Zoo and Wild Animal Dentistry

Edited by
Peter P. Emily
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WILEY Blackwell

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Dedicated to the Peter Emily International
Veterinary Dental Foundation
and
its ongoing improvement of oral health in captive animals worldwide

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Foreword

I am pleased to write this foreword for Drs. Emily and Eisner's textbook, the first entirely dedicated to zoo and wild animal dentistry.

Ever since I met Dr. Emily for the first time in the 1980s, we have enjoyed stimulating discussions on comparative odontology and I am grateful to him for introducing me to Osborn's concept of tribosphenic molar teeth. I also share with him and Dr. Eisner a strong interest in oral pathology occurring in animals and a curiosity about natural history in general, and its relation to dentition and dental pathology in particular. Since then, my research and teaching interests have directed me more to comparative dental pathology and odontology, respectively, while the authors have spearheaded clinical dentistry in zoo and wild animals, for which they should be commended.

Dentistry is, or should be, an essential part of the veterinary care of zoo and wild animals in captivity, both in terms of preventative care as part of their long-term husbandry, and in addressing dental conditions as they occur. The latter is the focus of this book. Great advances have been made in the practice of dentistry in domestic animals over the past decades. Zoo and wild animals should also benefit from these advances. There is no reason to believe that pain of dental origin, be it acute or chronic, is any less severe and debilitating in animals than it is in humans, greatly affecting their quality of life. The basic premise of being a veterinarian is to prevent and address pain in animals entrusted to our care. The stakes and challenges are particularly high in zoo and wildlife dentistry. Even under the best of circumstances and with the best of intentions of the care-takers, captivity of wild animals typically is associated with unphysiological conditions in terms of environment and diet. Wild animals in captivity must be housed in safe facilities – unfortunately, the combination of fences and boredom can cause significant dental injury. The human-animal bond in this case has two components: the zoo's animal care-taker has a very strong personal bond while the zoo's administration and the public typically would like to see an animal on display with an intact dentition.

Though the use of non-evidence based and non-FDA-approved materials and instruments should not be promoted, it is an unavoidable fact that procedures on non-domestic species may require medications and instruments that are not FDA-approved for use in those species. In addition, some dental materials, such as MTA, are cost-prohibitive to use in large volumes; hence "Dr. Emily's MTA's recipe", which I found to exemplify this book: empirical, practical and helpful. The practicality and helpfulness are important, given the fact that getting the procedure done in a timely fashion is especially important in these animals, in order to minimize the duration of anesthesia.

This is an important textbook and addition to the veterinary dental and zoological medicine literature. While this book is not an authoritative textbook on comparative odontology, like Berkovitz and Shellis' *The Teeth of Mammalian Vertebrates* (2018), nor a historical treatise on comparative dental pathology, like Colyer's *Variations and Diseases of the Teeth of Animals* (1936), it is a very practical compilation of the authors' many years of clinical experience treating dental problems in captive wild animals. Veterinary dentists may get called upon to see one of a species **once** in their career. The authors of this text have seen at least one case of the diseases and species described, and have generously shared their experience with their readers.

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About Peter Emily

Figure 1 Ed Eisner and Peter Emily, on Mulholland Drive, Burbank, CA USA, after completing a Dental Rescue in southern California, USA, 2009.

Peter Emily, a practicing dentist for people, has studied comparative odontology and has a passion for helping improve the oral health of wild, as well as pet animals since 1969. He has dedicated decades of his life to improving oral health and comfort, especially for captive animals; animals that have been rescued from abusive, illegal, or financially unsustainable situations and placed in "retirement facilities," sanctuaries where they can safely live the rest of their life to the fullest. He was my mentor, providing me with a dental education far exceeding any the finest veterinary schools had to offer in the 1980s and beyond. I will always be indebted to Peter for teaching me the technical nuances of dental practice, but even more so for the many dental insights that help elevate a good dental practice to that of one providing exceptional outcomes. The key to his brilliance and the value of his teachings has, even more than the technical education, been the sharing of the art of case assessment and treatment planning. The technical aspect of good dentistry is a cookbook science, achievable in several years of diligent study. The successful art of case assessment and therapeutic planning is the result of many more years of astute observation and creative application of those technical skills. These skills are never needed more than when dealing with the complex problems of large and small wildlife mammals and birds that are the residents of sanctuaries, zoos, and the natural habitats throughout the world. This is where Peter Emily excels, and this is where he is most comfortable.

1982

For eight years people who knew of both Pete and my interest in veterinary dentistry kept telling us we should meet and finally we did. It was in November, 1982. Peter was a certified national dog show judge. He performed dentistry on dogs and cats and sometimes on the animals at the Denver Zoo, Denver, Colorado USA. In 1982, at the inauguration of the new animal hospital at the Denver Zoo, someone who knew both Pete and I, spotted us at the soiree and introduced us to each other. That was the beginning of a many-decade friendship. In February of 1983, Peter and I travelled together to the Western States Veterinary Conference in Las Vegas, Nevada where the American Veterinary Dental Society was having one of its first meetings. A few of the pioneers of the veterinary dental evolution, Gary Beard, Ben Colmery, Tom Mulligan, Don Ross, and Chuck Williams, were delivering dental presentations. Peter and I had found our home; people who spoke our language. These were not the only people dabbling in veterinary dentistry at the time, but they were among the first. Bob Wiggs, Colin Harvey, Sandra Manfra Marretta, Keith Grove, Steve Holmstrom, Ron Gammon, Gary Goldstein, Ken Lyon, and Chris Visser were also among the pioneers. They and Pete and I all bonded quickly. We all felt the calling, we were all accomplished photographers and could share our work visually, we all didn't mind travelling to spread the word, and we all knew that we had something important to give to veterinary medicine.

