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DISEASE IN WILDLIFE OR EXOTIC SPECIES

Dental Pathology of the Hoary Marmot (*Marmota caligata*), Groundhog (*Marmota monax*) and Alaska Marmot (*Marmota broweri*)

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Summary

Museum specimens (maxillae and mandibles) of the three marmot species occurring in Alaska (*Marmota caligata* [$n = 108$ specimens], *Marmota monax* [$n = 30$] and *Marmota broweri* [$n = 24$]) were examined macroscopically according to predefined criteria. There were 71 specimens (43.8%) from female animals, 69 (42.6%) from male animals and 22 (13.6%) from animals of unknown sex. The ages of animals ranged from neonatal to adult, with 121 young adults (74.4%) and 41 adults (25.3%) included, and 168 excluded from study due to neonatal/juvenile age or incompleteness of specimens (missing part of the dentition). None of the teeth were missing, so 3,564 teeth were available for examination. All teeth were normal in morphology and none was affected by enamel hypoplasia. Two specimens displayed two supernumerary teeth each. One-third of specimens displayed attrition/abrasion and in 38.9% of these the change involved all premolar and molar teeth. The proportion of adult specimens affected by attrition/abrasion was three times as high as young adult specimens. Dental fractures were rare, noted in only two specimens, affecting 0.08% of teeth ($n = 3$). Periapical disease was also rare, with a striking lesion in one young adult female specimen. Some degree of periodontitis was seen in 26 specimens (16.1%), affecting 4.6% of premolar and molar teeth. The proportion of adults with periodontitis was over three times as high as that for young adults. Five specimens displayed mild malocclusion. Although the clinical significance of dental pathology in the marmot species of Alaska remains elusive, the occurrence and severity of some dental lesions may play an important role in their morbidity and mortality.

Keywords: Alaska; marmot; dental pathology; *Marmota* spp.

Introduction

Marmots are squirrel-like rodents in the family Sciuridae and genus *Marmota*, in which there are 15 species (Brandler and Lyapunova, 2009). Three species occur in Alaska: the hoary marmot (*Marmota caligata*), the groundhog or woodchuck (*Marmota monax*) and the Alaska marmot (*Marmota broweri*). Hoary and Alaska marmots are largely restricted to alpine habitats (Gunderson *et al.*, 2009), while the groundhog inhabits lowlands extending from Alaska to Georgia (Svendsen, 1999). The hoary marmot is distributed in suitable habitat across much of Alaska south of the Yukon River, as well as western Canada and the Pacific Northwest (Braun *et al.*, 2011); the Alaska marmot, in contrast, has a much narrower distribution, limited to the Brooks Range in northern Alaska and the Ray Mountains and Kokrines Hills of northern, interior Alaska (Gunderson *et al.*, 2009).

Marmots are exceptional in that they are the largest, truly hibernating mammals (Cardini and

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O'Higgins, 2004). The hibernation period of hoary and Alaska marmots typically spans 7–8 months; the hibernation period of the groundhog is shorter, ranging from 3.5 to 5.5 months, depending on location (Hock and Cottini, 1966; Armitage, 2003).

Hoary marmot adults range from 63 to 82 cm in total length (Howell, 1915; Braun *et al.*, 2011) and weigh an average of 7 kg in September and 3.75 kg in May (Barash, 1989). Dramatic weight variation is due to the prolonged hibernation period. The groundhog typically measures 55–67.5 cm and weighs 2.25–4.5 kg (Linzey and Brecht, 2002). The Alaska marmot weighs 4.5 kg or more and may exceed 76 cm in length (Marmot, 2016) (https://www.adfg.alaska.gov/static/education/wns/marmot.pdf).

With the exception of the groundhog, marmots typically live in colonies composed of a breeding pair and multiple generations of offspring. They are highly social and communicate via loud whistles and other vocalizations, warning one another against their predators, which can include eagles, wolverines, foxes, coyotes, wolves, lynx, mountain lions and bears (Holmes, 1984; Armitage, 2003).

Marmot diet varies by species, but in general is dominated by plants. The hoary marmot is a generalist herbivore, with a diet consisting of leaves and flowers (Barash, 1989; Taulman, 1990). The diet of the groundhog is similar to that of the hoary marmot, but also includes a small proportion of insects (Armitage, 2003). The Alaska marmot consumes tundra vegetation (e.g. grasses, flowering plants, berries, roots, mosses and lichens) (Marmot, 2016) (https://www.adfg.alaska.gov/static/education/wns/marmot.pdf).

