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The Dental Pathology of Feral Cats on Marion Island, Part I: Congenital, Developmental and Traumatic Abnormalities

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Summary

Skulls ($n = 301$) of adult feral cats from Marion Island, a sub-Antarctic island, were examined macroscopically. Congenital anomalies, which were rare, included a few supernumerary premolars, located mesially to those normally present. Supernumerary roots, mainly of the maxillary third premolar, were found in just over 10% of cases. The maxillary second premolar was absent in 16·8% of skulls; dichotomous and double-formed roots of this tooth were present in 20·1% and 1·9% of cases, respectively. Enamel hypoplasia, which is most unusual in this species, was noted in 24·6% of cases, and persistent deciduous teeth in 2·0%. Dental abrasion, which was noted in 19·3% of cats, affected only 2·3% of teeth, most commonly the lower fourth and upper third premolars. Dental fractures, mainly complicated crown fractures and root fractures, were noted in 54·8% of cats and 7·0% of teeth. Fractures were found most commonly in the canine and carnassial teeth, as also were periapical lesions, which were often severe. Mandibular fractures in various stages of healing were found in 11 cats (3·7%); such fractures most frequently affected the body of the mandible and resulted in malunion. It was concluded that the high prevalence of dental fractures and associated periapical lesions probably exerted a significant adverse effect on health and survival in this population of feral cats.

Introduction

Dental abnormalities, of which many have been recognized in human beings, dogs and cats, may affect the shape and number of the teeth, as well as eruption, exfoliation and structure; occlusal and maxillofacial defects may also occur. Such abnormalities may have a genetic background or be caused by environmental factors that interfere with fetal or neonatal development (Verstraete, 1993).

The normal dental formula of the cat is identical with that of virtually all other members of the Family *Felidae*, Subfamily *Felinae*, namely: $I\frac{3}{3}{:}C\frac{1}{1}{:}P\frac{3}{2}{:}M\frac{1}{1} = 30$. The maxillary second premolar (P2max), in particular, has

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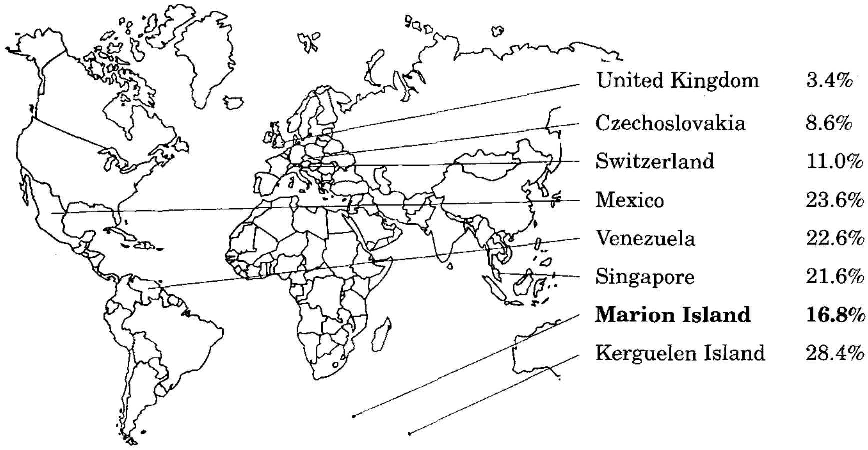

Fig. 1. Prevalence of congenital absence of the upper premolar in the cat (all data from Lüps [1980], except Marion Island).

received considerable attention from zoologists, its absence being interpreted as indicating a tendency towards reduced dentition in the cat, as compared with the original carnivore dentition (Lüps, 1980). The P2max was found to be absent in 3·4–28·4% of cat populations by Lüps (1980), who postulated that the tendency towards absence of P2max increased from North to South (Fig. 1). The tooth is also frequently absent in the cheetah (*Acinonyx jubatus*), caracal (*Felis caracal*), manul (*Otocolobus manul*), leopard cat (*Felis bengalensis*) and lynx (*Lynx lynx* and *L. rufus*) (Glass and Todd, 1977; Lüps, 1980; Skinner and Smithers, 1990). The P2max is generally described as a single-rooted tooth, although Jayne (1898) noted a 38% prevalence of two (often fused) roots. The tooth varies considerably in size and position (Graf *et al.*, 1976).

Surveys of dental disease, mainly in domestic cats, were summarized by van Wessum *et al.* (1992). Recent studies focused on the incidence of external odontoclastic resorption lesions and periodontitis, but enamel hypoplasia, which is common in dogs and man, was rarely recorded.

Traumatic lesions of the periodontium, teeth and supporting bone were classified in man by Andreasen and Andreasen (1994) and dental fractures in small animals by Verstraete (1993). In a study of 257 feral peri-urban cats, Lüps (1977) found that 27·6% had dental fractures, mainly root fractures of the incisors but rarely of the canine and carnassial teeth. Schlup (1982) found that 14·0% of 200 cats presented for veterinary care had dental fractures, 94·9% of which affected the canine teeth; most were crown fractures, and associated periapical lesions were common.

Marion Island is a 290 km^2 sub-Antarctic island (46°52′S, 37°51′E), approximately 2100 km south-southeast of Cape Town, South Africa. It is volcanic in origin and is best described as tundra biome (van Aarde, 1983). It is uninhabited except for a small number of scientists and meteorological personnel. In 1949, five domestic cats (presumably domestic short-hair cats), comprising three females, one intact male and one neutered male, were introduced as pets at the research station. Some of the offspring of these cats became feral and multiplied prolifically; in 1975, the population was estimated at 2139 ± 290 (SE) and had become a serious threat to the indigenous birdlife. To restore the normal ecology, the cats were exterminated by methods that included poisoning, trapping, the introduction of feline panleukopenia virus (in 1977) and shooting by professional marksmen (van Aarde, 1983; van Rensburg *et al.*, 1987; Skinner and Smithers, 1990). Various aspects of this cat population were studied, including demographic parameters, gene frequencies and diet (van Aarde, 1980, 1983; van Aarde and Robinson, 1980). The skulls of over 300 cats shot in 1975–1977 (before the introduction of feline panleukopenia virus) were examined to determine the age distribution of the population; for this purpose one canine tooth from each specimen was removed (van Aarde, 1983). This skull collection was subsequently made available for the present study of dental lesions. Of relevance to this study are the documented social and feeding behaviour of the cats. Most of the animals were solitary, but small groups of 2–5 were seen occasionally (van Aarde, 1978). Fighting was never observed and dead cats were never found. The diet consisted mainly of relatively large marine birds, namely burrowing petrels, prions and sheathbills. The gastrointestinal contents frequently contained small stones. Approximately 54% of the cats were less than 2 years of age and 71% less than 3 years. A steep increase in mortality rate after the age of 4 years was noted; this was attributed to harsh climatic conditions (van Aarde, 1983).