Pete came to my small animal practice every Thursday for the next three years. He would identify dental problems while performing as a dog show judge, and have the owners schedule for dental treatment at my office. I would also identify dogs and cats within my practice that needed advanced-level dental care and schedule them for Thursdays. Peter was an artist. He was a real artist. He not only performed excellent root canal therapy, gold crown work, and periodontal surgery, he also made bronze sculptures and gold pendant jewelry from dental gold. Weekly, for three years, I learned dentistry by the side of Peter. Peter was, in reality, a frenetic artist, but he was not a businessman. He cared little about fees, which are so very important for the survival of any for-profit practice. He just wanted to help the animals.

Peter would not have anything to do with fees for services, and I arranged for Peter to take home the fee for the dental procedure itself, while I retained the fees for the examination, anesthesia, hospitalization and dispensed medications. It resulted in approximately a 50:50 split, with Pete reluctantly letting me stuff a check into his shirt pocket as he packed up to leave my office each week.

Pete was a very significant positive force in the acceleration of the evolution of veterinary dentistry. A number of us had been performing advanced-level animal dentistry since the 1970s, but Pete helped further educate the pioneers in veterinary dentistry and gave us the knowledge to improve our animal dental services. Pete was instrumental in creating the first two important examinations; first the qualifying examination for the newly formed Academy of Veterinary Dentistry (AVD) in 1986, and, second, the qualifying examination for the American Veterinary Dental College (AVDC) in 1989. He lectured throughout the world, teaching and preaching the value of advanced level dental care for animals.

2005: The beginning of the Peter Emily International Veterinary Dental Foundation

The late Robert Bruce Wiggs of Dallas, TX, another of the original veterinary dental pioneers in its modern evolution, was in Denver. Pete invited Bob and myself to coffee at a breakfast restaurant. He shared with us that he had recently received a significant and unexpected return on an earlier investment.

Pete, age 73, viewed this as a chance to fulfill his dream, to help captive animals throughout the world, and he wanted some close friends to help manage the project. First, with Peter's participation, we enlisted Steve Holmstrom, veterinary dentist from San Carlos, CA, and Ron Ferrendelli, a local fellow dentist and former classmate of Peter, along with Bert Dodd, another veterinary dentist then of Austin, TX. We established a plan to generate enough working capital to launch a small private foundation while conserving his assets. The Board of Directors was expanded and membership adjusted. Susanne Pilla was hired as Managing Director of the private foundation formed in 2005, and which in turn became the public 501(c)(3) charitable Peter Emily International Veterinary Dental Foundation (PEIVDF). Three years after the birth of his idea, Peter's Foundation had three sets of portable dental equipment and thirty clinicians who donated their time, talent and energy several times a year to mount rescue missions to animal sanctuaries and zoos throughout the United States, providing free dental care to African lions, tigers, mountain lions, bears, primates, herbivores, birds, and other captive animals. As of writing this book, the PEIVDF has a thirteen-person Board of Directors, and nine-person Advisory Committee to help plan rescue missions. Today, the Foundation is setting up its most ambitious undertaking so far - affiliating with operations in South Africa. Peter's dream is becoming a reality.

Peter Emily has received national and international recognition, including from the American Animal Hospital Association. He is also the namesake of veterinary dental awards distributed at the Annual Veterinary Dental Forum each year. He will long be recognized as a giant in the field of veterinary dentistry and as a very special person in the hearts of all who have known him. He is one of a kind. His knowledge of comparative odontology is immense. It is a great privilege for me to be able to help him compile this information for all to see and share and for the benefit of animals now and in the future that will be the benefactors of this shared information.

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Acknowledgements

We want to express appreciation to the members of the Foundation for Veterinary Dentistry, for their ongoing dedication to improving and maintaining animal oral health.

From Peter Emily

I have had a lifelong passion devoted to helping animals. As a child, living with my grandparents Dominec and Josephine Primavera, I gained a culture of helping orphaned animals. We rescued injured birds and goats, as well as stray dogs and cats in Denver, Colorado; splinted broken legs and wings, and nursed them back to health. I applied to veterinary school, medical school and dental school and had my choice of careers. My first choice was veterinary medicine, but I was influenced by my peers to go to dental school first, and then to veterinary school. As fate would have it, marriage during dental school stalled my planned educational succession, but not my personal passion and studies of comparative dental anatomy and pathology.

Dr. Father Trane, a Jesuit priest at Regis University was influential throughout my formative years, encouraging my humane curiosity regarding oral health in all species. I practiced human dentistry after graduating from Creighton School of Dentistry, Omaha, Nebraska in 1959. Shortly after, I met Alan Krause, DVM. Both of us were certified dog show judges for the American Kennel Club and had special interest in the dental standards for the many recognized dog breeds. Dr. Krause made it possible and assisted me in continuing my passionate pursuit for improving animal oral health.

In the 1970s, Dr. Richard Cambry, veterinarian at the Denver Zoological Gardens, invited me to consult and treat dental disease in many of their exotic species, which I continue to do. It has given me inspiration to continually develop improved dental techniques for the many species of captive animals.

