VARIABILITY OF DENTAL DISEASES IN TWO POPULATIONS OF GREAT LAKES BLACK BEARS

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Abstract: Black bears (*Ursus americanus*) were live-trapped, immobilized, and examined to determine the incidence of dental caries, broken and missing teeth, and jaw and bone trauma; and the incidence and cause(s) of periodontal disease in northern Wisconsin in 1974-1975 ($N = 95$), and in Michigan's northern Lower Peninsula from 1977-1980 ($N = 35$). Based on tooth sectioning, Wisconsin bears ranged in age from 0.5 to 15.5 years (average age for males and females was 4.5 and 6.02 years, respectively); Michigan bears ranged in age from 0.02 to 8.1 years (average age for males and females, 4.5 and 4.29 years, respectively). As expected, dental caries were common in both Wisconsin (9 [10.5%] of 86 bears examined) and Michigan bears (7 [20%] of 35). In both cases, caries appeared to develop in older animals, ranging from 3.5 to 15.5 years of age in the Wisconsin sample and 3.5 to 8.1 years of age in the Michigan sample. Bears suffering from periodontal disease varied considerably between cohorts. In Wisconsin, only 1 (1.1%) of 95 bears, a 5.5-year-old female, was infected with the disease. In Michigan, however, 13 (37%) of 35 bears had periodontal disease in varying degrees of severity, suffering tooth loss, infection, edema, bleeding, and jaw and gum atrophy. There was insufficient evidence, however, to indicate that bacteria ($N = 12$) caused the disease. Using 2-dimensional isoelectric focusing, 5 samples of blood serum from diseased bears contained a minor protein band not present in disease-free samples. The results could not be replicated from other diseased bears, however. Selenium levels were low in bears examined (0.066-0.74 µg Se/ml serum), and although baseline values are not known for black bears, insufficient quantities of selenium in bear diets in Michigan's Lower Peninsula selenium-deficient belt are suspected of causing or at least contributing to the disease. Although periodontal disease was reported as age-dependent in other studies, such was not the case in Michigan (disease range = 1.75-6.5-years-old). Winter movements of several seriously-infected bears were related to disease infection.

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Colyer (1936) was perhaps the first to report dental variations and diseases in bears, including cavities and tooth eruption failures. He reported wild bears to be free of caries, but found dental cavities infrequently in captive bears. Hall (1940) found cavities in the teeth of 5 (3%) of 165 black bear skulls obtained from various localities in North America, and he reported in 1945 that dental caries were fairly common, particularly in older animals. He believed caries were most common in bears whose molars and low-rounded crowns and a topography of occlusal faces that, as in man, lead to penetration of enamel and decay of dentin. He also felt that bear diets high in honey, berries, and other carbohydrates could contribute to tooth decay. Erickson (1967) stated that dental diseases in black bears from Alaska were common, especially in older animals. He observed that canines often were broken, and that many other teeth were darkly stained and often decayed. Manville (1978) found dental cavities in 9 (11%) of 86 bears in northern Wisconsin, though only 1 had extensive decay.

Erickson (1967) reported that periodontal disease, too, was often encountered in black bears from Alaska, particularly among older animals. Eleven (79%) of 14 old-aged Alaska black bears examined by Rausch (1961) were noted to be infected with periodontal disease, while 7 (20%) of 35 prime-aged bears also were positive for that ailment. Periodontal disease was reported, however, only in 1 (1%) of 86 bears live-trapped in Wisconsin during 1974 and 1975 (Manville 1978). Colyer (1936) felt that injuries to individual teeth led to infection, yet the teeth of the 1 infected Wisconsin bear were not injured (Manville 1976).

Myrick (1988) suggested that tissue resorption and replacement in permanent teeth of black bears and several other mammals may be caused by stress-induced hypocalcemia. He proposed that although locally induced alteration — in response to local injury, pressure, disease, or malocclusion — is common in several mammalian species, systemic alteration of dental tissues by regulation of blood-serum calcium is also common. In his sample of 9 Montana black bears, the most detectable alteration occurred in winter and was usually fully repaired before the following winter.

This study was conducted to determine the incidence and possible cause(s) of dental diseases in 2 populations of black bears in northern Wisconsin and northern Lower Peninsula Michigan.

