DENTAL, ORAL AND MAXILLOFACIAL PATHOLOGY IN A WILD SERVAL (*Leptailurus serval*) POPULATION

by

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28047402

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Animal Ethics Committee

PROJECT TITLE	**The dental, oral and maxillofacial pathology of a wild serval population**
PROJECT NUMBER	**V044-17**
RESEARCHER/PRINCIPAL INVESTIGATOR	**Dr. R Emslie**

STUDENT NUMBER (where applicable)	**U_28047402**
DISSERTATION/THESIS SUBMITTED FOR	**MSc**

ANIMAL SPECIES	**Wild Serval**	
NUMBER OF ANIMALS	**30**	
Approval period to use animals for research/testing purposes		**May 2017 – May 2018**
SUPERVISOR	**Dr. G Steenkamp**	

KINDLY NOTE:

Should there be a change in the species or number of animal/s required, or the experimental procedure/s - please submit an amendment form to the UP Animal Ethics Committee for approval before commencing with the experiment

APPROVED	Date 13 November 2017
CHAIRMAN: UP Animal Ethics Committee	Signature

S4285-15

ACKNOWLEDGEMENTS

To have achieved this milestone in my life, I would like to express my sincere gratitude to the following people:

- My Heavenly Father, for blessing me with the opportunity to further investigate His glorious creation, and for providing me with the resources, grace and strength to complete this study;
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- DIAG Import and Export CC for the use of their dental diagnostic imaging equipment, their support was invaluable.
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ABSTRACT

Objective: Members of the family *Felidae* suffer from a wide range of dental, oral and maxillofacial conditions. These conditions can cause significant morbidity and mortality. However, no studies could be found investigating the dental, oral and maxillofacial pathology in serval (*Leptailurus serval*). Serval are frequently kept in captivity and occasionally as household pets. Having knowledge of the pathology affecting wild serval would greatly assist in improving preventative care practices and the welfare of serval in captivity. The objective of this study was therefore to describe the dental, oral and maxillofacial pathology of a wild serval population.

Animals: Thirty wild serval, which occur naturally on the Sasol Synfuels Operations property in Secunda, Mpumalanga, South Africa; were examined for dental, oral and maxillofacial pathology.

Methods: Detailed extraoral and intraoral examinations, as well as full-mouth dental radiographs, were performed on each anaesthetised serval.

Results: Fourteen different conditions affecting the teeth were recorded, but no oral or maxillofacial pathology was found. The most common dental pathology observed was tooth wear affecting 67% of the serval examined. Dental fractures, including complicated crown fractures, uncomplicated crown fractures and root fractures, were diagnosed in 23% of the serval. The two canine teeth with complicated crown fractures also displayed grey discolouration clinically and periapical radiolucencies radiographically. Abnormal root morphology was apparent at the maxillary canines in 20% of cases. Supernumerary roots of

maxillary third premolar teeth and supernumerary mandibular premolar teeth were noted in 17% and 10% of serval examined, respectively. Other dental abnormalities identified less frequently included rotated teeth, retained deciduous roots, enamel defects and tooth resorption.

Conclusion: This study indicates that intraoral and extraoral examinations, as well as dental radiography, are important aspects of the clinical evaluation of wild felines. These findings are particularly interesting as the study population represents the highest density of serval ever recorded, with their habitat consisting primarily of disturbed wetland and grassland directly surrounding a highly active industrial site. This demonstrates that even the most unexpected sectors and opportunities can be used to advance conservation efforts and to provide knowledge to assist in improving the husbandry of captive wild animals.

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LIST OF ABBREVIATIONS

C	Canine tooth
CCF	Complicated crown fracture
GPS	Global positioning system
I	Incisor tooth
M	Molar tooth
PM	Premolar tooth
RF	Root fracture
TR	Tooth resorption
UCF	Uncomplicated crown fracture

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1 GENERAL INTRODUCTION

Members of the family *Felidae* suffer from a wide range of dental, oral and maxillofacial conditions. These conditions can cause significant morbidity and mortality. The pathology associated with these conditions is investigated by oral examination, diagnostic imaging and histopathology. A number of studies have shown that similar dental, oral and maxillofacial conditions that are prevalent in domestic and feral cats (*Felis catus*), also occur in wild felines (1), including lion (*Panthera leo*) (2), leopard (*Panthera pardus)* (2), cheetah (*Acinonyx jubatus*) (3) (4), cougar (*Puma concolor*) (5), Eurasian lynx (*Lynx lynx lynx*) (6) (7) and California bobcat (*Lynx rufus californicus*) (8). However, no similar studies could be found investigating the dental, oral and maxillofacial pathology in serval (*Leptailurus serval*).

Serval are frequently kept in captivity and occasionally as household pets. Having knowledge of the oral, dental and maxillofacial pathology in wild serval would greatly assist in improving preventative care practices and the welfare of serval in captivity.

A recent study found that the highest density of serval recorded in the literature occurs on the Sasol Synfuels Operations property in Secunda, Mpumalanga, South Africa (9). As part of this long-term ecological study, serval in the area are captured and anaesthetised for collaring and sample collection. This opportunity was utilised to document the dental, oral and maxillofacial pathology of a wild serval population.

2. JUSTIFICATION

2.1 LITERATURE REVIEW

The serval is a member of the order Carnivora, family Felidae, and is the sole member of the genus *Leptailurus*. Serval are medium-sized, slender, spotted wild cats with particularly long legs, short tails and large ears. These largely solitary cats are endemic to Africa. Their distribution includes a narrow band extending from Senegal to southern Somalia and expanding into eastern and southern Africa (10). Serval occur most commonly in savannah, where they are strongly associated with wetlands, rivers and flood-plains. This habitat provides tall grass and reed-beds that serval need for cover and hunting of their preferred rodent prey. Rodents, particularly vlei rats (*Otomys spp*) and multimammate mice (*Mastomys spp*), make up more than 80% of the serval's diet. Serval also prey on birds and frequently eat small quantities of grass (11).

The International Union for Conservation of Nature (IUCN) classifies serval in the category of "least concern" (12). These wild cats are mainly threatened by wetland habitat loss. However, they are able to adapt to agricultural and disturbed areas, provided that enough cover is available (11). Unlike other wild cats, such as the caracal (*Caracal caracal*), serval are rarely implicated in livestock predation (11). Thus, these felids are unique as they assist in the biological control of rodent pests, without contributing to human-predator conflict.

As an adaptation to their small mammal and avian prey, serval have large pinnae, well-developed ear bullae, and a lightly built skull, especially in comparison with the similarly sized caracal (11). Serval dentition is typically felid with the dental formula I $\frac{3}{3}$, C $\frac{1}{1}$, PM $\frac{3}{2}$, M $\frac{1}{1}$ (13). In contrast to most caracal specimens (14), the second maxillary premolar teeth appear to always be present in serval (10). A domestic cat dental chart is therefore adequate

for the recording of normal and abnormal findings during oral examinations (7). Since periodontal disease is the most commonly reported disorder in domestic cats and dogs (15)(16), the oral examination is an important part of the clinical examination in both domestic and wild felines. An intraoral examination can also provide insight into the overall health of an animal, as oral manifestations accompany many systemic disorders (17). Diabetes mellitus, neoplasia, feline herpesvirus infection and renal failure are some of the common conditions of domestic cats in which an intraoral examination could aid diagnosis (17).

Although in some domestic cats a cursory oral examination may be performed in the conscious patient, a detailed examination requires general anaesthesia. Before performing the intraoral examination, an extraoral examination is performed in which the entire head is palpated for swellings and masses, as well as to determine symmetry. The jaws are also manipulated to detect crepitus or abnormal motion as a result of temporomandibular joint pathology (18).

The intraoral examination starts with inspection of the oropharynx, tonsils, palate, tongue and buccal mucosa. Each tooth is then examined individually. A periodontal probe is used to probe the gingival sulcus. A sulcus depth of greater than 1 mm is evidence of a periodontal pocket in domestic cats (19). The periodontal probe can also be used to measure gingival recession, as well as to exert pressure in various directions on the tooth to determine mobility. A calculus and gingivitis index score is awarded to each tooth (19). Enamel defects, caries, crown fractures, tooth resorption (TR) and furcation defects are investigated with a dental explorer (20). Gingival enlargement, oral masses and other oral lesions are also drawn and described on the dental chart.

Even though a thorough extraoral and intraoral examination can provide a wealth of information, dental radiography is a critical diagnostic aid in evaluating feline oral and dental health (21). For example, the full extent of pathology associated with the two most common dental conditions in domestic cats, namely periodontitis and TR, cannot be determined by oral examination alone (22). One study of 115 domestic cats reported that 1) radiographs of teeth without visible lesions yielded clinically important findings in 42% of the cats, and 2) radiographs of teeth with visible lesions yielded additional information in 54% of the cats (21).

The radiographic techniques used to obtain full-mouth radiographs in domestic cats include the parallel technique and the bisecting angle technique (23). The parallel technique is used to image the mandibular third and fourth premolar and molar teeth. With this technique, the film is placed along the lingual surface of the teeth, between the teeth and tongue, parallel to the roots. The incident x-ray beam is then directed perpendicular to the teeth and film (23). The rostrocaudal bisecting angle technique is used to image the incisor and canine teeth. The film is placed in the mouth touching the teeth at the incisal edge of the incisor and canine teeth. The incident x-ray beam is directed perpendicularly to an imaginary line that bisects the angle formed by the plane of the film and the long axis of the tooth (23). Owing to the facial anatomy of cats, when employing the lateral bisecting angle technique for imaging the maxillary premolar and molar teeth, the zygomatic arch interferes with visualisation of the tooth roots (23). The bisecting angle technique can be modified to avoid this superimposition, by aiming the tube head more laterally so that the incident x-ray beam courses below the zygomatic arch and the less tangential angle decreases the radiopacity of the zygomatic arch (24).

