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# CHANGING THE WAY WE FEED OUR HERBIVORES

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## Evaluating treatment outcomes and risk factors for Guinea Pigs (*Cavia Porcellus*) with dental disease in Australia

Hamish Baron

The Unusual Pet Vets

210 Karingal Drive, Frankston, Melbourne, Victoria, Australia

Hamish Baron, Damien Holden, Janice Seo, Sheryl Baron, Ben Stevenson and  
Deborah Monks

### Introduction

Dental disease is an all-encompassing term for a set of syndromes involving abnormal wear, malocclusion and occasionally abscess formation in guinea pigs (*Cavia porcellus*). It is a common condition diagnosed and treated by veterinarians, with prevalence reported to be between 23.4% and 36.3% (Jekl et al., 2008, Minarikova et al., 2015). Dental disease is a serious condition as it impacts an animal's ability to eat and acquire adequate nutrition, often leading to reduced body condition (Meredith, 2015). Symptoms for dental disease are not pathognomonic but include anorexia, reduced body condition, reduced faecal output and ill-thrift (Meredith, 2015). Clinical signs of dental disease can be difficult for owners to distinguish, especially if guinea pigs are housed in groups and given that guinea pigs are a prey species and tend to hide obvious signs of illness, early identification and diagnoses of dental disease is sometimes challenging (Capello, 2008).

The pathophysiology of dental disease in guinea pigs is not well understood; theories exist suggesting that it results from insufficient dental wear, lack of dietary vitamin C and calcium, inadequate vitamin D, or is related to husbandry or genetics, but these theories have not been well described or proven, in the literature (Jekl et al., 2008, Jekl and Redrobe, 2013, Müller et al., 2015). What can be concluded from the literature is that dental disease is likely multifactorial, making it more difficult to diagnose, manage and treat (Wills and Montrose, 2016). One study found a link between housing guinea pigs in outdoor environments and the lack of signs attributed to dental disease, which may support the importance of vitamin D in preventing dental disease (Norman and Wills, 2016). Work has been carried out in rabbits, linking the feeding of concentrated diets low in dietary fibre with dental disease, however, there is limited data suggesting this is the case for guinea pigs (Wills and Montrose, 2016). Because of the significant differences in dental and oral anatomy, it is unlikely that dental disease in rabbits and guinea pigs shares common pathophysiological origins (Legendre, 2016).

Dental disease in guinea pigs can manifest in several ways. The most common form of the disease includes malocclusion of the premolars and molars (cheek teeth), this can lead to overgrowth of teeth and eventually lingual entrapment (Legendre, 2016). Primary malocclusion of incisors is less common in the guinea pig and it often occurs secondary to cheek teeth malocclusion or trauma (Legendre, 2016). Diagnosis of dental disease is routinely based on a conscious intra-oral examination; however, assessing the full extent of dental disease in guinea pigs often requires general anaesthesia with examination of the oral cavity using an intra-oral device to aid in visualisation of the most caudal teeth and the buccal and lingual surfaces.<sup>2</sup> In order to completely understand the extent of the dental disease sub-gingivally, computed tomography or radiographs should be performed (Capello, 2008).

Treatment of malocclusion secondary to dental disease is often multi-faceted and requires general anaesthesia in order to best correct the occlusal surface. Anaesthesia can pose a risk to these patients; especially if the animal is anorexic or cachexic, which is not uncommon with a clinically unwell guinea pig suffering from dental disease.

Dental procedures typically involve burring of teeth to the appropriate length and maintaining the correct occlusal angle (Reiter, 2008, Wills and Montrose, 2016). Teeth may be extracted if necessary, and odontogenic abscesses exteriorised and marsupialised if present (Reiter, 2008).

The prognosis for guinea pigs receiving dental treatment has not been documented clearly in the literature. Because the underlying cause of dental disease is often unknown, true treatment of the disease is often impossible and eventually the dental issues will recur, resulting in the need for additional veterinary intervention. (Legendre, 2002). Even with veterinary intervention the likelihood of long-term survival is considered poor, but to date, survival time has not been assessed (Wills and Montrose, 2016).