STUDY AREA

This study was conducted in Ashland, Bayfield, Iron, Oneida, Sawyer, and Taylor counties in northern Wisconsin, and in Crawford, Kalkaska, Missaukee, and Roscommon counties in the northern Lower Peninsula of Michigan. Both northern Wisconsin and the Lower Peninsula of Michigan were covered by the Wisconsin glaciation of the Pleistocene epoch (Leet and Judson 1965). In consequence, Wisconsin soils in Ashland, Bayfield, Oneida, Taylor, and Sawyer counties are generally sandy to sandy loam types. Those in Iron County are heavier and more mature (Leet and Judson 1965). In Michigan's northern Lower Peninsula, soils are sands and sandy-loams to rocky, with various quantities of glacial drift (Leet and Judson 1965). The Lower Peninsula is also situated in a selenium-deficient belt (P.K. Ku, animal husbandry specialist, Mich. State Univ.; Soil

Conservation Service, E. Lansing, MI 1978 pers. commun.).

METHODS AND MATERIALS

In both study areas, bears were captured in culvert and barrel traps and in modified Aldrich foot snares. A steel-mesh box trap was also used on occasion in northern Wisconsin. In northern Michigan, bears also were captured in their dens. They were ear-tagged in both areas, and were instrumented with fitted or expandable radio-collars in Michigan (Manville 1983, 1987). Ages of captured bears were determined from premolar cross-sections (Stoneberg and Jonkel 1966, Willey 1974). Tooth extraction wounds also were checked during subsequent recaptures for proper healing.

Each bear was examined for dental caries and periodontal disease. Suspected decayed areas of the teeth were scraped with a dental probe to differentiate simple plaque deposits and tartar from true dental caries. Decay was evident where the enamel and dentin were broken down or disintegrated. Acid-producing bacteria and their products are the causative agents of dental caries (Dorland 1917). To determine the presence of periodontal disease — a degenerative disorder that affects the periodontal membrane (and its ability to hold the teeth in place), gums, cementum, and alveolar bone — gum tissues were examined for evidence of infection, atrophy, edema, bleeding, loss of teeth, or other signs of tissue degeneration. Care was taken not to classify tissue as infected with periodontal disease if the tissue appeared to be traumatized by injury, or if the tissue simply contained a gum pigmentation such as reported by Rogers (L.L. Rogers, North Central Forest Experiment Station, U.S. Department of Agriculture, Forest Service, Ely, MN 1989 pers. commun.) and others. All apparently-diseased tissues were scraped with a dental probe to determine their integrity, and all dental caries and periodontal-diseased tissues were photographed.

In the Michigan study, about 30 cc of blood were extracted from each immobilized bear for serum selenium determination and serum 2-dimensional isoelectric focusing protein preparation. No determinations, however, were made for serum calcium values. For protein analysis, blood was centrifuged and serum separated from the hematocrit. The serum was then subjected to isoelectric determination as described by Pierce and Eradio (1979).

Bacterial swabs for laboratory culture were taken from caries and diseased periodontal tissues. Cepti-Seal Culturettes, which contained modified Stuart's bacterial transport medium, were used for this purpose. The average time interval between obtaining the swab and plating was 36 hours. Cultures were maintained at ambient temperature, which ranged from -28 to 24 C, depending on the time of year samples were taken. Cultures were plated in a standard manner using blood agar in a 5% CO_2 environment, a plain MacConkey plate in a regular environment with no CO_2, and a plate of phenylethyl alcohol in conjunction with the blood agar plate at Michigan State University's Veterinary Medicine Department. Cultures were incubated at 37 C and read after 24 hours and daily for 72 hours. Anaerobic cultures were not obtained.

Bears also were physically examined for diseases such as canine adenovirus that may predispose them to periodontal disease, although no viral analyses were made nor antibody titers taken.

Black bear skulls in the National Museum of Natural History, Washington, D.C., were examined for dental caries and periodontal disease. Specimens with extensive damage were photographed.

Bear baiting, feeding, and the impact of garbage dumps on Wisconsin and Michigan bears were assessed by attempting to relate the number of bait, feeding, and landfill sites available to individual bears, and the amount of caries and periodontal disease present in bears known to feed at these sites.

Vegetation use by bears of the 4 major habitat types in Michigan's Lower Peninsula also was examined, trying to relate bear use to selenium deficiencies in these habitat areas. The randomization test for 2 independent samples (Siegel 1956) was used to test the statistical significance between the incidence of periodontal disease and the use of the major habitat types by bears. Precipitation levels also were examined by reviewing rainfall records as drought can suppress selenium and other trace mineral levels in vegetation.

