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C. Renn Tumlison  
*Oklahoma State University*

J. D. Wilhide  
*Arkansas State University*

V. Rick McDaniel  
*Arkansas State University*

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# DENTAL PATHOLOGY IN SELECTED CARNIVORES FROM ARKANSAS

RENN TUMLISON

Department of Zoology  
Oklahoma State University  
Stillwater, OK 74078

and

J.D. WILHIDE and V. RICK McDANIEL

Department of Biological Sciences  
Arkansas State University  
State University, AR 72467

## ABSTRACT

The occurrence and kinds of dental pathology in wild carnivore populations in Arkansas were investigated through examination of 1295 skulls of bobcat (*Felis rufus*), river otter (*Lutra canadensis*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), and raccoon (*Procyon lotor*). Pulpitis or abscesses in broken or otherwise exposed teeth were noted in all species, but bobcats had the fewest exposures while otter and gray fox had the most. Osteomyelitis occurred in all species except the bobcat. Caries were noted in the coyote, raccoon, and gray fox. Otter and coyote had alveolar thinning, and coyote had enamel dysplasia and maxillary sinusitis.

## INTRODUCTION

The effect of dental pathology on wildlife populations has received little attention, possibly because of an impression that due to evolved food habits and life styles wild animals are relatively free of disorders of dental tissues (Robinson, 1979). Because few studies have been conducted to evaluate the occurrence or the effects of dental pathology on wild populations, little is known concerning its prevalence or role in population regulation.

The condition of teeth directly affects nutritional status, thereby affecting behavior, reproduction, and longevity. Occurrence of dental pathology is logically a function of age due to increased exposure to mechanical, chemical, and bacterial attacks from the external environment. The fracture of a tooth may expose the pulpal tissue producing pulpitis, and the spread of infection along pulpal tissue may produce a periapical abscess. Erosion of subadjacent bone produces a fistulous tract and local osteomyelitis. Extension of this tract may produce maxillary sinusitis (Robinson, 1979). Interestingly, Stirling's (1969) study of Weddell's seals (*Leptonychotes weddelli*) indicated a correlation between tooth wear and adult mortality.

The present investigation was conducted to provide data on the kinds and prevalence of pathology in dentitions of bobcat (*Felis rufus*), river otter (*Lutra canadensis*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and gray fox (*Urocyon cinereoargenteus*) from Arkansas as represented in the Collection of Recent Mammals, Arkansas State University Museum of Zoology (ASUMZ). Knowledge of the frequency of pathological dentitions may aid in the study of population health and longevity.

## MATERIALS AND METHODS

A total of 1295 skulls (202 bobcat, 93 river otter, 150 coyote, 645 raccoon, and 205 gray fox) was examined for caries, fractures, pulp cavity exposures, abscesses, fistulae, excessive attrition (tooth wear), and other indicators of dental pathology. Most of these specimens were collected during the regular Arkansas trapping seasons (approximately December and January) of 1978 through 1982. Randomness of the sample was assumed because no specimens were obtained or rejected specifically because they showed some form of pathology. The only biases should be those incurred through the method of harvest, mostly shooting and trapping.

Frequencies of pathological conditions expressed as percentages of the sample are misleading. Juvenile dentitions have been exposed to risk for only a short time and consequently seldom show abnormality

(see Schultz, 1935; Hershkovitz, 1970). Therefore, frequency reflects age structure rather than the prevalence of dental disease in the adult population. For this reason, the importance of dental disease was analyzed with consideration for age structures. Results of this investigation are considered to be minimum representations because less progressed infections could not be noticed in prepared skulls. Also, dentitions with sharp-broken teeth were not included because such breaks may have occurred while the animal tried to free itself from the trap.

