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DENTAL AND MANDIBULAR ANOMALIES IN WHITE-TAILED DEER (*Odocoileus virginianus*) FROM CENTRAL GEORGIA

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ABSTRACT

The frequency of dental and mandibular anomalies in free-ranging white-tailed deer in the southeastern United States is not well documented. Characteristic irregularities include supernumerary and missing teeth, malocclusion, root abscesses due to bacterial infections, and tooth or bone damage due to trauma. In the present study, we examined 778 white-tailed deer dentaries collected from the Piedmont National Wildlife Refuge in central Georgia. All dentaries were inspected for lesions, tooth irregularities, developmental anomalies, and other pathologies. Thirty-two dentaries (4.1%) displayed signs of dental or bone abnormalities. More abnormalities were associated with infection or injury (22/778, 2.8%) compared to unusual tooth development (11/778, 1.4%). One specimen exhibited both types. Abnormalities included tooth or bone damage associated with root abscesses (1.2%), secondary bone deposition or mandibular tubular perforations not associated with abscesses (1.2%), tooth misalignment (1.0%), missing or broken teeth (0.5%), an extra tooth (0.1%), and a deciduous root fragment embedded in the bone between two permanent teeth (0.1%). The frequency of occurrence of abnormalities in the Piedmont National Wildlife Refuge sample is similar to that previously recorded for white-tailed deer in the north-central and northeastern United States.

Keywords: white-tailed deer, dental anomalies, mandibular pathology

INTRODUCTION

Dental and mandibular abnormalities in mammals often take the form of missing teeth, malocclusion, bone rot or remodeling associated with root abscesses, and secondary bone deposition associated with physical trauma (Bartosiewicz 2008; Free et al. 1972). A thorough summary of representative dental abnormalities in mammals and their possible causes was originally published by Colyer in 1936 (Miles and Grigson 1990). Robinson (1979a,b) provided a more recent review of pathologies in nondomestic animals. Free et al. (1972) noted that abnormal dentition may have varying effects on an animal's health depending on the location and severity, but rarely results in immediate death. Many paleontological studies have documented dental pathologies in extinct mammalian species (Bohmer and Rossner 2017; Mead 1999; Niven 2000 and references therein), however a better understanding of the frequency and causes of abnormalities in extant taxa is needed to understand the significance of the pathologies in extinct taxa. Furthermore, an understanding of abnormality-inducing stressors in extant game animals would be of value to wildlife professionals.

Published studies of abnormal dentition and mandibular pathology in extant free-ranging artiodactyls are relatively limited. Mandibular osteomyelitis is one of the more frequently reported dental pathologies in current literature. Often referred to as *lumpy jaw*, this condition is the result of a degenerative oral infection most often caused by the bacterium *Actinomyces bovis* (Konjevic et al. 2011). Animals with mandibular osteomyelitis typically display soft tissue inflammation associated with infection and swelling of the jaw due to bone remodeling with bone proliferation along the mandibular surface. The bacteria are usually introduced by oral food impactions or lacerations of the gingival tissue by sharp pieces of vegetation. Traumatic impact to the facial region can also result in contamination of soft tissue with oral bacteria, ultimately leading to this disease. Konjevic et al. (2011) documented mandibular osteomyelitis in a sample of roe deer (*Capreolus capreolus*) from Slovenia and concluded that the infections likely resulted from periodontal lacerations due to abrasive food or rapid tooth wear from overexposure to fluoride. Schultz et al. (1998) observed osteomyelitis on the mandibles of red deer (*Cervus elaphus*) from central Europe that were also exposed to high levels of fluoride. Azorit et al. (2011) recorded mandibular osteomyelitis in a population of red deer (*Cervus elaphus hispanicus*) and fallow deer (*Dama dama*) from southern Spain, attributing the infections to gingival tissue damage from coarse and abrasive food. Similar pathologies have been documented in South American artiodactyls as well. Flueck and Smith-Flueck (2008) recorded mandibular lesions consistent with mandibular osteomyelitis in 20 of 32 predator-killed huemuls (*Hippocamelus bisulcus*) from Patagonia. In this particular case, the authors attributed the high incidence of lumpy jaw to selenium deficiencies.

