeth, indicates that these teeth are not used for hunting, but rather canines and incisors are used for this purpose. Nevertheless, it can be stated that these teeth may be of considerable importance for breaking up the prey. Vila et al. (1992), quoting from Landry (1983), stated that the loss of some of these teeth did not affect individual survival, and increased food processing time.

Van Valkenburgh (1988) reported that the eating of bones by carnivores increases the risk of accidental fracture of the teeth because it produces unforeseen overloads. She also stated that the loss of all or part of a functionally important tooth can be a serious injury for the predator, that a thoroughly blunted canine has insufficient impact for both exhibiting its intent and killing, and that fractured premolars and molars are weak for the purpose of slaughtering and breaking bones.

In a study by Van Valkenburgh (2009), the wolf was categorized as a species with a high aggression level, hunting large prey, and regularly eating large bone. In this

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context, it was reported that, depending on the diet and aggression of the wolf, the frequency of tooth fracture was high. She also noted that canines had a higher incidence of fracture than other teeth, followed by carnassials, incisors, premolars, and postcarnassial molars, respectively.

Lazar et al. (2009) reported that the blunt of the broken teeth of a wolf, which were shot in Slovakia, and reossification of the lost maxillary premolar alveoli indicated that a trauma occurred before the animal's death. It was also reported that the animal was in good condition when it was shot, showing that the wolf was able to meet its dietary needs despite the trauma and broken teeth.

The aim of this study was to determine tooth loss and anomalies arising from the dietary habits of *Canis lupus* distributed throughout Turkey.

2. Materials and methods

As an ethics statement, no animal was killed for the purpose of this study. A total of 25 wolf specimens used in this

study were obtained from dead animals obtained through legal hunting and road kills. The specimens were divided into 3 age groups, as pups, youngs, and adults, determined according to dental wear (Gibson et al., 2000), the degree of fusion of the cranial sutures, bone porosity (Vila et al, 1992), as well as some external, cranial, and bacular characteristics. Mechanical wear, tooth loss, fractures, and anomalies in the tooth structure were investigated. In the case of tooth loss, the question of whether the tooth loss was mechanistic or not according to the state of alveolar reossification state was determined (Vila et al., 1992).

3. Results

Dental deviations were detected in 14 of the 25 specimens examined (56%). Tooth anomalies (supernumerary or excess teeth, root fusion, additional root) were identified in 4 samples, tooth loss was identified in 6 samples, tooth fracture was identified in 7 samples, and tooth remnants was identified in 4 samples (Table 1). The results of the

Table 1. Age distribution, dental anomalies, loss, and fractures of the specimens.

Skull No.	Sex	Date	Locality	Age	Tooth anomaly/ loss/ fracture
1	♂	17.04.2014	Nevşehir	Adult	—
2	♂	21.12.2014	Eskişehir	Young	—
3	♀	17.01.2015	Çankırı	Adult	Remnant and loss of P ⁴
4	♀	04.02.2015	Konya	Young	—
5	?	18.12.2014	Kırıkkale	Adult	—
6	♀	07.04.2015	Bitlis	Adult	Loss of P ¹ , fractures of I ² , I ³
8	♂	08.12.2015	Bayburt	Adult	—
9	♂	08.12.2015	Bayburt	Adult	Duplication of P ₁ (P ₁ P ₁) and fractures of I ₁ , I ₂
10	♀	08.12.2015	Bayburt	Adult	Loss of P ¹ , remnant of P ² , fracture of I ²
11	♂	08.12.2015	Bayburt	Adult	Additional roots of P ³ and P ₄ bilaterally
12	♂	29.02.2016	Ankara	Adult	Fracture of C ₁
13	?	26.09.2016	Kırıkkale	Adult	—
14	?	01.04.2016	Ankara	Adult	Fracture of P ¹
15	?	27.10.2016	Ankara	Pup	—
16	♂	23.01.2017	Çankırı	Adult	Loss of P ₁ and fracture of I ¹
17	♂	11.03.2017	Ankara	Adult	Fusion root of P ₂ bilaterally
18	♀	07.07.2016	Bolu	Adult	Fractures of M ¹ , P ² and I ² , P ¹ , P ³ , P ₁ , P ₂ , P ₃ bilaterally
19	♂	12.07.2017	Çankırı	Adult	Remnant of P ₄
20	?	21.09.2017	Kırklareli	Adult	Losses of P ₃ , P ²
21	♀	13.10.2017	Ankara	Pup	—
23	♂	27.11.2017	Çankırı	Pup	—
24	♂	03.12.2017	Çorum	Young	—
25	♂	24.12.2017	Çankırı	Young	—
27	♀	23.03.2018	Çankırı	Adult	Losses of P ³ , M ₃ , and remnant of P ³
29	?	?	?	Adult	Fusion roots tended to be 3-rooted of P ³ , P ₄ bilaterally and fracture of I ²