In 1983, Dr. Eisner and I attended the Western States Veterinary Conference in Las Vegas, Nevada where we met and joined forces with some of the veterinary dental pioneers including the speakers, Drs. Gary Beard, Ben Colmery, Tom Mulligan and Chuck Williams, in what was to become a lifelong professional friendship and the organized beginning of the evolution of contemporary animal dentistry. It has continued to fuel my insatiable desire to improve dental techniques practiced by veterinarians.

I also, wish to thank, among others, Drs. Colin Harvey and Robert Bruce Wiggs, for their friendship and joint collaboration in the pursuit of the advancement of veterinary dental techniques and service.

From Edward Eisner

A number of people, in addition to Dr. Peter Emily, have been “father” figures in my life, influencing the pathway I have traveled throughout my developing professional career. At the age of 13, I knew I wanted to be a veterinarian. Though, raised in New York State where my father and his father before him were New York City Wall Street attorneys, I spent five teenage years in northwest Montana, under the influence and tutelage of a rancher and wilderness guide, Sam Wicker. It was through Sam that I gained a true appreciation for hard work, individual responsibility, completing tasks without complaining, and the ways of, and management of, large and sometimes unruly animals, including horses, mountain lions, wolves and bears in the mountains 100 miles beyond the convenience of the paved road. My formative high school years were spent at The Millbrook School for Boys, a boarding school in the rolling hills of Dutchess County, in upstate New York. There, my science teacher, and founder of The Millbrook School Zoo, Dr. Frank Trevor took me under his wing, teaching me scientific process, as well as the responsible care of the wild zoo inhabitants that we managed. In the process of my

maturation, I held summer jobs traveling throughout the west as a livestock inspector for Oppenheimer Industries (OI), the largest livestock management company in the United States, headquartered in Kansas City, Missouri, and managing cattle in 14 states. CEO of OI, Larry Oppenheimer, gave me freedom and independent responsibility as well as access to the genetic information of his prized Hereford show herd via the first computerized herd program which was headquartered in Kansas City. This experience furthered my interest in the scientific process of understanding the power of genetics. I also worked as a farmhand for Ed Behrens, President of the Dairy Herd Improvement Association of New York State, at his Highland Hills Dairy Farm, where Ed continued my tutelage in uncompromised and thorough work ethic, working the land daily from before dawn to after dark.

My infatuation with the management of animals continued in my late teens and early 20 years, as I worked as a wilderness guide in the Bob Marshall Wilderness in northwest Montana and again in the Pipestone Wilderness in Alberta, Canada where I rode 2500 miles in the summer of 1956. At Cornell University in the New York Veterinary School, Professor Dr. Steven Roberts mentored me. Among other helpful attributes, he was on the Cornell veterinary school admissions committee, coach and veterinary caretaker of the Cornell polo team horses, and author and professor of equine obstetrics. I played polo for him, managed the team after an injury and received guidance from him before taking my job as the livestock inspector. Dr. Francis Fox, professor of livestock medicine and surgery at Cornell imprinted on me the importance of maintaining my skills in physical diagnosis, even in the presence of rapidly advancing automated technology. Throughout all of this, my father impressed upon me, by example, the importance of being ethical in my many pursuits. I am appreciative to all of these people, and others, who helped to shape my personal life as well as my professional profile that has spanned more than 55 years in a very rewarding professional career in the veterinary medical profession, culminating in 40 years of immersion in the evolution of advanced dental care for animals, and most lately, in joining Peter Emily in his crusade to help captive animals in the many sanctuaries, zoos and animal parks of the world.

Introduction

The purpose of this book is to educate the reader as to the essence of therapeutic modalities and pitfalls when performing dentistry on captive animals in sanctuaries, zoos or in the field. To cover every aspect of dentistry, or every species encountered, is beyond the scope of this book. We have included the most frequent species and dental pathologies that clinicians will see and be asked to treat. We hope this work will expand wildlife animal dental knowledge, resulting in increased success of dental procedures in the field.

It should be emphasized that dentistry and oral surgery is similar to other veterinary disciplines in that success of a clinician is dependent on knowledge, expertise, equipment, and patient compliance. The same ingredients make a good dentist as do a good surgeon, and the treatment for a number of oral conditions involve surgery. There are unique endodontic morphologies present in various species, especially large felids, that make it essential that the practitioner obtain hands-on tutoring before attempting endodontic therapy for large felids. One should be well rested, well prepared, well equipped and well skilled, especially before attempting to treat wild animals in zoological or sanctuary settings, where often, because of anesthetic risk, there will be only one opportunity to perform therapy. Well rested is self-explanatory. An alert, aware and energetic individual is one who can provide a smoothly executed procedure. A well-prepared individual is one who knows the protocol and instrumentation of planned procedures, as well as that of alternative procedures that might be required. Skill comes with experience, and experience comes with practice. Additionally, the well-prepared clinician will be well equipped. Using the appropriate instruments, well maintained, will help to lessen procedure time, minimize patient discomfort and reassure the clinician that they have performed a proper procedure in the best way possible.

Through the skill of veterinary dentists, enhanced comfort can be achieved for these animals who cannot help themselves, and improved longevity can be realized by the reduction of chronic oral pain and stress experienced by these animals who are less often treated.