Dental and mandibular abnormalities have also been observed in North American cervids. Miller and Tessier (1971) noted dental anomalies and Miller et al. (1975) documented mandibular lesions attributed to trauma and dental abscesses in barren-ground caribou (*Rangifer tarandus groenlandicus*) from the mainland range west of Hudson Bay, Canada. Doerr and Dieterich (1979) described mandibular lesions caused by preexisting dental abscesses or trauma in a population of Arctic caribou (*Rangifer tarandus*). Stimmelmayr et al. (2006) recorded incisor tooth breakage and enamel defects that likely resulted from physiological stresses (e.g., disease, malnutrition) in a population of Alaskan moose (*Alces alces*). Robinette (1958) recorded supernumerary and fewer than normal teeth in several mule deer (*Odocoileus hemionus*) from across the western United States. Short (1964) noted shortened mandibles and the absence of incisors in two mule deer from Colorado. Lastly, Cowan (1946) observed dental abscesses and mandibular anomalies in Columbian black-tailed deer (*Odocoileus hemionus columbianus*) from British Columbia, Washington, and California, noting that damage to the mandibular tooth row frequently leads to abscess formation.

North American white-tailed deer (*Odocoileus virginianus*) are the focus of the current study. Several previous studies have documented dental and mandibular anomalies in this species. However, most reports have been anecdotal and included a limited number of specimens. Benson (1957) reported several occurrences of the duplication of the lower fourth premolar and the presence of maxillary canines in deer from Nova Scotia. VanGelder and Hoffmeister (1953), Southwick (1954), Loveless and

Harlow (1959), and Ryel (1963) noted the presence of maxillary canines in deer from Mexico, Wisconsin, Florida, and Michigan, respectively. Other instances of supernumerary or missing teeth have been described by Fowle and Passamore (1948) for a single deer in Ontario, Wing (1965) for a small collection of deer in Florida, Verme and Ozoga (1966) for a single deer in Michigan, Verme (1968) for three deer in Michigan, and Abler and Scanlon (1975) for a single deer in Virginia. Guilday (1961) described abnormal lower third molars in white-tailed deer from Pennsylvania, and Johnson (1935) and Ryel (1963) discussed unusually short mandibles in mature deer from New York and Michigan, respectively. Couvillion et al. (1986) examined fourteen deer from South Carolina and Georgia infected with the arterial worm *Elaeophora schneideri*. All of the deer exhibited sublingual oral food impaction and six exhibited dental, mandibular, or maxillary abnormalities. More recently, Powers and Mead (2017) documented a healed mandibular fracture in a white-tailed deer from central Georgia.

A limited number of studies have examined larger samples of white-tailed deer. Rees (1969) analyzed cranial and mandibular variation and noted dental anomalies in several large collections from throughout the natural range of the species. Mech et al. (1970) and Mech and Frenzel Jr. (1971) described abnormal dentition in a large sample of hunter-killed and wolf-killed white-tailed deer from northeastern Minnesota. Free et al. (1972) recorded numerous dental abnormalities that included missing and extra teeth, mandibular fractures, twig impactions, and abnormal tooth eruption in deer from eastern Canada and the northeastern United States. Additional dental abnormalities were noted for deer in Maryland by Feldhamer and Chapman (1980). In the current study, we describe dental and mandibular abnormalities in a large sample of hunter-harvested white-tailed deer from central Georgia.

