POST MORTEM SURVEY OF EQUINE DENTAL DISORDERS

by

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DECLARATION

I hereby declare that this dissertation, submitted for the degree MSc in Veterinary Science, Companion Animal Clinical Studies, to the University of Pretoria, is my own work and has not been submitted to another university for a degree, and that the data in this dissertation are the results of my own investigations.

Ditte Cecilie Vemming

15 November 2013

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Dedication

I dedicate this thesis to my family in Denmark, Mikke, Bent, Dea, Rikke, Martin and Shaila, and to my new South African family, Sujan and Jeeva – without their loving support throughout my studies I would never have made it. They make a true example of how one should treat other people.

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ABBREVIATIONS

BCS	Body condition score
CT	Computed tomography
EOTRH	Equine odontoclastic tooth resorption and hypercementosis
MRI	Magnetic resonance imaging
OVAH	Onderstepoort Veterinary Academic Hospital
OEBH	Oral examination on bisected heads

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SUMMARY

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Dental care is an integral part of equine veterinary practice and increased focus has been put on the implications of dental disorders on equine welfare. In South Africa limited reports on dental disorders in the equine population are available, therefore the prevalence of dental disorders in horses in this region is unknown. Additionally, no study has reported on the difference between performing an oral examination on an intact head and a bisected head for the diagnosis of dental disorders.

The objectives of this study were to describe the prevalence of dental disorders in different age groups of an abattoir population of horses, and to compare oral examination of intact and bisected heads. A cross-sectional prevalence study was performed on heads of horses consigned for routine slaughter at Randfontein abattoir in South Africa. Individual horse gender and body condition score were recorded. Age was estimated from dental evaluation.

Oral examinations were performed on intact heads with a Haussmann gag head light, mirror, and dental probe by two observers blinded to the findings of each other. Heads were then bisected and examined by the observers individually and in consensus. Age and all lesions were recorded for each horse on a standardised dental chart.

Heads from 40 horses were examined between March and November 2012, 19 males and 21 females, divided into immature (2-5 years), adults (6-14 years) and older horses (≥ 15 years).

Older horses had a significantly higher prevalence of diastemata (66.7%), focal overgrowths (58.3%), fractures (58.3%) and caries (91.7%), whereas occlusal abnormalities affected all age groups. Disorders associated with deciduous premolars were periodontal pockets (84.6%), wave mouth appearance (53.8%), and diastemata (38.5%). Rostral and caudal overgrowths, periodontal pockets, and fractures were most likely to be diagnosed during the regular oral examination. No significant association was found between body condition score and severe dental disorders. *Gasterophilus* larvae were detected in the oral cavity of all age groups examined.

The prevalence of dental disorders detected was similar or higher than previous studies undertaken outside South Africa, most likely because the oral examination was also performed on bisected heads. The oral examination performed on intact heads was adequate for diagnosing gross dental lesions and disorders, compared to examination of bisected heads, but further diagnostic examination is needed for reliably diagnosing more subtle lesions and disorders. The clinical relevance of *G. pecorum* detected is of interest.

Key words*:* Dental disorders, horse, occlusal abnormalities, oral examination, post mortem.

CHAPTER 1 INTRODUCTION

Dental disorders are commonly found during routine dental examinations in equine practice (Brigham & Duncanson 2000b) and cadaver examinations show a widespread occurrence of dental disorders (Anthony *et al*. 2010; Gere & Dixon 2010; Masey O'Neil *et al*. 2010).

Early signs of dental disease are not easily detected, because the teeth are not easily accessible, and most clinical signs only occur at a later stage (Dixon *et al*. 2000b). Quidding, halitosis, and abnormal occlusal movements are more specific clinical signs (Dixon *et al*. 1999a, 1999b) and quidding horses have been found to be at higher risk to develop severe colic (Suthers *et al*. 2013). Weight loss has been reported in many cases of dental disorders (Dixon *et al*. 1999b, 2000a; Dixon *et al*. 2007) as have bit and head carriage problems, and head shaking (Dixon *et al*. 1999b; Dixon *et al*. 2007). In the past decade equine research has focused increasingly on dentistry, including the implications of dental disorders on equine welfare.

Most equine dental disorders may be diagnosed by direct oral examination, however the relatively poor visibility within the oral cavity sometimes makes clinical diagnosis in the live horse difficult. This has been demonstrated when post mortem studies (Gere & Dixon 2010) have shown a higher prevalence of dental disorders than studies in a live population of horses (Dixon *et al*. 1999a). Further diagnostics to enhance the oral examination or determine the existence or absence of dental pathology include oral (Simhoefer *et al*. 2008; Ramzan *et al*. 2009) and sinus endoscopy (Tremaine & Dixon 2001), radiography (Townsend *et al*. 2011), scintigraphy (Weller *et al*. 2001), computed tomography (CT) (Huggons *et al*. 2011) and magnetic resonance imaging (MRI) (Gerlach *et al*. 2013).

No studies have so far established the extent of the difference during oral examination on intact heads, as in the live patient, versus bisected heads examined post mortem. Limited reports are available on dental disorders in South African horses (Hofmeyer 1960) and zebras (Penzhorn 1984) and the prevalence of dental disorders in this region is unknown.

CHAPTER 2 LITERATURE REVIEW

2.1. DENTAL NOMENCLATURE AND ANATOMY

The horse has four types of teeth: incisors, canines, premolars and molars. The deciduous dentition consists of 24 teeth and the permanent dentition is comprised of between 36-44 teeth, the number depending on the presence of first premolars and canines (Easley *et al*. 2011). The modified Triadan system (Floyd 1991), which incorporates the “rule of 4 and 9” where all canines are indicated numerically as 4 and all first molars are indicated numerically as 9, may be used for equine dental nomenclature. The first premolar (wolf teeth) occurs in both males and females and can be found in both the maxillary and mandibular arcade, but they are most common in the maxillary arcade, where the prevalence is approximately 38% (Anthony *et al*. 2010). Canine teeth are most often found in stallions and geldings and the prevalence of individuals with all 4 canine teeth present has been found to be 50.0% in stallions and 52.1% in geldings in a large study on horses 18 months to 30 years of age (Anthony et al. 2010). In the cited study 42.9% of stallions and 38.6% of geldings lacked canine teeth, compared to 75.4% of mares (Anthony et al. 2010).

Eruption times of the deciduous incisor teeth are: the first incisor 3 days after birth, second incisor at the age of 4-6 weeks and third incisor at the age of 6 months (Easley *et al*. 2011). The permanent incisors erupt at the age of 2.5 years for the first incisor, 3.5 years for the second incisor, and 4.5 years for the third incisor (Easley *et al*. 2011). The deciduous caps on the premolars are lost at the age of 2.5 years for the second premolar, and 3.5 and 4.5 years for the third and fourth premolar, respectively (Easley *et al*. 2011). The time of shedding of the deciduous caps of the premolars can vary considerably

(Ramzan *et al*. 2009), and generally heavier breeds tend to have delayed shedding of deciduous caps (Myelle *et al*. 1997).

Horse teeth are hypsodont, i.e. they have a long crown, and erupt continuously throughout the horse's life (Easley *et al*. 2011). The visible part of the tooth is the clinical crown, the unerupted part is the reserve crown and the apex is the part where the roots develop (Easley *et al*. 2011). The size of premolars and molars are around 5-10 cm in height, 2.0-3.5 cm in width (Henninger *et al*. 2003). The infundibulum is an invagination of enamel from the occlusal surface and is found in the incisors and maxillary cheek teeth (premolars and molars). The infundibulum is normally, not always, filled with cementum and the length and surface area of the infundibulum decrease with age (Fitzgibbon *et al*. 2010).

The teeth of horses consist of three different dental tissues: enamel, dentine, and cementum. Enamel is the hardest structure in the body. The ameloblasts die off once the tooth is fully formed, therefore formation of new enamel is not possible (Easley *et al*. 2011). Equine enamel consists of three types: equine type-1, equine type-2, and equine type-3. The enamel found in incisors is primarily equine type-2 enamel, while the most common enamel type in cheek teeth is equine type-1 enamel (Kilic *et al*. 1997b). Dentine occurs in two main types, primary and secondary dentine. Secondary dentine can be subclassified into regular (physiological) and irregular (pathological, reparative or tertiary) dentine (Kilic *et al*. 1997c). Regular secondary dentine is produced on the periphery of the pulp cavity throughout the lifetime of teeth (Kilic *et al*. 1997c). The pulp horns are covered by subocclusal secondary dentine that serve to protect the pulp horns from pulpar exposure (Easley *et al*. 2011). The thickness of the secondary dentine layer varies between individual horses, but also between individual pulp horns from the same cheek teeth, and can be as low as 2 mm (White & Dixon 2010). Cementum serves as an attachment for fibres from the periodontal ligament (Dixon & Copeland 1993). Cementum also has a protective function - during eruption the enamel is covered with cementum that wears away over time (Kilic *et al*. 1997d) and cementum also covers the dentine around the apex (Dixon & Copeland 1993). Cementum is divided into peripheral and infundibular cementum (Kilic *et al*. 1997d).

Dentine and cementum have an organic component and are therefore more flexible than enamel (Easley *et al*. 2011). The difference in hardness of the dental tissues, where dentine wears faster than enamel, creates an uneven occlusive surface that serves as a grinding surface during mastication (Kilic *et al*. 1997a). The softer dental tissue provides elasticity to the hard, but brittle enamel, and the enamel protects the softer dentine from wearing down too fast (Kilic *et al*. 1997a).

The maxillary and mandibular cheek teeth have six pulp horns in Triadan 06 position, five pulp horns in 07-10 position, seven pulp horns in maxillary 11 position (Kopke *et al*. 2012), and six pulp horns in mandible 11 position (Dacre *et al*. 2007). Intercommunicating common pulp horns are usually seen in horses younger than 5 years (Windley *et al*. 2009; Kopke *et al*. 2012), but can also be seen in older horses (Kopke *et al*. 2012). Communicating pulp horns are more common in mandibular cheek teeth (Dacre *et al*. 2007; Kopke *et al*. 2012). In hypsodont and brachydont teeth the size of the pulp cavity decreases with age due to dentine deposition (Dacre *et al*. 2007; Easley et al. 2011).