This study was carried out to determine mean survival time of guinea pigs diagnosed with dental disease in Australia. It also examines whether there is a link between frequency of treatment, husbandry or environmental factors that may influence the survival time of guinea pigs affected by dental disease. This study is the first to provide peer-reviewed information for veterinarians to better prognosticate and provide evidence-based data on the mean survival of guinea pigs diagnosed with, and treated for, dental disease as a multifactorial syndrome. It also provides insight into what husbandry, diagnostic and environmental factors may contribute to increased survival.

## **Materials and methods**

### **Experimental design**

Medical records of guinea pigs diagnosed with dental disease were extracted from the computer database from two clinics; one in Sydney, New South Wales and the other in Brisbane, Queensland. Records were extracted using the species filter “guinea pig” and the keyword search included records that contained the terms: dental, dental disease, incisor, cheek teeth, malocclusion and tooth root abscess. Records were extracted and stored in a secure online storage portal (REDCap) whilst awaiting assessment.

A retrospective cohort study was carried out using the above data. Guinea pigs were included in the cohort if they were diagnosed with dental disease between the age of six months and eight years of age and had no other known concurrent, primary disease throughout the study. This age range was selected to prevent young, congenitally affected animals or natural lifespan of older guinea pigs confounding the data.

### **Results summary**

Guinea pigs housed indoors appear to have better survival than guinea pigs housed outdoors. Those supplemented with Vitamin C prior to presentation appear to have better survival than guinea pigs without Vitamin C supplementation, especially in the first 1000 days post-operatively. Guinea pigs that have more treatments appear to have better survival; importantly this should not be interpreted as a causative relationship. Guinea pigs that live with only one other guinea pig appear to have better survival than guinea pigs that live with two or more guinea pigs. Those guinea pigs that presented with lingual entrapment appear to have worse survival outcomes than those without lingual entrapment at the time of diagnosis.

## **References**

1. Capello, V. (2008). Diagnosis and treatment of dental disease in pet rodents. *Journal of Exotic Pet Medicine* 17(2), 114-123.



2. Jekl, V. and Redrobe, S. (2013). Rabbit dental disease and calcium metabolism – the science behind divided opinions. *Journal of Small Animal Practice* 54(9), 481-490.
3. Jekl, V., Hauptman, K. and Knotek, Z. (2008). Quantitative and qualitative assessments of intraoral lesions in 180 small herbivorous mammals. *Veterinary Record* 162(14), 442.
4. Legendre, L. (2016). Anatomy and disorders of the oral cavity of guinea pigs. *Veterinary Clinics of North America: Exotic Animal Practice* 19(3), 825-842.
5. Legendre L. (2002) Malocclusions in guinea pigs, chinchillas and rabbits. *The Canadian Veterinary Journal* 43(385)
6. Meredith, A. (2015). Guinea pigs: Common things are common. *Veterinary Record* 177(8), 198.
7. Minarikova, A., Hauptman, K., Jeklova, E., Knotek, Z. and Jekl, V. (2015). Diseases in pet guinea pigs: A retrospective study in 1000 animals. *Veterinary Record* 177(8), 200.
8. Müller, J., Clauss, M., Codron, D., Schulz, E., Hummel, J., Kircher, P. and Hatt, J.M. (2015). Tooth length and incisal wear and growth in guinea pigs (*cavia porcellus*) fed diets of different abrasiveness. *Journal of Animal Physiology and Animal Nutrition* 99(3), 591-604.
9. Norman, R. and Wills, A.P. (2016). An investigation into the relationship between owner knowledge, diet, and dental disease in guinea pigs (*cavia porcellus*). *Animals* (2076-2615) 6(11), 73.
10. Reiter, A.M. (2008). Pathophysiology of dental disease in the rabbit, guinea pig, and chinchilla. *Journal of Exotic Pet Medicine* 17(2), 70-77.
11. Wills, A.P. and Montrose, V.T. (2016). Diagnosis and treatment of dental disease in guinea pigs. *Journal of the American Veterinary Medical Association* 249(9), 1000-1001.

## **Advanced diagnostic imaging of the head of pet rabbits**

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

The oral examination and the diagnosis of oral disorders in pet rabbits are intrinsically difficult because of their size and oral anatomy. For these reasons, diagnostic imaging modalities assume particular importance in the evaluation of teeth and surrounding anatomic structures.