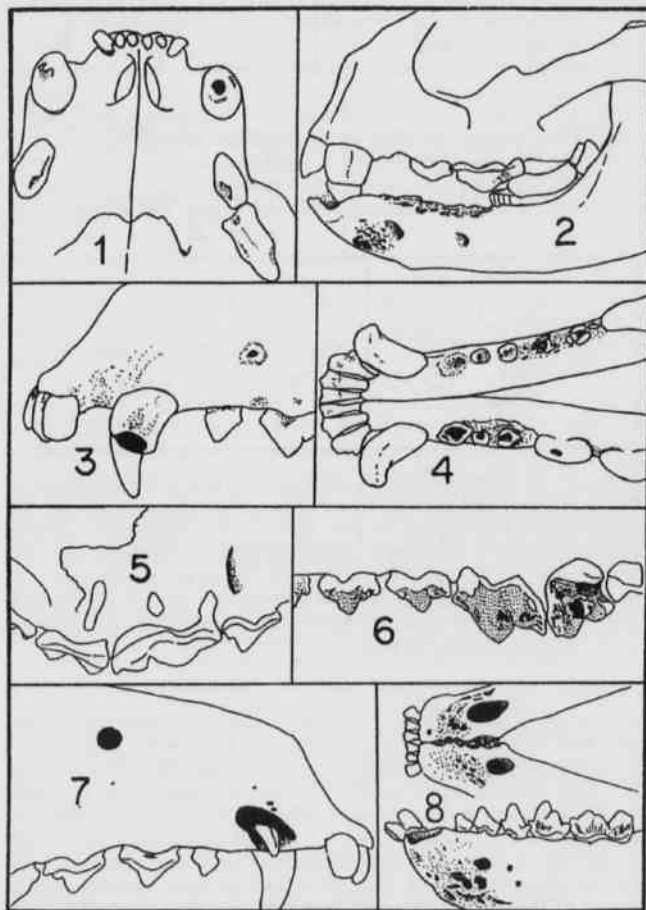
Table 1. Distribution of exposed cheek teeth in selected Arkansas carnivores; u = upper, l = lower teeth.

Species	C	P1	P2	P3	P4	M1	M2	Total
<i>Felis rufus</i>	u 6	--	--	1	0	0	--	7
N = 202	l 7	--	--	2	0	2	--	11
	13			3	0	2		18
<i>Lutra canadensis</i>	u 24	14	20	22	10	2	--	92
N = 93	l 20	--	18	19	7	4	0	68
	44	14	38	41	17	6	0	160
<i>Canis latrans</i>	u 3	0	2	0	0	0	0	5
N = 150	l 4	2	2	1	0	0	0	9
	7	2	4	1	0	0	0	14
<i>Procyon lotor</i>	u 24	9	10	10	10	8	6	77
N = 645	l 15	6	9	5	7	8	7	57
	39	15	19	15	17	16	13	134
<i>Urocyon cinereoargenteus</i>	u 24	23	42	51	22	6	0	168
N = 205	l 12	37	44	45	34	17	3	192
	36	60	86	96	56	23	3	360

## RESULTS AND DISCUSSION

**Bobcat** — Only eight of 202 bobcat dentitions were diseased. Seven of these were caused by mechanical breakage, most often of a canine, although premolars and a molar were also involved (Table 1). Bobcats have the fewest teeth (28) of North American carnivores and therefore are likely most affected by tooth loss. Disease in any major tooth could cause appreciable difficulty to the individual by terminating the function. Species with two or more premolars or molars may still retain some premolar or molar function if one of these teeth is lost, but this is not

true for bobcats. The relatively low incidence of disease in bobcat dentitions was similarly noted by Hall (1940), who suggested the reduced number of small teeth and the decreased chances of injury due to the presence of few teeth (law of probability) as explanations. In our sample, more progressed infections of the pulp cavity led to abscesses in the left upper canine of ASUMZ 7719 (Fig. 1), and the right lower molar of ASUMZ 7633, and pulpitis only was evident in four specimens.



Figures 1-8. Dentition of Arkansas carnivores expressing pathology. 1 - Exposed left C<sup>1</sup> of bobcat (ASUMZ 7719); 2 - extreme dental fragmentation and osteomyelitis of river otter (ASUMZ 7237); 3 - broken left C<sup>1</sup> of a coyote with periapical fistula (ASUMZ 7454); 4 - traumatic loss of premolars in a coyote (ASUMZ 7331); 5 - alveolar thinning through right maxillary wall at carnassial region of a coyote (ASUMZ 6934); 6 - right maxilla of coyote with enamel dysplasia and caries (ASUMZ 6912); 7 - abnormal eruption of the right C<sup>1</sup> with a periapical fistula in a coyote (ASUMZ 2786); 8 - large fistulae at C<sub>1</sub> of raccoon, ventral and lateral views (ASUMZ 8198).

Wear is an obvious function of age, but two specimens had unusual forms of wear. The outer surface of the right upper canine of ASUMZ 8684 was chipped off, probably as a result of a sharp downward bite against a hard object, but the pulp cavity was not exposed. The upper and lower canines of ASUMZ 7633, a 13-year-old specimen as determined by cementum analysis, developed too closely opposed. Friction over time had seriously eroded the opposing surfaces exposing the pulp cavities and resulting in pulpitis and possibly periapical abscesses of all canines.