The basic chewing cycle consists of an opening stroke, a closing stroke and a power stroke which are opening/closing the mouth and lateral excursion of the mandible (Easley *et al*. 2011).

2.2. DENTAL DISORDERS

2.2.1. Incisor abnormalities

Incisors are less likely to suffer from dental disorders than cheek teeth with a prevalence of incisor disorders of 10% reported (Masey O'Neil *et al*. 2010). The most common disorders of incisors are traumatic injuries, most often seen as fractures. They are more at risk for traumatic injuries because of their rostral position (Dixon *et al*. 1999a). Development disorders such as persistent caps are also commonly seen (Dixon *et al*. 1999a). Occlusal abnormalities in the incisors include focal overgrowths, smile mouth, and slant mouth and are also common, however they occur mostly in conjunction with other abnormalities in the molar arcade (Dixon *et al*. 1999a; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). Conditions rarely found in the incisors are diastemata, caries, malpositioning, missing teeth and supernumerary teeth (Anthony *et al*. 2010). Compared to cheek teeth diastemata, incisor diastemata are considered less common (Dixon & Dacre, 2005). A newly discovered syndrome named equine odontoclastic tooth resorption and hypercementosis (EOTRH), which involves the incisors and canines in aged horses, has been described (Staszyk *et al*. 2008). The EOTRH syndrome causes bulbous enlargement of the incisor roots with secondary gingivitis being a common sequelum; this condition causes severe discomfort often necessitating extraction of all affected teeth (Staszyk *et al*. 2008). The enlargement has been shown to be caused by odontoclastic cells that cause resorptive lesions in cementum, enamel, dentine (and in some cases also pulp); the resorptive lesions result in irregular cementum deposits on the roots (Staszyk *et al*. 2008).

2.2.2. Cheek teeth occlusal abnormalities

Sharp enamel points, wave mouth, step mouth and focal overgrowths are the most common occlusal abnormalities reported in the molar arcade (Brigham & Duncanson 2000a; 2000b; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010).

Sharp enamel points are the most common finding in oral dental examinations in horses (Brigham & Duncanson 2000b; Anthony *et al*. 2010) with a prevalence of up to 100% reported (Masey O'Neil *et al*. 2010). They can cause buccal and lingual abrasions (Gere & Dixon 2010), and be a source of discomfort for the horse (Dixon *et al*. 1999b). If not corrected, sharp enamel points can interfere mechanically with the normal lateral power stroke phase of mandible movement and as a result progress to shear mouth (Dixon 2000), which occurs when the angle of the occlusive surface is greater than 30˚ (Brown *et al*. 2008).

Wave mouth arises when the occlusal surface of the cheek teeth wears unevenly and results in an undulating, wave-like appearance of the occlusal surface of the arcade. The reported prevalence is 8-12.6% (Brigham & Duncanson 2000a; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). During the eruption of the permanent premolars a wave-like pattern of the premolars is a normal physiologic finding (Dixon *et al*. 2000a).

Step mouth is a localized overgrowth that occurs when the opposite tooth is missing, fractured, or severely worn. The prevalence is 0.5-18% (Brigham & Duncanson 2000a; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). Step mouth is a serious condition that interferes mechanically with the normal lateral jaw movement (Dixon *et al*. 2000a).

Focal overgrowths, commonly called hooks, are found at the rostral aspect of 106 and 206 and in many cases concurrently on 311 and 411 (Dixon *et al*. 1999a; Brigham & Duncanson 2000a). The prevalence of focal overgrowths varies greatly from 14.6-80% (Brigham & Duncanson 2000a, 2000b; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). This condition occurs most often in horses that are kept stabled (Masey O'Neil *et al*. 2010), which could be due to the position they are fed roughage from. When a horses' head is elevated the lower jaw retracts and extended periods of chewing in this position could facilitate the formation of focal overgrowths (Easley *et al.* 2011). The focal overgrowths can, if they are extensive, cause soft tissue trauma, restrict occlusal movements and are known causes of head shaking, bit and head carriage problems (Dixon *et al*. 1999b).

2.2.3. Soft tissue trauma

Buccal abrasions are trauma to the soft tissue of the buccal cavity. They occur commonly and the prevalence varying from 36.2-86.6% (Anthony *et al*. 2010; Gere & Dixon 2010). Buccal abrasions are most often caused by sharp enamel points (Anthony *et al*. 2010). Young horses (Allen 2004) and horses ridden in bit and bridle have a higher prevalence of buccal abrasions (Tell *et al*. 2008). Lingual soft tissue trauma may also be found, but is less common than buccal soft tissue trauma (Gere & Dixon 2010).

2.2.4. Periodontal disease

Periodontal pockets are a pathological deepening of the gingival sulcus. The prevalence has been reported as 17.3% (Anthony *et al*. 2010). Parasites such as *Gasterophilus* spp. were commonly found in periodontal pockets during routine dental examinations in one recent study (Osterman Lind *et al*. 2012). They have been shown to be closely associated with diastemata and their incidence increases with the horse's age (Anthony *et al*. 2010). Other types of periodontal disease include gingival recession (Ramzan & Palmer 2011).

2.2.5. Diastema

A diastema is defined as a pathological space between two adjacent teeth in the same dental arcade (Carmalt 2003). The term valve (or closed) diastema is used to define spaces between cheek teeth where the width of the diastema is narrower at the occlusal margin than the gingival margin, creating a space where food material can be entrapped and lead to deep pockets and periodontitis (Easley *et al.* 2011). With an open diastema the width of the space is the same at the occlusive and gingival margins and food material will not get impacted that easily (Easley *et al*. 2011). The prevalence of diastemata in horses varies greatly and has been reported as 4.0% (Dixon *et al*. 1999b) and -45.7% in a post mortem survey (Gere & Dixon 2010). Post mortem studies have a much higher reported prevalence of valve diastemata (Gere & Dixon 2010) than studies performed on live horses (Dixon *et al*. 1999b) most likely because post mortem examination of the oral cavity is not restricted to intact heads, thereby facilitating more detailed examination of the oral cavity. In an aged donkey population prevalence up to 85.1% was reported (du Toit *et al*. 2008). A predilection has been found for the more caudal interdental spaces (Dixon *et al*. 1999b; Gere & Dixon 2010), which makes diagnosis of diastemata difficult during oral examination of the live horse.

Diastemata can be congenital or acquired (Carmalt 2003). Congenital diastemata can be caused by the absence of dental buds, polydontia or oligodontia (Carmalt 2003), whereas acquired diastemata can be caused by fractures, dental displacements (Carmalt 2003), and retained deciduous caps (Dixon *et al*. 1999b), or by age-related differences in angulation of cheek teeth, named *senile* diastemata (Easley *et al*. 2011). Food material becomes entrapped in valve diastemata and extensive periodontal pockets impacted with food develop (du Toit *et al*. 2008; Dixon *et al*. 1999b). In the case of more extensive food pockets horses may show severe signs of discomfort such as quidding, abnormal occlusal movements and sensitive gingivae (Dixon *et al*. 1999b). Secondary conditions such as apical infection of the affected teeth with concurrent paranasal sinusitis (Dixon *et al*. 1999b) and oromaxillary fistulas can develop from valve diastemata (Hawkes *et al*. 2008). Several disorders found in conjunction with diastemata include peripheral caries (Gere & Dixon 2010; Ramzan & Palmar 2011) and periodontal pockets (Anthony *et al*. 2010).

2.2.6. Caries

Caries can be divided into peripheral and infundibular caries. Peripheral caries, which are defined as "macroscopic evidence of destruction of calcified dental tissue on any non-occlusal aspect of the clinical crowns of the cheek teeth" (Ramzan & Palmar 2011) affect horses of all age groups and the prevalence has been reported as 6.1% (Gere & Dixon 2010). A common finding on affected cheek teeth is food material firmly adhered to the site of peripheral caries (Gere & Dixon 2010).

Infundibular caries result from destruction of calcified tissue caused by local production of acids by bacteria fermenting carbohydrates (Easley *et al.* 2011). The prevalence of infundibular caries has been reported as 7-16% (Fitzgibbon *et al*. 2010; Gere & Dixon 2010) with a predilection for maxillary premolars and molars 108/208 and 109/209 (Veraa *et al*. 2009; Fitzgibbon *et al*. 2010). Infundibular caries mostly affect older horses from 10 years onwards and has been reported in up to 42% of horses over 20 years of age (Fitzgibbon *et al*. 2010). Infundibular caries can predispose to fractures and apical infection (Dixon *et al*. 2000a).

A normal non-diseased infundibulum is filled with cementum, but anatomical studies on horses without a history of dental disease show that developmental infundibular cemental hypoplasia, not of bacterial origin, and other cemental defects are widespread, indicating that the changes might be age-related and a normal finding (Windley *et al*. 2009; Fitzgibbon *et al*. 2010). Infundibular cemental hypoplasia is a developmental condition and is most commonly found in younger age groups (29.2% in age 3-5 years; 27.1% in age 6-11 years) (Fitzgibbon et al. 2010). The pathogenesis of infundibular cemental hypoplasia is not fully understood. Disruption of occlusal blood supply to the developing secondary tooth by premature cap removal cannot cause cemental hypoplasia of the molars (09-11's) as they do not have deciduous precursors, and the molar 11 position had the highest prevalence of cemental hypoplasia in the study cited (Fitzgibbon et al. 2010). In some infundibulae an apical blood supply has been detected that persists after eruption; the infundibulum thus receives a blood supply from both the apical and occlusal aspects until eruption, and thereafter from the apical aspect only in some infundibulae (Fitzgibbon et al. 2010). Detection of many areas of hypoplastic cementum apically suggests that loss of apical blood supply may compromise cementum formation (Fitzgibbon et al. 2010). Infundibular cemental hypoplasia had previously been incorrectly referred to as infundibular necrosis and infundibular caries (Easley, 2011). It is suggested that cemental hypoplasia predisposes to development of infundibular caries at a later stage (Fitzgibbon et al. 2010).