RESULTS

Tooth Decay

As expected, dental caries were common in both Wisconsin (9 [10.5%] of 86 bears examined) and Michigan bears (7 [20%] of 35). In both areas, caries appeared to develop in older animals, ranging from 3.5 to 15.5 years of age in the Wisconsin sample, 3.5 to 8.1 in the Michigan study. In the Wisconsin sample, caries occurred in: 3.5-year-old (1 bear), 5.5 (3), 6.5 (4), and 15.5 (1). In the Michigan sample, caries occurred in: 3.5-year-old (1), 3.75 (2), 4 (1), 4.1 (1), 4.5 (1), and 8.1 (1). A female with a severe case of periodontal disease did not show caries until between 3.1 and 4.1 years of age.

Periodontal Disease

Bears suffering from periodontal disease varied considerably between cohorts. In Wisconsin, only 1 (1.1%) of 95 bears, a 5.5-year-old female, was infected with the disease. A mild infection was noted behind both upper canines; all teeth were intact, and caries were not evident. In the Michigan study, however, 13 (37%) of 35 bears captured had periodontal disease in varying degrees of severity, suffering tooth loss, infection, edema, bleeding, and jaw and gum atrophy.

The blood sera from 6 denned bears (2 females and 4 males) were examined for selenium values in relation to periodontal disease; the 2 females had 0.066 and 0.074 μg Se/ml serum. If found in pigs, the 2 minimal values might indicate a beginning selenium-deficient problem, but no baseline values are known for black bears so that deficiency problems are difficult to predict. Since the Lower Peninsula is in a selenium-deficient belt, and since insufficient quantities of this element can cause periodontal disease in humans (Fredericks 1979), insufficient selenium is suspected of either causing or contributing to periodontal disease in Lower Peninsula bears. No similar problems with periodontal disease or selenium deficiencies were reported by Rogers (1987) in black bears in northeastern Minnesota, although he now feels that abnormally darkened and traumatized tissues seen in some of the Minnesota bears — not to be confused with those containing normal dark gum pigments — may have been periodontally diseased (L.L. Rogers, North Central Forest Experiment Station, U.S. Department of Agriculture, Forest Service, Ely, MN 1989 pers. commun.).

Both Erickson (1967) and Rausch (1961) indicated that periodontal disease in black bears examined in Alaska was age-dependent. In this study, such was generally not the case. Ages of bears in Michigan inflicted with the disease at the time of capture ranged from 1.75 to 6.5 years. The age:disease frequency was: 1.75 years (1 of 13), 2.75 (1), 3.5 (3), 4.5 (5), 5.0 (1), 6.1 (1), and 6.4 (1). By far the most extreme case of the disease was in a 2.75-year-old male. In that case, there was atrophy of the gum and jawbone, nearly complete exposure of the canine root, and infection (Fig. 1). The bear was shot as a nuisance in July 1980 while raiding bird feeders and bee hives. In a 4.5-year-old male, the disease was classed as serious with atrophy of buccal and lingual gum tissue, loss of premolars, and widespread infection (Fig. 2).

Serum protease inhibitors in turkeys and several mammals (not known to include bears) have been associated, due to their deficiency, with major diseases such as emphysema (Kueppers and Black 1974). Samples from 7 bears, 5 of which were known to have periodontal disease, were tested using 2-dimensional isoelectric focusing. All samples showed the expected 3 major protein bands, but the 5 samples from diseased bears also contained a minor additional band. Further tests on sera from other bears, both infected and disease-free, failed to duplicate the minor-band pattern. All protein samples showed normal alpha-1-antitrypsin activity. The addi-

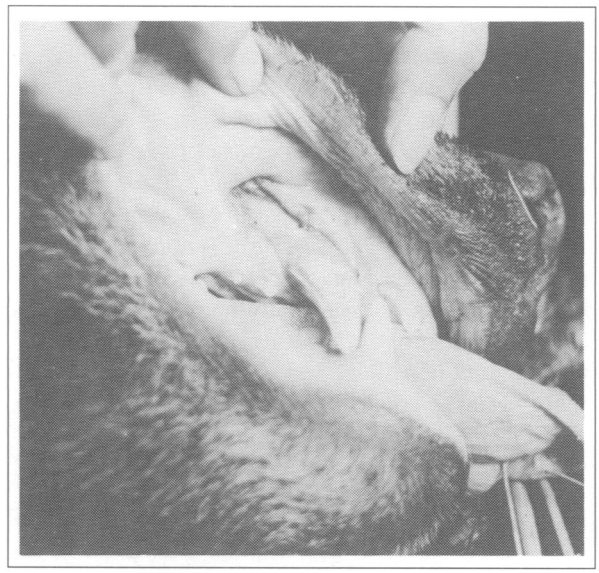

Fig. 1. Critical case of periodontal disease found in 2.75-year-old male DH, examined on 25 October 1977. Note nearly complete exposure of canine root, atrophy of gum and jawbone, and infection. Bear was shot as a nuisance in July 1980 raiding bird feeders and bee hives.