All rodents have a relatively similar anatomical dental arrangement, with the incisor teeth separated from the premolar and/or molar teeth by a substantial gap, sometimes erroneously referred to as a 'diastema' in the literature. Rodents are monophyodont, meaning they have a single set of teeth with no precursors or successors (Crossley, 1995; Hillson, 2005). The marmot dental formula is: I 1/1, C 0/0, P 2/1, M 3/3 (Fig. 1). Based on the terminal reduction theory and dental nomenclature, the present maxillary premolar teeth are the third and fourth, and the present mandibular premolar tooth is the fourth (Hillson, 2005). Marmots have continuously growing incisor teeth that are elodont, aradicular hypsodont (i.e. long anatomical crown, erupt continuously and remain open-rooted). The incisor teeth of all rodents are covered by enamel only on the labial, mesial and distal surfaces (Mancinelli and Capello, 2016). The premolar and molar teeth, often termed 'cheek teeth', are anelodont, brachydont (i.e. not continuously growing and erupting, close-rooted) in Sciuridae, the family of rodents that includes the marmots. The premolar and molar teeth of the Sciuridae typically are brachydont but 'high-crowned', with prominent transverse ridges on the occlusal surface (Hillson, 2005).

The dental pathology of pet rodents with elodont incisors and brachydont premolar and molar teeth, such as the rat (*Rattus norvegicus*) and hamster (subfamily Cricetinae), has been well described (Legendre, 2016; Mancinelli and Capello, 2016), contrary to the pathology of animals in the wild.

It has been proposed that species inhabiting alpine regions are particularly sensitive to climate change (McDonald and Brown, 1992), suggesting that the marmot may be susceptible to climate-related habitat loss (Krajick, 2004; Parmesan, 2006). While climate change may become the marmot's main threat, dental lesions, which are reportedly common in certain wildlife species, may be an important contributor to morbidity and mortality (Verstraete *et al.*, 1996a,b).

A series of papers has been published on dental pathology of mammalian species: the northern elephant seal (*Mirounga angustirostris*) (Abbott and Verstraete, 2005), the southern sea otter (*Enhydra lutris nereis*) (Arzi *et al.*, 2013; Winer *et al.*, 2013), the California sea lion (*Zalophus californianus*) (Sinai *et al.*, 2014; Arzi *et al.*, 2015), the northern fur seal (*Callorhinus ursinus*) (Aalderink *et al.*, 2015a), the Eastern Pacific harbour seal (*Phoca vitulina richardii*) (Aalderink *et al.*, 2015b), the bobcat (*Lynx rufus californicus*) (Aghashani *et al.*, 2016), the polar bear (*Ursus maritimus*) (Winer *et al.*, 2016a) and the walrus (*Odobenus rosmarus*) (Winer *et al.*, 2016b). In general, museum collections of skulls, such as those making up the aforementioned studies, are obtained from strandings and carcass recovery. Specific to the marmot, many specimens were collected for research purposes. The aim of this study was to determine the nature and prevalence of dental pathology in the marmot by examining museum specimen skulls.

Materials and Methods

Macroscopic examination of 330 marmot skulls, specifically the maxillae and mandibles, in the Mammal Collection at the University of Alaska Museum (Fairbanks, Alaska, USA) was performed. Of the 330 specimens, 220 were *M. caligata*, 74 were *M. monax* and 36 were *M. broweri*. Each specimen had been labelled previously with a unique catalogue number and the specimen's sex, collection location and collection date. 'Adult' versus 'young adult' categorization was determined by prominence of cranial sutures.

The teeth and surrounding bone were inspected systematically according to predefined criteria

(Table 1) utilized in former studies (Abbott and Verstraete, 2005; Winer *et al*., 2013; Sinai *et al*., 2014; Aalderink *et al*., 2015a,b; Aghashani *et al*., 2016; Winer *et al*., 2016a,b). Care was taken to rule out post-mortem trauma or preparation artefacts such as hairline cracks, artefactual sharp-edged fractures and flaked off enamel, potentially due to excessive heating and/or drying during skull preparation.

The presence or absence (i.e. congenital, acquired or artefactual) of all teeth was recorded. Teeth were assessed for normal or abnormal form. The presence of supernumerary teeth adjacent to the normal dentition was looked for. Attrition/abrasion was assigned to describe the wear of cusp tips; incisor teeth were not inspected for attrition/abrasion, as physiologically they need to be ‘worn down’ in order to maintain proper occlusion. Six fracture types were assigned according to American Veterinary Dental College nomenclature (Tooth Fracture Classification, 2016) (http://www.avdc.org/Nomenclature/Nomen-Teeth.html#fracture). Periapical lesions were searched for; these were considered a bony fenestration or a periosteal reaction overlying the apex of a tooth. Periodontal status was assessed based on an established classification system adapted for use on skulls (Verstraete *et al*., 1996a,b). Periodontitis stages 2–4 were assigned to the bony lesions indicative of periodontitis; stage 1 was excluded, as it refers to gingivitis, a soft tissue lesion that could not be assessed. Stage 2 shows increased vascularity (i.e. increased bone porosity) at the alveolar margin. Stage 3 shows rounding of the alveolar margin with more than 3 mm of vertical or horizontal bone loss. Periodontitis stage 4 shows widening of the alveolar margin with severe vertical or horizontal bone loss and teeth that are unstable in the alveoli or missing secondary to alveolar changes. Enamel changes consistent with the clinical signs of enamel hypoplasia were looked for.

Data from all adult and young adult specimens were pooled according to tooth type and were analysed with descriptive statistics. Prevalence of lesions was compared with age group and sex. Significance was calculated by Fisher’s exact test and $P < 0.05$ was considered significant.