2.2.7. Fractures

The prevalence of fractures of cheek teeth in post mortem studies are 10.9 % in horses (Gere & Dixon 2010), and 3.4 % in donkeys (du Toit *et al*. 2008). Fractures can be divided into traumatic and idiopathic fractures. Traumatic fractures can be caused by external trauma and iatrogenic trauma during dental treatments (Dixon *et al*. 2000a). Idiopathic fractures are without known cause. However, it is postulated they could be caused by a weakening of the tooth by caries that subsequently results in a fracture (Dixon *et al*. 2000a). Pulpar exposure has also been found in cases of idiopathic fractures (van den Enden & Dixon, 2008), but in many cases the tooth has a normal endodontic appearance (Dacre *et al*. 2007). Clinically, idiopathic fractures will usually be slab fractures involving pulp chambers or sagittal midline fractures through the infundibulae in maxillary teeth (Dacre *et al*. 2007; Gere & Dixon 2010). The teeth most commonly affected by fractures are Triadan 08 and 09 in both the maxillary and mandibular arcades (Dixon *et al*. 2007).

Occlusal fissures are fine cracks in the occlusal surface of the cheek teeth, often extending from the peripheral enamel folds to the secondary dentine, that have recently been reported to be widespread (54.3-58.2% prevalence) during oral endoscopy of horses referred for dental examination (Simhoefer *et al*. 2008; Ramzan & Palmar 2010). However, they have yet to be associated with dental disease (Ramzan & Palmar 2010). Mandibular fractures can also affect the roots of the cheek teeth (Huggons *et al*. 2011).

2.2.8. Apical infection

Apical infections are divided into primary and secondary apical infections. Primary apical infection is believed to arise from anachoretic (exposure to bacteria through a haematogenous route) pulpitis, while secondary apical infections occur secondary to other dental disorders such as fractures, and valve diastemata (Dixon *et al*. 2000b). This classification of primary and secondary is not always used and some reports group all apical infections together (Tietje *et al*. 1996; Tremaine & Dixon 2001; Henninger *et al*. 2003; Huggons *et al*. 2011).

Early signs of apical infection are not easily detected, since the clinical signs only occur at a later stage once the infection has progressed (Dixon *et al*. 2000b). External signs such as facial swelling (Dixon *et al*. 2000b); facial, nasal (Tremaine & Dixon 2001; Huggons *et al*. 2011), or mandibular draining tracts (Dixon *et al*. 2000b; Huggons *et al*. 2011); and unilateral nasal discharge (Dixon *et al*. 2000b; Tietje *et al*. 1996; Huggons *et al*. 2011) have been reported. Apical infection has a predilection for 108/208 (Henninger *et al*. 2003). Sagittal midline fractures and slab and crown fractures, if they involve the pulp cavity, may also result in apical infection (Dixon *et al*. 2000a).

2.2.9. Secondary dental sinusitis

Dental sinonasal disease has been shown to account for 22% of cases with secondary sinusitis (Tremaine & Dixon 2001). The clinical signs are most commonly a foul-smelling, unilateral nasal discharge (Tietje *et al*. 1996; Dixon *et al*. 2000c; Huggons *et al*. 2011). Facial swelling and facial tracts are also seen (Tremaine & Dixon 2001). Secondary paranasal dental sinusitis occurs when a tooth has an apical infection that has spread to the associated sinus (Dixon *et al*. 1999b).

2.2.10. Tumours in the oral cavity

Masses in the oral cavity are quite rare. Ameloblastomas (Dixon *et al*. 1999a; Dixon *et al*. 2000a), osteosarcoma (Dixon *et al*. 2000a) and squamous cell carcinoma (Easley *et al.* 2011) are some of the tumours reported in the oral cavity.

2.2.11. Congenital dental disorders

Congenital disorders of cheek teeth include: oligodontia, polydontia (Dixon *et al*. 1999b; Carmalt 2003), and absent dental buds (Carmalt 2003).

Dentigerous cysts in equids are a congenital branchial arch disorder with aberrant tooth-like structures adhered to the temporal bone of the skull and they often have a sinus tract ending at the medial pinna of the ear (Easley *et al*. 2010). They have also been reported in the sinuses (McClure *et al*. 1993; de Mira *et al*. 2007), can occur bilaterally (Smith *et al*. 2012), or unilaterally, and may contain structures that resemble permanent and deciduous teeth (Easley *et al*. 2010).

Another congenital disorder is wry nose (*campylorrhinus lateralis*), a nasal deviation, where the premaxilla (paired incisive bones), nasal bones, vomer and nasal septum are shortened and deviated; the severity of the deviation varies (Schumacher *et al*. 2008). Wry nose can result in partial or total failure of incisor occlusion (Schumacher *et al*. 2008).

2.2.12. Iatrogenic disorders

Iatrogenic disorders mostly occur as a complication of corrective dental care. Pulp exposure occurs when the sub-occlusive dentine is rasped excessively and exposes the sensitive dentine pulp complex, causing pain and possibly infection. It mostly occurs during mechanical reduction of cheek teeth, but can also occur when valve diastemata are mechanically widened or when bit seating is performed (Bettiol & Dixon 2011) or with crown height reduction of canine teeth. Motorised mechanical rasps used for reduction of cheek teeth also pose a risk as a result of thermal injury from prolonged use, resulting in pulp necrosis and death of the tooth (Baker & Allen, 2002; Wilson & Walsh, 2005; O'Leary *et al*. 2013). Pulp exposure is often found in cases of apical infection (van den Enden & Dixon 2008; Casey & Tremaine 2010). Besides thermal injuries, motorised mechanical rasps can also cause iatrogenic soft tissue trauma and result in traumatic fractures during dental treatments (Dixon *et al*. 2000a). Anecdotally, hand rasps, especially those with tungsten carbide heads, may cause extensive soft tissue trauma in unskilled hands.

2.3. DIAGNOSTIC TECHNIQUES

When abnormalities are found on clinical and oral examination, diagnostic imaging procedures are generally conducted as the next step towards diagnosing the extent of the dental disorder. Diagnostic imaging may give information about conditions which may or may not be identified during the oral examination, including apical infection (Huggons *et al*. 2011; Townsend *et al*. 2011), fractures, diastemata and oral tumours (Dixon *et al*. 2000a), disorders that extend from the oral cavity into the paranasal sinuses (Tremaine & Dixon 2001) and bone, causing sinusitis and osteomyelitis (Dixon *et al*. 1999b). Further diagnostics include oral and sinus endoscopy, radiography, scintigraphy, CT and MRI.

2.3.1. Endoscopy

Oral endoscopy improves visibility during oral examination and facilitates the diagnosis of less prominent disorders such as infundibular caries and gingival recession (Simhoefer *et al*. 2008; Ramzan *et al*. 2009). Sinoscopy has been shown to be useful to diagnose gross changes to the bone overlying the dental apex, however sinoscopy of the rostral maxillary sinus is of limited value in young horses because the length of the reserve crown makes visibility poor (Tremaine & Dixon 2001).

2.3.2. Radiography

Radiography is currently the most commonly used method for diagnosing apical infection in cheek teeth in horses (Huggons *et al*. 2011; Townsend *et al*. 2011). The principal projections are oblique views ranging from 45° to 35° (Townsend *et al*. 2011). If erupted (clinical) crown lesions are of interest the oblique views can be performed with an open mouth procedure (Barakzai *et al*. 2003). Radiographic signs of apical infection with the highest sensitivity are periapical sclerosis, periapical halo formation, and clubbing of roots

(Townsend *et al*. 2011). Radiography has a reported sensitivity of 51-76% and a specificity of 90- 95% in diagnosing apical infection (Weller *et al*. 2001; Townsend *et al*. 2011).

2.3.3. Nuclear scintigraphy

The main difference between the other diagnostic imaging modalities, such as radiography, MRI or CT, and scintigraphy is that scintigraphy reflects active remodelling of tissue whereas the other reflect existing changes.

Scintigraphy has been compared with radiography and has an excellent sensitivity of 95.5% and moderate specificity of 86.4%, compared with a low sensitivity of 51.5% and excellent specificity of 95.0% of radiography for diagnosing dental disease in horses (Weller *et al*. 2001). Teeth with apical infection showed significantly increased radiopharmaceutical uptake (Weller *et al*. 2001). Scintigraphy has also proven useful to diagnose a dental origin of paranasal sinus disorders (Barakazi *et al*. 2006). A benefit of scintigraphy is that no general anaesthesia of the patient is required. However, the equipment and facilities required for scintigraphy are relatively expensive and registration to handle radioactive material is required.

2.3.4. Computed tomography

The use of CT allows a more detailed investigation of enamel, infundibulae, and pulp horns because of the avoidance of superimposition of complex anatomical structures and better contrast (Windley *et al*. 2009). This provides an opportunity for diagnosing conditions like infundibular abnormalities (Veraa, *et al*. 2009) as well as lesions also noted on radiographs, such as apical infection, dental sinusitis, and fractures (Henninger *et al*. 2003; Veraa *et al*. 2009; Huggons *et al*. 2011). These cited studies provide strong support for the use of CT as an aid to diagnose dental disorders and have added greatly to our knowledge of dental anatomy.

Compared to radiographs, CT allowed detection of a higher degree of disorders such as apical infections and fractures (Huggons *et al*. 2011), however, the study cited was limited in that it was retrospective and the cases were pre-selected for CT examination based on the presence of either abnormal clinical signs on external examination and/ or during oral examination.

2.3.5. Magnetic resonance imaging

Recently MRI has also been shown to be a reliable tool in evaluating pathological changes in the pulp horn at an earlier stage than other diagnostic modalities, but is of limited use to investigate disorders that are not of soft tissue origin (Gerlach *et al*. 2013).

CHAPTER 3 HYPOTHESES, OBJECTIVES AND BENEFITS

3.1. HYPOTHESES

i. The prevalence of dental disorders in an abattoir population of South African horses increases with age.

ii. Horses with more severe dental disorders will have lower body condition score (BCS).

iii. Post mortem oral examination of bisected heads has greater accuracy for diagnosis of dental disease than oral examination of intact heads using a Hausmann's gag.

3.2. OBJECTIVES

3.2.1. Primary objectives

i. To investigate the prevalence of dental disorders in different age groups of an abattoir population of South African horses.

ii. To investigate the effect of dental disorders on BCS.

iii. To compare post mortem oral examination of bisected heads with post mortem oral examination of intact heads using a Hausmann's gag for diagnosis of dental disease.