MATERIALS & METHODS

White-tailed deer dentaries (n = 778, one side per deer [both sides in one individual, yet we only counted one side in our total]; 248 females, 530 males) were obtained over several years from a hunter check station during regulated quota hunts at the Piedmont National Wildlife Refuge (PNWR), located approximately 32 km west of Gray, in central Georgia. The PNWR contains 14,000 ha of upland pine and bottomland hardwood forests. The first collection consisted of 349 dentaries obtained during the 2001 fall hunting season (Morris and Mead 2016). The second included 268 dentaries gathered during the 2016 fall hunting season. Lastly, 161 dentaries were collected during the 2017 fall hunting season. Each collection was obtained during October and November. At the time of collection, deer were physically examined for mandibular or dental abnormalities (through manual palpation). All dentaries were cleaned of soft tissue by dermestid beetles and those displaying evidence of abnormal dentition or bone pathology were aged based on tooth eruption (Thompson 1958) and then further examined with the use of a dissecting light microscope. It should be noted that Davis and Mead (2013) documented enamel hypoplasia in the 2001 collection of dentaries, and that particular dental anomaly was excluded from the current study. All dentaries are housed in the Georgia College mammalogy collection (GCM).

RESULTS

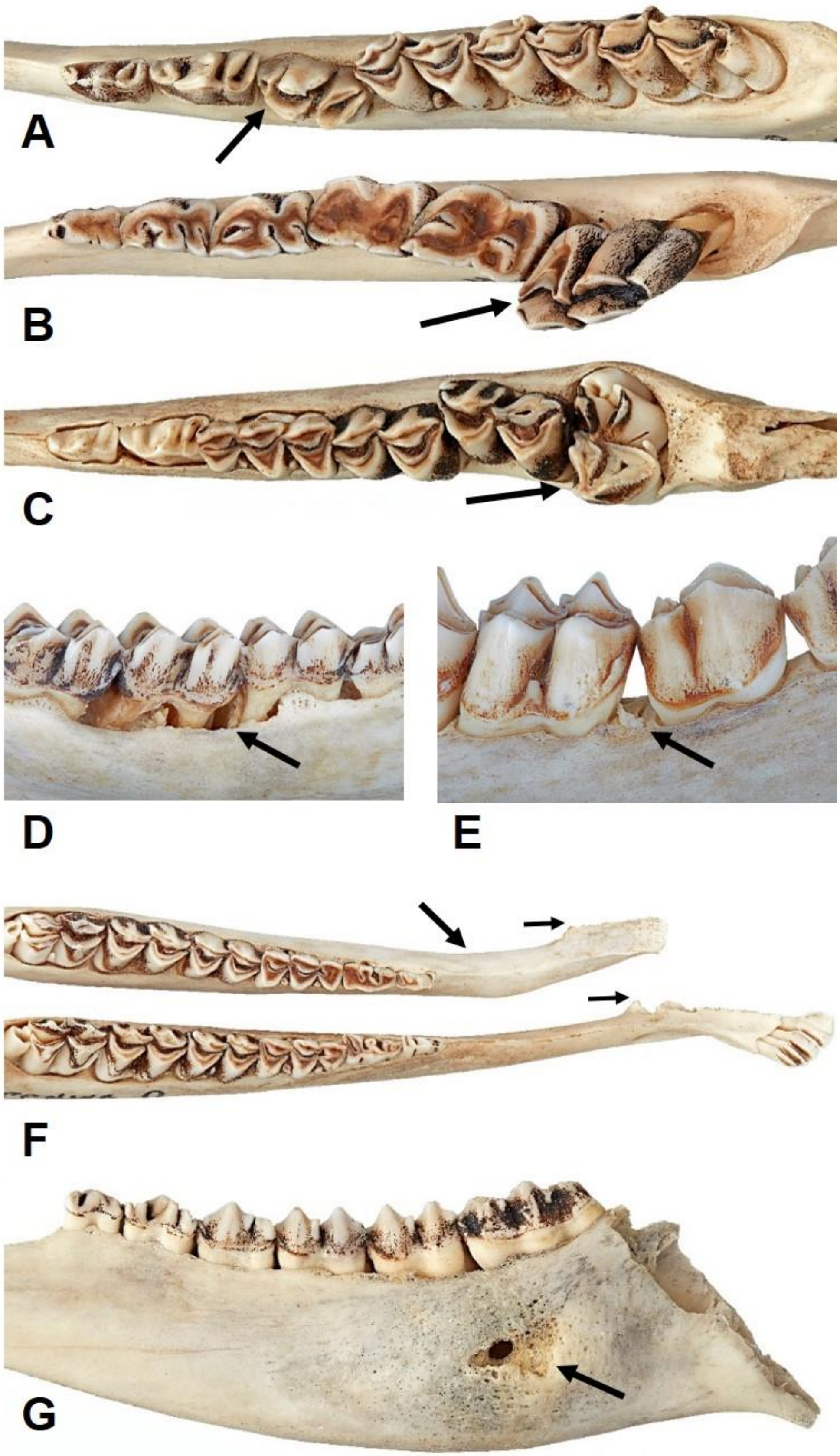
Dental or bone abnormalities were observed in 32 of 778 (4.1%) dentaries examined (Figure 1, Table I). Abnormalities occurred in 14 of 248 females (5.6%; median age = 2.5–3.5 years) and 18 of 530 males (3.4%; median age = 2.5 years). In relation to apparent cause, more abnormalities were associated with infection or injury (22/778, 2.8%) compared to unusual tooth development (11/778, 1.4%). Both infection and development related abnormalities were recorded in one specimen (GCM 3504). Tooth or bone damage associated with root abscesses (Figure 1D, 1G) was seen in nine of 778 (1.2%) jaws. Of these nine, evidence of mandibular osteomyelitis (Figure 1G) was found in three specimens (3/778, 0.4%). Trauma-related secondary bone deposition (Figure 1F, 1I) or mandibular tubular perforations not associated with abscesses (Figure 1H) were also evident in nine of 778 (1.2%) dentaries. Tooth misalignment (Figure 1A, 1B, 1C) was the third most common abnormality observed (8/778, 1.0%). Although only counted once, the medially inflected m3 of GCM 3430 was observed on both the left and right dentaries. This was the only deer in the sample for which both sides of the mandible were collected. The m3's exhibited wear facets on the anterior protoconids, but lacked wear on the hypoconids and hypoconulids. The maxillae for this deer were not available to check for the presence of the upper third molars which, in normal dentition, would occlude with these unworn cusps. Missing or broken teeth (Figure 1J; 4/778, 0.5%), an extra tooth (1/778, 0.1%), and a deciduous root fragment embedded in the bone between two permanent teeth (Figure 1E; 1/778, 0.1%) were seen less frequently.