Increased knowledge of the species-specific anatomy, physiology and oral function will be invaluable in achieving proper diagnosis and treatment. This does not reduce the importance of hands-on experience, as each case and each animal is unique. For example, the vast majority of tiger upper canines have a bulbous apical root canal morphology with an extended apical delta at the root end terminus. Thus, treatment for each species will be different, and will require adaptation in the field.

Wildlife dentistry is infrequently encountered in veterinary practice. The diverse dental findings as to endodontic morphology, occlusal, and radicular forms, tooth sizes, and numbers of teeth all complicate exotic animal dentistry. Difficulty in obtaining routine oral examination to intercept developing problems and provide routine dental maintenance is a large factor in maintaining or regaining oral health. Additionally, poor financial rewards, lack of exotic animal dental knowledge and education, all contribute to the challenges of providing successful oral care for these animals.

All the dental disciplines practiced in human and small animal dentistry can be practiced in exotic animal or zoo dentistry. However, the many dental morphological and pathological differences seen in the various species create treatment challenges that can extend far beyond routine procedures. Dental problems can be multiple, complex, and often unseen in domestic small animal dentistry. Therapy can be complicated by limited oral access in some species. Most zookeepers are untrained in recognition of developing dental problems. This results in advanced dental pathology before the condition becomes clinically evident. Because of advanced levels of pathology, therapy is often more difficult and with uncertain prognosis for success.

Zoo dentistry includes many and varied species. New technologies are now beginning to be seen, or at least contemplated, in the treatment of some of the large species. If

we consider, for example, that an elephant tusk is an upper lateral incisor, with pulp tissue and an open apex, then we can pursue the possibility of endodontic therapy for affected tusks rather than the very difficult procedure of tusk extraction.

Avian species primarily present with lost or fractured beak segments or beak malocclusion resulting from poor nutrition. Replacement of lost beak segments can be performed with dental acrylic, threaded pins, ligature wire and cyanoacrylate. Congenital or traumatic malocclusion or "cross beak" is not uncommon, especially in psittacine birds. Active rubber orthodontic ligatures and threaded pin anchors can sometimes effectively correct this form of malocclusion. Like birds, the most common dental problem seen in reptiles is oral trauma, and the same principles of repair as employed in avian dentistry can be utilized. For example, turtles, can present with "beak" fracture. Dental acrylics, threaded wire, and cyanoacrylate can rehabilitate these animals. Though not a dental procedure, the repair of fractured turtle shells with dental materials is also a commonly successful and practical procedure.

An excellent example of advanced pathology with limited therapy and success is seen in mandibular and maxillary abscesses in herbivores and ruminants. Their dentition is primarily selenodont, which has parallel rows of crescent-shaped occlusal ridges that run in a mesial to distal direction. Selenodont dentition is the principal dental form in the order Artiodactyla, which includes most sheep, cattle, antelope, deer, camels, boars, and hogs. However, the animals most affected with mandibular/maxillary abscesses are the Marsupialia, primarily kangaroos and wallabies. Their molar form is a rather primitive tribosphenic form – that is, having three basic cusps. They are the protocone (the lingual cusp of the upper molar – it is generally narrow), the metacone (the posterior buccal cusp), and the paracone (the anterior buccal cusp). There are accessory cusps on metacone and paracone, termed metaconule and paraconule. These accessory cusps, such as the metaconule, are very important in Artiodactyle masticatory function.

The principal dental morphological difference between marsupials and placental species is the relative shape of the external part of the molar. The other dental form found in common herbivores is lophodont dentition. Lophodont dentition has parallel ridges that course across the entire coronal width from lateral to medial. Lophodont dentition is found in the order Perrisodactyla, as well as the families Tapiridae and Rhinocerotidae (the tapir and the rhinoceros).

It is impractical, though possible, to develop successful techniques for orthodontics, restoratives, crown coverage, and possibly bridge procedures in wildlife dentistry, but many oncology cases present unique therapeutic challenges that can be managed with diagnostic and therapeutic help of oncology specialists.

Periodontal Disease

Most forms of periodontal disease seen in domestic animals can be found in exotic animals, with treatment similar to that performed in humans. Primates display periodontal disease very similar to humans. Extensive periodontitis with advanced tooth-supporting bone loss can also be severe in non-primates, especially so in orangutans, where it is accompanied with the usual symptoms of bacterial infection and general malaise. Periodontal therapy is diverse, ranging from simple prophylaxis to advanced surgical gingival flap procedures with bone augmentation, lateral sliding flaps, and advanced procedures that also include surgical exodontia. Cases of gingival hyperplasia can be treated with either electro-surgery or sharp dissection.

Many of the anatomical peculiarities and proposed treatments in this book may not be found elsewhere in print, as they are the result of an accumulation of 50 years of personal hands-on treatment and personal experience while working on thousands of animals among hundreds of species. We still have much to learn, and with dedication we will continue to improve our ability to help the many species that cannot help themselves as we provide better oral health, comfort and increased longevity in animals worldwide. This book provides a foundation of information. We hope that future contributors will add to this information in an ever-expanding source of information that will serve to help improve and maintain improved oral health in the many species of animals throughout the world.

Finally, due to the constraints of length within the Table of Contents, it has not been possible to list the most common (but not inexhaustible) 352 species found in animal sanctuaries and zoos throughout the world. However, these are listed in the index and should be easily identifiable, helping all readers to identify the myriad of animals they may be called upon to examine and treat.