*River otter* — Otter are known to crack mussel shells with their teeth (Morejohn, 1969) and thereby risk breakage, especially of the premolars, of their 36 teeth. Several otter dentitions contained broken or diseased teeth (Table 1). Estimated ages of otters with exposed pulp cavities indicated that all age groups, including young-of-the-year, experienced exposures. In accordance with age-specific risk, younger otters had fewer exposures than older individuals. Canines were almost always involved, but the first two premolars were less often severely affected than the third premolars (note: the otter does not possess the lower first premolar).

The short jaws and strong masseter muscle provide the otter with a powerful bite. Sharp bites to break hard objects often chip teeth and sometimes result in exposures, most notably of the canines and high cusps of the fourth upper and third lower premolars, which first contact hard objects. Young permanent dentitions are more susceptible to these mechanically-induced exposures because juvenile pulp cavities are larger (Kuehn and Berg, 1983) and therefore more easily reached through chipping. Major chipping, in which 2-4 mm diameter chips were lost from the entire anterior surface of canines, was observed in four specimens.

Extreme dental pathology was exhibited by ASUMZ 7237 (Fig. 2); a 4+ year-old female (age determination by cementum analysis may be biased downward when based on diseased teeth) that possessed no healthy teeth. Only the right third lower incisor was present and most of the upper incisors showed pulpitis. All canines were broken and abscessed, and osteomyelitis had progressed on the right upper and both lower canines. The fistulous tracts of the lower canine region exposed the canine roots. The right fourth upper premolar and left third and fourth upper premolars were the only intact ones, but even these had pulpitis and abscesses. Both upper molars were broken and abscessed. The fragmented right first lower premolar was the only lower premolar present, and osteomyelitis was quite apparent. Both first lower molars were severely fragmented and abscessed with prominent fistulae present on the buccal aspect of the right mandible. Only the last lower molars were intact.

Alveolar thinning was found in three specimens (3.5% of sample) and was relatively minor — the posteroexternal root of the first upper molars showed only slightly through the floor of the orbit. Beaver *et al.* (1981) noted this condition in 23.3% of their sample of otter from Maryland. Because this condition is believed to be caused by pressures of mastication, it is possible that harder prey available to estuarine otters may be responsible for the observed disparity in occurrence.

*Coyote* — Of the carnivores examined, the coyote and gray fox possess the greatest number of teeth (42), providing the most opportunities for disease. Trauma-induced pathology is probably less likely to occur in the coyote than in the fox because the coyote's teeth are larger. Accordingly, exposed pulp cavities in coyotes were few (Table 1). Pulp cavities of incisors from ASUMZ 2786, 6466, and 7454 were exposed and infection had produced abscesses in 2786 and 7454. Further, ASUMZ 2786 and 7454 had abnormal occlusal wear by the third upper incisors on the lower canines, accounting for lower canine exposures on 2786. ASUMZ 7454 also suffered traumatic loss of the left upper canine in early life, causing a large exposure and a severe abscess with osteomyelitis (Fig. 3). Only peg-like roots of most of the premolars remained in an additional specimen, ASUMZ 7331 (Fig. 4), which had developed abscesses and osteomyelitis. Infection was not apparent, but ASUMZ 6934 (Fig. 5) had alveolar thinning around the roots of the upper fourth premolars and the first and second upper molars. Alveolar thinning is normally associated with these teeth in other mammals (Smith *et al.*, 1977; Beaver *et al.*, 1981).

Colyer (1936) found carnivores to contain few caries and Hall (1940) found caries to be present only in bears, attributing the observation to a high-sugar diet. However, Schitoskey (1971) found caries to be common in feral nutria, *Myocastor coypus* (a rodent). Caries were found in two coyotes, ASUMZ 6466 and 6912. Caries on 6466 occurred on both left upper and both right lower molars, and on the left and right fourth upper premolar, and on the right upper first molar. Attrition had exposed the dentine and probably allowed high-sugar foods (e.g., persimmons) to cause caries. Similarly, caries in the carnassial region

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of specimen 6912 were attributed to exposed dentine, but without an attrition etiology.