The objective of the present study was to document the prevalence and nature of congenital, developmental and traumatic dental abnormalities in a well-defined population of cats with the same genetic, dietary and environmental influences. Such information might be of interest in relation to dental disease of domestic cats, as well as contributing to a better understanding of the ecology of the Marion Island feral cat population. The obvious limitation of the study was that although hard tissue lesions could be studied, periodontal trauma and minor periapical lesions were excluded.

Materials and Methods

Skulls ($n = 301$) of cats with a permanent dentition were examined macroscopically. All animals had been shot and the skulls subsequently prepared. The lesions recorded were based on pre-determined and repeatable criteria (Table 1), determined from a study of the first 40 skulls. Teeth were examined by careful visual inspection, root morphology was studied after the teeth had been removed from the alveoli. Radiographs were not taken. Very recent mandibular fractures with macroscopically visible traces of lead were considered to be gunshot injuries and were not recorded as mandibular fractures.

The dental pathology was recorded for each cat and each individual tooth, as virtually all skulls were incomplete, one or more teeth or jaw fragments having been lost in post-mortem handling over the years. The teeth unavailable for examination included one canine taken from almost every cat for age determination (van Aarde, 1983); the morphologically normal empty alveoli were easily discernible (see Table 1). Missing teeth were taken into account in calculating prevalences. The sex of 170 (56·5%) of the cats was known; these animals comprised 51·2% males and 48·8% females. Gender differences were evaluated by the permutation test (Agresti, 1990).

Table 1
Congenital, developmental and traumatic conditions noted and inclusion criteria

Observation	*Criteria*
Tooth unavailable for examination	Jaw fragment is missing or tooth is absent, but a well-defined, sharp-edged, normally shaped empty alveolus is present; no pathological signs are visible in the alveolar bone; tooth is presumed lost during preparation or post-mortem manipulation of the skull.
Tooth absent—presumably congenital	Tooth and alveolus are absent; smooth, morphologically normal bone is present at the site; no evidence of acquired tooth loss of adjacent teeth.
Tooth lost—presumably acquired (i.e. due to disease)	Tooth is absent; alveolus or remnant of alveolus is visible; alveolar bone shows pathological signs (rounding of the alveolar crest, shallow alveolus, periosteal reaction on alveolar bone, increased vascular foramina).
Morphologically normal; no abnormalities	Tooth and supporting alveolar bone are morphologically normal.
P2max dichotomous root	Specific category for P2max: incomplete double formation or fused double root of P2max.
P2max two roots	Specific category for P2max: two fully-developed roots of P2max.
Supernumerary root	Presence of a third root in a tooth that normally has two roots.
Supernumerary tooth	Presence of a supernumerary tooth adjacent to the tooth in question.
Enamel hypoplasia	Irregular pitting or a band-shaped absence or thinning of the enamel, consistent with the clinical signs of enamel hypoplasia.
Malformed tooth	Abnormally shaped crown.
Enamel fracture	A chip fracture or crack of the enamel only.
Uncomplicated crown fracture	A fracture affecting enamel and dentine, but not exposing the pulp.
Complicated crown fracture	A fracture affecting enamel and dentine, and exposing the pulp.
Uncomplicated crown-root fracture	A fracture affecting enamel, dentine and cementum, but not exposing the pulp.
Complicated crown-root fracture	A fracture affecting enamel, dentine and cementum, and exposing the pulp.
Root fracture	A fracture affecting dentine, cementum and the pulp.
Periapical lesions	The presence of macroscopically visible periapical bone loss, root tip resorption, sinus tract formation originating periapically, or obvious focal periosteal reaction overlying the apex.
Abrasion	Rounding or flattening of the cusp tip; exposure of dentine with or without tertiary dentine formation.
Fracture mandible	Presence of a fractured mandible not considered to have occurred at the time of killing.

Results

Artefacts

The total number of teeth available for examination was 5813 (64·4%), out of a potential maximum of 9030. Only six cats (2·0%) had a complete dentition. The teeth most frequently absent due to artefact included the canines (41·2–52·2% of cats) and incisors (38·9–56·8% of cats); premolars and molars were less often unavailable for examination; for example, the P3maxR was missing in only 11·3% of cats.

Supernumerary Teeth

These were found in only 11 cats (3·7%). They included 12 supernumerary premolars (seven mesial to P3mandR, two mesial to P2maxR, two mesial to P3mandL, one mesial to P2maxL) and one supernumerary maxillary incisor.

Congenitally Absent Teeth

This abnormality was identified in 50 cats (16·6%) and represented 1·5% of teeth potentially available for examination. In addition to the P2max (see below), eight M1maxR (3·5%), five M1maxL (2·2%) and one I3mandR were considered to be congenitally absent.

The frequency of congenital absence of P2max was 16·8% (16·7% on the left and 16·9% on the right). Twenty per cent (20·1% left, 20·2% right) of P2max present had a dichotomous or partly fused double root, while 1·9% (1·4% left, 2·3% right) had two fully formed roots (Fig. 2). The dimensions of P2max were not measured, but it was apparent that considerable variation existed in the size of this tooth.

Supernumerary Roots

Supernumerary roots were present as a third root in teeth that normally have only two. Such roots were noted in 10·3% of P3max (10·5% left, 10·1% right) and in one (0·5%) P4mandR, P4mandL and M1mandL. The size of the extra root in P3max varied from near normal to slender (Fig. 3).

Persistent Deciduous Teeth

These were noted in six cats (2·0%), affecting the CmaxL (2·1% of teeth), CmaxR (2·1%) and P3maxR (1·1%). The persistent deciduous maxillary canines were, like those seen in the dog, located distally to the permanent canines. No cases of persistent deciduous mandibular canines or other teeth were found.

Enamel Hypoplasia

Seventy-four cats (24·6%) showed signs of enamel hypoplasia, affecting 34·1% of their teeth. The lesion was seen most commonly in the canines, premolars and mandibular molars (Figs 4, 5). It was characterized by irregular pits or a band-shaped absence or thinning of the enamel, with secondary staining, and it resembled enamel hypoplasia in the dog. Of the affected cats whose sex was known, 35 (61·4%) were male and 22 (38·6%) female ($P = 0{\cdot}074$).