3.2.2. Secondary objective

i. To collect and archive radiographic and CT images of the heads examined for later reporting and comparison of CT with radiography and oral examination for diagnosis of dental disease.

3.3. BENEFITS ARISING FROM THE STUDY

i. The prevalence of dental disorders in an abattoir population of South African horses of different age groups was determined.

ii. The relationship between dental disorders and BCS in the population examined was determined.

iii. The prevalence data collected from an abattoir population of horses with unknown history of dental care may serve as basis for later comparison with a cared-for population of horses with a known history of dental care.

iv. The radiographic and CT images archived will be used for future studies comparing CT with radiography and oral examination for diagnosis of dental disease.

CHAPTER 4 MATERIALS AND METHODS

4.1. MODEL SYSTEM

A post mortem prevalence survey of dental disorders in heads of horses consigned for routine slaughter at a registered commercial abattoir was performed.

Heads from 40 horses of light, medium to heavy weight breed, age two years and older, of any gender were included. It was targeted that the male and female groups be of approximately equal size. Miniature breeds and horses with evidence of severe external head trauma were excluded.

The horses were subjected to humane slaughter by captive bolt pistol and exsanguination performed by staff at the Randfontein Abattoir (Registration number 1/30, Plot 114 Middelvlei, Randfontein, 1764). The heads were obtained from the abattoir processing line, identified and transported to the Onderstepoort Veterinary Academic Hospital (OVAH), Faculty of Veterinary Science, University of Pretoria. At the OVAH the experimental procedures were performed in the following sequence: (1) radiography, (2) CT, (3) oral examination using a Hausmann's gag on intact heads, and (4) oral examination of bisected heads.

4.2. EXPERIMENTAL DESIGN

A prospective, cross-sectional prevalence study on heads from horses consigned for routine slaughter, equally distributed between gender and age groups, was conducted during 2012 at the OVAH.

Heads were grouped into three age groups based on estimation of age from dentition. As no history was available on the signalment of the horses, three relatively wide age groups were chosen as a measure to reduce the risk of uncertainty in ageing, as follows:

- <u>Immature</u>: 2 to ≤ 5 years [where the estimated age from dentition is based on the shedding of the deciduous incisors]
- <u>Adults</u>: > 5 to < 15 years [that showed the features used for estimation of age such as 7 year focal overgrowth of 103 and 203, enamel spots, dental stars (du Toit 2006) emergence of Galvayne's groove (Myelle *et al*. 1997)]
- <u>Older horses</u>: ≥ 15 years [an older group where most features used for estimated age had disappeared (Myelle *et al*. 1997) and the angle of the incisor teeth and occlusive surface suggested a horse of old age (du Toit 2006)]

4.3. EXPERIMENTAL PROCEDURES

4.3.1. Horses

Before slaughter the individual horse's gender, BCS (9 point scale, Henneke, *et al*. 1983), and colour were observed and recorded. After slaughter estimated age from dental evaluation was recorded.

4.3.2. Heads

On receipt of heads from the abattoir processing line they were immediately identified by placement of a numbered ear tag. A 7 cm diameter PVC cylinder was placed across the interdental space, without contact to the incisors and premolars, so that the mouth remained in an open position when *rigor mortis* occurred to facilitate later intra-oral and oblique radiographs and oral examination. Heads were sealed in double plastic bags at the abattoir and transported in rigid plastic containers containing ice bricks to the OVAH for further examination.

4.3.3. Radiography

Standard radiographs were taken of the heads using a Magnum 80 high frequency digital X-ray machine[1] at the Diagnostic Imaging section, within 24 hours of arrival at the OVAH.

Radiographic projections included:

<u>Cheek teeth</u>: Dorsoventral

Lateral

Le15°DRtVO open mouth

Rt15°DLeVO open mouth

<u>Incisors</u>: Intra-oral bisecting angle of the maxilla and mandible

Lateral

[1] Axim Pty. Ltd., Gazelle Avenue, Corporate Park South, Midrand, South Africa.

For the DV, lateral, intra-oral bisecting views of the maxilla, and incisors lateral view radiographs were taken with the head resting on the mandible in a ventral position. For the open mouth oblique views, as described by Barakzai and Dixon (2003), the head was supported in the desired position using sand bags and polystyrene blocks. The beam angle was checked using a custom-made 15° cardboard wedge. For the intra-oral bisecting views of the mandible the head was resting in a dorsal position. The PVC cylinder was retained in the interdental space on all views except the intra-oral views. All heads were in *rigor mortis* at the time of processing for radiographs and CT, and no attempts were made to distract the jaws further.

4.3.4. Computed tomography

A CT scan was performed on each head within 24 hours of arrival at the OVAH, using a Siemens Somatom Emotion machine[2].

In brief, the CT-procedure was performed in a rostro-caudal direction with the head resting on the mandible, using a bone window and scanning of the whole head using 5 mm slices. The entire premolar and molar arcade was rescanned using 1 mm slices. Any additional lesions noted during the CT procedure were rescanned using 1 mm slices.

4.3.5. Oral examination

Oral examination was conducted at the Pathology section of the Faculty of Veterinary Science, OVAH. The oral examination was conducted in two parts, first on intact heads and thereafter on bisected heads. Fifteen heads underwent examination intact and bisected and 25 heads were only examined as bisected heads.

[2] Siemens Medical Solutions USA, Inc., 51 Valley Stream Parkway, Malvern, PA 19355, USA.

Part 1: Oral examination of intact heads was performed as follows: heads were assigned a random number and packed in black plastic bags with only the muzzle protruding to blind observers. Heads were positioned on a table for oral examination using a Hausmann's gag, head light, dental mirror, and dental probe. Oral examination was performed by the primary investigator (DV) and the supervisor (PP) or co-supervisor (GS). Each observer had a time limit for the oral examination of five minutes per head. The time limit was chosen to be five minutes in order to make the oral examination comparable to an oral examination done in the field, where limited time may be allocated for examination. Estimated age from dental evaluation was recorded.

Part 2: Oral examination of bisected heads: The buccal mucosa was transected horizontally from the commissure to the level of the last molar. The exposed buccal, lingual and palatal mucosa were inspected for ulceration and other macroscopic lesions. Heads were severed through transversely caudal to the incisors and subsequently bisected sagittally using a band saw. A detailed clinical examination of the oral cavity was performed by the primary investigator. A dental probe was used to explore dental pockets. The supervisor or co-supervisor also performed an oral examination followed by review and recording of consensus findings by both observers on a separate chart. Dental pockets were measured with a dental probe. Following completion of examination of the dental arcades the frontal and maxillary sinuses were exposed from the medial aspect and presence of fluid or other macroscopic lesions recorded. Digital photographs were taken of the buccal, lingual, palatal, labial and occlusion surfaces of the teeth.

Dental disease recorded was grouped into two main categories, occlusal abnormalities (sharp enamel points, wave mouth appearance, step mouth, slant mouth, smile mouth, focal overgrowth, ramped overgrowth) or dental disorders [diastemata (open and valve grouped), fractures, periodontal pockets, infundibular caries, and buccal abrasions].

The findings of each observer during the examination on intact and bisected heads were recorded on separate, standardised dental charts using the modified Triadan system (Floyd 1991) (Appendix A). Following oral examination on bisected heads by both observers, consensus findings were recorded on a separate chart. Observers were blinded to the identification of the heads, to each other's findings prior to consensus evaluation of the bisected heads, and to the findings of the radiographs and CT. The consensus findings were used for prevalence analysis and the separate observer sheets were used for observer agreement analysis.

4.3.6. Parasite identification and histology

Any parasites or masses found within the oral cavity were described and samples were collected in formalin for later identification.

4.4. OBSERVATIONS

The primary investigator recorded individual horse gender, body condition score, colour and estimated age. The primary investigator, supervisor and co-supervisor recorded dental lesions identified during oral examinations on standardised dental charts. The findings were recorded in a spread sheet software package[3] with identification numbers, BCS, estimated age and dental disorders found.

[3] Excel 2010, Microsoft Corporation, USA

4.5. DATA ANALYSIS

Data were analysed presenting observer agreement using the Kappa statistic to assess agreement between raters, and descriptive statistics presented for continuous parameters. The Kruskal-Wallis test was used for the comparison of scores between categories of factors while the Chi-square test was used to test for associations between BCS and gender, and dental disorder. In order to investigate whether horses with severe dental disorders had a lower BCS than the remaining individuals, horses with the following disorders: fractures, periodontal pockets measuring >10 mm in depth, diastema, focal overgrowths, and step mouth were grouped together and tested against the remainder of the population.

Commercial statistical software[4] was used for all analyses. Significance level was set at $P < 0.05$. Radiographic and CT images were archived on the OVAH picture archive system.

4.6. ETHICAL CONSIDERATIONS

Approval by the Faculty Research Committee and waiver from the institutional Animal Use and Care Committee was obtained prior to the initiation of the study (Study V049-12). The heads used were obtained from horses consigned for routine slaughter and humanely slaughtered at a registered abattoir. The horses were observed from a distance and briefly palpated for body condition score estimate and gender recording before slaughter. Estimated ageing from dentition and all other procedures were performed post mortem.

[4] Stata 12, StataCorp, USA

CHAPTER 5 RESULTS

Forty horses were included in the study between March and November 2012, 19 males and 21 females, divided into the following three age groups: immature: 13 horses (6 males and 7 females), mean age 3.0 years; adults: 15 horses (7 males and 8 females) mean age 8.6 years; and older horses: 12 horses (6 males and 6 females) mean age 17.0 years. The male group consisted of five stallions and 14 geldings.

The mean BCS for all horses was 4.4. Mean BCS for the immature, adults, older age groups was 4.2, 4.9 and 3.9, respectively. No significant difference was found between the BCS and either the age groups or gender or between horses classified with severe dental disorders and the rest of the population.

First maxillary premolars (105 + 205) (wolf teeth) were found in 12 (30%) of the horses. No mandibular first premolars were detected. Canines (104, 204, 304 and 404) were found in 12 (30%) of the horses. Canines were seen in males only, with 12 (63.2%) males having canines.

Prevalence of occlusal abnormalities and dental disorders in the 40 horses is summarised in Table 1. The prevalence of abnormalities of wear and dental disorders by age group, and statistical comparison between age groups, is summarized in Table 2.