Specimen 6912 (Fig. 6) demonstrated enamel dysplasia. The incisors had the most normal enamel covering of the dentition, decreasing in quality from the first to the third incisors. The gingival one-third to one-half of the canines possessed enamel, and some enamel was present in scattered locations toward the apex. The canines were the only teeth with root dwarfism, which made them loose and easy to remove. Paracones and paraconids of the first premolars were of exposed dentine, and the fourth lower premolar showed abnormal eruption. Scattered chalky enamel was discernable on the premolars. Normal enamel was present only on the ridge of the molars with the paracones, metacones, protocones, and talons (and their lower homologs) composed of dentine with deposits of chalky enamel scattered over them. The condition was very similar in appearance to the genetic condition termed amelogenesis imperfecta (Colby *et al.*, 1971); however, siblings were not available for verification of that etiology. Similar enamel disorders have been reported for primates (Colyer, 1936; Jones and Cave, 1960; Molnar and Ward, 1975), but, to our knowledge, not in carnivores.

Another form of dental disease was apparent in ASUMZ 2786. The right upper canine did not erupt from the alveolus but grew through the inner wall of the maxilla, into the nasal conchae, and posteriorly to the plane of the anterior area of the third upper premolar. At this point a 5 mm fistula appeared through the maxilla at the root tip of the abnormal canine (Fig. 7). Maxillary sinusitis was undoubtedly a complication.

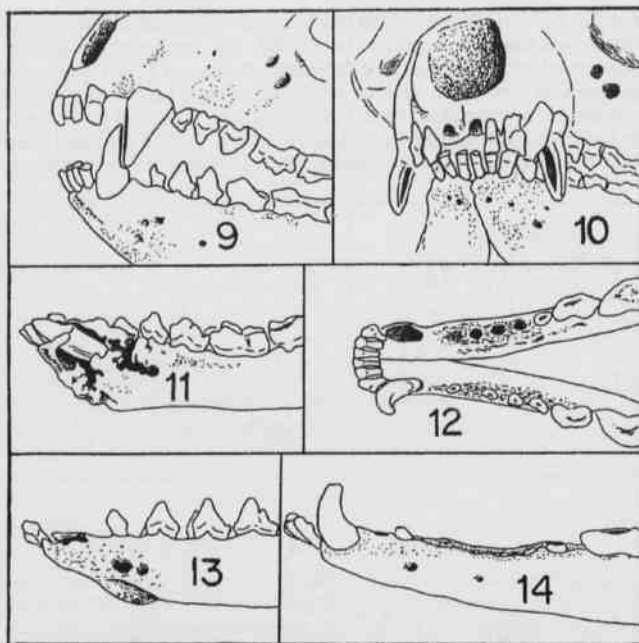
**Raccoon** — Raccoons possess 40 teeth, the smaller premolars of which were the most often broken in diseased specimens. Canines were the most commonly exposed teeth (Table 1). The presence of exposures in individuals seemed relatively uncommon (3.9% of sample) considering the large sample of 645 specimens. However, approximately 72% of the sample were young-of-the-year, leaving 181 specimens of our sample as assumed adults, of which 13.8% had pulpal exposures.

Chipping or more traumatic breakage of canines, premolars, and occasionally molars was evident in 13 specimens. All of these traumas had resulted in abscesses of varying sizes. Small maxillary fistulae were observed at the canine root tip of ASUMZ 8177, 8198, and 8539. Progressed osteomyelitis occurred in 4535 and 8198. Numerous fistulae, up to 7 mm maximum diameter, appeared in the area of the lower canines of 8198 (Fig. 8). Specimen 4535, a juvenile, had extreme bone resorption around the right lower canine while the infection around the left lower canine was so severe that bone destruction had practically separated the post-canine mandible from the pre-canine and symphyseal portion (Fig. 11). Hence, the left mandible was flexible and could not be functional for mastication.

Moderate degrees of osteomyelitis were encountered in seven additional specimens. In all cases these were explained through attrition. Raccoons are omnivorous and their diet gradually erodes the low cusps of their teeth. Erosion eventually results in dentine and finally pulp cavity exposure, providing the precondition for pathological events. In time, pulpitis leads to bone destruction. The inclusion of fruits in the diet helps explain the observation of caries in the more proximal premolars of eight old (5+ years) specimens, in which attrition was a factor.

Misposition of the left lower canine of ASUMZ 9136 was effected by the failure of the corresponding lacteal to be disposed. The permanent canine was forced to erupt posterior to its normal position, causing some malocclusion. This was a young specimen, and further complications had not yet appeared.