Aside from standard radiographs, advanced diagnostic imaging has become popular in exotic mammal medicine. Increased owner education and demand, coupled with the availability of referral centers for diagnostic imaging like computed tomography and magnetic resonance, make it both feasible and affordable. In the case of dental disease and other oral disorders it is of paramount importance for both diagnosis and diagnostic accuracy, for detailed prognosis, and for the treatment choice. In the case of extraoral surgical treatment, it is critical to plan the most effective surgical technique or approach.

### **Computed tomography**

#### **Basic principles**

Computed tomography (CT) is a radiologic technique to obtain multiple, parallel cross sectional image slices of the tissues of the patient (Capello and Cauduro, 2008; Capello and Lennox, 2008). Multiple x-ray exposures are made as an x-ray tube within a gantry rotates around the patient as it moves along the gantry on a couch. The final image is generated by a computer. The main advantage of CT over radiography is that in the first, all tissues in the area of interest are not superimposed over a single plane. CT scans elaborate images via the standardized, internationally recognized DICOM format, acronym of Digital Imaging and Communication in Medicine. Imaging exotic patients is a challenge because of their small size. The consequence of smaller patient size is production of a small image which would be of lower resolution when magnified. Because spiral and multislice scanners offer very thin slices (even less than 1 mm) and large image matrices (512 x 512 pixels), resolution is superior to that obtained with most single slice scanners. High resolution CT images can be magnified 1.5 to 2.0 x with computer software allowing better detection of subtle anatomic changes.

#### **Patient positioning and anesthesia**

Despite the flexibility of viewing modalities, proper positioning of the patient and the patient's head are of critical importance to obtain a good scanning and then interpreted by the radiologist and/or veterinarian.

Modern CT units are capable to scan the entire head in a few seconds. Although owners are reluctant about anesthesia that is not related to surgery or other procedures, deep sedation or anesthesia are essential for proper positioning for CT and to reduce breathing artifact, especially in smaller mammals with higher respiratory rate.

The patient is commonly positioned in sternal recumbency, with the head elevated slightly and kept horizontal, parallel to the table (Capello and Cauduro, 2008; Capello and Lennox, 2008). The endotracheal tube will not create a superimposition as in conventional radiographs. However, care must be taken that the connection with the anesthetic circuit would not prevent proper symmetric positioning of the head. The use of face masks is not recommended during scanning because the rubber material may create artifacts, or simply cover part of the face in the 3D renderings. Even though the



scanning time is short, simple inhalant induction of anesthesia is not an effective option, increasing the chance the patient will revive and move during the scanning procedure. The author's preferred anesthetic protocol for any stable patient is with injectable drugs and oxygen administration via a face mask (to be removed just before scanning). The anesthetic effect allows adequate time for positioning, scanning and verification of the CT images. Before scanning, a scout view is collected in both dorsoventral and lateral projection. Scout projections are standard x-ray images that are used to ensure accurate positioning and symmetry of the patient's head for CT scanning. The dorsoventral scout view is useful for evaluating bilateral symmetry, and the lateral projection is useful to assess the proper angle of the scanning plane. A provisional transverse scan through the tympanic bullae allows a further assess of symmetric position of the head. The thickness of the slices is selected, as well as the extent of the scan. The face mask is then removed during the short scanning time and replaced once the scanning is completed.

Intravenous contrast medium can be used during CT imaging of rabbits (Veraa and Shoemaker, 2013).

### **Interpretation of CT**

Data is usually acquired in the transverse plane (axial slices) but can be reformatted by the computer and displayed also in sagittal, coronal and oblique planes (Capello and Cauduro, 2008; Capello and Lennox, 2008). This capability is called multiplanar reformation and has been exploited by the advent of spiral CT. Despite the fact that the resolution of analog or digital radiography is superior, viewing slices of the patient in sagittal and coronal planes as well as the standard axial plane, offers tremendous advantages. Radiologists agree that axial views and additional two-dimensional (2D) views represent the standard interpretation and are the most sensitive for diagnosis. However, dedicated imaging software allow various reconstruction techniques, including three dimensional (3D) volume rendering (VR) techniques, and shaded surface displays (SSD). Image volume presented in this fashion is virtually 3D, because the actual image is obviously two dimensional on the computer screen. VR can be rotated on the monitor to allow the observer to visualize any surface. Also, additional functions can be operated, such as cropping part of the volume for evaluation of deeper anatomic structures. Both hard and soft tissues can be virtually added or subtracted to different extent and degree of density, providing detailed relationship between soft and hard tissues. SSD presents a contoured surface map of the entire image volume, converting CT data into an image very similar to an image of a bony anatomical specimen, well within the range of interpretation of a trained clinician. Deep structures are masked, however it is still very important for evaluating abnormalities of the bones of the skull such as deformities, osteomyelitis and skull fractures. Depending on the specific case, volume and surface renderings may be of critical importance for diagnostic accuracy and to select the best surgical approach, when indicated (Capello and Cauduro, 2016; Van Caelenberg et al, 2011). Software for viewing DICOM images is readily available as freeware.