Table 1
Congenital, developmental and acquired abnormalities noted, and inclusion criteria

Observation	*Criteria*
Tooth artefactually absent	Jaw fragment missing or tooth absent, but a well-defined, sharp-edged, normally shaped, empty alveolus present; tooth presumed lost during preparation or post-mortem manipulation of the skull.
Tooth absent – presumably acquired	Tooth absent; alveolus or remnant alveolus visible; alveolar bone shows pathological signs (e.g. rounding of the alveolar margin, shallow alveolus, periosteal reaction on alveolar bone, increased vascular foramina).
Tooth absent – presumably congenital	Tooth and alveolus absent; smooth, morphologically normal bone present at the site; no physical space for that tooth to have occupied.
Malformed tooth	Presence of an abnormally shaped crown.
Supernumerary tooth	Presence of a supernumerary tooth adjacent to an expected tooth (or alveolus).
Attrition/abrasion	Exposure of dentine on the cuspal tip, with or without tertiary dentine formation.
Enamel fracture	A chip fracture or crack of the enamel only.
Uncomplicated crown fracture	A fracture involving enamel and dentine, but not exposing the pulp.
Complicated crown fracture	A fracture involving enamel and dentine, with pulp exposure.
Uncomplicated crown-root fracture	A fracture involving enamel, dentine and cementum, but not exposing the pulp.
Complicated crown-root fracture	A fracture involving enamel, dentine and cementum, with pulp exposure.
Root fracture	A fracture affecting dentine, cementum and the pulp.
Periapical lesions	Macroscopically visible periapical bone loss, root tip resorption, sinus tract formation originating periapically, or obvious focal periosteal reaction overlying the apex.
Periodontitis stage 2	Evidence of increased vascularity at the alveolar margin (i.e. more prominent vascular foramina in, and slightly rougher texture of, the bone of the alveolar margin).
Periodontitis stage 3	Rounding of the alveolar margin; moderate horizontal or vertical bone loss.
Periodontitis stage 4	Widening of the periodontal space; severe horizontal or vertical bone loss; tooth mobile in the alveolus.
Enamel hypoplasia	Irregular pitting, or a band-shaped absence or thinning of the enamel, consistent with the clinical signs of enamel hypoplasia.

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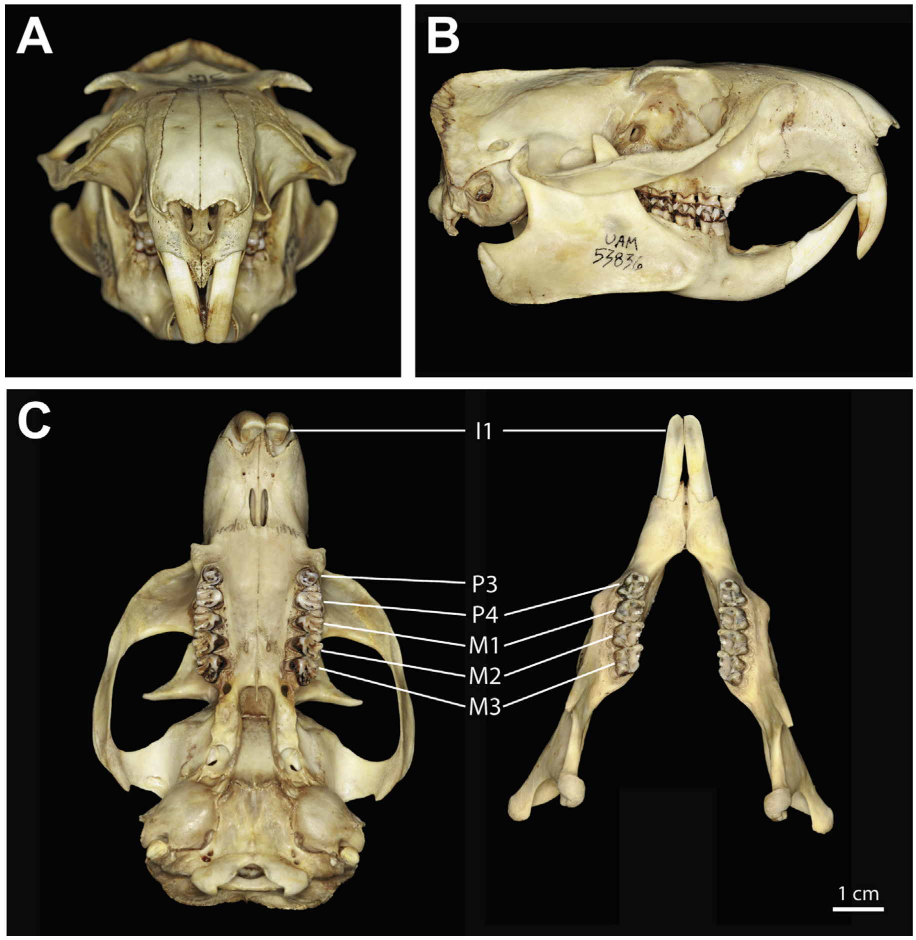

Fig. 1. Representative dentition of the marmot (*Marmota caligata*, UAM 53836). (A) Rostral view. (B) Lateral view. (C) Labelled dentition.