examination of the tooth structures and numbers are presented below.

3.1. Tooth anomaly

a) Supernumerary teeth: Supernumerary first premolars were encountered in the upper jaw of 1 adult male (Table 2) (Figure 1).

b) Root fusion: It was determined that the lower second incisor (P_2) had a fused root bilaterally in 1 adult male (Table 2) (Figures 2 and 3). In another sample of unknown sex, 2 of the roots of the upper third premolars (P^3) and the lower fourth premolars (P_4), which tended to be 3-rooted, were not separated bilaterally (Table 2) (Figure 2).

c) Additional root: In 1 adult male, the upper third premolar (P^3) and the lower fourth premolars (P_4) had more roots bilaterally (Table 2). These teeth overlapped, showing triple root anomalies (Figure 3).

3.2. Tooth loss

a) Congenital loss of teeth: Not observed in our samples

b) Early tooth loss: Tooth loss was determined as the upper right first premolar (P^1), upper left first premolar (P^1), and lower left third molar (M_3) in 3 adult females; the lower left first premolar loss (P_1) in 1 adult male; and the lower right third premolar (P_3) and upper left second premolar (P^2) in 1 specimen of unknown sex. It was recorded that the alveoli of these lost teeth were filled with porous bone tissue (Table 2) (Figure 4).

c) Late tooth loss: Mechanical tooth loss in the upper left fourth premolar (P^4 , carnacal or dens sectorius) and upper left third premolar (P^3) in 2 adult females were recorded, but the alveoli of these teeth and bone tissue were not recorded (Figure 5) (Table 2).

3.3. Tooth fracture

Tooth fractures were determined as the right lower first incisor (I_1), lower right canine (C_1), and upper first incisor (I^1) in 3 adult males; the upper right second incisor (I^2), lower right second incisor (I_2), lower right second premolar (P_2), lower right first molar (M_1), upper left first premolar (P^1), upper left second premolar (P^2), upper left third premolar (P^3), and upper left first molar (M_1) in 2 adult females; and the upper left first premolar (P^1) in 1 adult specimen of unknown sex (Table 2) (Figure 6).

3.4. Remnant tooth

Remnant teeth were determined in the upper left fourth premolar (P^4) in 1 of the 2 adult female specimens and in the upper left second premolar (P^2) in the other; and in the lower left fourth premolar (P_4) in 1 adult male specimen (Table 2) (Figure 7).

4. Discussion

It was reported that, in the former Soviet Union, fractures in the tooth base or any tooth loss (not just wear) in 12.8% of the wolf population was considered to be a widespread

Table 2. Tooth anomalies and losses of specimens according to sex and age (l: tooth loss, r: remnant tooth, f: fractured tooth, s: supernumerary tooth, rf: root fusion, ar: additional root).