Peter P. Emily, DDS, Certification Periodontics, Endodontics, and Oral Surgery, Hon. Diplomate American Veterinary Dental College

Part I

A History of Veterinary Dentistry and of Teeth, and Dental Therapy of Wild Animals

1

History of Veterinary Dentistry, Including Development of Oral and Dental Treatment of Wild and Zoo, Safari Park and Refuge Animals

Colin E. Harvey

Surgery and Dentistry School of Veterinary Medicine, University of Pennsylvania, Philadelphia, PA, USA

This review is limited to a narrow definition of dentistry – conditions affecting the teeth, periodontium and jaws, and treatment of these structures. Mention of the major infectious oral diseases that affect wild, as well as domestic herbivores, such as viral stomatitis for example, are not included.

Veterinary dental history can be considered as having two major periods, the first in which the horse was the focus of most attention, because of its importance for transportation, mechanical power, military use and sport. The jaws and teeth were important because bits are used to control speed and direction of motion in horses. The internal combustion engine was invented in the mid-1850s; by the early 1990s, this form of transportation and mechanical power was rapidly displacing the horse and, as a result, equine dentistry no longer has the critical societal importance it once had.

The second period is ongoing, and is largely based on application of human dental procedures to pet domestic animals. As experience with these procedures, initially in dogs, grew, they started to be applied to non-domesticated species by a pioneering group of human dentists and veterinarians. Experience with dental treatment of food animals is largely limited to management of tooth loss in sheep.

We only have a very incomplete glimpse of what was known about animal dentistry in the ancient world, because much of the records have been lost. The fire in the largest library of the ancient world, at Alexandria in 48 BCE, was catastrophic – 700 000 volumes were lost.

The ancient Greeks produced several important veterinary manuscripts, such as "The Veterinary Art, Inspection of Horses," by Simon of Athens (430 BCE), which includes an accurate description of eruption times and aging of horses by examination of the teeth. Aristotle's "History of Animals'" (333 BCE) also includes a section on aging by teeth of horses, and comments on periodontal diseases in horses.

The Roman Empire produced some practical veterinary material, though much of it was copied from Greek sources. Around 400 CE, Chiron wrote a series of books on animals; Book VI includes material on tumors of the jaw, diseases of the teeth and management of fractured jaws, and Book VIII includes a description of the dentition. "The Veterinary Art" by Vegetius (450–500 CE) is the major Roman veterinary contribution; it describes use of splints for managing broken jaws, and aging of horses by teeth; this manuscript was translated and printed as a book one thousand years later, in 1528 – one of the first veterinary books printed.

Written c550–580 CE, originally in Sanskrit, the work of Ippocras was translated into Greek or Arabic in the ninth century, then from Arabic to Latin – it is now known to exist only as a fifteenth-century manuscript in Latin; it includes a section on determining the age of the horse by examining the teeth, and vices and bit injuries, also an operation for "chesel," which is extraction or shortening of the tushes (canines) and corner incisors to accommodate the bit.

With the degeneration of the Greek and Roman empires, the focus of learning shifted eastward to the Byzantine Empire. In about 950 CE, the "*Hippiatrika*" was written by order of Emperor Constantine VII. This tome contained all Greek and Latin veterinary manuscripts in Constantinople, collected and arranged; it includes a section on Dentition. It was translated by Ruellius from Greek to Latin and printed in 1530 in Paris.

The fascination of Arabs with horses was recognized in some important manuscripts; one, written about 1100 CE by Ibn-al-Awan in Spain, includes a section on dentition. Around 1200 CE, Abou Bekr produced "*The Naceri*" in Egypt; Book 11 includes a section on dentition and dental operations.

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Beyond the translation of ancient sources, there was very little real progress for about one thousand years, until, starting in the thirteenth century in Italy, ancient manuscripts translated into Italian also began to include personal observations of the translator. Ruffus wrote "Equine Medicine" in 1250, and Rusius wrote "Hippiatria" about 70 years later; the latter includes sections on dentition and descriptions of lampas, cutting the lip to accommodate the bit, and an "operation on the teeth to improve the temper" (extraction of lower canines and corner incisors). Later, came the equine anatomical masterpieces of Leonardo da Vinci and Ruini. Though these were important contributions to the veterinary knowledge base, there was little that was new in the field of clinical veterinary dentistry.

Northern Europe was largely an intellectual backwater regarding veterinary medicine until late in the eighteenth century. Available written materials include an early manuscript written in Britain in about 1000 CE entitled "The Medicine of Quadrupeds," which is largely a compilation from earlier Roman manuscripts. As an example of what now seems ridiculous, from the 1723 edition of a book originally published in 1610: "*A horse may have pain in his teeth through diverse occasions, as partly by the descent of gross humors from the head down to the teeth and gums*."

Dental extractions in horses have been performed and described for many centuries. Initially, this was performed by striking accessible teeth, such as wolf teeth, directly. "*With the horse's head tied up high, and his mouth opened wide, take a carpenter's gouge, place the edge at the foot of the wolf tooth, turn the hollow side downwards, holding your hand steady so that the tool may not swerve or slip, then strike the head of the tool a good stroke wherein you may loosen the tooth and bend it inwards, then wrench the tooth out with the hollow side of the tool. Then fill up the empty hole with salt finely brayed*." Trephining was developed as a means of opening the frontal and maxillary sinuses for treatment of nasal diseases caused by glanders or sometimes by dental disease by Lafosse in 1749.