Table 1. Prevalence (%) of occlusal abnormalities and dental disorders detected during post-mortem oral examination of intact (n=15) and bisected heads of 40 horses, examined between March and November 2012 in South Africa. (Number of horses affected)

Classification	Dental disease	Total % prevalence
Occlusal abnormalities	Sharp enamel points	97.5% (39)
	Wave mouth appearance	57.5% (23)
	Focal overgrowths	40.0% (16)
	Step mouth	15.0% (6)
	Smile mouth	15.0% (6)
	Ramped overgrowth	10.0% (4)
	Slant mouth	7.5% (3)
Other dental disorders	Periodontal pockets	70.0% (28)
	Diastemata	40.0% (16)
	Infundibular caries	35.0% (14)
	Fractures	25.0% (10)
	Buccal abrasions	17.5% (7)

Focal overgrowths at 106 and 206 were associated with focal overgrowths at 311 and 411 in four (25%) horses with focal overgrowths (Fig. 1). None of the focal overgrowths were associated with trauma to adjacent soft tissue. Sharp enamel points (Fig. 2) and ramped overgrowths (Fig. 3) were some of the occlusal abnormalities found.

The mean number of lesions per affected horse for periodontal pockets, diastemata (Fig. 4, Fig. 5), infundibular caries (Fig. 5) and fractures (Fig. 6, Fig. 7) was 3.8, 2.8, 3.3, and 1.5, respectively. A wave mouth appearance and diastema formation in young horses was associated with shedding of deciduous caps (Fig. 8).

Table 2. Prevalence (%) by age group of occlusal abnormalities and dental disorders detected during post-mortem oral examination of intact (n=15) and bisected heads of 40 horses examined between March and November 2012 in South Africa. (Number of horses affected)

Dental disease	Prevalence by Age Group			
	Immature (*n* = 13 horses)	**Adult** (*n* = 15 horses)	**Older** (*n* = 12 horses)	**Probability** (KW χ^2)
Sharp enamel points	92.3% (12)	100.0% (15)	100.0% (12)	NS (2.08)
Wave mouth appearance	53.8% (7)	53.3% (8)	66.7% (8)	NS (0.57)
Focal overgrowths	23.1% (3)	40.0% (6)	58.3% (7)	0.0007 (14.63)
Step mouth	15.4% (2)	0.0% (0)	33.4% (4)	0.06 (5.67)
Smile mouth	7.7% (1)	13.4 % (2)	25 % (3)	NS (1.48)
Ramped overgrowth	0.0% (0)	20.0% (3)	8.4% (1)	NS (0.0)
Slant mouth	7.7% (1)	0.0% (0)	16.7% (2)	NS (2.61)
Periodontal pockets	84.6% (11)	53.3% (8)	75.0% (9)	NS (3.36)
Diastemata	38.5% (5)	20.0% (3)	66.7% (8)	0.05 (5.92)
Infundibular caries	7.7% (1)	13.4 % (2)	91.7% (11)	0.000 (23.69)
Fractures	7.7% (1)	13.4 % (2)	58.3% (7)	0.014 (8.49)
Buccal abrasions	15.4% (2)	20.0% (3)	16.7% (2)	NS (0.55)
Gasterophilus larvae	38.5% (5)	13.4 % (2)	8.4% (1)	NS (4.10)

NS = not significant at $P < 0.05$

Gasterophilus larvae were found in periodontal pockets in the oral cavity in eight (20.0%) of the horses. Up to 80% of the heads examined in May and June, winter months in South Africa, had larvae in the oral cavity. The larvae were vertically orientated, with the cephalic portion embedded in the gingival mucosa and the posterior stigmata visible, with each pocket containing up to 15 larvae (Fig. 9).

Species determination was performed on larvae from one horse. The larvae were identified as second instar *G. nasalis* and *G. pecorum*. One horse had multiple larger larvae attached to the soft palate with local inflammation and swelling at the point of attachment (Fig. 10).

One horse had a marked thickening of the left mandibular body that was unstable when palpated, suggesting a fracture. No masses were found in the oral cavity in this study. No rasp marking, indicative of previous dental care, was detected in any of the heads examined.

The level of agreement between observers for age determination based on dentition was 98%. The findings and agreement between observers, and findings during the oral examination on intact heads compared to oral examination on bisected heads are summarized in Table 3.

Table 3. Agreement between observers performing oral examination on intact heads and kappa statistics between oral examination on intact heads and oral examination on bisected heads (OEBH) of 15 horses

	Observer 1 / Observer 2 (Agreement %)	**Observer 1 / OEBH (Agreement %)**	**Observer 2 /OEBH (Agreement %)**	**Observer 1 + observer 2 /OEBH (Kappa)**
All cheek teeth erupted	60.0	53.3	93.3	0.2045
Sharp enamel points	80.0	66.7	86.7	0.1541
Wave mouth appearance	53.3	53.3	73.3	0.1492
Rostral focal overgrowth	100.0	100.0	100.0	1.00
Caudal focal overgrowth	80.0	80.0	100.0	0.4231
Ramped overgrowth	93.3	93.3	100.0	0.4767
Slant mouth	86.7	86.7	100.0	0.2857
Periodontal pocket (lingual side)	73.3	73.3	86.7	0.5370
Periodontal pocket (buccal side)	93.3	86.7	80.0	-0.0714
Diastemata	80.0	80.0	86.7	0.2308
Fracture	93.3	93.3	100.0	0.7750
Infundibular caries	73.3	86.7	86.7	0.2308
Buccal abrasions	86.7	93.3	93.3	0.2857
Gasterophilus larvae	93.3	73.3	80.0	0.1000

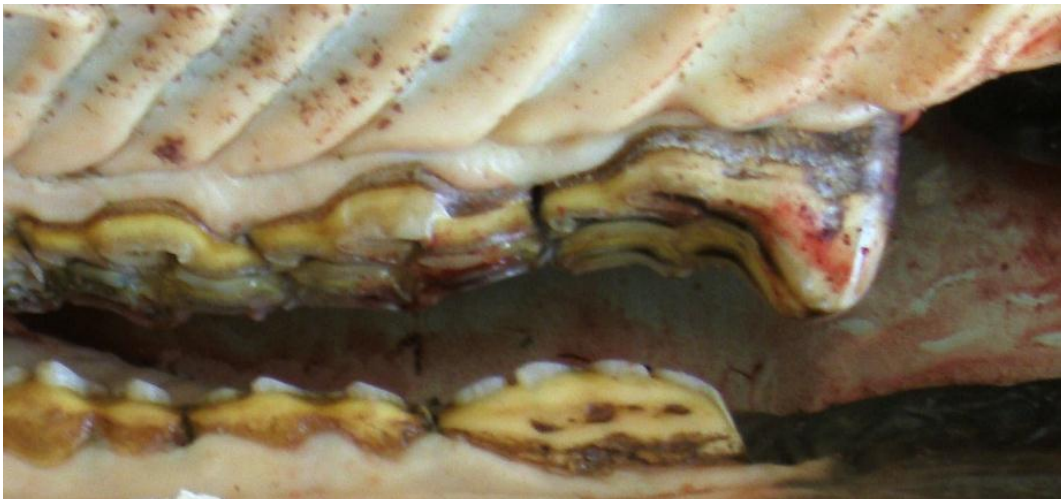

Figure 1. Focal overgrowth of 206, diastema between 206 and 207 (secondary to the focal overgrowth of 206). Rostral to the right. Horse number 6.

Figure 2. Sharp enamel points of the mandibular arcade and wave formation. Rostral to the right. Horse number 34.

Figure 3. Ramped overgrowth of the mandibular premolars. Small focal overgrowth of 206, Rostral to the right. Horse number 42.

Figure 4. Diastema (open) between 109 and 110, food impaction removed (the pocket is 2.5 cm deep). Rostral to the left. Horse number 9.

Figure 5. Infundibular caries in 209, pulpar damage of fourth pulp horn (marked with a needle) of 207. Diastema (open) between 207 and 208. Rostral to the left. Horse number 10.

Figure 6. Sagittal fracture of 108 with a large grass impaction. Buccal ulceration adjacent to 408. Rostral to the right. Horse number 32.

Figure 7. The same sagittal fracture of 108 from Figure 6 with the grass impaction removed. The buccal fragment is loose; the fracture involves pulp horns number 1 and 2 on the buccal aspect. Cupping out of the infundibulae can be seen in 108 and 107. Rostral to the right. Horse number 32.

Figure 8. Wave mouth appearance and diastema (open) formation in a young horse associated with shedding of deciduous caps. Rostral to the right. Horse number 29.

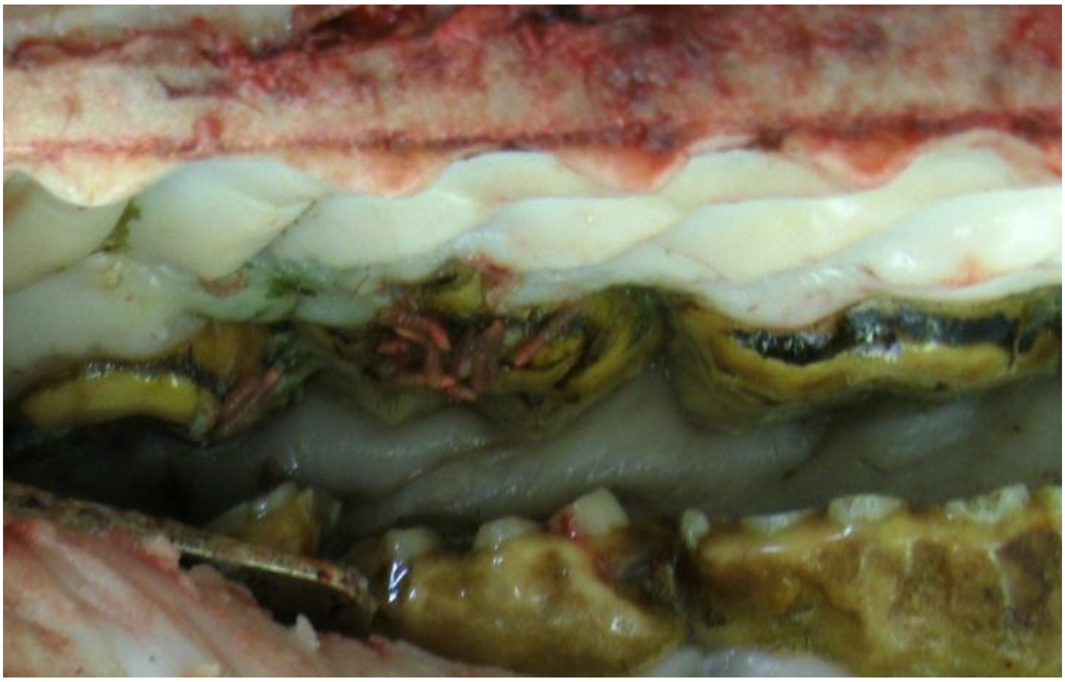

Figure 9. *Gasterophilus* larvae in a periodontal pocket between 210 and 211. Rostral to the right. Horse number 11.