Malformed Teeth

Two malformed (right) upper fourth premolars were found. One tooth had an extra cusp and the other a divided crown with the distal aspect separated

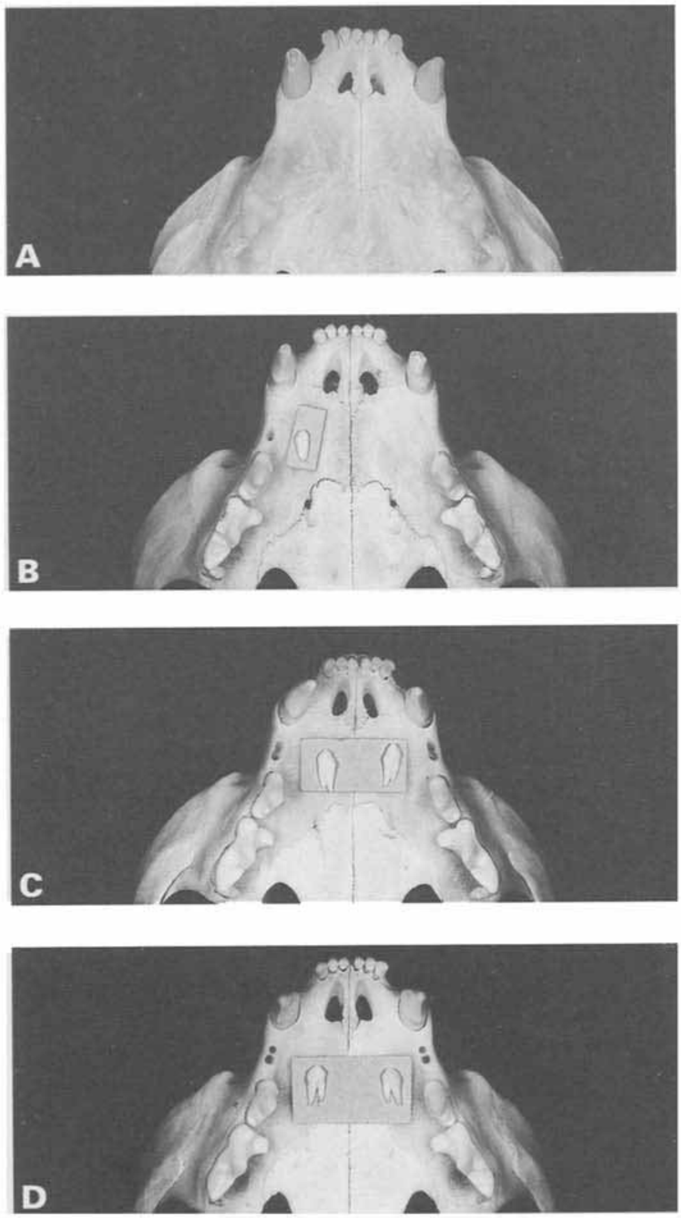

Fig. 2. (A) Bilateral congenital absence of P2max. (B) Unilateral absence of P2maxL and a normally shaped P2max R. (C) Bilaterally present P2max with dichotomous roots. (D) Bilaterally present P2max with fully-formed double roots.

from the rest of the tooth and displaced buccally. Geminated (or dichotomous) teeth were not found.

Dental Abrasion

This lesion was noted in 19·3% of cats but affected only 2·3% of teeth:

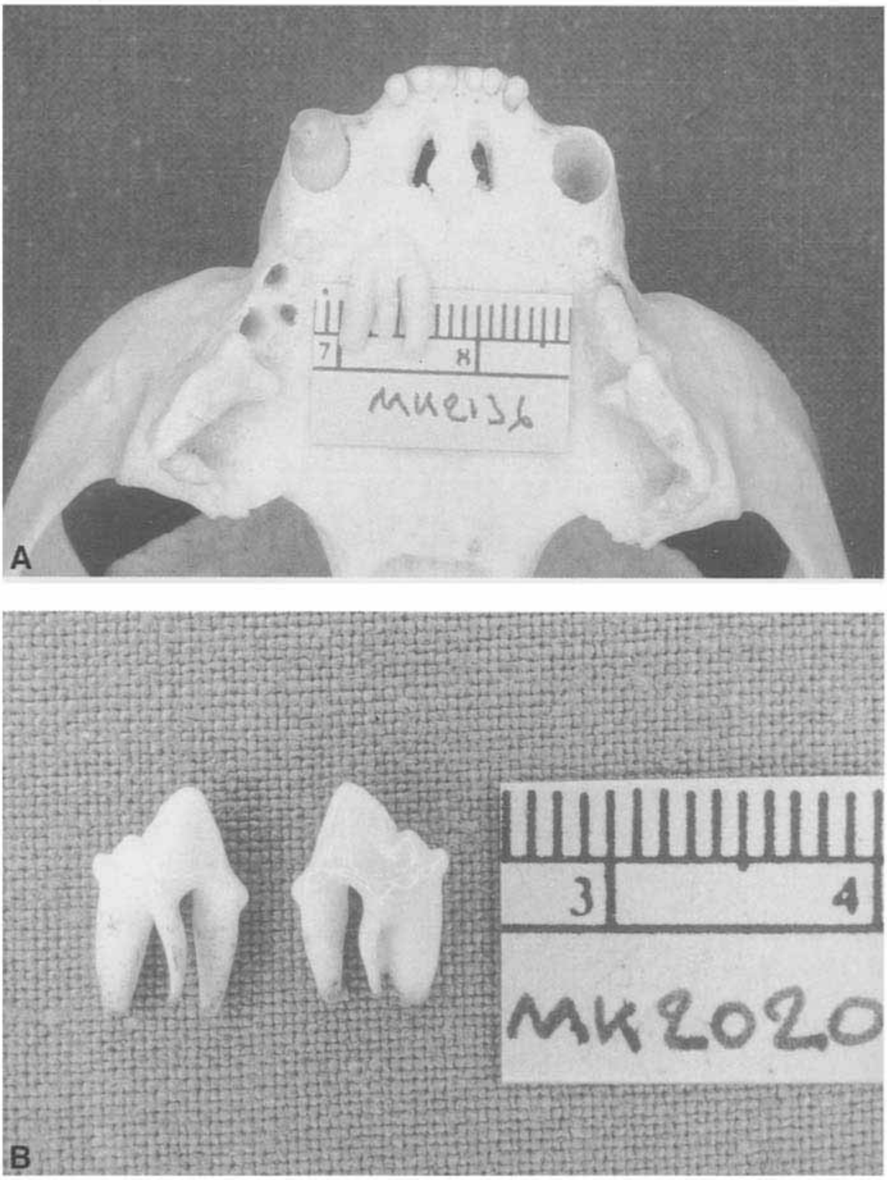

Fig. 3. (A) Well developed third root in P3maxR. (B) Small third roots in both P3max.

P4mand and P3max were the most commonly affected teeth (Figs 6, 7). Abrasion of the carnassial and canine teeth was relatively uncommon.