Until the nineteenth century, dental procedures in animals largely were performed by the owner of the animal, or by horse leechers, farriers and other often illiterate practitioners. "Learning" was handed down from generation to generation, mistakes, superstition, and all. Though the invention of printing in the fifteenth century permitted major advances in the distribution of material, it did not necessarily improve the quality of the information. With few exceptions, there is a distinct lack of critical, observant minds evident in the "veterinary" books of the sixteenth, seventeenth and first half of the eighteenth centuries.

By the end of the nineteenth century, though the horse was losing its critical utility in the human world, equine dentistry was sufficiently advanced that "Equine Dental Colleges" were established; these were not associated with veterinary schools.

Two factors that did bring considerable subsequent progress to equine dentistry were development of mechanical gags and of powered dental rasps for "floating teeth." These features together resulted in significantly improved ability to manage occlusal abnormalities.

We now accept without question that anesthesia is essential for veterinary dental procedures; however, safe, effective anesthetics are a relatively recent addition to the veterinary armamentarium. Major advances were use of: IV opium in dogs in 1665; nitrous oxide gas in cats in 1779; ether in animals in 1847; barbiturates in 1902; flexible endotracheal tube in1914; and pentobarbital and pentothal in 1931–1934.

Small animal dentistry got off to a slow start compared with horses. The very early descriptions of dental or oral surgical procedures in dogs sound barbaric (particularly given the absence of practical anesthetic techniques). The indications were sometimes based on superstition rather than medical reality, such as excision of the lyssa (the fibromuscular tube that supports the rostral end of the tongue) to prevent rabies in the dog, described by Pliny (50 CE). On this topic, six hundred years later, Samuel Johnson (author of the first English dictionary) says of the "worm" of the dog's tongue, "*it is a substance, nobody knows what, extracted nobody knows why*"! There were occasional reports of "advanced" procedures, such as placement of dentures in dogs, in the late nineteenth century, however, significant growth in recognition of and means of treating oral and dental conditions in companion animals did not occur until the latter part of the twentieth century.

The need for attention to oral health in dogs and cats was, in part, precipitated by the major change in pet diets from about 1930 onwards; when domesticated dogs and cats are required to hunt for their own food, or cadaver material was their only food provided, the diet provided significant chewing activity that largely kept severe periodontal disease at bay during the life-time of the animal. When a defined nutritional profile convenience diet is fed, there is reduced chewing activity and greater build-up of dental plaque and calculus, such that periodontal disease became the most common clinical abnormality observed in dogs and cats by the end of the twentieth century. When owners provide hard materials such as cleaned processed bone, antlers or cattle hooves, or hard nylon toys, in an attempt to provide chewing activity, the risk of fracture of teeth increases. In addition, dogs and cats were living longer, because major viral diseases such as distemper and parvovirus infection in dogs and panleucopenia in cats were prevented by vaccination, thus enhancing the likelihood of development of chronically progressive diseases

such as periodontal disease. The result of these changes is that by mid-twentieth century, the increasing prevalence and severity of oral and dental diseases in dogs and cats was recognized, primarily among small animal practitioners rather than by those in academia. The impact of use of convenience foods on the oral and dental health of non-domesticated animals in zoological collections is considerable, because the mouths cannot be examined frequently, and brushing or wiping the surfaces of the teeth as an oral hygiene measure is not possible. This is true not just of carnivores, but also of herbivores, where, for example, chopped hay may provide far less chewing activity than full pasture grazing. Rather than grinding meat and mixing in additional ingredients as required, as was normal previously, most zoos now feed diets that match the form of the natural diet for that species, and provide the essential micronutrients by, e.g. stuffing them into large raw meat pieces for carnivores; this combination provides the tearing and chewing activity necessary to prevent rapid accumulation of dental plaque and calculus.

Another source of new veterinary dental knowledge from the mid-part of the twentieth century onward has been use of beagle dogs as a favored animal model for research in dental school laboratories, which has significantly increased the canine periodontal knowledge base.

One of the important sources of training for the initial core group of "dentally aware" small animal practitioners was human dental practitioners who were invited to consult on canine and feline dental patients. A few human dentists became critical players in veterinary dental continuing education programs, and some (such as Drs. Peter Emily, Peter Kertesz, Mark Tholen, Carl Tinkelman, John Scheels and Boyd Welsch) were important early contributors as volunteer dental consultants to zoos and other non-domesticated animal collections. As companion animal and particularly zoo and wildlife dentistry developed, the limitations of human dental instruments became evident, particularly in endodontics because of the grossly insufficient length of human endodontic instruments when treating a canine tooth in a large dog or a tiger, in which the root is typically several times as long as the longest human tooth root.

As veterinary dentistry became a standard part of veterinary medicine in the latter quarter of the twentieth century, individual veterinarians began to devote all of their professional effort to dentistry, and began meeting to discuss topics of mutual interest. This led to the formation of the American Veterinary Dental Society in 1976, and to recognition of dentistry as an area of veterinary specialization starting in 1987. The leaders of this group of board-certified veterinary dentists included several who, like their dental colleagues mentioned above, volunteered their time as consultants to zoos; early examples were: Drs. Chuck Williams (National Zoo, Washington DC), Ben Colmery (Detroit Zoo), Bob Wiggs (Dallas Zoo), Don Ross (Houston).