### **Indication for CT**

Computed tomography of the skull is a critical diagnostic imaging tool in rabbits for acquired dental disease and related complications, such as osteomyelitis of the mandible and the maxilla (Capello 2011, Veraa and Shoemaker, 2013), empyemas of the bony cavities of the skull, and the tympanic bullae for diagnosis of otitis media (Capello 2011). Nasal and paranasal cavities including meatuses, nasal septum, turbinates and recesses can be visualized in detail, making CT complementary to rhinoscopy (Capello, 2014).

### **Radiography vs. computed tomography**

Computed tomography is usually considered to be superior to standard radiography by default. A recent retrospective study performed on 30 rabbits with dental disease and related complications compared RAD and CT on two different levels: diagnostic consistency and diagnostic accuracy (Capello and Cauduro, 2016). Observations were statistically consistent for diagnosis between the two techniques. However, diagnostic accuracy of CT was superior in 80% of patients in diagnosis and prognosis, and in 56.6% of patients for guiding extraoral dental and surgical treatment. Higher sensitivity and superior accuracy for clinical diagnosis and prognosis was in particular for cases of osteomyelitis following periapical infections, rhinitis and otitis media. Radiography provided superior accuracy in 16.6% of patients for guiding intraoral dental treatment. RAD and CT should be ideally performed together in most cases to improve diagnostic quality.

### **Micro-computed Tomography**

Micro-computed tomography (micro-CT) has recently emerged in private practice for small exotic mammals. Originally designed for laboratory animal imaging (De Rycke et al, 2012), it may represent the new, advanced step for diagnosis of dental disease in rabbits and rodents. The pet rabbit has been used as a model for a new micro-CT unit of 190 mm diameter, with 5µm resolution, producing 2D standard images and 3D renderings of exceptional quality and with a superior level of detail (Sasai et al, 2014). The basic principles of CT scanning and operation are the same; however advantages are represented by a much smaller CT unit, configured with a shield structure so that an additional lead shield chamber is not required to protect the veterinarians operating the device from X-ray exposure. Its compact size allows it to be used in standard-sized examination rooms and can accommodate animals weighing up to 3 kg inside the gantry. The disadvantage is represented by the limited range of species in regard to their size, including large rabbits. This may be a concern or a limitation for veterinary practices different than exotics-only.

Other micro-CT units allow 20 cm of scanning extent, and can accommodate animals up to 15 Kg, with lower resolution.

The accurate and detailed images make micro-CT an outstanding modality for small exotic patients.

### **Oral endoscopy**

#### **Indications**

Unlike other diagnostic imaging modalities, endoscopy provides direct visualization of internal anatomic structures related to a real or virtual body cavity (Divers, 2012). For this reason, the number of organs that can be evaluated is more limited than with other diagnostic techniques. The specific name of oral endoscopy is stomatoscopy, and it represents a critical tool for diagnosis of dental disease in pet rabbits and rodent species (Divers 2012, Capello and Lennox, 2012).

The most important advantages of stomatoscopy can be summarized as follows:

- the basic equipment is not very expensive;
- stomatoscopic procedures are relatively simple, and non-invasive. They require basic skill;
- it allows thorough inspection of the narrow oral cavity of herbivorous species, and of the little oral cavity of smaller species;
- it offers a magnified perspective of dental structures;
- it highly reduces the risk of missing subtle lesions, facilitating early diagnosis;
- it facilitates coronal reduction of cheek teeth and other therapeutic procedures;
- it facilitates endotracheal intubation in selected patients;
- it allows the simultaneous visualization of the clinical case by multiple observers;
- it allows documentation of images for tracking progress of disease, for medical records, and for both veterinary and client education.