Dental Fractures

Dental fractures were noted in 54·8% of cats, affecting 7·0% of teeth (on average 2·5 fractured teeth per affected cat). In 12·3% of these teeth the fractures were associated with periapical lesions; conversely, 50 (71·4%) of the

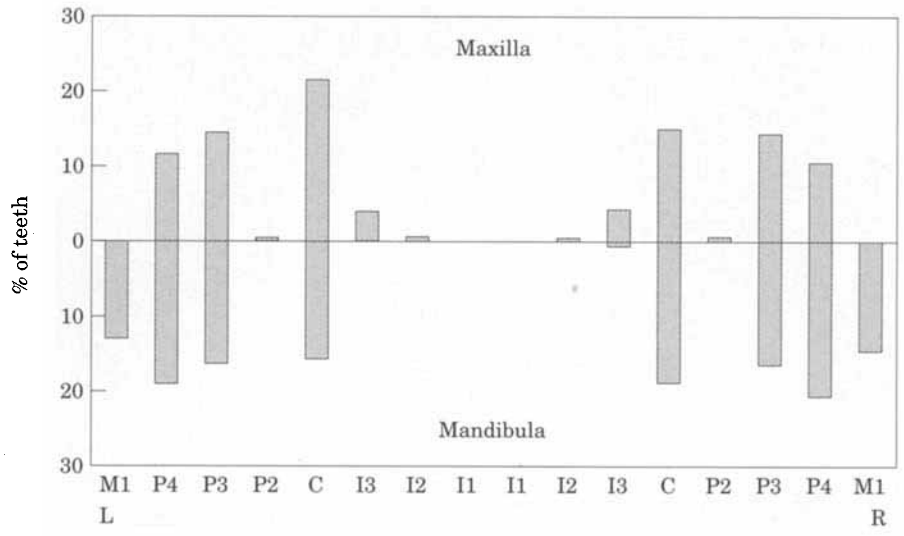

Fig. 4. Distribution of enamel hypoplasia lesions.

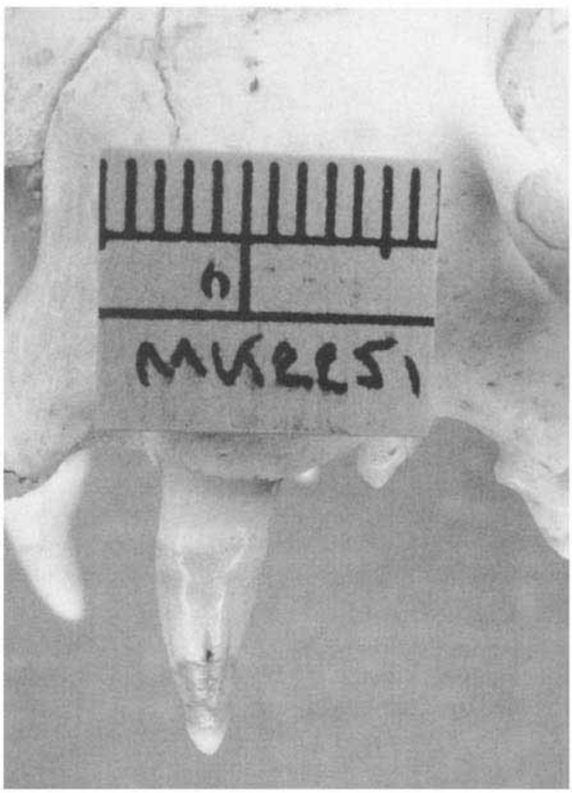

Fig. 5. Enamel hypoplasia.

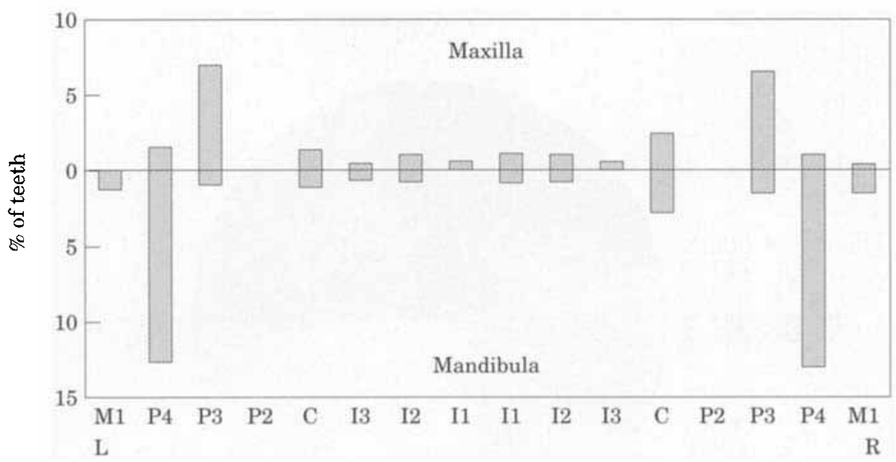

Fig. 6. Distribution of abrasion lesions.

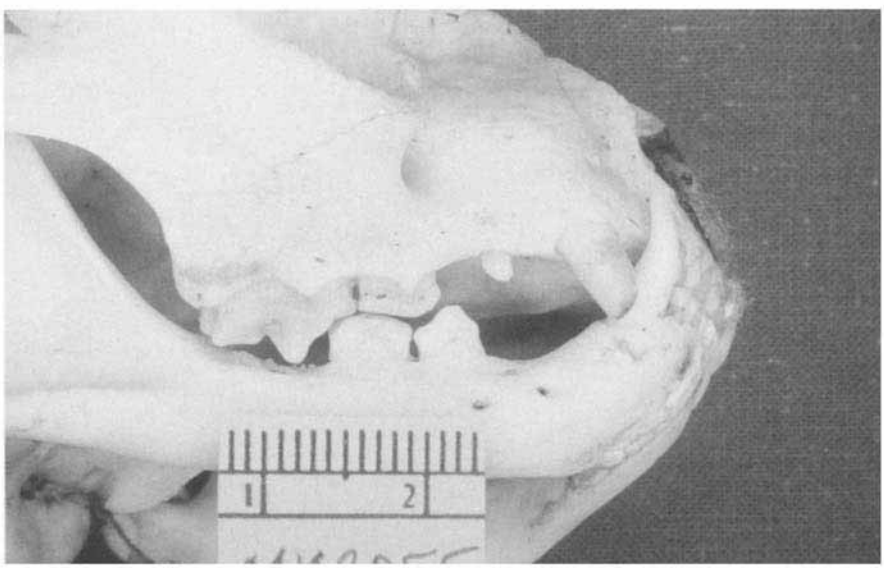

Fig. 7. Abrasion of P4mand and P3max, due to abnormal occlusion resulting from thickening of the mandible.

70 teeth with periapical lesions (see below) were fractured. Complicated crown fractures were most commonly (23·2%) associated with periapical lesions. The prevalence of dental fractures in males (48·6%) was similar to that of females (51·4%) ($P=0{\cdot}43$).