Prevalence of an unusual pathological condition affecting raccoon canines is especially noteworthy. Upper and lower canines do not normally come in direct apposition, but many specimens in the sample showed shear on the posterior face of the lower and on the anterior face of the upper canines. Assuming genetic implications, the effect of this phenomenon could be significant to a population if shear resulted in pulp cavity exposure leading to more severe pathological conditions. Affected individuals were expected to show greater wear with increasing age, and 202 specimens for which age estimates were available were



Figures 9-14. Dentitions of Arkansas carnivores expressing pathology. 9, 10 - Lateral and anterior views of raccoon canines demonstrating shear sufficient to expose the pulp cavity of the canines; 11 - extreme bone resorption from infection around the left C<sub>1</sub> of a raccoon (ASUMZ 4535); 12 - traumatic fragmentation of lower premolars with osteomyelitis in a gray fox (ASUMZ 6708); 13 - periapical fistulae at left C<sub>1</sub> of a gray fox (ASUMZ 8239); 14 - complete loss of premolars and scalloped dentary of gray fox.

used to test that assumption. Specimens from this sample were ranked on a scale of 0-3 according to the amount of wear, where 0 = no wear, 1 = noticeable faceting (approximately 0.5 mm diameter), 2 = appreciable faceting (approximately 1.0 mm diameter), and 3 = wear sufficient to expose the pulp cavity (Fig. 9, 10). Frequency within this system (from 0-3) was 138, 44, 15, and 5, respectively. Specimens of age one or older were considered to be capable of showing wear. Of the 138 of rank 0, 68 were old enough to show faceting. Hence, 48.5% of the adult sample were apparently predisposed to the condition and 3.8% (specimens of rank 3) were exposed to infection. Thus, the shearing phenomenon probably does not cause dental disease in enough cases to be a significant factor in raccoon population biology due to loss of life or reduction in fitness. Four additional individuals of unknown age had shear-exposed canines.

Generally, degree of wear was a function of age although some younger specimens had high rank and some older individuals had low rank. The mean age of rank 1 specimens was 1.7 years (range 0-8), compared to 2.9 years (range 1-7) for rank 2 and 4.8 years (range 3-6) for rank 3.

**Gray fox** — Gray foxes are probably more susceptible to mechanically-induced dental disease because of their number of teeth (42) and the relative delicacy of their premolars in comparison to the other carnivores examined. Forty-eight specimens (23.4%) had exposures, but 45.9% of the adults were affected. Gray foxes in Arkansas seldom reach five years of age, and their dentitions indicate that attrition may restrict longevity to approximately that age. Many of the exposures, especially when affecting the carnassials and molars, were explained by attrition. However, exposure by traumatic fragmentation or complete loss of teeth was also noted in younger specimens (and no doubt was also a factor in older dentitions which were explained by attrition).

Two individuals (ASUMZ 6708, 8239) were affected by osteomyelitis. Bone destruction in 6708 (Fig. 12) was noted along the jaws where the first three upper and lower premolars had been totally broken. Two larger fistula (3-5 mm diameter) were present at the root tip of the lower left canine of 8239 (Fig. 13).

Examination of Table 1 reveals that the second and third premolars are the most commonly affected teeth. Apparently, some aspect of gray fox behavior affects dental condition. Fifteen of the dentitions exhibited a near complete loss of premolars 1-3 in all jaws. Of these, 10 specimens had eroded the gingival tissues exposing the bone and had also scalloped into the dentary (Fig. 14). Sex was known for eight of these specimens, seven females and one male. Because of the skewed sex ratio, it may be that some aspect of female fox behavior, perhaps denning habits, predisposes females to dental trauma. Presumably, such tooth loss in either sex is caused by 'sawing' with the premolars against roots, limbs, bones, or other hard objects. We conjecture that den construction by females results in this phenomenon or perhaps physiological demands for calcium during gestation and lactation weakens the teeth and renders them more fragile in females.

One specimen (0.7% of sample) was affected by caries of the first upper molars. This was an older specimen in which attrition had exposed the dentine and pulp cavity. Abscesses of the upper molars were a complication.

#### CONCLUSIONS

The occurrence and importance of dental pathology to wild carnivores is related to age and the number and size of teeth. Bobcats possess the fewest (but generally largest) teeth, and the occurrence of dental disorders is low. Bobcats from the sample lived to be 15 years old. Coyotes have the most teeth of the carnivores examined but their teeth are generally large and dental disease was infrequent. Raccoons and gray foxes have several relatively delicate premolars and incidence of disease was highest for these. Raccoons may live to be eight years old and foxes five years. In both cases, dental attrition indicates these ages approach the functional maximum. Therefore, it appears that dental pathology may be influential as a limiting factor on longevity of individuals in some carnivore populations. However, this study also shows that animals can survive with a variety of dental problems. If dental pathology reduces an individual's success in predation, fitness may be affected if energetic requirements for reproductive success cannot be acquired or handled efficiently. At present, the effect of dental disease on fitness is not known.

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