Fig. 2. Serious case of periodontal disease in 4.5-year-old male Gr, examined on 20 June 1978. Note atrophy of gum tissue, loss of premolars, and infection.

tional protein band in the sera from infected bears is curious but needs to be examined further using this and other techniques before possibly linking periodontal disease to proteolytic enzyme causes.

Bacterial swabs were taken from teeth and gums from 12 different Michigan bears (7 males and 5 females; Table 1). Specimens from all except 2 showed a presence of *Micrococcus* sp. This organism is normally considered to be only a skin contaminant, being associated with man and animals as a generally harmless commensal (Carter 1979). *Staphylococcus aureus* and *S. epidermidis*, present in 4 and 2 bears, respectively, also commonly occur as commensals on the skin and mucous membranes of man and other animals. *S. aureus*, however, has been reported to cause abscesses in many animal species, and is a frequent secondary invader and opportunist in a wide variety of diseases (Carter 1979). *S. epidermidis* also has been implicated as causing abscesses and skin infections in various animal species.

Bacillus sp. was present in 1 bear swab and can cause abscesses in teeth. *Actinomyces* sp. also has been known to cause infection. Although these 2 organisms were present in swabs from 4 bears infected with periodontal disease, they probably were not responsible for the initial infection. Alpha-hemolytic *Streptococcus* sp. is a common throat organism, beta-hemolytic *Streptococcus* sp. has been implicated in potential primary and secondary infection problems, and nonhemolytic *Streptococcus* sp. is generally considered to be a commensal organism. All 3 organisms were variably present. Most other bacteria that were present in the samples collected from teeth and gums were probably there because of fecal contamination, since bears usually defecated in barrel and culvert traps.

There is insufficient evidence to indicate that any of the bacteria collected ($N = 13$ species identified from 12 bears) were the cause of periodontal disease in Michigan bears. Their presence may have been opportunistic, possibly related to secondary infection. According to Page and Schroeder (1982), periodontal disease in humans, domestic dogs, and monkeys is usually bacterial in origin. Colyer (1936) felt that periodontal disease was caused by injuries to individual teeth. In this study, most infected cases showed no indication of tooth injury or damage.

In 7 cases, bears that had the disease at initial capture were found not to have evidence of it when recaptured 7 to 13 months later. In 2 cases, bears having the disease when initially captured continued to show presence of it when recaptured. In 2 other cases, the disease was not present at the time of initial capture but was present at subsequent recapture. In the remaining 2 cases, the diseased bears were not recaptured.

The museum skulls of 618 black bears from Canada, United States, and Mexico were examined for evidence of possible periodontal disease. In contrast to the 37% incidence of periodontal disease infections in Michigan bears, only 5 (4%) of 136 Alaskan black bear skulls showed evidence of bone atrophy and degeneration possibly indicative of the disease. One (3%) of 32 skulls from Arizona, 1 (8%) of 13 from Florida, 3 (16%) of 19 from New York, and 1 (4%) of 23 from Mexico showed evidence of the disease.

In Wisconsin, baiting, bear feeding, and garbage were reviewed as possible factors relating to the disease. Although landfills in the Wisconsin study area were actively used by a number of bears, and the landfills remained open throughout the study, only 1 (1.1%) of 95 bears showed evidence of the disease. This incidence was mild. While baiting at the time was legally limited to "liquid scents," bear baiters liberally interpreted this limitation, and many outright violated it, using breads, pastries, meat scraps, fish, oatmeal, and other non-liquid scent materials. In Michigan, however, the level of periodontal disease was high (13 [37%] of 35 bears) but most of the sanitary landfills were closed in the study area in 1978, although at least 6 bears appeared to feed at a landfill in northeast Roscommon County until after its closure in 1978. Although baiting regulations in Michigan were more liberal than in Wisconsin, baiting was not as prevalent, except perhaps just before and during the bear bow and gun hunting seasons.