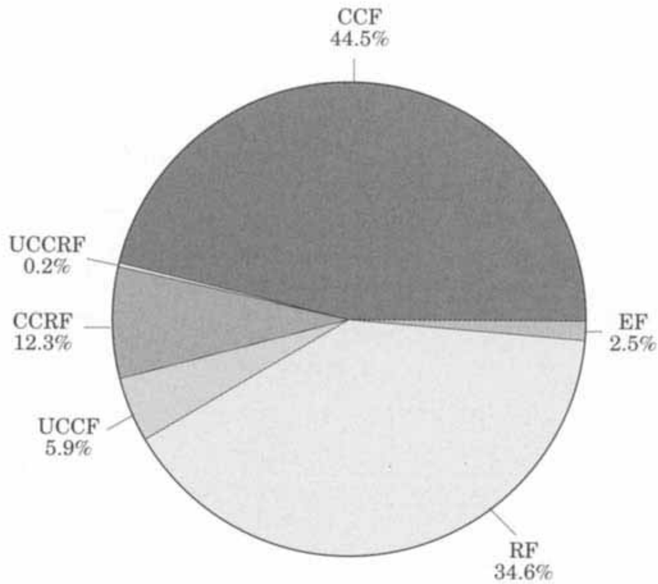

Fig. 8. Prevalence of types of dental fracture ($n=407$ teeth).
EF = enamel fracture; UCCF = uncomplicated crown fracture; CCF = complicated crown fracture; UCCRF = uncomplicated crown-root fracture; CCRF = complicated crown-root fracture; RF = root fracture.

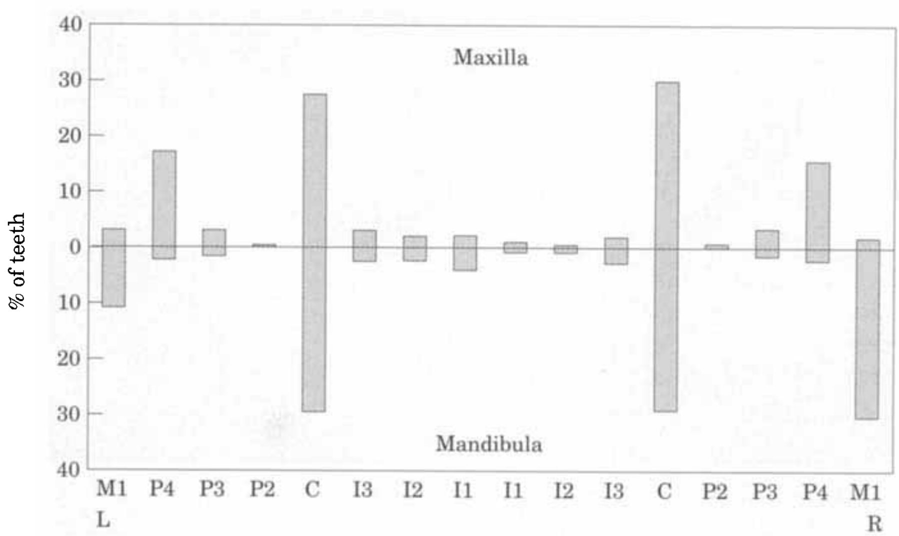

Fig. 9. Distribution of dental fractures.

The prevalence of the various types of fracture is illustrated in Fig. 8; complicated crown fractures and root fractures (with loss of the coronal fragment) were by far the most common. No attempt was made to sub-classify the fracture-types further. Fig. 9 shows that fractures of the canines and carnassials were the most common. Approximately 30% of all canines available

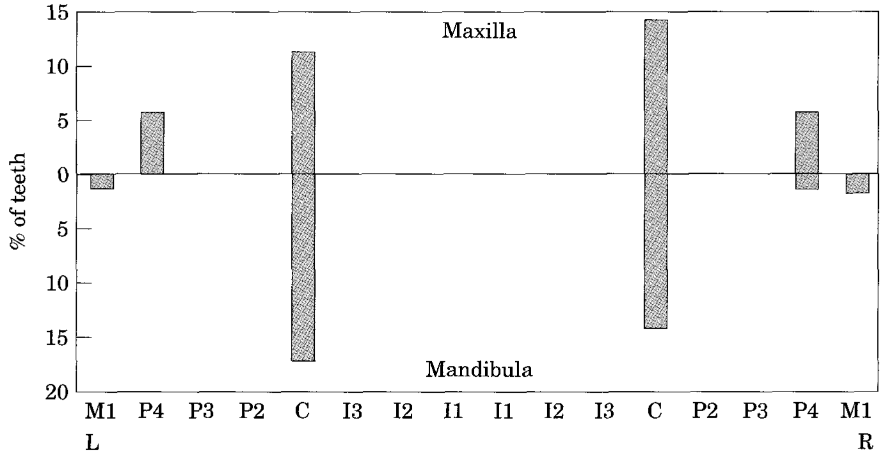

Fig. 10. Distribution of periapical lesions.

for examination were fractured. Left and right P4max were almost equally affected (16·0 and 17·4% respectively), but a considerable difference was noted between the left and right M1mand (10·8% vs 30·3%). The prevalence of fractures in other teeth was low.

Periapical Lesions

The distribution pattern of periapical lesions (Fig. 10) was similar to that of fractures (Fig. 10). The lesions occurred most commonly in the canine teeth and were often extensive, giving rise to osteomyelitis, sinus tract formation or endodontic-periodontic lesions (Fig. 11A). External resorption of the apical portion of the root was commonly observed (Fig. 11B). Periapical lesions associated with lost teeth were noted in only nine cats (12 teeth). External odontoclastic resorption lesions, described elsewhere (Verstraete *et al.*, 1996) were associated with periapical lesions in 36·5% of teeth affected.

Mandibular Fractures

Mandibular fractures in various stages of healing were diagnosed in 11 cats (3·7%); the body of the mandible was affected most frequently, and malunion often occurred (Fig. 12A). One pathological fracture due to a large periapical lesion affecting Cmand was noted (Fig. 12B). No maxillary fractures were found. One healed bony lesion of the hard palate, possibly a healed fracture, was seen.

Abnormalities Not Found

All other congenital and developmental conditions as listed in the human literature (Shafer *et al.*, 1983), as well as orthodontic abnormalities, were sought but not found. The only occlusal abnormalities encountered were a