No	Sex	Age	I^1	I^2	I^3	C^1	P^1	P^2	P^3	P^4	M^1	M^2	I_1	I_2	I_3	C_1	P_1	P_2	P_3	P_4	M_1	M_2	M_3
3	♀	Adult								r,l													
6	♀	Adult			f																		
9	♂	Adult												f									
10	♀	Adult																					
11	♂	Adult																					
12	♂	Adult														f							
14	?	Adult																					
16	♂	Adult	f																				
17	♂	Adult																					
18	♀	Adult																					
19	♂	Adult																					
20	?	Adult																					
27	♀	Adult																					
29	?	Adult		f																rf			l



Figure 1. Supernumerary tooth (Skull No: 9).

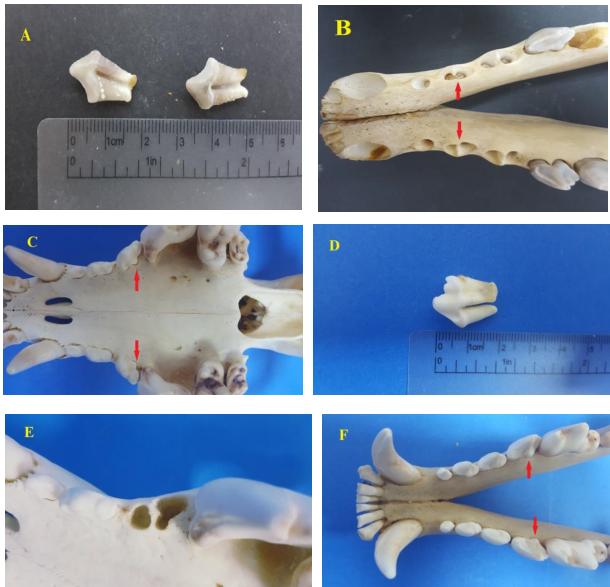


Figure 2. A- Root fusion of the premolars (Skull No: 17), B- alveoli of the root fusion (Skull No: 17), C- root fusion (Skull No: 29), D- premolar tended to be 3-rooted (2 roots could not be separated) (Skull No: 29), E- alveol of the root fusion (Skull No: 29), and F- root fusion anomaly in the lower jaw (Skull No: 29).

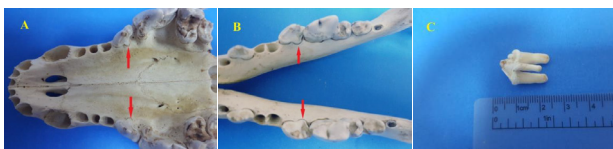


Figure 3. A- Premolar additional root bilaterally (Skull No: 11), B- additional root anomaly of the lower premolars overlapped the upper third premolars (Skull No: 11), and C- 3-rooted tooth (Skull No: 11).

phenomenon (Vila et al., 1992). It was also reported that in Ukraine, Lihotop (1994) found oligodontia and polyodontia in 16.2% of wolf skulls, Hell and Duricka (1989)



Figure 4. A- Premolar loss (Skull No: 6), B- premolar loss (Skull No: 10), C- premolar loss (Skull No: 16), D- premolar loss (Skull No: 20), E- premolar loss (Skull No: 20), and F- molar loss (Skull No: 27).

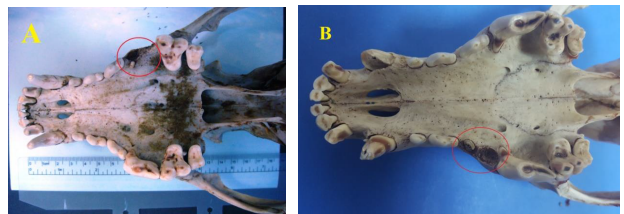


Figure 5. A- Carnassial loss (Skull No: 3) and B- premolar loss (Skull No: 27).

recorded tooth variations in 27.7% of western Carpathian wolves, and Yudin (1989) determined a deviation in the normal dental formula, from 21.3% to 38.3%, in the wolf population in eastern Russia. In Latvia, it was declared that the tooth formulas were relatively conserved in the wolf population, and that the anomalies were only 9.6% (Andersone and Ozolins, 2000). In this study, tooth loss, fracture, and anomalies were determined in 14 of the 25 head skeletons (56%) examined, as stated by Vila et al. (1992).