Radiographs should be used in the investigation of periodontitis, TR, endodontic disease, tooth wear, persistent deciduous teeth, clinically absent teeth, dental fractures, as well as mandibular and maxillary fractures. Up to 85% of domestic cats older than three years suffer from periodontal disease (25). The investigators of one study found that among 147 domestic cats, 72% had periodontitis, 68% had missing teeth, 67% had TR, 51% had retained roots and eight percent had endodontic disease (26). Limited research has been performed to determine the prevalence of dental, oral and maxillofacial disease in wild cats. Lesions in the skull of a captive leopard, two wild lions and one wild leopard, were found to be similar to the lesions observed in domestic cats (2). In a visual inspection and radiographic evaluation of skulls of wild cats from Namibia, varying stages of tooth resorption were found in 16% of the 73 specimens. Other dental anomalies included fused teeth, supernumerary roots and missing teeth (1). The most prevalent dental conditions found in a study on the California bobcat were attrition/abrasion, periodontitis and tooth fractures (8). In 41 serval skull specimens examined by James Colyer, no teeth displayed an irregularity of position (13). However, no in-depth study of the dental, oral and maxillofacial pathology in serval could be found in the literature.

2.2 AIM

To describe the dental, oral and maxillofacial pathology present in a wild serval population.

2.3 OBJECTIVES

The main objectives of this study were to:

- perform complete extraoral and intraoral examinations to clinically describe dental, oral and maxillofacial pathology;
- perform full-mouth dental radiographs to radiographically describe dental, oral and maxillofacial pathology; and
- obtain biopsy samples to perform histopathological analysis of oral masses and other oral lesions present in a wild serval population.

2.4 EXPERIMENTAL DESIGN

A prospective descriptive study was performed to determine and characterise dental, oral and maxillofacial pathology of a wild serval population.

2.5 BENEFITS ARISING FROM THIS EXPERIMENT

- A better understanding of the dental, oral and maxillofacial pathology that occur in wild serval was gained.
- Knowledge of the dental, oral and maxillofacial pathology in wild serval can be used to assist in improving preventative care practices and management of serval in captivity.

3. MATERIALS AND METHODS

This study was carried out in conjunction with an anaesthetic study (V108-17), as well as a serval population study (EC040-14), both of the University of Pretoria.

3.1 STUDY ANIMALS AND SETTING

The serval that were captured occur naturally on the Sasol Synfuels property in Secunda, Mpumalanga, South Africa, at the geographical location 26° 33'S, 29° 10'E; at the highest density of serval recorded in the literature (9).

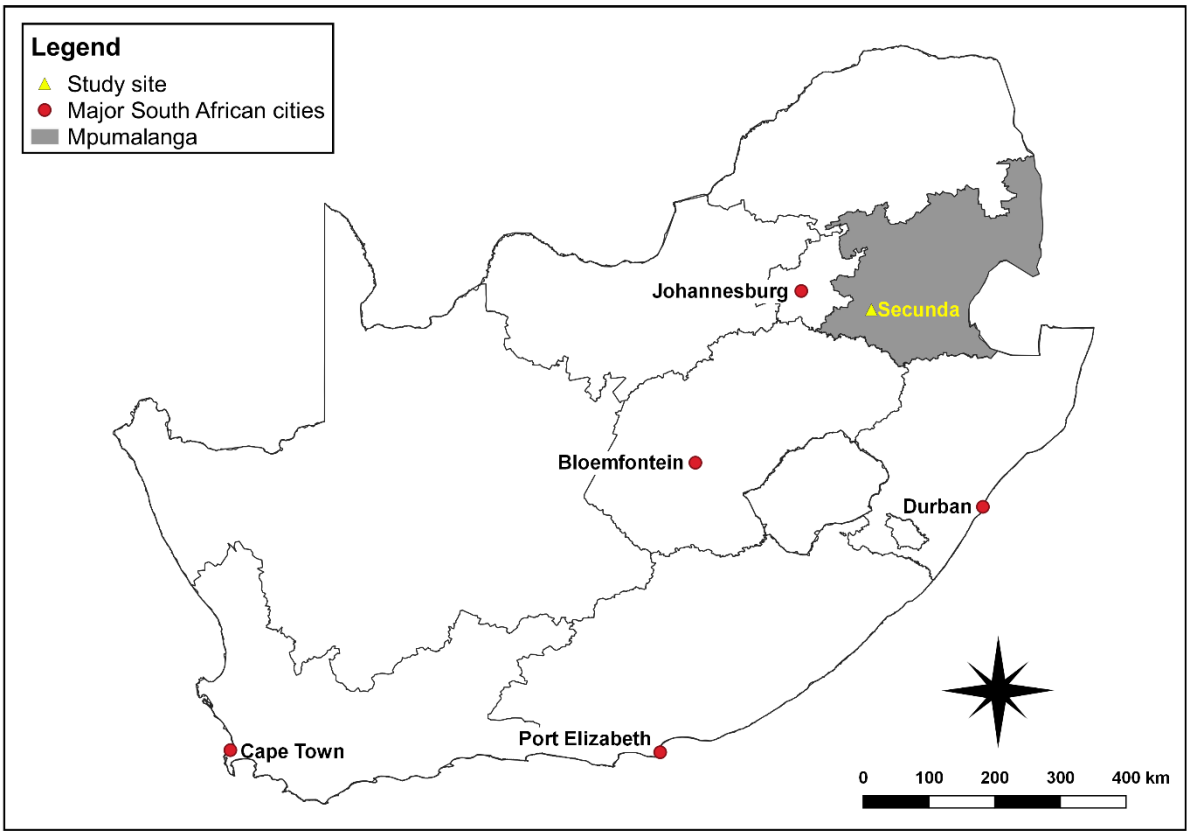

Figure 3-1. Map showing the location of the study site, Sasol Synfuels, Secunda, Mpumalanga, South Africa, where the wild serval were captured.

Wild serval were captured over three sessions of five days each. The first session was carried out 18-22 September 2017, the second session 13-17 November 2017 and the third session 12-16 March 2018.

Baited traps, consisting of a cage (length 2 meters, width 0.8 meters and height 0.8 meters) with a guillotine door connected to a footpad by a metal arm, were used to capture the serval. The bait, a fresh helmeted guinea fowl (*Numida meleagris*) carcass, was strung from the top of the trap at the opposite end to the door, ensuring that serval lured into the trap would step on the footpad and trigger the guillotine door, resulting in its capture. Camouflage netting was used to cover the trap, providing shade and minimising stress caused by researchers approaching the cage. The traps were set up at various locations on the property, based on serval densities determined by camera trap and GPS collar data, and were monitored frequently. This capture protocol was approved by the Animal Ethics Committee of the University of Pretoria (protocol number EC040-14) and a capture permit from Mpumalanga Tourism and Parks Agency (permit number 5467) was obtained.

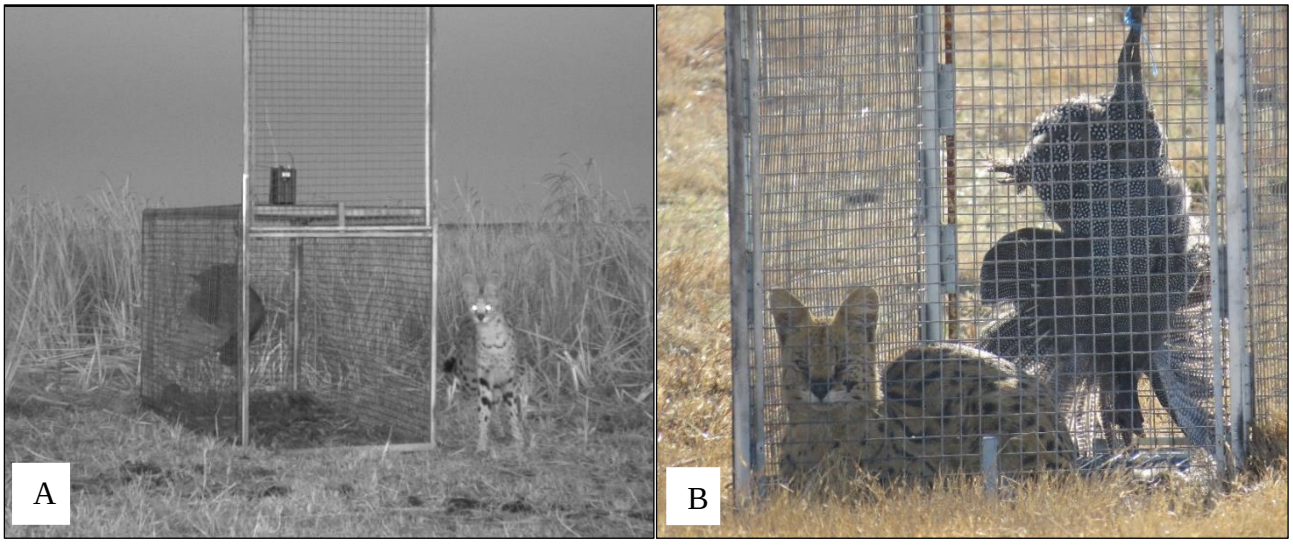

Figure 3-2. (A and B) Baited traps with a guillotine door connected to a footpad by a metal arm, were used to capture the wild serval.