DISCUSSION

While there are a number of anecdotal descriptions of dental and mandibular abnormalities in white-tailed deer, a limited number of published studies have shown abnormalities in large random samples of lower jaws. Rees (1969) examined variation in 366 mandibles from several localities throughout North America. Only two dental irregularities were noted. The presence of a hypoconulid spur on m3's was found in 2.5% (1/40) of the dentaries from Ontario, 2.0% (2/102) from Northern Lower Michigan, and 2.8% (2/72) from Arizona. The absence of at least one p2 was seen in 4.9% (2/41) of the dentaries from Ontario and 12.2% (10/82) of the dentaries from the George Reserve in Michigan. In a smaller sample of deer from Maryland, Feldhamer and Chapman (1980) also recorded the absence of one or both p2's in 16.7% (4/24) of the mandibles examined.

Free et al. (1972) described mandibular and dental anomalies in two samples of jaws. The first group of 45 was collected from New York, Massachusetts, Quebec, and Ontario. It was not a random sample as all of the jaws displayed abnormalities. The second sample was a random sample from New York (roadkills, dog kills, starvation kills, and hunter kills). The authors noted dental abnormalities in 11 of 422 specimens (2.6%). More of these abnormalities were related to irregular tooth development (7/422, 1.7%) than infection or injury (4/422, 0.9%). The most common abnormality recorded in the New York sample was the absence of the p2 (5/422, 1.2%).