Vegetation use by bears of the 4 major habitat types in Michigan's Lower Peninsula also was examined, trying to relate use to selenium deficiencies. In decreasing amount of use, swamp conifers, lowland brush, lowland hardwoods, and upland hardwoods were most utilized. No definitive conclusions, however, could be reached and the statistical tests were not significant. Precipitation levels also were reviewed, but drought was not a problem during this study, and mast was plentiful.

DISCUSSION AND CONCLUSIONS

Winter movements of 2 periodontal-diseased bears, including the 2.75-year-old male with the most extreme case of periodontitis and an adult female with 2 cubs, may have been related, in part, to irritation from the periodontal infection. In both cases, the male and female each had 6 dens during a 2-winter period.

Although considerable research has been done on the blood chemistry of black bears (Nelson et al. 1984;

Table 1. Incidence of bacteria collected from gums and teeth of black bears handled between June 1978 and March 1980, Lower Peninsula of Michigan.

Bear	Periodt disease	Dental caries	Date sample collected	Bacterial presence and degree of infestation: α-hemolytic *Streptococcus* sp.	β-hemolytic *Streptococcus* sp.	nonhemolytic *Streptococcus* sp.	*Acinetobacter* sp.
MALES							
Du			6 13 78	light	—	—	—
Gr	+		6 20 78	heavy	—	heavy	—
LA	+		2 3 79	light	—	—	—
Go	+	+	1 26 80	—	light	—	—
OC	+		2 23 80	—	—	—	heavy
LS	+		3 1 80	—	—	—	—
MP	+		3 2 80	—	—	—	—
FEMALES							
Rh	+		6 15 78	light	—	—	—
Ta	+	+	3 11 79	moderate	—	—	moderate
DM		+	1 26 80	light	light	—	—
Ta	+[a]	+	2 17 80	—	—	—	—
Lu	+	+	3 5 80	—	—	—	—

Bear	*Actinomyces* sp.	*Bacillus* sp.	*Enterobacter* sp.	*Klebsiella pneumoniae*	*Micrococcus* sp.	*Proteus mirabilis*	*Proteus* sp.	*Staphylococcus aureus*	*Staphylococcus epidermidis*
MALES									
Du	—	—	—	—	light	—	—	—	—
Gr	—	—	—	—	heavy	—	—	—	—
LA	—	—	—	—	light	—	—	—	—
Go	—	—	—	—	light	—	—	—	—
OC	—	—	heavy	—	heavy	—	—	—	heavy
LS	light	—	—	—	light	—	—	—	—
MP	—	—	—	light	light	—	—	light	light
FEMALES									
Rh	—	—	—	—	light	—	—	light	—
Ta	—	—	—	—	moderate	—	—	—	—
DM	—	light	—	—	—	—	—	—	—
Ta[a]	—	—	—	—	moderate[b]	heavy[c]	light[b]	light[b]	—
Lu	—	—	—	—	—	—	—	very light	—

[a] = second sample taken from this bear
[b] = sample taken from dental caries
[c] = sample taken from periodontal diseased tissue

Franzmann and Schwartz 1988, and others), no additional recent studies have been conducted on the causative agent(s) of periodontal disease in Michigan black bears (Dr. H. Lowe, Director, Office of Dental Information, National Institutes of Health, Bethesda, MD 1989 pers. commun.). The recent evidence of Myrick (1988) indicating that dental alteration in black bears may be under systemic control, with alteration features repeatedly connected to winter periods, suggests the need for a closer look at this mechanism both as it relates to dental caries and to periodontal disease. Myrick suggested that resorption may be due to stresses such as winter cold, fasting, and cubbing. He felt, presumably, that resorption was associated with fasting in all individual bears (except neonatal cubs that nurse), as well as with late pregnancy, parturition, and early lactation in mature females.

It is therefore strongly recommended that additional research on dental diseases of black bears in the northern Lower Peninsula, Michigan be conducted. The study should possibly be conducted through the University of Michigan Dental School, with guidance, direction, and assistance from the Michigan Department of Natural Resources. In particular, baseline determinations for selenium, copper, magnesium, other trace minerals, and calcium need to be made. Vegetation being eaten by bears there needs to be analyzed for trace mineral levels. Additional bacterial analyses and viral studies need to be conducted, and diseases that may predispose bears to periodontitis need more scrutiny. If reproduction is being limited, correlations need to be attempted between reproduction and trace mineral levels. An answer to these questions about periodontitis in Michigan bears (and elsewhere, for that matter) has important medical and dental ramifications for humans and other wildlife as well.

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