3.2 EXPERIMENTAL PROCEDURES

Each trapped serval was chemically immobilised according to the protocol detailed in the anaesthetic study mentioned previously. Once immobilised, the serval was moved from the trap to an examination table, where it was monitored by an anaesthetic team while undergoing the various examinations detailed in this protocol. As a means of identification, each serval was scanned for the presence of a microchip. If a microchip was not detected, one was inserted subcutaneously at the level of the scapulae. A body condition score, using a five-point scale (Appendix 1) was allocated. Full-mouth dental photographs were taken and an age-category (juvenile, subadult or adult) was assigned to each serval (Table 3-1). Serval that were recaptured over the course of the current study were excluded from the data evaluation unless a change of age-category between examinations was apparent. Since a serval's dietary requirements and behaviours differ at different life stages, variation in the dental, oral and maxillofacial pathologies may occur.

Figure 3-3. Wild serval were trapped and immobilised according to the protocol outlined in the anaesthetic study (V108-17). (Courtesy KW Emslie)

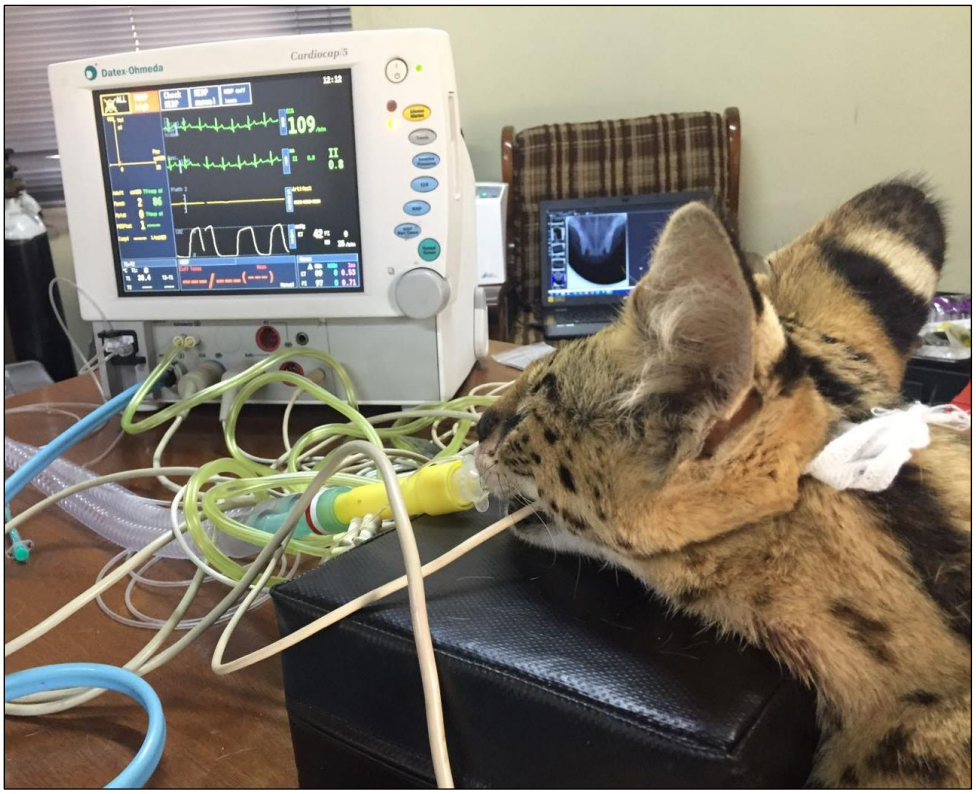

Figure 3-4. The anaesthetised serval were monitored by an anaesthetic team while the extraoral and intraoral examinations, as well as full-mouth radiographs, were performed.

Table 3-1. Criteria for designation of age-category for each examined serval.

Age-category	**Criterion**
Juvenile	Deciduous or mixed dentition
Subadult	Permanent dentition in which the apices of the maxillary canines are still open
Adult	Permanent dentition in which the apices of the maxillary canines are closed

The dental terminology used in this study includes the descriptive names of teeth, according to the *Nomina Anatomica Veterinaria* (27), as well as the modified Triadan system (28).

Table 3-2. Dental terminology using the descriptive names of teeth, according to the *Nomina Anatomica Veterinaria* (27) as well as the Modified Triadan nomenclature system (28).

Tooth	**Right**	**Left**	**Tooth**	**Left**	**Right**
Maxilla			Mandible		
First incisor tooth (I1)	101	201	First incisor tooth (I1)	301	401
Second incisor tooth (I2)	102	202	Second incisor tooth (I2)	302	402
Third incisor tooth (I3)	103	203	Third incisor tooth (I3)	303	403
Canine tooth (C)	104	204	Canine tooth (C)	304	404
Second premolar tooth (PM2)	106	206			
Third premolar tooth (PM3)	107	207	Third premolar tooth (PM3)	307	407
Fourth premolar tooth (PM4)	108	208	Fourth premolar tooth (PM4)	308	408
Molar tooth (M)	109	209	Molar tooth (M)	309	409

Complete extraoral and intraoral examinations were performed on each animal, using a feline dental chart to record all findings (Appendix 2). During the extraoral examination, the entire head was palpated, and the mandible manipulated to detect abnormalities. The intraoral examination began with inspection of the oropharynx, tonsils, palate, tongue and buccal mucosa. Each tooth was then examined individually. Calculus and gingivitis index scores were awarded to each tooth (29) (19). Full-mouth calculus and gingivitis indices were calculated for each individual, by totalling the scores awarded to each tooth and dividing this figure by the number of teeth examined. Periodontal pocket depth, gingival recession and furcation defects were measured using a periodontal probe. A dental explorer was used to investigate enamel

defects, crown fractures, tooth resorption and tooth mobility. Oral masses and other oral lesions were described and drawn on the dental chart.

Figure 3-5. The intraoral examination included probing each tooth using a dental probe.

Table 3-3. Scoring system used in the dental, oral and maxillofacial evaluation of wild serval against 14 parameters.

Pathology/Abnormality	**Score**	**Description**
Calculus index score (29)	0	No calculus
	1	0-24%
	2	25-49%
	3	50-74%
	4	75-100%

Pathology/Abnormality	Score	Description
Gingivitis index score (19)	0	Healthy gingiva
	1	Slightly inflamed
	2	Delayed bleeding on probing
	3	Profuse bleeding on probing or bleeds when touched lightly
Mobility (19)	0	No mobility
	1	Horizontal movement of <1 mm
	2	Horizontal movement >1 mm
	3	Vertical movement as well as horizontal movement.
Dental fractures (30)	1	Uncomplicated Crown fracture: A fracture affecting enamel and dentine, but not exposing the pulp
	2	Complicated Crown fracture: A fracture affecting enamel and dentine, and exposing the pulp
	3	Root fracture: A fracture affecting dentine, cementum and the pulp
	4	Uncomplicated crown-root fracture: A fracture affecting enamel, dentine and cementum, but not exposing the pulp
	5	Complicated crown-root fracture: A fracture affecting enamel, dentine and cementum, and exposing the pulp
Tooth discolouration (31)		Staining of dentine by extrinsic or intrinsic sources
	0	Tooth discolouration absent
	1	Tooth discolouration present

Pathology/Abnormality	Score	Description
Tooth wear (30)		Rounding or flattening of the cusp tip; exposure of dentine with or without tertiary dentine formation
	0	Tooth wear absent
	1	Tooth wear present
Enamel defect (31)		Focal reduction in quantity or quality of enamel
	0	Enamel defect absent
	1	Enamel defect present
Retained deciduous root		Deciduous root still present adjacent to the corresponding permanent root
	0	Retained deciduous root absent
	1	Retained deciduous root present
Supernumerary root (30)		Presence of a third root in a tooth that normally has two roots
	0	Supernumerary root absent
	1	Supernumerary root present
Supernumerary tooth (30)		Presence of an additional tooth not normally included in the dental formula
	0	Supernumerary tooth absent
	1	Supernumerary tooth present
Abnormal root morphology (30)		Malformed root
	0	Abnormal root morphology absent
	1	Abnormal root morphology present

Pathology/Abnormality	Score	Description
Tooth rotation (32)		Movement of a tooth around its long axis
	0	No tooth rotation present
	1	Tooth rotation present (in approximate degrees)
Tooth resorption (7)		Progressive loss of dentine and cementum or enamel
	0	Tooth resorption absent
	1	Tooth resorption present
Periapical lesion (30)		Presence of periapical bone loss
	0	Periapical lesion absent
	1	Periapical lesion present
Capture injuries		Any pathology deemed to be as a result of trapping

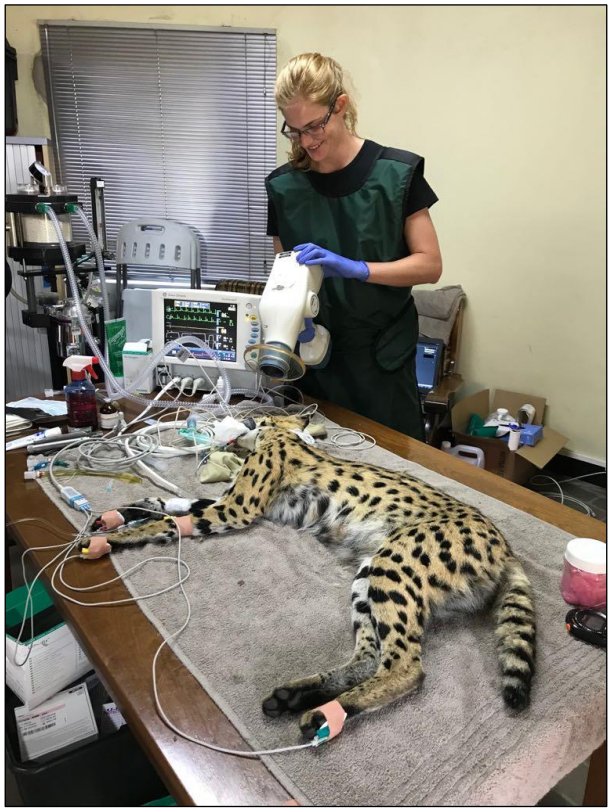

Figure 3-6. Full-mouth intraoral radiographs were taken of each serval included in this study.