Rhinoscopy and pararhinoscopy (i.e. endoscopy of the paranasal recesses) may be adjunct endoscopic procedures in case of selected complications of advanced dental disease such as empyema of the nasal cavity in rabbits.

### **Equipment**

Detailed features of endoscopic instrumentation have been reported (Divers, 2010). The most common used in exotic mammal medicine and surgery are the 2.7 mm (30° view) and the 1.9 mm telescope. Both have dedicated sheaths, either protecting or operating, the latter with several ports and instrument channels. The 1.9 mm semiflexible and the 1.7 flexible miniscopes are a useful adjunct for smaller exotic mammals.

Additional, basic endoscopic equipment includes: a light source and a light cable; endoscopic video camera, monitor, and a digital recording device.

As well as other endoscopic procedures, stomatoscopy is always performed under general anesthesia. Additional dental instruments and equipment needed for intraoral inspection such as mouth gags and cheek dilators have been extensively reported (Capello and Gracis, 2005).

### **Endoscopy of the normal oral cavity of the rabbit**

Entering the mouth, the area on the dorsal aspect of the tongue is the lingual torus (*torus lingualis*). The mucosa of the lingual torus is light pink, thick, and prominent compared to the rest of the lingual mucosa.

Mandibular cheek teeth arcades are visible lateral to the tongue. Normal length of clinical crown must be assessed. Positioning the endoscope tangential to the occlusal plane allows detailed inspection and assessment of the normal zig-zag pattern.

Normal, small enamel points are visible on the lingual aspect of the mandibular cheek teeth.

The inferior alveolar vessels are visible below the thin oral mucosa distal to the most distal (caudal) mandibular cheek teeth. Special attention must be paid to avoid injuring these vessels during coronal reduction.

Clinical crowns of maxillary cheek teeth are normally shorter than those of the mandibular teeth, and maxillary CHT6 is significantly smaller than the other five cheek teeth.

A better view of the maxillary dental arcades may be obtained by turning the endoscope 180° (Capello and Gracis, 2005).

### **Endoscopic abnormalities of the cheek teeth in the rabbit**

The earliest stage of ADD of cheek teeth in rabbits detectable with stomatoscopy is elongation of the clinical crowns. Changes of occlusal plane are due to excessive and irregular coronal elongation, with the differences in height of up to a few millimeters between one cheek tooth and the adjacent tooth. This abnormal occlusal plane is called “wave mouth”. When abnormality of the occlusal plane is evident, with marked differences of crown length between two adjacent cheek teeth, this abnormal occlusal plane is called “step mouth”.

Usually, in cases of both “wave mouth” and “step mouth”, sharp spurs are not present, and clinical signs and symptoms may be mild or absent.

Lingual curvature of clinical crowns of mandibular cheek teeth, and buccal curvature of clinical crowns of maxillary cheek teeth, lead to the development of points and sharp spikes. Spikes and spurs from mandibular cheek teeth may develop over the tongue or may be oriented aside the tongue producing severe damage to the lingual mucosa. In order to detect small but sharp spikes, the tongue must be carefully deflected during stomatoscopy. For this reason, these spikes are may be very difficult to visualize during examination of the oral cavity in the conscious patient. symptoms such as excessive salivation can suggest these types of lesions.

Bilateral dental spurs of one or more mandibular teeth represent a more severe stage

of dental disease than wave mouth or step mouth. The lingual edge may not be always sharp, but overgrown mandibular cheek teeth can impinge on the tongue and affect chewing and swallowing. Discomfort is present, and at this stage clinical signs may include teeth grinding, reluctance to chew, changes in food preference, excessive salivation and signs related to gastrointestinal disorders.

A common sequela of excessive coronal elongation of cheek teeth is fracture, especially of mandibular cheek teeth. The longitudinal fracture of the mandibular first premolar (CHT1) is relatively common. This often occurs when the rabbit chews improper hard foods like seeds. Inspection of the oral cavity with a metal cone (especially when improperly inserted between the cheek teeth arcades), may also cause or predispose to this fracture.