Results

The collection date of specimens ranged from 1951 to 2015. Of the 330 specimens available, 162 were included in this study; the other specimens were omitted due to excessive ante-mortem or post-mortem trauma preventing the ability to analyse teeth for pathology, or if a complete skull was not available (i.e. the mandibles or maxillae were absent). Of the 162 included specimens, 108 were *M. caligata*, 30 were *M. monax* and 24 were *M. broweri*. Of the total number of specimens included in this study, 71 (43.8%) were from female animals, 69 (42.6%) were from male animals and 22 (13.6%) were from animals of unknown sex. Young adult and adult specimens comprised 121 (74.7%) and 41 (25.3%) of the total included specimens, respectively.

Presence of Teeth

All teeth were present in all specimens; therefore, 3,564 teeth were available for examination.

Tooth Form

All teeth were normal in morphology.

Supernumerary Teeth

Two young adult male specimens displayed supernumerary teeth. One *M. caligata* specimen (UAM 112364) had supernumerary right and left mandibular fourth premolar teeth (Fig. 2); one *M. monax* specimen (UAM 83196) possessed a supernumerary left maxillary first molar tooth and a supernumerary left mandibular first molar tooth.

Attrition/Abrasion

Exactly one-third of specimens ($n = 54$) displayed some degree of attrition/abrasion of the premolar and molar teeth. Of these 54 specimens, 21 (38.9%) had all premolar and molar teeth affected by attrition/abrasion (Fig. 3). Of all premolar and molar teeth examined, there were 633 (21.7%) with worn cuspal tips consistent with attrition/abrasion. The

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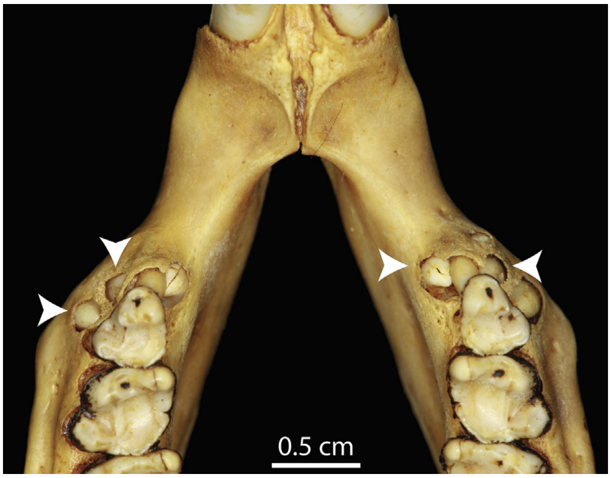

Fig. 2. Supernumerary teeth at the left and right mandibular fourth premolar teeth (arrowheads) in a *M. caligata* specimen (UAM 112364).

same number of adult (n = 27) and young adult (n = 27) specimens displayed attrition/abrasion; however, the proportion of adult specimens with attrition/abrasion was significantly higher than young adult specimens (65.9% versus 22.3%, respectively; P >0.0001). The proportion of affected males versus females was not significantly different (31.9% [n = 22] versus 43.7%, respectively; P = 0.17).

Tooth Fractures

Dental fractures were noted in only two marmots, both of the species *M. caligata*, affecting 1.2% of specimens and 0.08% of teeth (n = 3). One specimen (UAM 112360) was an adult male with a complicated crown-root fracture of the right mandibular second molar tooth (Fig. 4), and the other (UAM 115800) was a young adult female with complicated crown fractures of the right and left maxillary third molar teeth.

Periapical Disease

One young adult female specimen (UAM 112325) possessed a markedly lytic lesion overlying the apex of the left maxillary incisor tooth (Fig. 5). It is probable that this lesion represents severe periapical disease (i.e. a 'tooth root abscess'); however, it was not possible to entirely rule out a neoplastic process as the underlying aetiology of this lesion. No additional periapical lesions were noted.

Alveolar Bony Changes Consistent with Periodontitis

There were 26 specimens (16.1%) affected by some degree of periodontitis. No incisor teeth were affected