A total of 10 radiographs were taken of each serval using a handheld dental x-ray unit (Aribex NOMAD, Aribex, Charlotte, North Carolina, USA) with 2.3 mA and 60 KV; iM3 dental phosphor imaging plates of sizes 2 and 4 and the iM3 CR-7 dental radiographic reader and software (iM3, Vancouver, Washington, USA, available via DIAG Import and Export CC, RSA). The radiographic views employed to obtain full-mouth radiographs are listed in Table 3-4.

Table 3-4. Intraoral radiographic views used to obtain a full-mouth radiographic set (23) of each serval examined for dental, oral or maxillofacial pathology.

Structures Imaged	Radiographic View
Incisor and canine teeth	Intraoral rostrocaudal bisecting angle
Canine teeth	Intraoral lateral bisecting angle
Maxillary premolar and molar teeth	Modified intraoral lateral bisecting angle
Mandibular premolar and molar teeth	Intraoral parallel

If oral masses or other oral lesions were identified on oral examination, incisional biopsies were taken and stored in 10% buffered formalin to be submitted to Prof. Sonja Boy at the Sefako Makgato Health Sciences University for histopathological analysis.

3.3 DATA ANALYSIS

Data were assessed for normality by plotting histograms, calculating descriptive statistics and performing the Anderson-Darling test for normality. Frequencies of dental, oral and maxillofacial pathology found were compared between sex (male, female) using Mann-Whitney-U test. Data describing the population and dental, oral and maxillofacial pathology were displayed in frequency tables. Full-mouth calculus and gingivitis indices were calculated for each individual. This was calculated by totalling the scores awarded to each tooth and dividing this figure by the number of teeth examined. The association of the body condition score to the presence of dental, oral and maxillofacial pathology was estimated using the Spearman's correlation. Data were analysed using commercially available software (MiniTab 18.1; MiniTab Inc.; USA) and results were interpreted as significant at $p < 0.05$.

4. RESULTS

Twenty-nine individual serval were captured. Five serval were recaptured during the course of the study and only one recapture was included (as the serval changed age-category between captures) to make a total of 30 data sets available for evaluation. A total of 902 (of an expected 900) teeth were examined, without any teeth being absent. Nineteen of the examined servals were female (63%) and 11 were male (37%). Two captured serval were classified as juveniles (7%), four as subadults (13%) and 24 as adults (80%).

Tooth wear

Tooth wear was the most commonly observed dental anomaly in the study population in both males and females. Only mild occlusal wear, with no pulp exposure or tertiary dentine formation, was noted. This abnormality was noted in 20 serval (67%), affecting 66 teeth (7%) overall. One juvenile, no subadults and 19 adults displayed mild tooth wear. The canine teeth, particularly the maxillary canine teeth, were the most commonly affected teeth. The maxillary third premolar teeth also frequently displayed wear. In four individuals, the incisal edges of all the maxillary incisor teeth were worn.

Figure 4-1. Tooth wear at the maxillary incisor teeth and maxillary right canine tooth in a wild serval. An uncomplicated crown fracture is also present at the left maxillary canine tooth.

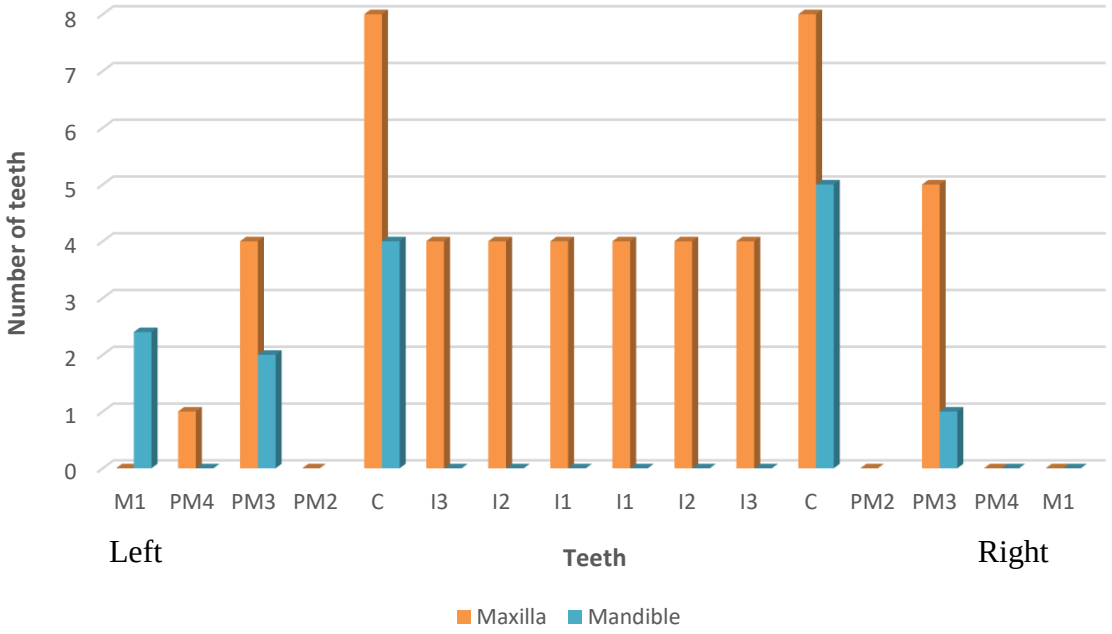

Figure 4-2. Distribution of tooth wear diagnosed in a wild serval population.

Supernumerary roots

Supernumerary roots were present in five of the captured serval, as a third root of the maxillary third premolar tooth, which normally only has two roots. In all five cases (17%), the third root was smaller than and situated between the two regular roots of the third premolar tooth. Such supernumerary roots were noted on the right-hand-side in four serval and bilaterally in one serval. The difference in occurrence of supernumerary roots between jaw side or sex was not significant. Four of the five cases were adult serval and one was a subadult.

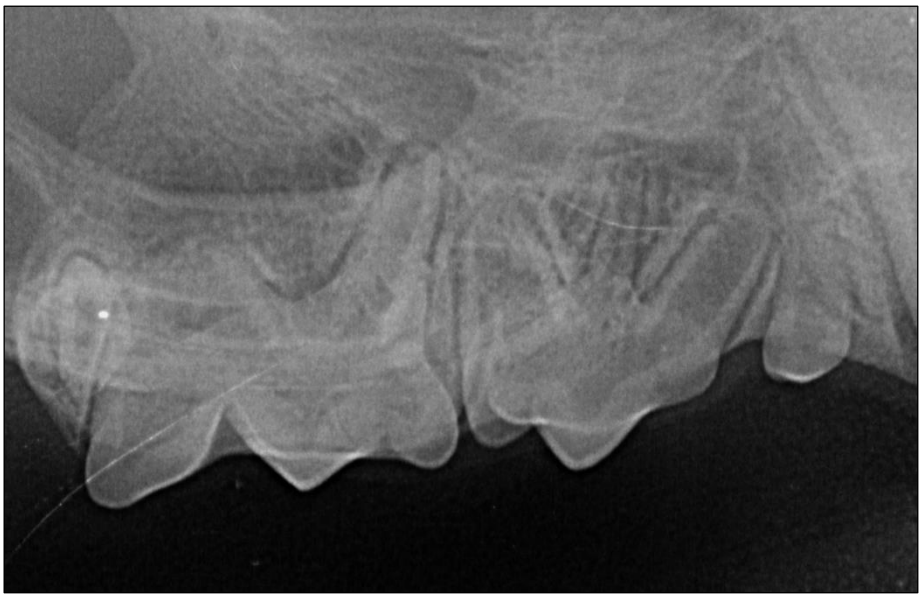

Figure 4-3. Supernumerary third root at the right maxillary third premolar tooth in a wild serval.

Supernumerary teeth

Supernumerary teeth were found in three serval (10%); all adult males (sex: $p = 0.028$). The supernumerary teeth were all unilateral premolar teeth, situated rostral to the mandibular third premolar tooth. One supernumerary tooth was unerupted.

Figure 4-4. Supernumerary premolar tooth observed in a wild serval.