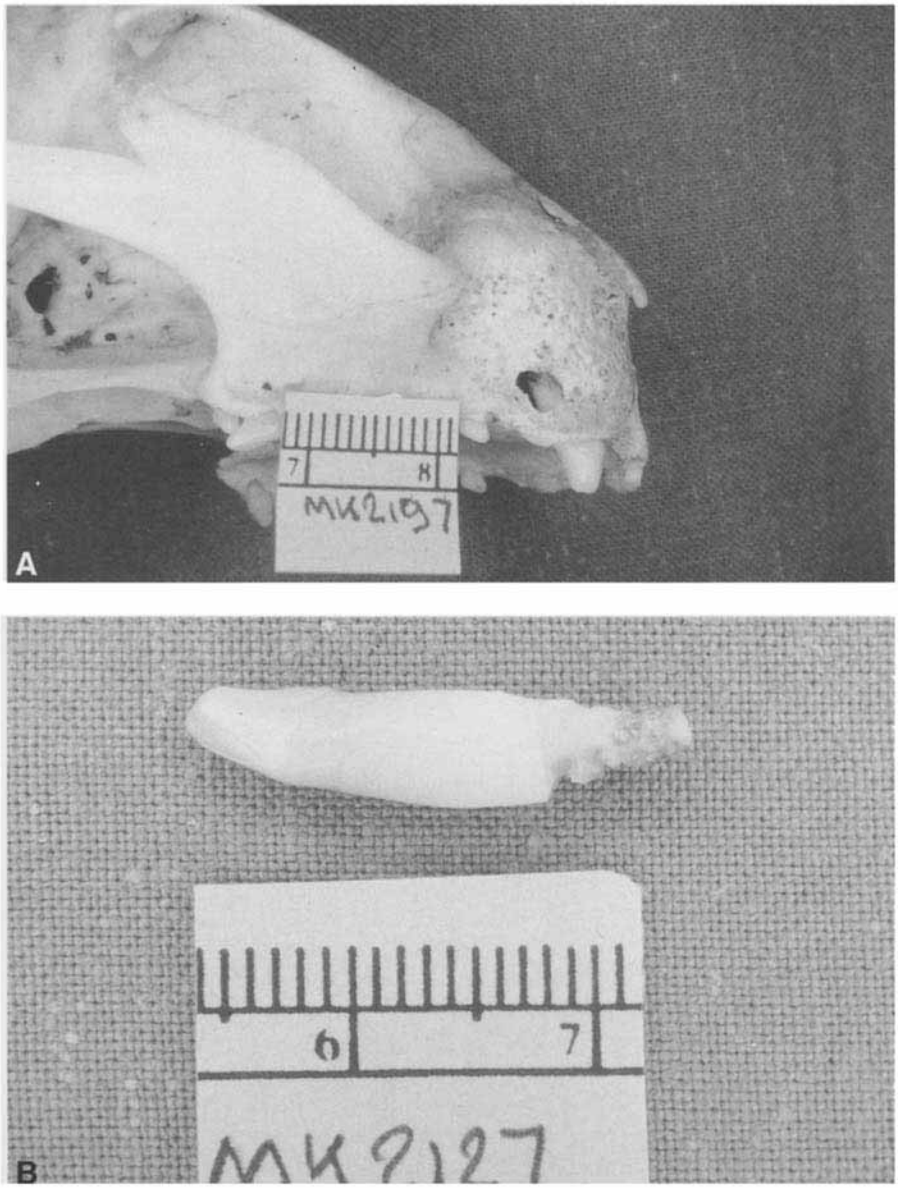

Fig. 11. (A) Complicated crown fracture of CmaxR, with a large periapical lesion and osteomyelitis. (B) Complicated crown fracture of CmandR, with extensive resorption of the apical part of the root.

few cases of relatively minor skeletal malocclusion secondary to mandibular fractures and with thickening of the mandibula (see Verstraete *et al.*, 1996); in some cases this caused a buccal expansion of the mandibles, bringing P3max and P4mand into occlusal contact.

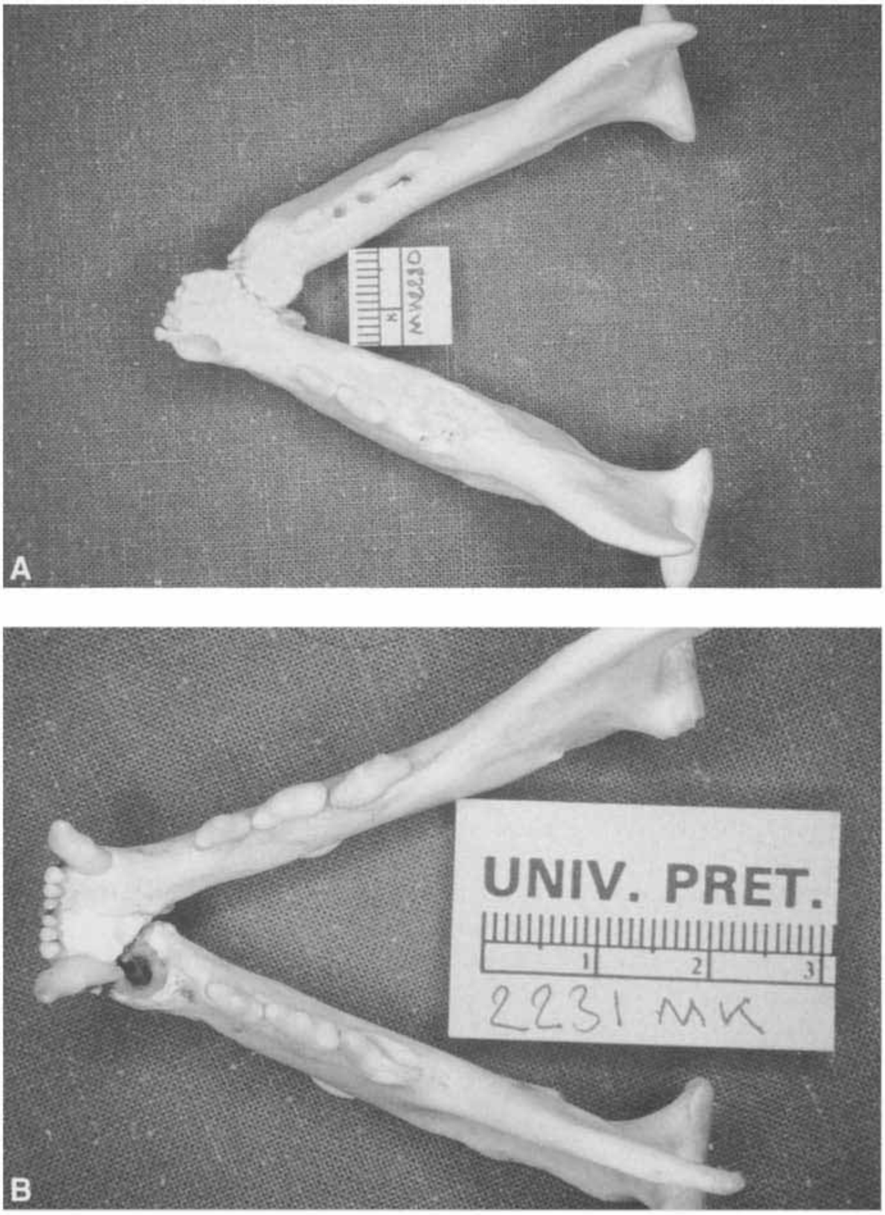

Fig. 12. (A) Healing fracture of the body of the right mandible, with loss of the right mandibular incisors and CmandR; root fractures of both M1mand are evident. (B) Pathological fracture of the body of the left mandible, caused by a large periapical lesion associated with a complicated crown fracture of CmandL; a complicated crown-root fracture of M1mandL is also present.