Figure 10. *Gasterophilus* larvae attached to the soft palate. Rostral to the right. Horse number 29.

CHAPTER 6 DISCUSSION

The prevalence of dental disorders in horses in South Africa is unknown, with only limited reports on dental disease in equids in this region (Hofmeyer 1960; Penzhorn 1984). With the increasing interest in rescue and rehoming of horses destined for abattoirs in South Africa more information regarding the health status, particularly the prevalence of dental disease, of this population is needed.

The population in the present study consisted of horses with unknown history from a rural area of South Africa. Horses of all breeds, older than two years of age were accepted in this study. Horses were not enrolled at random; a selection of horses in order to fulfil the age and gender distribution specified was necessary at the abattoir, since the majority of horses available at each sampling occasion at the abattoir were adults. The selection was only made on the basis of gender and estimated age.

The horses were divided into age groups based on their estimated age from incisor dentition, a method that has been shown to be relatively unreliable (Walmsley 1993; Myelle *et al. 1997*). However, as no detailed history was available on the horses the most practical clinical option available was to estimate age from the incisor dentition, as indicated under Materials and Methods.

Dental disorders and occlusal abnormalities were found to be widespread in the population examined. Occlusal abnormalities, such as sharp enamel points, were found in all age groups with a higher prevalence (97.5%) than in other abattoir studies (Brigham & Duncanson 2000a; Anthony *et al*. 2010). Studies on live horses have shown that up to 100% have sharp enamel points, however (Simhoefer *et al*., 2008; Masey O'Neil *et al*. 2010). Only one horse did not have sharp enamel points, which could be due to recent dental care – this could not be confirmed due to the lack of history available, however, none of the horses showed evidence of dental treatment such as rasp marks. Sharp enamel points could be considered a normal physiologic finding, caused by the chewing cycle (Easley et al. 2011), but can cause problems such as buccal and lingual abrasions (Gere & Dixon 2010). Sharp enamel points can progress to shear mouth (Brown *et al*. 2008), a condition not found in the horses in the present study. Shear mouth arises from an excessive vertical chewing action due to mechanical impedance of normal lateral mandibular masticatory movement, or pain (Dixon 2000).

The horses in the present study had a lower prevalence (17.5%) of buccal abrasions than reported previously (Allen 2004; Tell *et al*. 2008). Young horses (Allen 2004) and horses ridden in bit and bridle have been shown to have a higher prevalence of buccal abrasions (Tell *et al*. 2008). An age predilection for buccal abrasions was not found in the present study. As the history of the horses enrolled was unknown, no information about the use of bridle and nose bands on these horses was available.

The prevalence of wave mouth appearance (57.5%) was unexpectedly high compared with other studies that have shown a prevalence of 8-12.6% (Brigham & Duncanson 2000a; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). These cited studies were however done on horses over the age of 5 years (Masey O'Neil *et al*. 2010), or included very few young horses (Brigham & Duncanson 2000a). Therefore, one explanation for the higher prevalence detected in the present study could be that more immature horses in the process of shedding their deciduous caps, were classified as having a wave mouth appearance, based on detection of an undulating occlusal surface in the rostrocaudal plane. Wave mouth appearance was, however, not significantly associated with any age group.

The prevalence of focal overgrowths has been reported to range from 14.6-80% (Brigham & Duncanson, 2000a, 2000b; Simhoefer *et al*., 2008; Anthony *et al*. 2010; Masey O'Neil *et al*. 2010). These overgrowths may be associated with mandibular brachygnathism (overjet/ parrot mouth) defined by Easley *et al* (2011) as "a congenital deformity in which the upper incisors overlap the lower incisors" and mandibular prognathism (underjet / sow mouth) defined as a condition where the "mandibular incisors are more rostral than the maxillary incisors". Focal overgrowths are one of the occlusal abnormalities that have been shown to have a significantly higher prevalence in stabled horses fed concentrates (Masey O'Neil *et al*. 2010) and the position of roughage feeding may also have an influence (Easley *et al.* 2011). The number of focal overgrowths on 106 and 206 that were associated with focal overgrowths at 311 and 411 was similar to other studies (Brigham & Duncanson 2000a, 2000b). If focal overgrowths are found on 106 and 206 emphasis should be put on examining the caudal mandibular molars for similar lesions. The area caudal to the last molars (11's) was examined for soft tissue trauma secondary to focal overgrowths, with no trauma detected, however, in some horses post mortem changes complicated assessment of the soft tissue.

Periodontal pockets were the most common dental disorder in this study (70% prevalence). Previously a lower prevalence of 17.5% has been reported (Masey O'Neil *et al*. 2010) in a study sample of horses all older than 5 years and younger than 15. Comparison with the prevalence detected in the adult age group of the present study is therefore considered more relevant. The adult group had a much higher prevalence of 53.3%; the discrepancy is most likely due to the difference between a post mortem study and a study based on oral examination in live horses. Generally, horses with periodontal pockets in the present study had several pockets detected, suggesting that periodontal disease is most likely an extensive problem in affected horses. Periodontal disease is most often found in older individuals (Easley *et al.* 2011).

The prevalence of cheek teeth diastema has varied widely (Dixon *et al*. 1999b; Simhoefer *et al*. 2008; Anthony *et al*. 2010; Gere & Dixon 2010). In the present study the prevalence (40.0%) of diastema (open and closed) was high compared to previous reports. The higher prevalence could be ascribed to the relatively high number of affected immature horses enrolled; younger horses may have diastemata formation while shedding their deciduous caps, although this is considered a temporary problem (Dixon et al. 1999a). Another reason is the better visibility when performing an oral examination on bisected heads, contributing to a higher level of detection. The affected horses had on average close to three diastemata. This is comparable to Dixon *et al*. (1999b) who reported diastemata in 16 horses with 53 affected teeth. A significant difference in the distribution of diastemata between the age groups was found, with the older age group more likely to be affected. This tendency has also been shown in geriatric donkeys that were widely affected by diastemata, with up to 85.1% affected (du Toit *et al*. 2008).

Infundibular caries has been shown to have a predilection for the maxillary premolars and molars 108/208 and 109/209 (Veraa *et al*. 2009; Fitzgibbon *et al*. 2010). The older age group in the present study, which included horses 15 years and upwards, showed a much higher prevalence of infundibular caries (91.7%) than previously reported, where 42% of horses in populations over 20 years of age had infundibular caries (Fitzgibbon *et al*. 2010). Horses that suffered from caries had on average 2.8 affected teeth.

Sagittal midline fractures were the most common fracture in the older age group in this study. These fractures are thought to be caused by a weakening of the tooth by infundibular caries (Dixon *et al*. 2000a). The fractures detected in the younger age groups were cheek teeth clinical crown fractures and incisor fractures, most likely of traumatic origin. Step mouth was associated with the older age group. The prevalence of fractures and step mouth reported could be expected to be approximately the same, since step mouth is a localized overgrowth caused by a fractured or missing tooth that results in a supraeruption and lack of wear of the opposing tooth (Dixon 2000). The lower prevalence of step mouth in this study suggests that the fractures detected might be more acute, or be of a fracture type that does not allow the opposite tooth to develop into a step formation.

The relatively low overall prevalence (30%) of canines in the male population compared to other studies (Anthony *et al*. 2010) is most likely as a result of the immature group enrolled in the present study where the mean age was 3.0 years. Several horses were under the age when canines are reported to erupt (Brigham & Duncanson 2000a). Only erupted canines were recorded and the interdental space was not palpated. This most likely contributed to the lower prevalence reported. The prevalence of first premolars (30%) is slightly lower than reported previously (Anthony *et al*. 2010). Since no previous dental care history was available for the horses in this study, some of them could have had these teeth removed previously, thus resulting in a lower recorded prevalence.

Osterman Lind *et al*. (2012) recently reported *Gasterophilus* larvae to be commonly found in the oral cavity during routine dental examinations. *Gasterophilus intestinalis, G. nasalis, G. haemorrhoidalis, G. inermis,* and *G. pecorum* have been reported in the horse (Principato 1989). The migration route of *G*. *intestinalis* involves burrowing in the tongue and interdental spaces at the first larval instar and the root of the tongue in the second instar (Cogley *et al*. 1982). The other species most likely share the same migration route (Principato 1989). *G. intestinalis* is the most common species in Europe (Otranto *et al*. 2005), but was not detected in the present study. However, no studies report on *Gasterophilus* prevalence in South Africa, so geographical difference might be the cause of this discrepancy. A seasonal pattern was noted as larvae were only found in the oral cavity of heads collected during the winter months. This could be due to parasite life cycle, previous deworming in horses enrolled in the summer, or due to other unknown cause.

The presence of larvae in the soft palate of one horse was unusual, however this has previously been reported (Smith *et al*. 2005). *Gasterophilus pecorum* were also found in this study and this might indicate that it has a migration route that involves attachment to the soft palate. The prevalence of *G. pecorum* is generally low, around 2% (Otranto *et al*. 2005), which explains the few reports of this parasite. The clinical implications of *Gasterophilus* larvae affecting the soft palate have as yet to be determined. However, as local swelling and inflammation were found dysphagia and respiratory disorders may be a consequence. Old reports describe fatal oesophageal constriction and hypertrophy of the musculature of the oropharynx and oesophagus associated with *G. pecorum* (Hall and Wall, 1995 and Zumpt 1965 as cited by Smith, 2005).