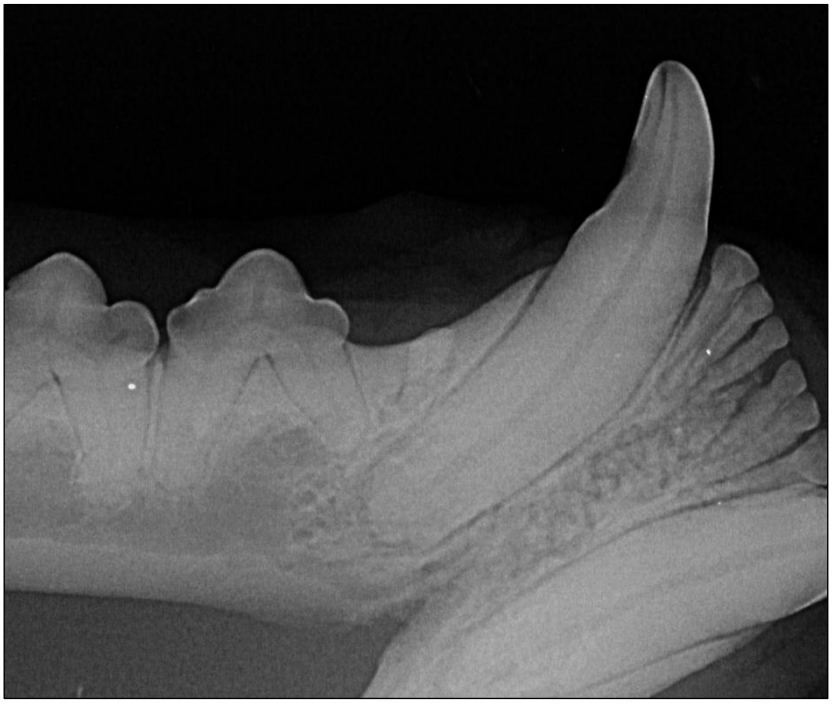

Figure 4-5. Unerupted supernumerary premolar tooth.

Abnormal root morphology

One maxillary right canine tooth had a prominent indentation at the mesial aspect of its root. The left maxillary canine tooth in the same individual had a very square root apex. In five other individuals, square root apices were apparent bilaterally at the maxillary canine teeth. Therefore, 20% of captured serval and 1.2% of examined teeth displayed abnormal root morphology. This abnormality was only detected in adult male serval (sex: $p = 0.022$).

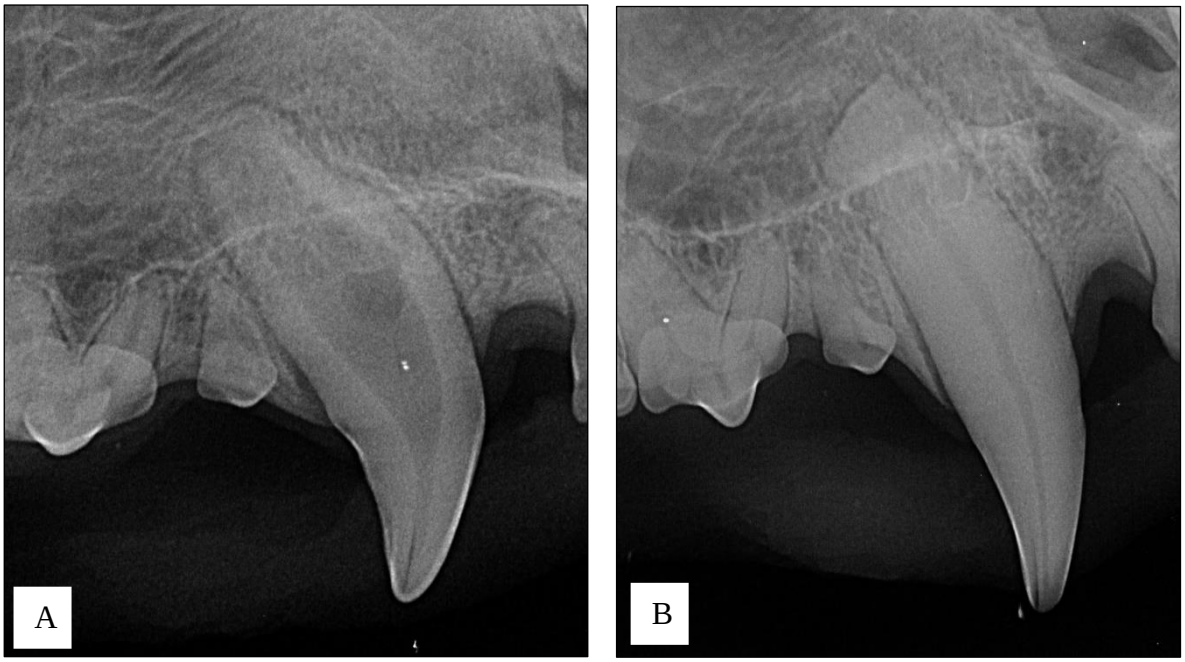

Figure 4-6. (A and B) Abnormal root morphology of right maxillary canine teeth in adult male wild serval.

Rotated teeth

One adult female displayed bilateral rotation of the maxillary second premolar teeth around their long axes, by approximately 30˚, so that the mesial aspect of the tooth was orientated more palatally and the distal aspect more buccally.

Retained deciduous roots

In two serval, one adult female and one subadult male, there were retained, fractured deciduous roots adjacent to the roots of the permanent dentition. In one serval, these additional roots were present bilaterally adjacent to the maxillary third premolar teeth, and in the second serval, the additional roots were present bilaterally adjacent to the maxillary second premolar teeth. All of these structures had thick dentinal walls, a periodontal ligament space and a root canal, and were situated adjacent to the corresponding permanent tooth roots and thus appeared to be retained, fractured deciduous roots. No periapical pathology was evident radiographically.

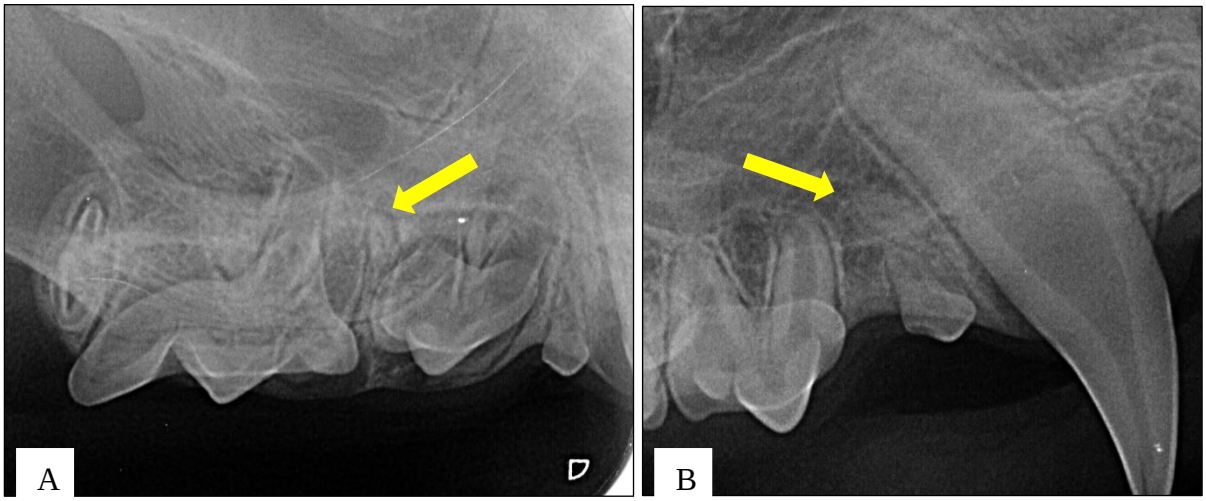

Figure 4-7. Retained fractured deciduous roots at right maxillary (A) third premolar tooth and (B) second premolar tooth.

Enamel defects

One adult male serval displayed an enamel defect on the crown of the left mandibular canine tooth.

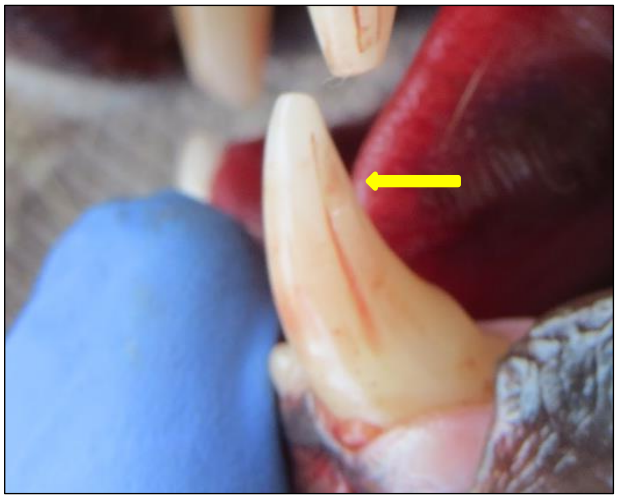

Figure 4-8. Small enamel defect at the distal aspect of the crown of the left mandibular canine tooth.

Tooth Resorption (TR)

Only one incidence of TR was diagnosed among the captured serval. Type II TR was evident at the roots of the first and second left maxillary incisor teeth in one adult female. A root fracture was visible radiographically at the second maxillary incisor tooth with associated mobility of 2.

Figure 4-9. Type II tooth resorption of the left maxillary first and second incisor teeth, with an associated root fracture of the second incisor tooth.

Dental fractures and tooth discolouration

Dental fractures were noted in seven captured serval (23%), affecting eight teeth (0.9%). The prevalence of dental fractures was no different between the sexes. Maxillary teeth were affected more frequently than mandibular teeth. (87% vs 13%). Maxillary canine teeth were the most commonly affected teeth. Uncomplicated crown fractures, complicated crown fractures, as well as root fractures were diagnosed in the study population. Root fractures were noted in three individuals, each with a root fracture of a single tooth evident radiographically. The affected teeth included left first and second maxillary incisor teeth and a left second maxillary premolar tooth. Uncomplicated crown fractures of maxillary canine teeth accounted for three of the eight dental fractures noted. In one adult female serval, complicated crown fractures were observed in the left maxillary and mandibular canine teeth, with associated grey discolouration of the crowns.