Andersone and Ozolins (2000) quoted Yudin (1989) as recording that “Premolars and minor molars were less functional than other teeth and therefore they were subjected to active evolutionary transformations resulting in deviations in teeth numbers”. Additionally, Andersone and Ozolins (2000) quoted from Wolsan (1984) that variations were also observed in incisors. Buchalczyk et al. (1981) also described 2 additional symmetrical incisor



Figure 6. A- Incisor fracture (Skull No: 9), B- incisor fracture (Skull No: 10), C- canine fracture (Skull No:12), D- premolar fracture (Skull No: 14), E- incisor fracture (Skull No: 16), F- multiple fractures (Skull No: 18), G- multiple fractures (Skull No: 18), and H- incisor fracture (Skull No: 29).

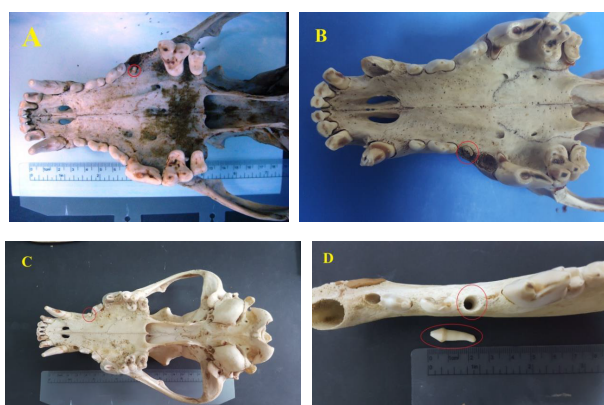


Figure 7. A- Carnassial remnant (Skull No: 3), B- premolar remnant (Skull No: 10), C- premolar remnant (Skull No: 19), and D- premolar remnant (Skull No: 27).

teeth in Poland. It was stated that 2 out of 3 anomalies, as well as most duplications, occurred in the premolars and that these teeth may not have been exposed to strong selective pressure (Vila et al., 1992).

The excess roots observed in the premolars were thought to be an improved safety factor to reduce the risk of fracture due to the load to which these teeth were exposed.

Anomalies of the current samples were in agreement with the data of Vila et al. (1992) in terms of where the anomalies occurred.

Explanations given in the aforementioned literature might be considered consistent with the occurrence of the tooth loss and fractures detected in 12 specimens, and a supernumerary tooth anomaly found in 1 specimen in the current study.

In contrast to the study of Van Valkenburgh (2009), fewer fractures in canines and more fractures in incisors were detected in this study.

Vila et al. (1992) concluded that tooth loss was not an obstacle to individual survival because a large proportion of adults still survived. Andersone and Ozolins, (2000) found that the rare occurrence of traumatic deviations (2.1% of all skulls) in the tooth formula prevented the seriously injured from surviving. The results in this study are in agreement with those determined by Vila et al. (1992).

Moreover, the observation of the blunt of the broken teeth and reossification of the lost tooth alveoli appeared to be similar to the data reported by Lazar et al. (2009).

In wolves, the dental anomalies were described and anomaly dominance was recorded in the first premolars (Vila et al., 1992). Of the 4 anomalies in the current study, 1 was found in the first premolar. Van Valkenburgh (1988) reported that the frequency of fractures in teeth occurred most often in canine teeth, premolars, carnassials, and incisors, respectively. Additionally, in contrast to Van Valkenburgh (1988), the most common tooth fractures were found in the premolars, rather than in the canines in the specimens herein.

Dental anomalies, present in large populations, as described in the literature, were also identified in a small number of the samples in the present study, inferring that these anomalies are common in wolf populations. Considering the fact that *Canis lupus* in Turkey is distributed across a wide variety of geographical areas, a further study is needed to explore tooth anomalies relevant to different diets in more specimens.

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