A more detailed investigation of the prevalence of the different *Gasterophilus* subspecies in the oral cavity from horses in South Africa is required. Such a study should attempt to also describe the migration route of *G. pecorum.* It would be of interest to see if the migration route does include attachment to the soft palate and whether this is specific for *G. pecorum*. Larvae attached to the soft palate might not be visualised in a normal oral examination, an oral endoscopic examination is considered the best way of visualizing these lesions affecting the soft palate.

When young horses shed their deciduous teeth findings such as periodontal pockets, diastemata, and wave mouth appearance are to be expected (Dixon *et al*. 1999b). These findings are considered part of the physiological process of changing the deciduous teeth and are usually transient. These conditions, in the immature age group of this study, were included as pathological findings even though they may not be permanent, to emphasise that they may be detected during shedding of the deciduous dentition.

Persistent caps may cause severe food entrapment and diastemata formation. Because of the risk of pathological disorders some veterinarians choose to routinely remove the caps ready to be shed (Ramzan *et al*. 2009). A cap is considered ready to shed when it can be digitally manipulated, demarcation can be noted on the clinical crown and there is little or no gingival attachment to the cap (Ramzan *et al*. 2009). Removing caps not ready to be shed is not advised, as it can interrupt cementum deposition in the immature permanent tooth and supposedly result in central infundibular cementum hypoplasia (Dixon & Dacre, 2005). In the present study food entrapment and concurrent gingivitis were found under caps that were not close to shedding, as well as gingivitis associated with persistent caps.

The adult group tended to have the lowest prevalence of disorders and most were related to occlusal abnormalities. The older age group had a higher prevalence of fractures, step mouth, infundibular caries, diastema and focal overgrowths, which is not unexpected as it is the age group where age-associated changes are found. The mean number of lesions per affected horse was 2.8-3.8 for periodontal pockets, diastemata and infundibular caries, indicating that these lesions often occur at multiple sites in affected horses. The former two disorders are associated with loss of gingival attachment to the tooth and might be age-related. Detection of these abnormalities should prompt investigation for multiple lesion sites in affected horses.

The age group association of dental disorders supports careful monitoring of immature horses while changing deciduous teeth, and that removal of caps are considered in those teeth ready to be shed (according to the predefined criteria (Ramzan *et al*. 2009). Annual or more frequent dental examination of the adult age group of horses is recommended. Dental examination should be performed at least twice a year in horses older than 15 years, since the extent of dental disorders and occlusal abnormalities in the older age group examined increased with age. Earlier detection of lesions could facilitate earlier institution of customised treatment programmes.

In geriatric donkeys colic and weight loss have been associated with severe dental disorders (du Toit *et al*. 2008). In horses it has been shown that mastication forces decrease with age (Huthmann *et al*. 2009) and pain is associated with some disorders such as diastemata (Dixon *et al*. 1999b) and idiopathic fractures (Dixon *et al*. 2007). These factors can influence the ability to eat, causing weight loss and loss of BCS. In this study no significant association between BCS and specific severe dental disorder or age groups or between specific dental disorder and gender were detected, however. The older age group had a non-significant lower BCS than the immature and adult age groups. The reason for this is unknown, but could be due to dental or other body system disorders, or nutrition, or related to the small sample size of this study. As no complete post mortem examination was conducted the impact of underlying disease on BCS is undetermined.

The present study compared agreement between observers performing oral examination on intact heads and kappa statistics between oral examination on intact heads and oral examination on bisected heads. For clinical use a kappa value between 0.3 and 0.5 is considered acceptable, between 0.5 and 0.7 is good and above 0.7 is excellent (Martin and Bonnet 1987). Kappa values over 0.4 were found for rostral overgrowths, caudal overgrowths, ramped overgrowths, periodontal pockets on the lingual side, and fractures. A limitation was the reduced sample size (n=15) on which oral examination of intact heads was performed, however. Based on the present study a 5 minute oral examination with a Hausmann’s gag, head light, dental probe and mirror may be sufficient to detect more obvious lesions and disorders. However, less obvious lesions such as periodontal pockets on the buccal aspect, *Gasterophilus* larvae in pockets, infundibular caries and diastema were less likely to be detected during an oral examination with a 5 minute time limit. These specific lesions might be small in size, but they may have a great impact on the horse's well-being if not detected, and a time-limited oral examination as conducted might not be sufficient for detection of these lesions. More time for the oral examination of intact heads could have been allowed to facilitate detection of smaller lesions, as well as allowing digital palpation of each tooth. However, during oral examination of a horse under field conditions more of the time may be allocated for corrective dentistry procedures, and an unlimited time in the present study may have resulted in conditions not comparable to those in the field. In the present study the time limit was considered adequate to perform an oral examination in most cases, the exception was if the dental disorders were severe and multiple.

Oral endoscopy has been shown to enhance the likelihood of diagnosing infundibular caries (Simhoefer *et al*. 2008) and minor lesions like gingival recession (Ramzan 2009). Oral endoscopy could be a useful modality to complement the oral examination. The comparison of oral examination on intact heads and bisected heads in the present study could also have been improved with inclusion of ante mortem oral examination, however the nature of the abattoir study population and ethical considerations precluded this. The oral examination on the intact heads in the present study could ideally also have included an oroscopic examination, however due to logistic and cost reasons this was not included.

While the present study provides prevalence data on dental disorders in an abattoir population in South Africa, further study is indicated to investigate the prevalence of dental disorders in the cared for equine population in the region. During the oral examination in the present study dental disorders such as gingival recession and peripheral caries were not recorded. Recently, focus has been put on associating these disorders with diastema (Gere & Dixon 2010; Ramzan & Palmar 2011) and it would have been beneficial to investigate such an association in the present study.

One of the main limitations of the present study is the relatively low total number of horses enrolled, which was dependent on the horses available at the specific abattoir during the data collection window period. The horses were divided into age groups which lowered the number in each group; more horses enrolled would have enhanced the statistical power. The study population also constitutes a limitation since it was an abattoir population with no history of previous dental care, nutrition, deworming, purpose, age and reason for slaughter.

This study provides relevant welfare-related information regarding rescue and rehoming of horses from abattoirs in South Africa. Dental disorders were found in all age groups, with the older age group affected by generally more extensive and serious disorders. These disorders would either not be amenable to successful treatment or would require costly and/or prolonged care-giving that new owners would need to be aware of. The decision to rehome a horse destined for an abattoir needs to take into consideration various physiologic and welfare needs of such an individual horse. It is proposed that one such welfare criteria should be based upon the dental disease present. The prevalence of dental disorders detected on oral examination in the present study was similar to or higher than studies conducted in other regions, such as Europe and North America. Whilst similar and larger studies in other geographic populations have been published, this study provides relevant prevalence data that can be used for comparison of the radiographic and CT images archived, and can be compared with future studies in cared for horse populations in South Africa.

CHAPTER 7 CONCLUSIONS

This South African study revealed a similar or higher prevalence of dental disorders than reported in other studies, and this was particularly pronounced in the older age groups. The study population was an abattoir population, however with likely little or no routine dental care, and direct comparisons to future prevalence studies performed on cared for horses in South Africa should be made with caution.

The severity of dental disorders reported emphasises the importance of regular dental examination and care in all age groups, especially older horses, and has implications on potential for successful rehoming of horses in the specific population examined. The detection of multiple periodontal pockets, diastemata and/ or infundibular caries in individual horses supports more detailed investigation for multiple lesion sites in affected horses.

Gasterophilus larvae were detected in the oral cavity of all age groups examined. The clinical relevance of attachment of *G. pecorum* to the soft palate and the migration route of this species is of interest and could be investigated further.

Oral examinations performed with a Hausmann’s gag, head light, dental mirror, and dental probe are a useful diagnostic modality for routine dental examination, but further diagnostic examination is needed for reliably diagnosing more subtle lesions and disorders.

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APPENDICES

Appendix A: Dental record chart

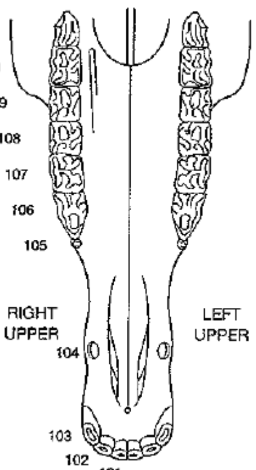
DATE	OWNER	FARM NAME/PHONE	WORK PHONE

ADDRESS	CITY	STATE	ZIP CODE	HOME PHONE

HORSE REG. NAME	STABLE NAME	COLOR	BREED	SEX	YR. FOALED

Hair Coat: EX VG G P
Condition Score: ____________
Lateral Jaw Excursion: N AB
History: ____________________________

D. Age ____________ Reg. Age ____________
Feces: Fine Med Coarse
Palpation Response: + –
Soft Tissue ____________________________

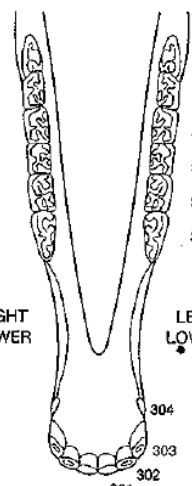


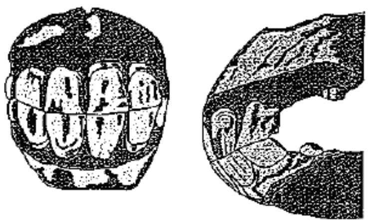
COMMENTS

____

CANINES

REDUCTION NEEDED? YES NO





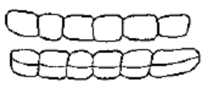
INCISOR ALIGNMENT

NORMAL ABNORMAL

INCISOR CORRECTION/RE-ALIGNMENT NEEDED? YES NO

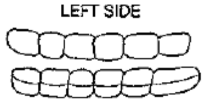
MOLAR TABLES

RIGHT SIDE



Deciduous Teeth (Caps) ____
Rostral Hook (PM2) Y N
Caudal Hook (M3) Y N
Abnormal Occlusion Y N
Step/Wave Mouth
Occlusion Correction Needed Y N

LEFT SIDE



Deciduous Teeth (Caps) ____
Rostral Hook (PM2) Y N
Caudal Hook (M3) Y N
Abnormal Occlusion Y N
Step/Wave Mouth
Occlusion Correction Needed Y N

CHARGES	Initial Est	Actual Amt Chrg
Farm Call		
Professional Exam		
Sedation/Tranquilization		
Anaesthesia		
Radiography		
Anti-inflammatory		
Antibiotics		
Medication/Treatment Other		
Problem		

RE-EXAM NEEDED
****
DATE

TOTAL AMOUNT DUE
****

All services are strictly cash and must be paid at the time of service.