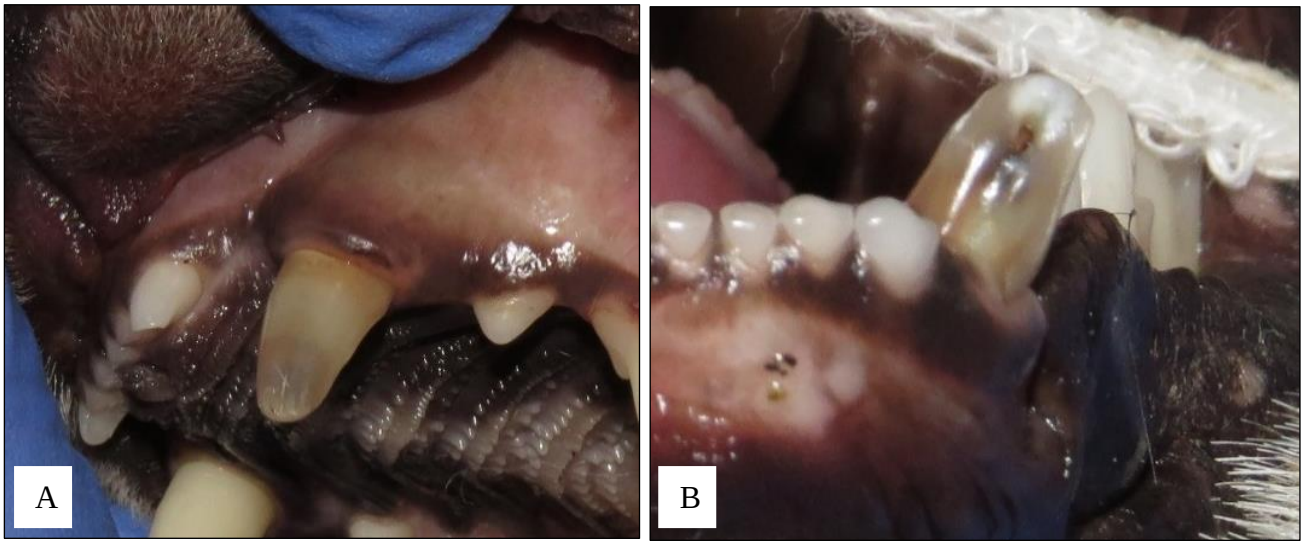

Figure 4-10. Complicated crown fracture, with grey discolouration, of the left (A) maxillary and (B) mandibular canine teeth in an adult female wild serval.

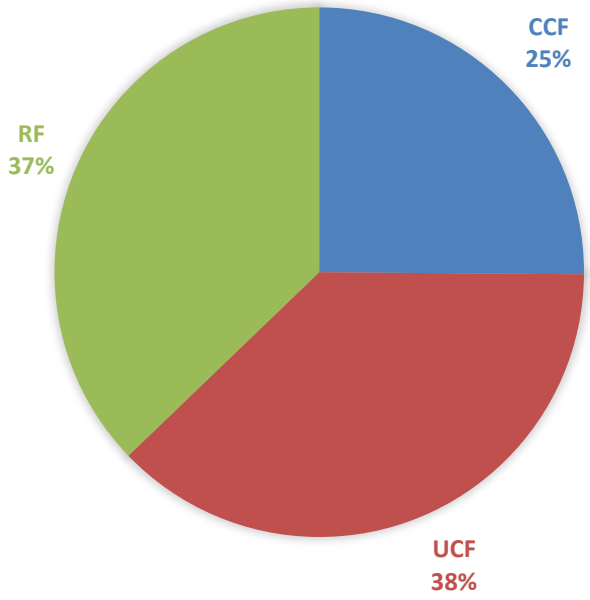

Figure 4-11. Prevalence of types of dental fractures (n=8 teeth) diagnosed in a wild serval population. CCF = complicated crown fracture; UCF = uncomplicated crown fracture; RF = root fracture.

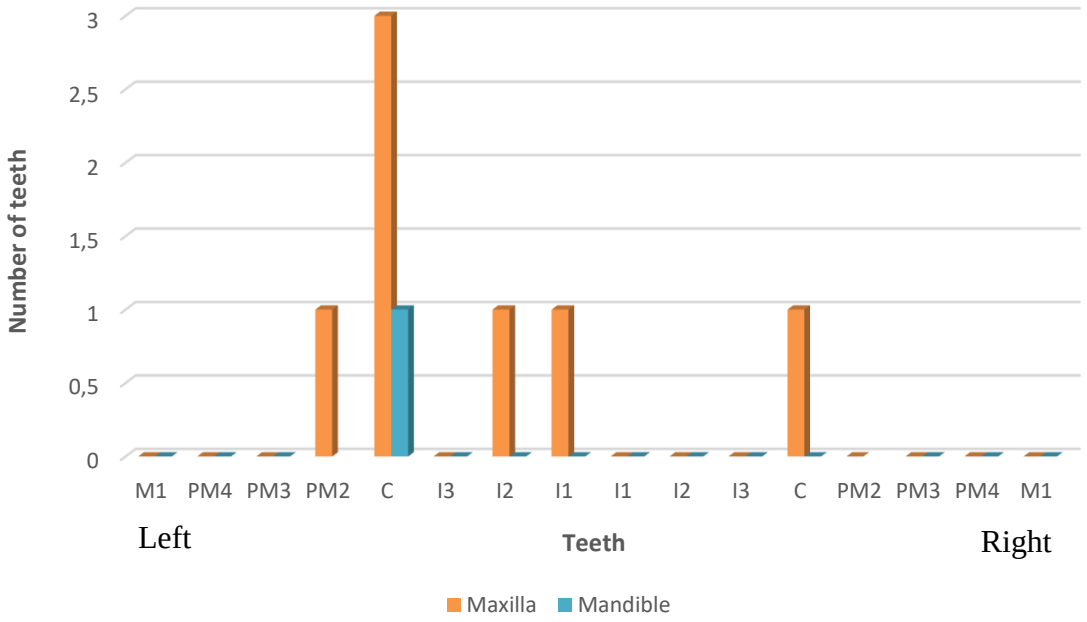

Figure 4-12. Distribution of dental fractures diagnosed in a wild serval population.

Periapical lesions

Periapical lesions were noted radiographically in only one adult female with complicated crown fractures of the left maxillary and mandibular canine teeth.

Figure 4-13. Periapical radiolucencies at the left (A) maxillary and (B) mandibular canine teeth due to complicated crown fractures.

Mobility

Mobile teeth were discovered in two of the serval examined, one adult female and one adult male. The male's left maxillary second premolar tooth and the female's left maxillary second incisor tooth both had a mobility of two due to root fracture.

Figure 4-14. Root fracture of a left maxillary second premolar tooth resulting in the tooth being mobile.

Calculus and gingivitis

The full-mouth calculus scores ranged from 0 to 0.3 with the mode across all age groups being 0.07. Mild dental calculus accumulation was found in 27 cats (90%), but only 85 teeth (9%). The full-mouth gingivitis scores ranged from 0 to 0.4. Seven serval (23%) displayed mild focal gingivitis. Bleeding on probing, indicating a gingivitis index score of 2, occurred at one tooth in five serval, two teeth in one serval and six teeth in one serval.

Figure 4-15. Only mild calculus accumulation and mild focal gingivitis were observed in the study population.

Table 4-1. Summary of the dental pathology diagnosed in wild serval, including the number and percentage of serval affected, age-category and sex of affected serval, number of teeth affected and the teeth most frequently affected by each type of dental pathology.

PATHOLOGY	SERVAL NO. (%)	ADULTS	SUBADULTS	JUVENILES	FEMALES	MALES	NO. OF TEETH	MOST FREQUENTLY AFFECTED TEETH
Tooth wear	20 (67%)	19	0	1	14	6	66	Maxillary canine teeth
Uncomplicated crown fracture	3 (10%)	3	0	0	0	3	3	Maxillary canine teeth
Complicated crown fracture	1 (3%)	1	0	0	1	0	2	Left maxillary and mandibular canine teeth
Root fracture	3 (10%)	3	0	0	1	2	3	Maxillary incisor teeth
Periapical radiolucency	1 (3%)	1	0	0	1	0	2	Left maxillary and mandibular canine teeth
Crown discolouration	1 (3%)	1	0	0	1	0	2	Left maxillary and mandibular canine teeth
Mobility	2 (7%)	2	0	0	1	1	3	Maxillary second premolar teeth

PATHOLOGY	SERVAL NO. (%)	ADULTS	SUBADULTS	JUVENILES	FEMALES	MALES	NO. OF TEETH	MOST FREQUENTLY AFFECTED TEETH
Retained deciduous root	2 (7%)	1	1	0	1	1	4	Maxillary second and third premolar teeth
Tooth resorption	1 (3%)	1	0	0	1	0	2	Maxillary incisor teeth
Supernumerary tooth	3 (10%)	3	0	0	0	3	3	Mandibular premolar teeth
Supernumerary root	5 (17%)	4	1	0	3	2	6	Maxillary third premolar teeth
Tooth rotation	1 (3%)	1	0	0	1	0	2	Maxillary second premolar teeth
Abnormal root morphology	6 (20%)	6	0	0	0	6	12	Maxillary canine teeth
Enamel defect	1 (3%)	1	0	0	0	1	1	Left mandibular canine tooth

Twenty-nine of the thirty serval included in this study had a body condition score of three or three and a half out of five. Only one adult female had a body condition score of two and a half out of five. Since the body condition was similar among all captured serval regardless of the presence of dental pathology, sex or age, it was not possible to evaluate the association of these factors. Sixty percent of serval with dental pathology were female and 40% were male. Eighty-four percent of affected serval were adults, 12% subadults and 4% juveniles.