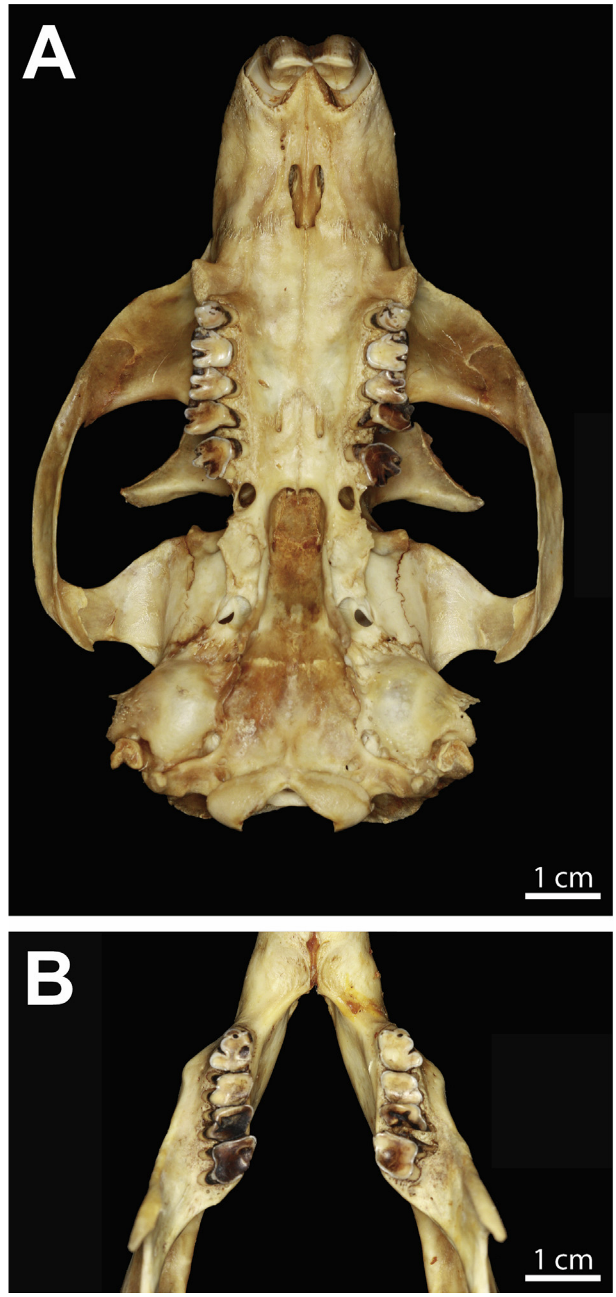

Fig. 3. Adult male *M. caligata* specimen (UAM 112360) displaying attrition/abrasion of all (A) maxillary and (B) mandibular premolar and molar teeth.

by periodontitis; of all premolar and molar teeth, 4.6% (n = 133) were associated with bony changes indicative of periodontitis. The proportion of adults with periodontitis (34.1%, n = 14) was over three times as high as that for young adults (9.9%, n = 12). The proportion of affected male and female marmots was similar, with 12 males (17.4%) and 13 females (18.3%). Thus, there was a significant difference in prevalence based on age (P = 0.0008), but not sex (P = 1.00). Overall, stage 3 periodontitis was most

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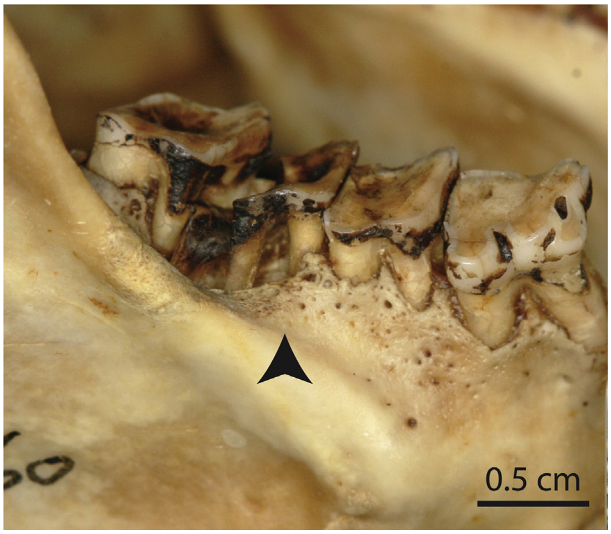

Fig. 4. Adult male specimen (UAM 112360) with a complicated crown-root fracture of the right mandibular second molar tooth (arrowhead points to the fractured tooth).

common (n = 81, 60.9% of alveoli affected by periodontitis), followed by stage 4 (n = 42, 31.6%) and stage 2 (n = 10, 7.5%) (Fig. 6). The mandibles were more affected by periodontitis than the maxillae: 72.9% of alveoli with periodontitis were mandibular (n = 97) versus 27.1% that were maxillary (n = 36). The right and left mandibular fourth premolar teeth were most commonly affected by periodontitis (n = 44), making up one-third of recorded locations (33.1%), followed by the right and left mandibular first molar teeth (n = 30, 22.6%). Most specimens displayed symmetrical lesions; however, there was a slight trend toward the left quadrants having more teeth affected by periodontitis: 21 left maxillary teeth were affected in total versus 14 right maxillary teeth, and 51 left mandibular teeth were affected in total versus 46 right mandibular teeth.

Enamel Hypoplasia

None of the marmot specimens was affected by enamel hypoplasia.