Discussion

The skulls examined had lost a considerable number of teeth due to shooting, skull preparation and removal for age determination. Further tooth loss occurred during specimen handling between 1977 and 1994. Pooling the available data per individual tooth would appear to be acceptable, given the large number of skull specimens. The teeth most frequently absent due to artefact were the canines and incisors, but it is unlikely that this skewed the results. Radiographical examination, had it been performed, might well have revealed the presence of unerupted teeth, and subtle lesions such as concrescence.

Congenital and developmental abnormalities were rare. Given the harsh environmental conditions prevailing on Marion Island, it is conceivable that animals with major defects would have succumbed at an early age. It is therefore not surprising that no severe maxillofacial defects, such as cleft palate, major malocclusion or gross dental abnormalities were found.

Polyodontia was rare in this population, as in other cats. The occurrence of supernumerary premolars mesial to the P3mand and P2max, an abnormality previously noted by Colyer (1936) and Lüps (1977), was the most common finding.

Anodontia, the complete congenital absence of teeth, has rarely been documented in the cat (Ueberberg, 1965; Elzay and Hughes, 1969). On the other hand, hypodontia, which is the congenital absence of one or a few teeth, is a more common finding (Verstraete, 1993). Both anodontia and hypodontia should be distinguished from failure to erupt and tooth loss resulting from extraction, trauma, external odontoclastic resorption lesions or periodontitis. In some studies this distinction is not clear, and all absent teeth are referred to as "missing teeth" (Kratochvíl, 1971; Schlup, 1982). In the current study an attempt was made to distinguish between teeth missing as a result of artefact or dental disease, and true hypodontia. The two teeth most commonly congenitally absent were P2max and M1max. The occasional absence of P2max is well described, but no reference could be found to M1max. P1 and M3 are most commonly affected in the dog (Verstraete, 1993). The frequency of congenital absence of P2max was 16·8%. This figure does not support Lüps' theory (1980) of a North-South gradient (Fig. 1), but it should be borne in mind that the island's cats originated from South Africa, and that the South African domestic cat population is probably derived from cats imported from Western Europe. The variation in crown size found by other workers was confirmed in this study (Kratochvíl, 1971; Graf *et al.*, 1976; Lüps, 1980). The possibility that this tooth may have two roots (Jayne, 1898) was also confirmed; when extrapolated to domestic cats this may have clinical implications.

Supernumerary roots represent an anatomical variation occasionally seen in the dog and cat. Verstraete (1993) noted that the maxillary premolars, particularly the third, are most commonly affected, an observation supported by the current study. A prevalence of 10·3% for the presence of a third root for the maxillary third premolar is substantial; this abnormality would be clinically important in the domestic cat, in which extractions are commonly performed.

Persistent deciduous teeth (Wissdorf and Hermanns, 1974; Harvey and Emily, 1993) are rare in the cat. The low number of cases in the present study makes it impossible to draw conclusions from the finding that the maxillary canines were most commonly involved, and that no cases of persistent deciduous mandibular canines were found.

A prevalence of 24·6% for enamel hypoplasia is most unusual in the cat. Although mentioned in the literature (Pedersen, 1992; Harvey and Emily, 1993), no case descriptions could be found, and a single photograph seemed to depict an atypical lesion (Kertesz, 1993). Enamel hypoplasia is defined as the incomplete or defective formation of the organic enamel matrix of teeth (Shafer *et al.*, 1983; Verstraete, 1993). It results from damage to the ameloblasts while the teeth are developing. The location of the lesion on the tooth is related to the developmental stage in which the ameloblasts were damaged. Hereditary and environmental forms occur in man, but only the environmental form has been recognized in the dog. This is most often caused by epitheliotropic virus diseases, particularly morbillivirus infections such as distemper in the dog and measles in man. No such virus diseases are known to affect the cat, with the exception of a rare feline paramyxovirus encephalomyelitis (Greene, 1990). Enamel hypoplasia resulting from viral infections and other systemic causes affects the entire dentition. Enamel hypoplasia due to excessive fluoride intake during tooth formation has been recorded in the dog (Verstraete, 1993). Unfortunately, data on the cats' dietary fluoride content were not available. Arnbjerg (1986) noted a high incidence of generalized root hypoplasia in dogs with distemper-induced enamel hypoplasia. This was not found in the present study.

Dental abrasion, noted in 19·3% of the cats, had a rather specific pattern of distribution. These lesions may have resulted from attrition as well as abrasion. The term attrition, defined as the physiological wearing down of teeth by tooth-to-tooth contact, as in mastication (Shafer *et al.*, 1983), is not readily applicable to carnivore dentition, as most teeth lack occlusal contact. Abrasion, defined as the pathological wearing away of tooth substance through some abnormal mechanical process, is also not entirely appropriate. It is conceivable that the tooth wear in these cats was due largely to the mastication of abnormally hard food, including avian bones and small stones. The distribution pattern may be attributable to the thickening of the mandible noted by Verstraete *et al.* (1996) in a number of the cats. In some cases this brought the P3max and P4mand into occlusal contact.

Traumatic injuries, which were very prevalent, included all types of dental fracture. The overall prevalence of tooth fractures (54·8%) was high, compared with the 14·0% found in domestic cats in Switzerland (Schlup, 1982). Fracture type determines clinical importance (Verstraete, 1993; Andreasen and Andreasen, 1994). Enamel fractures and uncomplicated crown fractures are clinically unimportant in small animals. The exposed dentine is sensitive until sclerosis of the dentinal tubules and the formation of tertiary dentine in the pulp chamber have occurred. Dentine is somewhat rougher than enamel and thus facilitates plaque and calculus accumulation. Sharp fracture edges may cause soft tissue trauma. Crown-root fractures affect the periodontal ligament and may lead to periodontitis because of the altered gingival contour. Complicated crown fractures cause pulp exposure and ensuing endodontic disease. Root fractures of traumatic origin may become covered by bone and gingiva in the absence of infection. Alternatively, pulp necrosis may take place and lead to periapical lesions. Pathological root fractures are common in the cat because of stage 4 external odontoclastic resorption associated with periodontitis (Lyon, 1992). In the present series the clinically more important fracture types accounted for the vast majority of fractures.

The distribution pattern of dental fractures resembled that found by Schlup (1982), in that canines were most commonly affected. In our series, the carnassial teeth were also often fractured. This is in sharp contrast to a study on Swiss feral cats, in which the incisors were affected most often, and the carnassials and canines rarely (Lüps, 1977). Animal interaction and aggression may have been important causes of canine fractures in this population; and small stones, often found in the stomach contents, may have accounted for the high prevalence of carnassial fractures. However, the much higher prevalence of M1mandR fractures cannot readily be explained. The fact that these cats were feeding almost exclusively on relatively large birds may also have contributed to the high prevalence of dental trauma. In contrast, the diet of the Swiss feral cats consisted mainly of household food, and sometimes small rodents (von Goldschmidt-Rothschild and Lüps, 1976).

It is interesting that canine fractures appeared to have caused periapical lesions more readily than fractures of other teeth. Possibly, subtle lesions, especially those of smaller teeth, may have been missed, since radiography was not used.