Mech et al. (1970) reported dental irregularities in 13 of 401 (3.2%) white-tailed deer mandibles in a random sample (wolf and hunter killed) collected from northeastern Minnesota. However, from the same sample of specimens, the authors later described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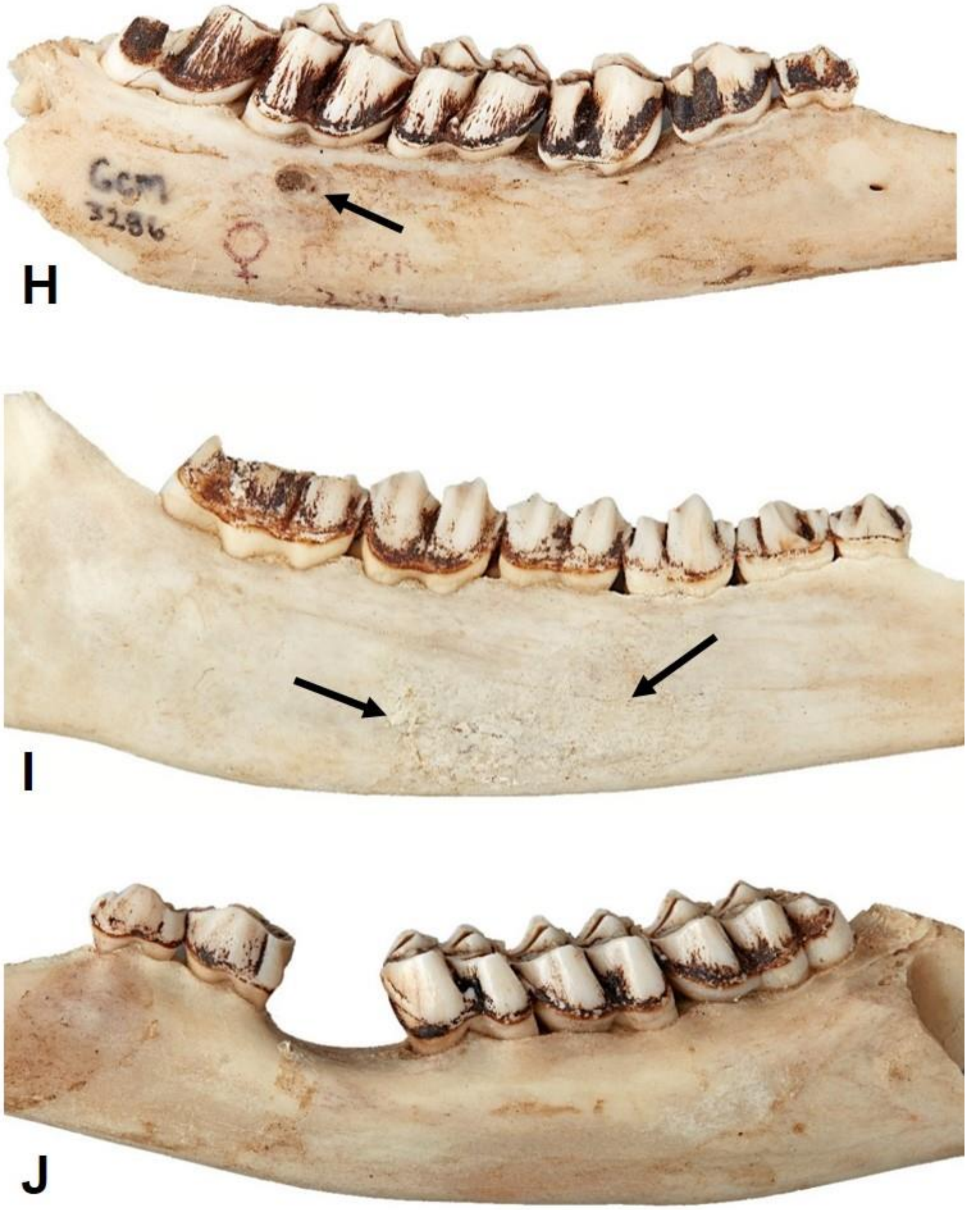