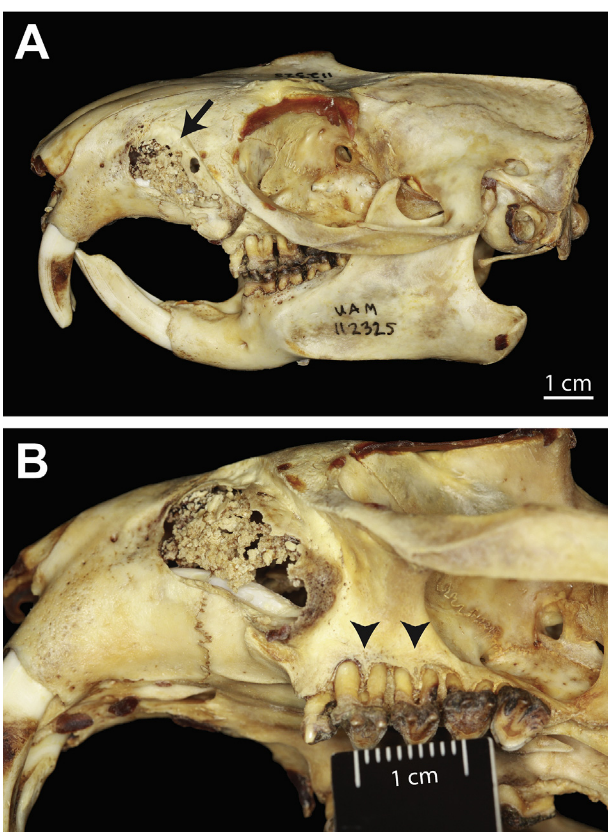

Fig. 5. (A, B). Periapical disease (marked lytic lesion) of the left maxillary first incisor tooth (arrow) in a young adult female specimen (UAM 112325). Also note the severe periodontal disease (stage 4) of the left maxillary fourth premolar tooth and first molar tooth (arrowheads).

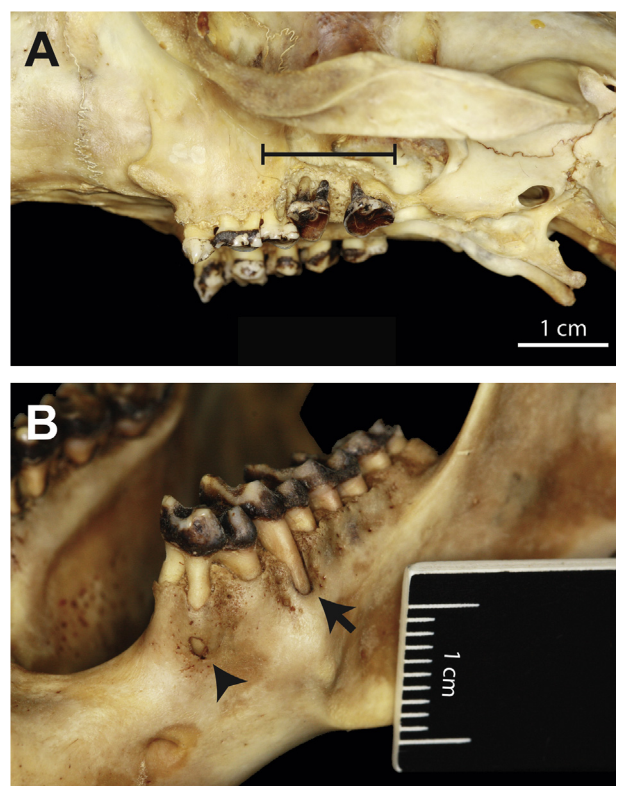

Fig. 6. (A) Stage 4 periodontitis affecting the left maxillary first through third molar teeth (bracketed) in an adult male *Marmota caligata* specimen (UAM 112360). (B) Stage 4 periodontitis affecting the left mandibular fourth premolar tooth (arrowhead marking fenestration) and left mandibular first molar tooth (arrow marking dehiscence) (UAM 112571).

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Fig. 7. Mild malocclusion of the mandibular incisor teeth in a young adult male *M. caligata* (UAM 113902).

Other Findings

Five specimens displayed malocclusion, four of which were maloccluding mandibular incisor teeth (Fig. 7) and one of which had mild torsion of the maxilla when the premolar and molar teeth were in occlusion.

It was noted while examining specimens with partially erupted or recently erupted teeth that most often the maxillary and mandibular third molar teeth were the most recent to erupt (observed in four specimens); however, one young adult male *M. monax* (UAM 83195) had right and left mandibular fourth premolar teeth and right and left maxillary third and fourth premolar teeth that were the most recent to erupt (Fig. 8).

Discussion

A collection of 162 young adult or adult specimens (i.e. skulls with both maxillae and mandibles available for review) was examined to characterize the nature and prevalence of dental pathology in the hoary marmot, groundhog and Alaska marmot. A total of 168 specimens (neonates/juveniles, or those with evidence of post-mortem trauma or preparation artefacts) were excluded from the study. Investigating lesion variability over the 64-year collection period was problematic because specimen procurement was erratic, with inconsistent numbers and ages of specimens collected over time. It was also impossible to compare pathology between species, as the number of specimens was not equivalent across species, with relatively many *M. caligata* specimens and fewer *M. monax* and *M. broweri* specimens. Therefore, no obvious trends correlating to chronology or species differences could be identified.