Appendix B: Raw data summary of dental disorders detected

ID	Gender	Age	BCS	Sharp enamel points	Wave mouth	Step mouth	Smile mouth	Slant mouth	Diastema	Fracture	Perio-dontal pockets	Focal over-growths	Caries	*Gasterophilus* larvae	Buccal abrasions	Ramped over-growth
2	F	20	2	1	1	1	0	0	1	1	1	1	1	0	0	0
3	F	2	2	1	0	0	0	0	0	0	1	0	0	0	0	0
4	F	15	3	1	1	1	0	0	1	1	1	0	1	0	0	0
5	F	12	4	1	1	0	1	0	1	0	0	0	0	0	1	0
6	F	7	8	1	0	0	0	0	0	0	1	1	0	0	0	0
7	F	11	6	1	0	0	0	0	0	0	0	1	0	0	0	0
8	F	11	5	1	0	0	0	0	0	0	0	0	0	0	0	1
9	F	11	5	1	0	0	0	0	1	0	1	0	0	0	1	0
10	F	15	3	1	1	1	0	0	1	1	1	1	1	0	0	0
11	F	3.5	4	1	1	0	0	0	1	0	1	0	0	1	0	0
12	M	18	8	1	0	0	0	1	1	0	0	1	1	0	0	0
13	M	18	2	1	1	0	1	0	1	0	1	0	1	0	0	0
14	F	18	5	1	1	0	0	0	0	1	1	0	0	1	0	0
15	F	3	6	1	0	0	0	0	1	1	1	0	0	0	0	0
16	F	6	4	1	1	0	0	0	0	0	1	0	0	0	0	0
17	F	3	3	1	0	1	0	0	0	0	1	0	0	0	0	0
18	M	6	5	1	1	0	0	0	0	0	1	0	0	1	0	0
19	F	2	4	0	0	0	0	0	0	0	1	0	0	1	0	0
20	M	2	3	1	1	0	0	0	0	0	1	0	0	1	0	0
21	M	4	5	1	1	0	0	1	1	0	1	1	0	0	0	0

ID	Gender	Age	BCS	Sharp enamel points	Wave mouth	Step mouth	Smile mouth	Slant mouth	Diastema	Fracture	Perio-dontal pockets	Focal over-growths	Caries	*Gasterophilus* larvae	Buccal abrasions	Ramped over-growth
23	M	12	4	1	1	0	0	0	0	1	1	1	0	1	1	0
24	F	12	3	1	0	0	0	0	1	0	1	0	0	0	0	0
25	M	3	5	1	1	0	0	0	1	0	1	0	1	0	1	0
26	F	20	3	1	0	0	1	0	1	0	1	0	1	0	0	0
27	M	6	4	1	0	0	0	0	0	0	1	0	1	0	0	1
28	M	15	3	1	0	1	0	1	1	0	1	1	1	0	1	0
29	M	2.5	5	1	1	0	0	0	1	0	1	0	0	1	0	0
30	M	4	5	1	0	0	0	0	0	0	0	1	0	0	1	0
31	M	2	4	1	1	1	0	0	0	0	0	0	0	1	0	0
32	M	15	3	1	1	0	0	0	1	1	1	1	1	0	1	0
33	M	9	4	1	1	0	0	0	0	1	1	0	0	0	0	0
34	M	18	5	1	1	0	1	0	0	1	0	1	1	0	0	0
35	F	5	4	1	0	0	1	0	0	0	1	1	0	0	0	0
36	M	15	6	1	1	0	0	0	0	1	0	0	1	0	0	0
37	F	17	4	1	0	0	0	0	0	0	1	1	1	0	0	1
38	F	4	5	1	1	0	0	0	0	0	1	0	0	0	0	0
39	M	6	5	1	0	0	0	0	0	0	0	1	0	0	0	0
40	M	11	7	1	1	0	1	0	0	0	0	1	0	0	0	0
41	M	9	5	1	1	0	0	0	0	0	0	1	0	0	0	0
42	F	7	5	1	1	0	0	0	0	0	0	0	1	0	0	1
Total				**39**	**23**	**6**	**6**	**3**	**16**	**10**	**28**	**16**	**14**	**8**	**7**	**4**

Age Group: Immature 2-5 years

ID	Gender	Age	BCS	Sharp enamel points	Wave mouth	Step mouth	Smile mouth	Slant mouth	Diastema	Fracture	Perio-dontal pockets	Focal over-growths	Caries	*Gasterophilus* larvae	Buccal abrasions	Ramped over-growth
3	F	2	2	1	0	0	0	0	0	0	1	0	0	0	0	0
19	F	2	4	0	0	0	0	0	0	0	1	0	0	1	0	0
20	M	2	3	1	1	0	0	0	0	0	1	0	0	1	0	0
31	M	2	4	1	1	1	0	0	0	0	0	0	0	1	0	0
29	M	2.5	5	1	1	0	0	0	1	0	1	0	0	1	0	0
15	F	3	6	1	0	0	0	0	1	1	1	0	0	0	0	0
17	F	3	3	1	0	1	0	0	0	0	1	0	0	0	0	0
25	M	3	5	1	1	0	0	0	1	0	1	0	1	0	1	0
11	F	3.5	4	1	1	0	0	0	1	0	1	0	0	1	0	0
21	M	4	5	1	1	0	0	1	1	0	1	1	0	0	0	0
30	M	4	5	1	0	0	0	0	0	0	0	1	0	0	1	0
38	F	4	5	1	1	0	0	0	0	0	1	0	0	0	0	0
35	F	5	4	1	0	0	1	0	0	0	1	1	0	0	0	0
Total				**12**	**7**	**2**	**1**	**1**	**5**	**1**	**11**	**3**	**1**	**5**	**2**	**0**

Age Group: Adult 6-14 years

ID	Gender	Age	BCS	Sharp enamel points	Wave mouth	Step mouth	Smile mouth	Slant mouth	Diastema	Fracture	Perio-dontal pockets	Focal over-growths	Caries	*Gasterophilus* larvae	Buccal abrasions	Ramped over-growth
16	F	6	4	1	1	0	0	0	0	0	1	0	0	0	0	0
18	M	6	5	1	1	0	0	0	0	0	1	0	0	1	0	0
27	M	6	4	1	0	0	0	0	0	0	1	0	1	0	0	1
39	M	6	5	1	0	0	0	0	0	0	0	1	0	0	0	0
6	F	7	8	1	0	0	0	0	0	0	1	1	0	0	0	0
42	F	7	5	1	1	0	0	0	0	0	0	0	1	0	0	1
33	M	9	4	1	1	0	0	0	0	1	1	0	0	0	0	0
41	M	9	5	1	1	0	0	0	0	0	0	1	0	0	0	0
7	F	11	6	1	0	0	0	0	0	0	0	1	0	0	0	0
8	F	11	5	1	0	0	0	0	0	0	0	0	0	0	0	1
9	F	11	5	1	0	0	0	0	1	0	1	0	0	0	1	0
40	M	11	7	1	1	0	1	0	0	0	0	1	0	0	0	0
5	F	12	4	1	1	0	1	0	1	0	0	0	0	0	1	0
23	M	12	4	1	1	0	0	0	0	1	1	1	0	1	1	0
24	F	12	3	1	0	0	0	0	1	0	1	0	0	0	0	0
Total				**15**	**8**	**0**	**2**	**0**	**3**	**2**	**8**	**6**	**2**	**2**	**3**	**3**

Age Group: Older horses ≥ 15 years

ID	Gender	Age	BCS	Sharp enamel points	Wave mouth	Step mouth	Smile mouth	Slant mouth	Diastema	Fracture	Perio-dontal pockets	Focal over-growths	Caries	*Gasterophilus* larvae	Buccal abrasions	Ramped over-growth
10	F	15	3	1	1	1	0	0	1	1	1	1	1	0	0	0
28	M	15	3	1	0	1	0	1	1	0	1	1	1	0	1	0
32	M	15	3	1	1	0	0	0	1	1	1	1	1	0	1	0
36	M	15	6	1	1	0	0	0	0	1	0	0	1	0	0	0
4	F	15	3	1	1	1	0	0	1	1	1	0	1	0	0	0
37	F	17	4	1	0	0	0	0	0	0	1	1	1	0	0	1
12	M	18	8	1	0	0	0	1	1	0	0	1	1	0	0	0
13	M	18	2	1	1	0	1	0	1	0	1	0	1	0	0	0
14	F	18	5	1	1	0	0	0	0	1	1	0	0	1	0	0
34	M	18	5	1	1	0	1	0	0	1	0	1	1	0	0	0
2	F	20	2	1	1	1	0	0	1	1	1	1	1	0	0	0
26	F	20	3	1	0	0	1	0	1	0	1	0	1	0	0	0
Total				**12**	**8**	**4**	**3**	**2**	**8**	**7**	**9**	**7**	**11**	**1**	**2**	**1**

Appendix C: Scientific outputs

Poster presentation with peer-reviewed abstract, title: “Post Mortem Survey of Equine Dental Disorders”, Faculty Day 9th September 2012 at Faculty of Veterinary Science, University of Pretoria, Onderstepoort. Authors: D.C. Vemming, G. Steenkamp, A. Carstens, S. Olorunjo, R. M. Stroehle and P. C. Page.

Original scientific paper submitted 8th of October 2013 to international peer-reviewed veterinary journal, title: “Post-mortem survey of equine dental disorders in South Africa: comparison of oral examination of intact and bisected heads” Authors: D.C. Vemming, A. Carstens, G. Steenkamp, S. Olorunjo, R. M. Stroehle, and P. C. Page.

Oral presentation, title: Post mortem and imaging survey of equine dental disorders in South Africa, accepted for presentation at South African Equine Veterinary Association Congress 16-20 February 2014, Kruger National Park, South Africa, Authors: D.C. Vemming, G. Steenkamp, A. Carstens, S. Olorunjo, R. M. Stroehle and P. C. Page.