The most common sequela of fractures is periapical infection and abscess. Fractures often produces no clinical signs and symptoms therefore the first clinical sign may be the appearance of a lump representing the developing abscess.

Excessive coronal elongation and malocclusion (including wave mouth and step mouth) also affects maxillary cheek teeth. Coronal elongation is usually accompanied by an increase in the height of both the alveolar crest and the gingival margin. These changes are more apparent in maxillary, rather than mandibular cheek teeth malocclusion.

Spurs of maxillary cheek teeth typically form on the buccal aspect of the tooth and may cause ulcerations of the mucosal surface of the cheek. Clinical signs and symptoms are usually less severe than those associated with spurs of mandibular cheek teeth. Nevertheless, in other cases they can lead to odontogenic, non periapical abscesses (Capello and Gracis, 2005).

### **Magnetic resonance**

Magnetic Resonance Imaging (MRI) is considered a non-invasive imaging modality because it does not use radiation for generating images. Similar to CT, it is a computed based modality; but in the case of MR images are obtained visualizing the movements of hydrogen atoms in the body of the patient, in reaction to a very strong magnetic field placed around the patient (Gavin and Bagley, 2009; Capello, 2011; Veraa and Shoemaker, 2013) The patient undergoing MR exam is always under general anesthesia.

MR represents the diagnostic imaging modality of choice for soft tissues. It is most commonly used for the central nervous system, but other soft tissues can be visualized in detail with superior quality than CT, even after administration of contrast (Capello, 2011; Veraa and Shoemaker, 2013).

Different types of sequences (i.e. images) can be acquired, depending on the tissues to be emphasized. Sequences are produced and visualized in one of the three standard views (transverse or axial, dorsal or coronal, lateral or sagittal). Acquisition of MR sequences also depends on several technical factors: the most important and most practical are the type of sequence, the sequence views, and the overall number of sequences. These factors, together with resolution, have an impact on the time for resonance.

Two potential disadvantages of MR are actually resolution (especially for small patients), and prolonged scanning time, when compared to CT. Resolution depends on the magnet of the MR unit. Low power magnets capable of field strengths of 0.2-0.4 Tesla will produce lower resolution images than magnetic fields of 1 Tesla or higher. Or, higher resolution can be achieved with prolonged resonance time. The average time for acquisition of diagnostic sequences a rabbit patient using a low-field MR unit can range from 20 to 40 minutes, while acquisition time for CT scanning can be less than a minute. Due to long acquisition time, images might be affected by respiratory and cardiac rate which are higher in small sized mammals. However, this does not usually represent a concern since they are significantly reduced under anesthesia, and when the thorax is not the diagnostic target.

### **Indications and applications for rabbit dental disease**

Thick pus and the capsule, typical of rabbit odontogenic abscesses, has a signal intensity similar to other soft tissues. However, standard fluid pus can be displayed as well. For this reason, MR of the head for indications other than investigation of the central nervous system represents an interesting and very useful application in pet rabbits and rodents to diagnose the presence and the extent of abscesses (Capello, 2011). In the case of mandibular abscesses, retrobulbar and parabulbar abscesses, and single or multiple empyema affecting one or more cavities of the rabbit skull (nasal cavities, maxillary recess, diseased alveolar bulla, and tympanic bulla) MR provides excellent information, even superior that CT which is less specific for lower radiodensities (Capello, 2011). As well as CT, MR can provide a high level of diagnostic accuracy, providing a critical help in preoperative planning. The exact visualization of the abscess, superior to the soft tissue window of CT, may optimize the difficult surgical approach.

CT remains superior for diagnosis of dental disease and related bone infection (Capello, 2011; Veraa and Shoemaker, 2013).

For this reason CT and MRI of the head are best used as complementary tests. Since in most cases this is not feasible for practical and financial reasons, the clinical exam and survey radiographs would guide the clinician to pick the most useful diagnostic imaging test for that specific case.