A critical step in the development of zoo and wildlife dentistry has been the willingness of these, and later individuals, to share their experience; there have been two Zoo and Wildlife Dentistry conferences, with abstracts of one of these meetings published in the Journal of Veterinary Dentistry.

As the content of this book will demonstrate, there are very unique challenges associated with zoo and wildlife dentistry; sharing information about successes and failures is critical to minimize the risk of repetition of failure during the learning curve of individual veterinary dentists. This book is designed to provide a strong collective foundation in that regard.

In 2017, the American Veterinary Dental College recognized the increasing interest in zoo and wildlife dentistry by establishing an AVDC Zoo and Wildlife Dentistry Certificate program. A Delphi process and examination resulted in recognition of 15 founding AVDC-ZWD Certificate holders. They are: Drs. Kris Bannon, Jan Bellows, David Clarke, Stephen Coles, Edward Eisner, Roberto Fecchio, Nadine Fiani, Barron Hall, Steven Holmstrom, Loic Legendre, Michael Lowder, Clarence Sitzman, Gerhard Steenkamp, Frank Verstraete and Douglas Winter. This process included developing a list of publications on zoo and wildlife dentistry and related topics, which the ZWD Certificate Organizing Committee plans to make available. Though AVDC-ZWD certificate holder status is limited to veterinarians, a list of human dentists who have contributed significantly to the development of zoo and wildlife dentistry is under consideration for recognition for honorary status in the ZWD Certificate program.

This chapter is based on a review of some of the classic histories of veterinary medicine, a recent description of veterinary dental history, a personal collection of veterinary antiquaria accumulated over the last 50 years that includes items dating to the seventeenth century, and personal interactions with the pioneers in zoo and wildlife dentistry. There may be some important sources that I have missed. I would appreciate receiving comments on this chapter, and, in particular, details of any sources that I have not included, or corrections of or different interpretations of material that I have included.

2

Odontology

A History of Teeth

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The history of teeth mirrors the evolution of the world. As environmental changes occurred, teeth needed to adapt for survival. Except for fossilized contents, teeth were the best clue to the diets that changed dentition over time.

Primate and human dental evolution were nearly as varied as the evolution of carnivores and herbivores. Following, is some of the many evolutionary concepts of herbivore and carnivore evolution. The various theories on dental evolution hold that teeth evolved from scales of dermal denticles. Oskar Hertwig showed that skin denticles and teeth are homologous – skin denticles being very similar to tricuspid secodont teeth. Evidence of the ascending Paleozoic fish and reptiles show dermal plates throughout the palate that led to a primitive dental function. The mouth of Pelycosaur Edaphosaurus is an example of palatal nodules. The area of the mouth covered in teeth was greatest among these ancient reptiles. They were an adaptation for eating hard-shelled prey, as seen in the Placodonts from the later Triassic period (see Figure 2.1).

As teeth became more specialized, the fixation to the jaws by bony attachment evolved. In particular, Pleurodont, Acrodont, Thecodont, and Prothecodont dentition evolved. These forms of attachment still remain to the present day.

In the long Carboniferous period, adaptation to land evolved among the oldest reptiles, the synapsid Pleosaurs. The Transition from gill-breathing to lung-breathing tetrapods took place toward the end of the Devonian period, 200 plus million years BCE. Therapsids bridged the chasm between the reptiles and primitive mammals. Therapsidia had several families that were partially herbivorous and partially carnivorous. Dicynodon had only one single tooth on each side of the maxilla. Some were toothless herbivores. A second subgroup of therapsids was composed of theridonts and cynodonts. They were possibly the first to show mammal-like heterodontous dentition.

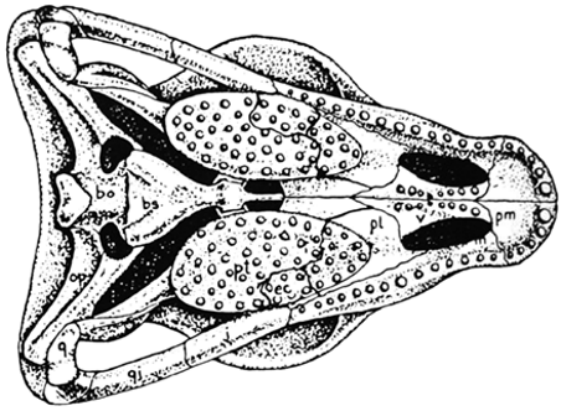

Figure 2.1 Pelycosaur Edaphosaurus. *Source:* A.S. Romer [1].

The Pelycosaurs showed the beginnings of a segregation of the dentition into pre-canine and post-canine tooth series. Later, advanced synapsids possessed differentiation of tooth form in different regions of their dentition. In the late Triassic period, some forms of reptiles such as Ictidosauria, had mammal-like teeth, yet belonged to a class of reptiles.

Pelycosaurs show clear evidence of heterodonty in some species with numerous teeth of equal size but with two larger anterior maxillary teeth, which points to the possible beginning of canine teeth. Dimetrodon and Edaphosaurus both possessed similar body structure but their mode of life differed appreciably since according to their dentition, Edaphosaurus was an herbivore, and Dimetrodon a predacious carnivore (see Figures 2.2–2.4).

Early Evolution

From their reptilian ancestors, the earliest mammals inherited dentition subdivided into incisiform, caniniform as well as premolar and molariform teeth. Anterior post

Zoo and Wild Animal Dentistry, First Edition. Edited by Peter P. Emily and Edward R. Eisner.