Injuries of the jaws in wild animals may interfere with self-defence and food and water intake, but a few of our specimens, which had mandibular fractures, showed that spontaneous healing was possible. Healed jaw fractures in *Felidae* were also documented by Colyer (1936).

It can be concluded that the spectrum of congenital and developmental dental pathology in this population of feral cats largely coincided with that found in domestic cats; but the unexplained high prevalence of enamel hypoplasia was a notable exception. The prevalence of traumatic injuries, dental fractures in particular, was high. The associated periapical lesions may have contributed to the short life-expectancy of these cats. In considering the results of this study, the limitations of dental pathology surveys based on dry skulls should be borne in mind.

References

Agresti, A. (1990). *Categorical Data Analysis,* John Wiley & Sons, New York.

Andreasen, J. O. and Andreasen, F. M. (1994). *Textbook and Color Atlas of Traumatic Injuries to the Teeth,* 3rd Edit., Munksgaard, Copenhagen.

Arnbjerg, J. (1986). Schmelz- und Wurzelhypoplasien nach Staupe. *Kleintierpraxis,* **31,** 323–326.

Colyer, F. (1936). *Variations and Diseases of the Teeth of Animals,* John Bale, Sons & Danielsson, London.

Elzay, R. P. and Hughes, R. D. (1969). Anodontia in a cat. *Journal of the American Veterinary Medical Association,* **154,** 667–670.

Glass, G. E. and Todd, N. B. (1977). Quasi-continuous variation of the second upper premolar in *Felis bengalensis* Kerr, 1792 and its significance for some fossil lynxes. *Zeitschrift für Säugetierkunde,* **42,** 36–44.

Graf, M., Grundbacher, B., Gschwendtner, J. and Lüps, P. (1976). Grössen- und Lagevariation der zweiten Prämolaren bei der Hauskatze *Felis silvestris f. catus*. *Revue Suisse de Zoologie,* **83,** 952–956.

Greene, C. E. (1990). Feline paramyxovirus encephalomyelitis. In: *Infectious Diseases of the Dog and Cat,* C. E. Greene, Ed., W. B. Saunders, Philadelphia, pp. 360–361.

Harvey, C. E. and Emily, P. P. (1993). *Small Animal Dentistry,* Mosby Year-Book, St Louis, pp. 294–295.

Jayne, H. (1898). *Mammalian Anatomy; a Preparation for Human and Comparative Anatomy. Part I. The Skeleton of the Cat; its Muscular Attachments, Growth, and Variations Compared with the Skeleton of Man,* J. B. Lippincott, Philadelphia, pp. 402–457.

Kertesz, P. (1993). *A Colour Atlas of Veterinary Dentistry and Oral Surgery,* Wolfe Publishing, London, p. 57.

Kratochvíl, Z. (1971). Oligodonty and polyodonty in the domestic cat (*Felis silvestris f. catus* L.) and the wild cat (*Felis silvestris silvestris* Schreber). *Acta Veterinaria Brno,* **40,** 33–40.

Lüps, P. (1977). Gebiß- und Zahnvariationen an einer Serie von 257 Hauskatzen (*Felis silvestris f. catus* L., 1758). *Zoologische Abhandlungen Staatliches Museum für Tierkunde in Dresden,* **34,** 155–165.

Lüps, P. (1980). Vergleichende Untersuchung am zwiten oberen Vorbackenzahn P^2 der Hauskatze *Felis silvestris f. catus*. *Zeitschrift für Säugetierkunde,* **45,** 245–249.

Lyon, K. F. (1992). Subgingival odontoclastic resorptive lesions—classification, treatment, and results in 58 cats. *Veterinary Clinics of North America: Small Animal Practice,* **22,** 1417–1432.

Pedersen, N. C. (1992). Inflammatory oral cavity diseases of the cat. *Veterinary Clinics of North America: Small Animal Practice,* **22,** 1323–1345.

Schlup, D. (1982). Epidemiologische und morphologische Untersuchungen am Katzengebiß—I. Mitteilung: Epidemiologische Untersuchungen. *Kleintierpraxis,* **27,** 87–94.

Shafer, W. G., Hine, M. K. and Levy, B. M. (1983). Developmental disturbances of oral and paraoral structures. In: *A Textbook of Oral Pathology,* 4th Edit., W. B. Saunders, Philadelphia, pp. 2–85.

Skinner, J. D. and Smithers, R. H. N. (1990). Family Felidae. In: *The Mammals of the Southern African Subregion,* 2nd Edit., University of Pretoria, South Africa, pp. 391–423.

Ueberberg, H. (1965). Beobachtungen einer sogenannten Anodontie bei einer Hauskatze. *Zentralblatt für Veterinär Medizin A,* **12,** 193–196.

van Aarde, R. J. (1978). Reproduction and population ecology in the feral house cat on Marion Island. *Carnivore Genetics Newsletter,* **3,** 288–316.

van Aarde, R. J. (1980). The diet and feeding behaviour of feral cats, *Felis catus* at Marion Island. *South African Journal of Wildlife Research,* **10,** 123–128.

van Aarde, R. J. (1983). Demographic parameters of the feral cat *Felis catus* population at Marion Island. *South African Journal of Wildlife Research,* **13,** 12–16.

van Aarde, R. J. and Robinson, T. J. (1980). Gene frequencies in feral cats *Felis catus* on Marion Island. *Journal of Heredity,* **71,** 366–368.

van Rensburg, P. J. J., Skinner, J. D. and van Aarde, R. J. (1987). Effects of feline panleucopaenia on the population characteristics of feral cats on Marion Island. *Journal of Applied Ecology,* **24,** 63–73.

van Wessum, R., Harvey, C. E. and Hennet, P. (1992). Feline dental resorptive lesions—prevalence patterns. *Veterinary Clinics of North America: Small Animal Practice,* **22,** 1405–1416.

Verstraete, F. J. M. (1993). Dental pathology and microbiology. In: *Textbook of Small Animal Surgery,* 2nd Edit., D. H. Slatter, Ed., W. B. Saunders, Philadelphia, pp. 2316–2326.

Verstraete, F. J. M., van Aarde, R. J., Nieuwoudt, B. A., Mauer, E. and Kass, P. H. (1996). The dental pathology of feral cats on Marion Island, Part II: periodontitis,

external odontoclastic resorption lesions and mandibular thickening. *Journal of Comparative Pathology,* **115,** 283–297.
von Goldschmidt-Rothschild, B. and Lüps, P. (1976). Untersuchungen zur Nahrungsökologie "verwilderten" Hauskatzen (*Felis silvestris f. catus* L.) im Kanton Bern (Schweiz). *Revue Suisse de Zoologie,* **83,** 723–735.
Wissdorf, H. and Hermanns, W. (1974). Persistierende Milchhakenzähne (Cd) im Oberkiefer einer Hauskatze. *Kleintierpraxis,* **19,** 14.
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