Capture injuries

Due to the inherent stress of trapping and darting, capture injuries were sustained by some of the animals. The most common injury was abrasion of the skin of the head. On intraoral examination, small gingival lacerations were diagnosed in five serval and small lingual lacerations were found in two serval. In one serval, a complicated crown fracture of the right maxillary third incisor tooth was diagnosed on intraoral examination. It was assumed that the fracture occurred at the time of darting as the pulp was bleeding on examination. The affected tooth was extracted. A footpad laceration was noted in one captured serval. This was treated by suturing the wound closed. One adult female developed acute pulmonary oedema during general anaesthesia. The condition was successfully treated, and the serval's recovery and release were uneventful.

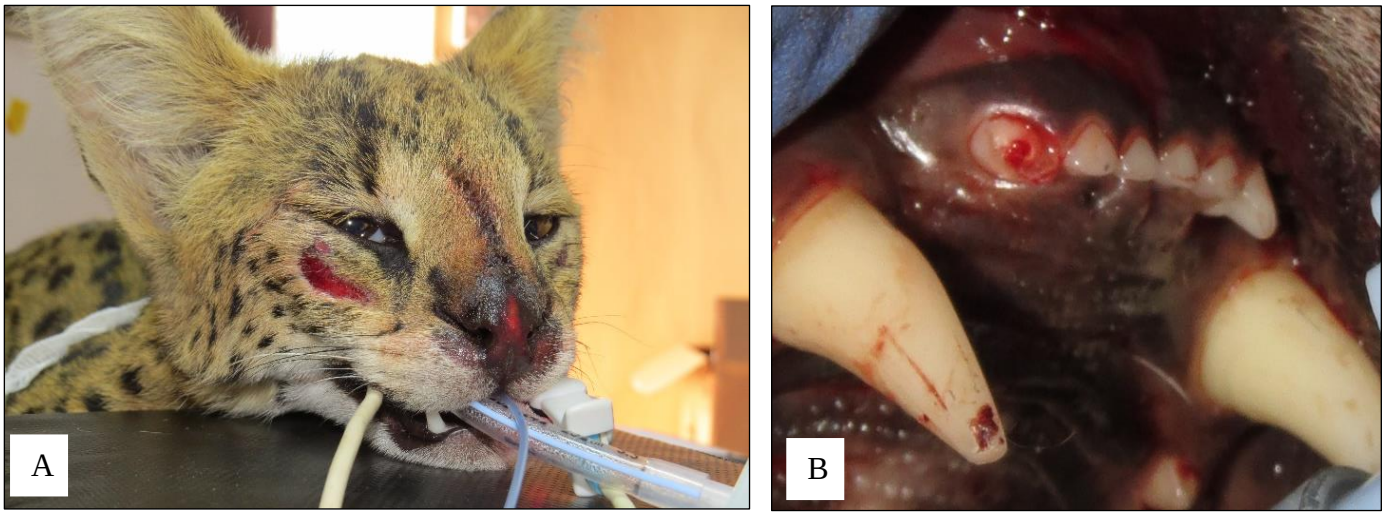

Figure 4-16. (A) Abrasion of the skin was the most common capture injury. (B) One serval sustained a complicated crown fracture of the right maxillary third incisor tooth during darting.

5. DISCUSSION

This study describes the dental, oral and maxillofacial pathology in wild serval captured on the Sasol Synfuels Operations property in Secunda. Fourteen different dental pathologies were diagnosed, but no oral or maxillofacial pathology was identified.

The most common dental pathology observed among the captured serval was tooth wear. The affected teeth displayed minor wear of the cusp tips. The maxillary canine teeth were most commonly affected, followed by the mandibular canine teeth, maxillary incisor and maxillary third premolar teeth. The pattern of tooth wear of the study population is more similar to that recorded for the California bobcat (8) than that recorded for feral cats (30). Like the California bobcat, the canine and incisor teeth were the most commonly affected teeth (8). The maxillary third premolar teeth, which were the most frequently affected teeth in a feral cat population on Marion Island (30), were also often affected in the current study. Even though the distribution of tooth wear in the two previous studies was different, both studies concluded that the observed tooth wear was most likely related to diet. It is possible that the same may be true for wild serval. Since the serval's diet consists of at least 80% rodents (10), it is conceivable that tooth wear may be due to abrasion from the rodents' hair coat. Serval often eviscerate the carcass and tear it into small pieces that require little mastication before swallowing (10). Rodents are burrowing animals and thus sand will accumulate among the hair fibres. Sand and hair can be abrasive to teeth (33). The serval's feeding behaviour may explain the frequency of wear of rostrally situated teeth.

Seventeen percent of captured serval displayed a supernumerary root. In all cases, the supernumerary root was a slender third root situated between the two regular roots of the maxillary third premolar tooth. In four of the five individuals, the supernumerary root was

present unilaterally on the right-hand side. In one individual, supernumerary roots were present bilaterally. This finding has been described in domestic and feral cats (30), as well as in the California bobcat (8).

Supernumerary teeth were found in 10% of the serval examined. All the supernumerary teeth were unilateral, single-rooted premolar teeth situated rostral to the mandibular third premolar tooth. Such supernumerary teeth have been found in domestic and feral cats (30), but, to the author's knowledge, have not been described in any wild cat species. Colyer mentioned that in his extensive examination of felid skulls, supernumerary teeth were most commonly premolar teeth. However, the position of the supernumerary premolar teeth was not further described (13).

Colyer also noted that in serval, no teeth displayed an irregularity in position (13). In the current study, this statement was largely found to be true. However, in one serval, both maxillary second premolar teeth were slightly rotated. Most of the teeth examined in the current study displayed normal morphology, although, 20% of examined serval exhibited maxillary canine teeth with very square root apices, and one of these animals also had a marked indentation at the mesial aspect of its right maxillary canine root. One left mandibular canine displayed a small enamel defect at its distal surface. The root indentation, as well as the enamel defect, may be the result of localised inflammation due to trauma or infection during development of the tooth (32). It is possible that the square root apices are a normal variation in serval.

Another interesting radiological finding was the presence of what appeared as retained fractured deciduous roots. The structures in question were seen bilaterally in two individuals. In the first affected serval, the structures were adjacent to the developing distal root of both

third maxillary premolar teeth, and in the second serval, the structures were adjacent to the apices of both second maxillary premolar teeth. The structures were described as retained fractured deciduous roots as they had the shape of a tooth root, with a periodontal ligament space, a root canal and thick dentinal walls. It is possible that the corresponding deciduous teeth were affected by root fractures prior to resorption of the roots. However, the fact that in both cases the condition occurred bilaterally at the same tooth makes this explanation less likely.

The prevalence of dental fractures in the study population was 23%, which is far lower than what has been recorded for feral and other wild cats (30)(8)(1). Three types of tooth fractures were diagnosed in the study population, including root fractures, uncomplicated and complicated crown fractures. The two canine teeth affected by complicated crown fractures displayed a grey discolouration. Intrinsic tooth discolouration occurs when haemoglobin-related pigments are deposited in the dentine following pulp haemorrhage or pulp necrosis. Due to the almost translucent nature of enamel, the colour of the underlying dentine influences the overall colour of the tooth (31). Radiographs also revealed evidence of endodontic disease of the teeth affected by complicated crown fractures. The radiographic signs included periapical radiolucency as well as a slightly wider pulp canal in comparison to the contralateral tooth. Two teeth were determined to be mobile during the oral examination. Both teeth were mobile due to root fractures.

Only one case of tooth resorption was diagnosed, which was associated with a root fracture of the left second maxillary incisor tooth. Both the first and second left maxillary incisor teeth displayed evidence of Type II TR, with narrowing of the periodontal ligament space and decreased radiopacity of the roots. It is possible that the root fracture occurred secondary to

TR, however, since no other incidences of TR were diagnosed in the study population, it is more likely that TR was secondary to inflammation at the site of the dental fracture.

The only sign of periodontitis observed in the study population was mild focal gingivitis (periodontitis stage 1). Bleeding on probing occurred at only 1.4% of examined teeth. No periodontal pockets, furcation exposure nor alveolar bone loss was diagnosed. Mild calculus accumulation was evident with most animals only displaying calculus at the maxillary fourth premolar teeth, covering less than 25% of the tooth surface.

Regardless of dental pathology present, almost all the examined serval had an ideal body condition. Only one adult female had a slightly lower body condition, and this serval, interestingly, was not affected by any dental, oral or maxillofacial pathology. Therefore, the body condition was not significantly influenced by the dental pathologies affecting this population. The assumption that adult serval would be more likely to display dental pathology than subadults or juveniles, due to accumulation of pathology throughout an animal's life, was found to be true.

Although every effort was made to reduce the stress of the serval while in the traps, some mild capture injuries were sustained. Upon approach of the trap by the anaesthetic team, the serval would usually run into the side of the trap in an attempt to escape. Therefore, the most common capture injury sustained was abrasion of the skin of the facial and cranial regions. All capture complications were appropriately treated, and the recovery and release of each serval was uneventful.