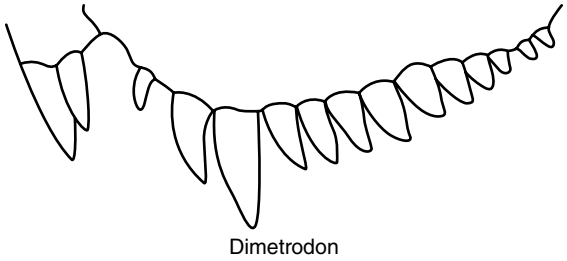

Figure 2.2 Dimetrodon. *Source:* A.S. Romer [2].

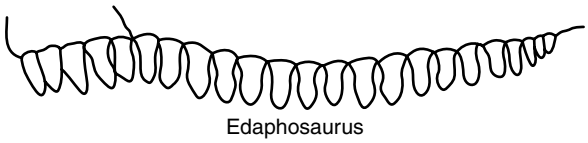

Figure 2.3 Edaphosaurus (From Romer [1968] [2]). *Source:* Teeth and Dentition in the Different Groups of Vertebrates page 172, as published in *Comparative Odontology*, by Bernhard Peyer, translated and edited by Rainer Zangerl, with a forward by Alfred S. Romer with permission. University of Chicago Press 1968. Library of Congress Catalog Card number 66-20578. Previously published in A.S. Romer an L.I. Price's article "Review of the Pelycosauria" in Geological Society of America Special publications, Volume 28. GS of A Special Publications allows "use up to three items (. . .figures. . .) from GSL published material without permission or charge with acknowledgement of source."

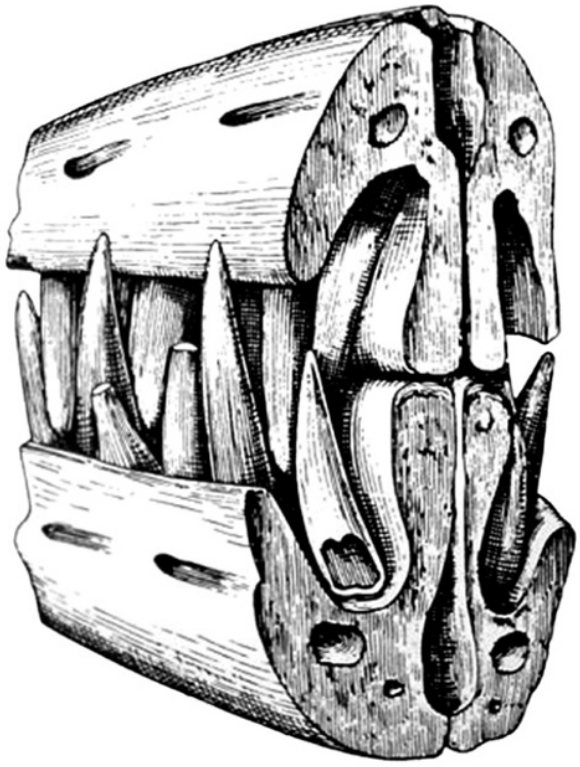

Figure 2.4 Snout fragment of an ichthyosaur (After Quenstedt from Peyer [3] [1937]). *Source:* Teeth and Dentition in the Different Groups of Vertebrates page 144, as published in *Comparative Odontology*, by Bernhard Peyer, translated and edited by Rainer Zangerl, with a forward by Alfred S. Romer with permission. University of Chicago Press 1968. Library of Congress Catalog Card number 66-20578. Originally appeared in Handbuch der vergleichenden Anatomie der Wirbeltiere Gesamt-Inhaltsubersucht published originally by Urban & Schwarzenberg and acquired by Elsevier.

canines were lost and not replaced. Molariform teeth seemed to have been added to the distal arcade, a dental characteristic typical to mammals, though this characteristic was not seen in early mammals. Unlike tribosphenic teeth, their occlusal surfaces require extensive abrasion to come into occlusion. Marsupials and placentals differentiated from a common ancestral stock of mammals possessing tribosphenic dentition. This differentiation took place before the end of the early Cretaceous, approximately 100 million years BCE.

The plant-eating ancestral reptilian dinosaurs had leaf-shaped homodont dentition. Since they were browsers, the need for broad occlusal surfaces was not seen until the evolution of grazers.

Early mammals of the Triassic period wore the occlusal surfaces into occlusion as did their reptilian contemporaries. They had dentition unlike teeth of the tribosphenic pattern. Their occlusion required a significant amount of abrasion before they matched. The earliest mammals investigated by Moss and Pool lacked the prismatic structure of enamel.

The earliest mammal molariform teeth, prior to development of a true tribosphenic molar, produced a different action. This was more of a shearing action between the crests of the trigon and stylar shelf and those of the talonid and trigon. Food could still be crushed between these segments. By the early Cretaceous period,100 million years BCE. Mammals with fully developed tribosphenic dentition were in existence.

Even though mammals existed as far back as 200 million years BCE, most of the dentition had been extensively altered during the previous 100 million years BCE, or more. The extinction of the dinosaurs around 65.5 million years BCE precipitated a rapid evolution in mammalian dentition.

Enamel

One of the dental features distinguishing the dentition of reptiles from mammals is their enamel formation. Reptiles have non-prismatic enamel while mammals have prismatic enamel. Reptile enamel is characterized by greater