Figure 1. Dental and bone abnormalities observed in white-tailed deer dentaries (*Odocoileus virginianus*) from the Piedmont National Wildlife Refuge in central Georgia. A) A misaligned p4 (arrow) on a left dentary, GCM 2730; B) A medially inflected m3 on a right dentary, GCM 3430. A wear facet (arrow) is evident on the protoconid, but lacking on the hypoconid and hypoconulid; C) A misaligned m2 and m3 rotated 90^{o} to normal (arrow) in a left dentary, GCM 3211; D) Medial view, bone erosion due to a root abscess below m1 and m2 (arrow) on a left dentary, GCM 2769; E) Lateral view, a fragment of a deciduous premolar root (arrow) embedded in bone between p4 and m1 on a right dentary, GCM 2774; F) Top: A thickened, shortened, and irregularly shaped diastema region (thick arrow) on a right dentary, GCM 2630. Bottom: A normal right dentary of a same-aged individual for comparison, GCM 3483. Thin arrows indicate corresponding locations on the mandibular symphyses; G) A mandibular perforation, "lumpy jaw", on the medial surface (arrow) of a right dentary, GCM 2873; H) A mandibular perforation, not associated with a tooth abscess, on the lateral surface (arrow) of a right dentary, GCM 3286; I) A secondary superficial calcification on the medial surface (between arrows) of a left dentary, GCM 2621; J) A missing p4 on the left dentary, GCM 3398.

Table I. Dental and mandibular abnormalities observed in a sample of 778 white-tailed deer dentaries (*Odocoileus virginianus*) from the Piedmont National Wildlife Refuge in central Georgia

Specimen	Abnormality	Age[1]	Sex
GCM 2918	root abscess below L p2	3.5	F
GCM 2847	root abscess below L p4	3.5	F
GCM 2767	root abscess below L p4	3.5	F
GCM 2857	root abscess below L m1	5.5	F
GCM 2780	root abscess below L m2	2.5	M
GCM 2769	root abscess, bone thickening below L m1-m2	3.5	F
GCM 2873	root abscess, bone thickening, lingual perforations below R m2-m3	2.5	F
GCM 3212	bone thickening, lingual and labial perforations below L p4-m1	2.5	M
GCM 2609	bone thickening, lingual perforation, tooth rot L m2	3.5	M
GCM 2730	L p4 misalignment	2.5	M
GCM 2973	L p4 misalignment	4.5	M
GCM 2644	L p4 misalignment	2.5	M
GCM 3536	R p4 misalignment	2.5	M
GCM 3550	L p4 misalignment	2.5	M
GCM 3251	L p4 misalignment	2.5	M
GCM 3211	R m2 misaligned, m3 rotated 90°	1.5	M
GCM 3430	misalignment, malocclusion, L and R m3	5.5	F
GCM 3504	L p1 present, labial tooth decay L p1-p2, L m3 missing	5.5	F
GCM 3324	R p2 broken, fragment of root in bone	2.5	M
GCM 3297	R p2 broken, fragment of root in bone	5.5	M
GCM 3222	L p4 metaconid missing due to tooth trauma	3.5	M
GCM 3398	L p4 absent	2.5	F
GCM 2774	root fragment of R dp4 embedded in bone between m1 and p4	2.5	F
GCM 2630	shortened, thickened, lingual inflection, R diastema	1.5	F
GCM 2650	nodular thickening, labial side of L diastema	2.5	M
GCM 2845	nodular thickening, labial side of R diastema	1.5	M
GCM 2706	nodular thickening, labial side below L m2	1.5	F
GCM 3404	nodular thickening, labial side below L m3	2.5	M
GCM 3286	labial tubular perforation at R m2	2.5	F
GCM 2870	labial tubular perforation at superior edge of mandible at R m2	2.5	F
GCM 2621	superficial lingual calcification below L p4-m2	2.5	M
GCM 2637	superficial lingual calcification below L m1-m2	1.5	M

[1] In years

three occurrences of root abscesses (3/401, 0.7%) and four cases of boney mandibular lumps (4/401, 1.0%; probable healed fractures) not included in their initial total (Mech and Frenzel 1971). With these anomalies added (20/401), the incidence of abnormalitiesfor this sample was 5.0%. Further analysis of these abnormalities indicates that more were related to irregular tooth development (13/401, 3.2%) than infection or injury (7/401, 1.7%). The most common abnormalities in the Minnesota sample were signs of tooth abscesses (4/401, 1.0%), abnormal m3 hypoconulids (4/401, 1.0%), absence of p2's (3/401, 0.7%), and presence of p1's (2/401, 0.5%). Mech et al. (1970) also described

22 additional pathologic specimens that were chosen nonrandomly from a sample of unknown size.