6. CONCLUSION

Fourteen different types of dental pathology were diagnosed in the study population, with mild wear of cusp tips being the most frequently identified pathology. In contrast to domestic cats, dental fractures and TR were rarely identified. No neoplasia, malocclusions nor maxillary or mandibular fractures were diagnosed in any serval examined, and no teeth were missing due to congenital or acquired loss. Since the current study was performed on live serval and not on skulls, it was possible to evaluate the oral and maxillofacial soft tissues for pathology. Only mild focal gingivitis was observed in a few animals, but neither generalised gingivitis nor stomatitis was diagnosed. To the author's knowledge, this is only the second study of the dental, oral and maxillofacial pathology in wild felines to be performed on live animals rather than on skulls. This is significant as only pathology affecting the bone and/or teeth can be examined on skulls. However, the early stages of many types of pathology do not result in bony changes and some pathologies exclusively affect soft tissues.

This study indicates that intraoral and extraoral examinations, as well as dental radiography, are important aspects of the clinical evaluation of wild felines. It is intriguing that even at the highest density of serval recorded in the literature, and with their habitat consisting predominantly of disturbed wetland and grassland directly surrounding a highly active industrial site; minimal pathology was found. This demonstrates that even the most unexpected sectors and opportunities can be used to advance conservation efforts as well as to provide knowledge to assist in improving the husbandry of captive wild animals.

Figure 6-1. Camera trap photo of a wild serval on the Sasol Synfuels property in Secunda. (Courtesy DJ Loock).

7. DECLARATION OF CONFLICT OF INTEREST

The primary investigator, as well as the supervisors, have no conflicts of interest to declare.

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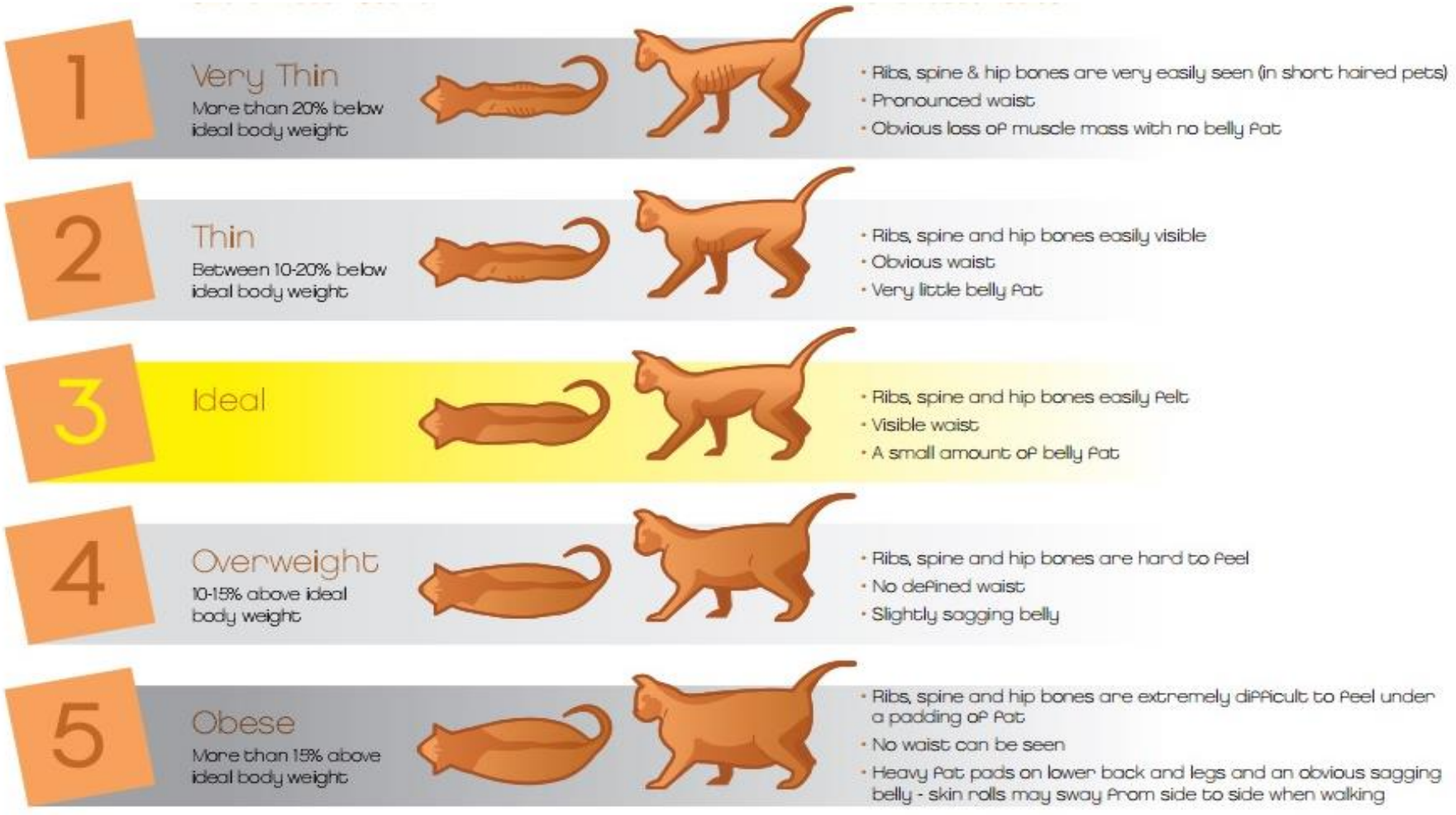
9. APPENDIX 1: BODY CONDITION SCORE CHART



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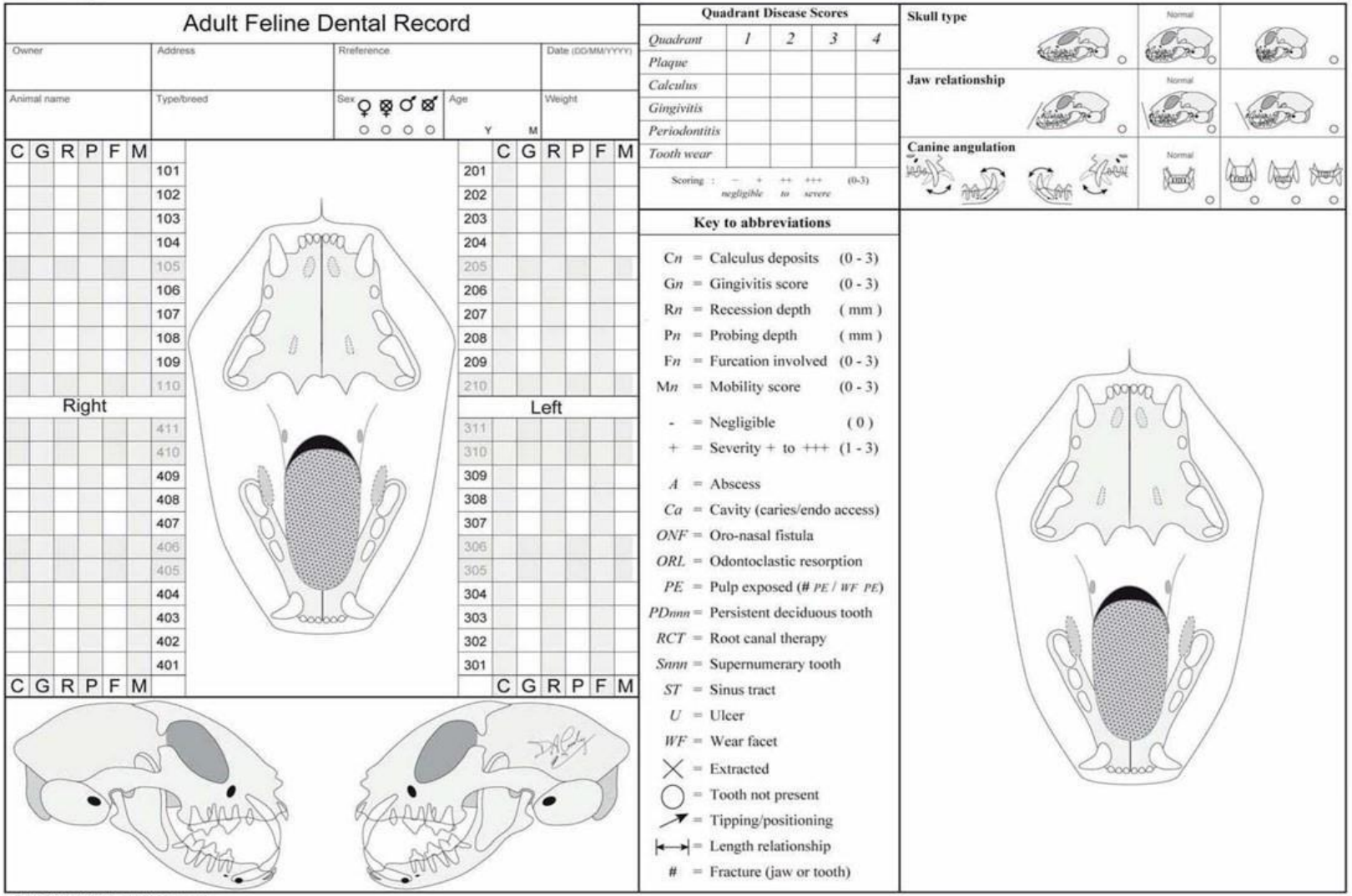
10. APPENDIX 2: FELINE DENTAL CHART



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