Congenital lesions were consistently infrequent in this sample of marmots. All teeth were present and of normal morphology. Two specimens each had two supernumerary teeth. Supernumerary teeth have been recognized previously in a variety of other rodents, including those belonging to the family Sciuridae (Goodwin, 1998). Previously documented supernumerary teeth in rodents most often occur distal to the maxillary third molar teeth, either unilaterally (Johnson, 1952; Lechleitner, 1958) or bilaterally (Hooper, 1955), or distal to the mandibular third molar teeth (Goodwin, 1998). Supernumerary teeth have been reported more rarely in association with other teeth, such as mandibular incisor teeth (Hansen, 1956) and mesial to the mandibular fourth premolar teeth (Harris and Fleharty, 1962). In a study of 1,667 Richardson's ground squirrels (*Spermophilus richardsonii*), there were five specimens with supernumerary teeth, all occurring bilaterally and distal to the maxillary third molar teeth (Goodwin, 1998). The prevalence encountered in that study (0.3%) is similar to that in the present study (0.8%); however, none of the marmot specimens possessed supernumerary teeth in that location.

Malocclusion in mammals can be due to congenital causes (i.e. abnormal tooth position or misshapen skull) or acquired causes (i.e. trauma or loss of an opposing tooth) (Capello, 2008). Congenital malocclusion in rodents is rare; an elongated (prognathic) or foreshortened (brachygnathic) jaw is not recognized in rodent species, with the exception of anecdotal reports in the hamster (Capello, 2008). Dramatic instances of incisor tooth malocclusion have been documented previously in marmots (Pratt and Knight, 1981; Elliott, 1989). The cases of malocclusion noted in the present study were subtle, with the chisel edge of the incisor teeth not meeting appropriately, but instead being mildly askew. However, additional subtle instances of malocclusion may have been overlooked, as some intermandibular joints (symphyses) were disarticulated, while others were glued together at a mildly misaligned angle and thus not counted. No instances of dramatic malocclusion at the magnitude of the two previously reported cases (Pratt and Knight, 1981; Elliott, 1989) were encountered in this population of marmots.

Eruption sequence was inferred based on degree of attrition/abrasion and staining, with less worn and less extrinsically discoloured teeth concluded to have erupted more recently. Of the five specimens noted to have recently erupted or partially erupted teeth, one specimen (UAM 83195) differed in its apparent eruption pattern, with the most rostral cheek teeth most recently erupted versus the more commonly observed caudal-most cheek teeth most recently erupted. Further studies are necessary to determine the typical eruption pattern of marmot dentition and if deviance from this standard is pathological or considered a variation of normal.

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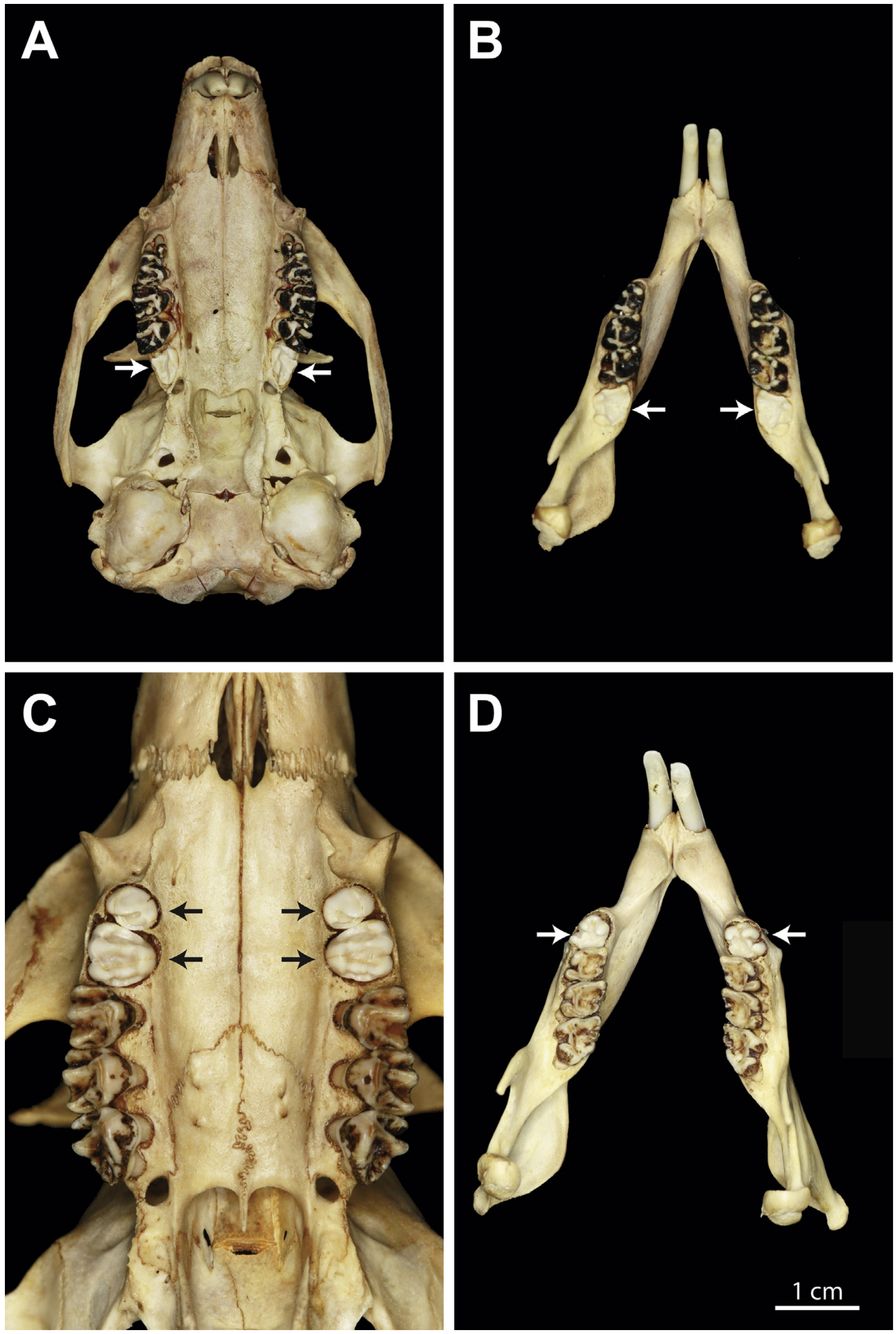