Each type of abnormality observed in the current study has been previously noted in deer (Cowan 1946; Free et al. 1972; Mech and Frenzel 1971; Mech et al. 1970; Rees 1969). We detected more infection or injury related abnormalities than incidences of unusual tooth development in the PNWR sample. While the frequencies of infection or injury and developmental dental abnormalities in the New York, Minnesota, and PNWR samples are not identical, they are all similarly between approximately 1% and 4%. Interestingly, although it was recorded in each of the previously described samples, the absence of p2's was not observed in the PNWR sample.

Similar to the findings of Mech and Frenzel (1971) for white-tailed deer in Minnesota, root abscesses were one of the more commonly observed abnormalities in the PNWR sample. Couvillion et al. (1986) found that dental and mandibular abnormalities associated with oral food impaction occurred most often in the region between p2 and m1. In his study of Columbian black-tailed deer, Cowan (1946) found that root abscesses were more common in mandibular tooth rows compared to maxillary tooth rows, recording abscesses in 11 of 156 mandibles (7.1%) examined. Cowan (1946) did not, however, distinguish the presence of mandibular osteomyelitis. Root abscesses are considered localized infections, while in mandibular osteomyelitis the infection is more pervasive and spreads through the bone causing necrosis and remodeling (Miles and Grigson 1990). Osteomyelitis was evident in a small number of PNWR jaws, but with the lack of comparative samples it is difficulty to ascertain the significance.

Injury related abnormalities, such as bone perforation, nodular bone thickening, and superficial calcification, were as common as root abscesses in the PNWR sample. The localized, cylindrical nature of the bone perforations appeared to be due to puncture, possibly by thorns or twigs. The nodular bone thickening, mainly along the diastema, and the superficial calcification along the dentary below the cheek-tooth row appeared to have been caused by blunt force bone injuries and soft tissue injuries, respectively. The nodular bone thickening did not exhibit the bridging calcification characteristic of mandibular fractures (Powers and Mead 2017). In both of the PNWR specimens displaying superficial calcification, the pathology was located on the lingual side of the mandible and, although not noted at the time of collection, may have been associated with sublingual oral food impaction. An observation of note for the PNWR sample is the first reported case of an embedded deciduous root fragment in the mandible of a white-tailed deer. This pathology had been previously mentioned for adult Columbian black-tailed deer from California and Washington (Cowan 1946).

As demonstrated by the current study, the prevalence of dental and mandibular abnormalities is low in white-tailed deer in the southeastern United States, as is the case in other regions of North America. All of the deer examined in this study were hunter harvested and appeared to be in good health at the time of death. The observed dental and mandibular abnormalities obviously were not fatal and appear to have had little detrimental effect on the health of the animals. The causes of the pathologies could have genetic origins (Miles and Grigson 1990; Verme 1968) or were associated with infection or trauma (Couvillion et al. 1986; Cowan 1946; Miles and Grigson 1990) resulting from numerous stressors such as food impaction, bacterial infections, intraspecific and interspecific interactions, vehicle-wildlife collisions, and hunter-induced injuries. It is likely that minor developmental irregularities such as slight misalignment of teeth rarely result in a subsequent infection or abscess. Broken teeth, mandibular fractures, gingival tissue punctures, and food impaction, however, may introduce harmful bacteria leading to dental abscesses and tooth rot, and more pronounced pathologies such as mandibular osteomyelitis. The low prevalence of dental and mandibular abnormalities suggests that these pathologies do not have a major impact on the overall health of the white-tailed deer population in central Georgia.

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