Fig. 8. (A, B) Recently erupted maxillary and mandibular third molar teeth (arrows) (UAM 22881). (C, D) Recently erupted right and left mandibular fourth premolar teeth and right and left maxillary third and fourth premolar teeth in a young adult male *M. caligata* (arrows) (UAM 83195).

Of the acquired lesions, attrition/abrasion of the premolar and/or molar teeth was most common, affecting one-third of specimens. Incisor teeth were excluded, as attrition/abrasion is the normal means by which their continual growth is controlled. However, if severely affecting the premolar and molar teeth, attrition/abrasion may be pathological, decreasing masticatory efficacy. As long as abrasion remains mild and is slower than the rate of tertiary dentine formation, it should not contribute to morbidity or mortality. In a study of 91 wild red squirrels (*Sciurus vulgaris*), attrition of the cheek teeth was the second most common lesion encountered, but only affected 3.3% of specimens (Sainsbury *et al.*, 2004). In that study, attrition of the premolar and molar teeth was assumed to be a normal consequence of ageing (Sainsbury *et al.*, 2004). Attrition/abrasion may be more prevalent in the marmot due to a coarser diet.

Aside from attrition/abrasion, endodontic disease was rarely noted in this population of marmots. Periapical lesions typically result from pulp exposure and subsequent pulp necrosis. As lesions are only obvious macroscopically when severe and dramatic, it is probable that this pathology was underdetected; dental radiographical examination could have revealed smaller, subtler lesions. The sole periapical lesion observed was associated with an incisor tooth, which is reported to be the most common tooth type affected by periapical disease in rodents (Sainsbury *et al.*, 2004). Periapical abscesses have been observed previously in the alpine marmot (*M. marmota*) (Sainsbury *et al.*, 2004). The low prevalence of periapical pathology correlates with the low prevalence of dental fractures, as the most common cause of periapical pathology is pulp exposure from a complicated fracture. Anecdotally, premolar and molar tooth fractures in Sciuridae have been noted to occur frequently in older individuals kept as pets (Capello, 2008). Dental fractures and periapical lesions typically cause considerable discomfort and pain, leading to decreased function.

Alveolar bony changes consistent with periodontitis were observed in 16.1% of specimens, affecting 4.6% of premolar and molar teeth. Periodontal disease is more commonly noted in captive rodents, but is not well documented in free-living rodents (Sainsbury *et al.*, 2004). Diagnosis of periodontal lesions from dry skulls is fundamentally flawed because soft tissue lesions, crucial in pathogenesis, are unavailable for study. However, an increase in vascular foramina and alveolar bone loss are signs of periodontal disease. Periodontitis is typically not a painful process and is unlikely to have impacted substantially on these marmots.

Attrition/abrasion and periodontitis were more prevalent in adult specimens than in young adult specimens, as expected. This is not surprising, as with advancing age there is increased exposure to inciting causes of acquired dental pathology and likelihood of chronic lesions developing (Winer *et al.*, 2013). In part because of our robust sample size, differences in prevalence of these lesions by age group were statistically significant. Dental fractures and periapical disease were not encountered frequently enough to determine if these acquired lesions are more prevalent in adults versus young adults, as would be anticipated.

A limitation of this study was that only hard tissues were available for macroscopic examination, which could lead to underdiagnosis of pathologies such as periodontal disease (i.e. subtle periapical lesions and gingivitis could not be detected) or overdiagnosis, as at times it can be difficult to differentiate true pathology from artefacts secondary to specimen preparation or variations of normal anatomy. Studies conducted on live marmots are needed to better understand and classify periodontitis and malocclusion.

In conclusion, a diversity of dental lesions and abnormalities was discovered in the three marmot species occurring in Alaska. Marmots exhibiting pronounced attrition/abrasion, periapical disease and dental fractures possibly suffered morbidity and perhaps mortality secondary to these lesions. Documenting the prevalence of the various dental lesions present in three species of marmot contributes to a better understanding of the overall health of these species and strengthens the foundation for advancing the understanding of dental disease in this genus.

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Supplementary data

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