### **References**

1. Capello V, Gracis M, Lennox AM (ed). Rabbits and rodents dentistry handbook. Lake Worth, FL, Zoological Education Network; 2005.
2. Capello V, Cauduro M. Application of computed tomography for diagnosis of dental disease in the rabbit, guinea pig, and chinchilla. J Ex Pet Med 2008; 17: 93-101
3. Capello V, Lennox AM. Clinical radiology of exotic companion mammals. Ames: Wiley Blackwell 2008.
4. Capello V. Novel diagnostics and surgical techniques for treatment of difficult facial abscesses in pet rabbits. Proceedings of the North Am Vet Conference. Orlando, FL: 2011, p. 1685-1689.
5. Capello V, Lennox AM. Small mammal dentistry. In: Quesenberry KE, Carpenter JW, editors. Ferrets, Rabbits and Rodents Clinical Medicine and Surgery, 3<sup>rd</sup> edition. St Louis: Elsevier Saunders; 2012. p. 452-471.
6. Capello V: Rhinostomy as surgical treatment of odontogenic rhinitis in three pet rabbits. J Exotic Pet Med 23(2):172-187, 2014.
7. Capello V, Cauduro A. Comparison of diagnostic consistency and diagnostic accuracy between survey radiography and computed tomography of the skull in 30 rabbits with dental disease. J Exotic Pet Med 25(2): 115-127, 2016
8. De Rycke LM, Boone MN, Van Caelenberg et al: Micro-computed tomography of the head and dentition in cadavers of clinically normal rabbits. Am J Vet Res 73(2):227-232, 2012.
9. Divers SJ. Endoscopy equipment and instrumentation for use in exotic animal medicine. Vet Clin Exot Anim 2010; 13: 171–185

10. Divers SJ. Exotic mammal diagnostic and surgical endoscopy. In: Quesenberry KE, Carpenter JW, editors. *Ferrets, Rabbits and Rodents Clinical Medicine and Surgery*, 3<sup>rd</sup> edition. St Louis: Elsevier Saunders; 2012. p. 485-501.
11. Gavin PR, Bagley RS. *Practical small animal MRI*. Ames, IA: John Wiley & Sons; 2009.
12. Sasai H, Iwai H, Fujiita D et al. The use of micro-computed tomography in the diagnosis of dental and oral diseases in rabbits. *BMC Vet Res* 10: 209, 2014
13. Van Caelenberg AI, De Rycke LM, Hermans K et al: Comparison of radiography and CT to identify changes in the skulls of four rabbits with dental disease. *Journal of Veterinary Dentistry*, 28(3):172-181, 2011.
14. Veraa S, Schoemaker N. CT and MRI scanning and interpretation. In: Harcourt-Brown F, Chitty J, eds. *Manual of rabbit surgery, dentistry and imaging*. 1st ed. Quedgeley, Gloucester British Small Animal Veterinary Association, 2013; 9:107-114



## Dentistry of guinea pigs

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

Acquired dental disease is frequent in guinea pigs. It determines a complex of clinical signs and symptoms both primarily related to the dental function, and secondarily related to other organs and systems. For this reason, dental disease is better defined as a syndrome (Capello and Lennox, 2012). Despite some anatomic and physiologic similarities with the rabbit, dental disease in guinea pigs presents distinct peculiarities at any stage of the medical trial: diagnostic, prognostic and therapeutic. Therefore, the common belief referring the guinea pig as a “smaller rabbit” in regard to dental disease, is misleading and potentially harmful.

### Normal dental anatomy and physiology

Proper diagnosis and treatment of dental disease in guinea pigs requires a thorough understanding of normal dental anatomy and physiology. Rodents have one pair of well-developed maxillary and mandibular incisor teeth, representing the best-known anatomical peculiarity of this Order. Incisor teeth are continually growing, open rooted (elodont). Incisor teeth of rodents are covered by enamel only over the labial surface, which is white in guinea pig. The length of the clinical crown of mandibular incisors is normally two to threefold the clinical crown of maxillary incisor teeth. As in rabbits, both maxillary and mandibular incisors present a “chisel-shaped” occlusal surface; they lack canine teeth and there is a diastema between the incisor and the first premolar tooth. Premolar and molar teeth are anatomically indistinguishable, and are therefore simply called: “molariforms” or “cheek teeth” (CHT). The hundreds of species belonging to the Order of Rodents are grouped into three suborders. Guinea pigs belong to the “caviomorph” (“cavy-like”) or “hystrichomorph” (“porcupine-like”) group, having elodont cheek teeth. The dental formula is  $2x (1I\ 0C\ 1P\ 3M)$ , for a total of 20 teeth and a total of 16 cheek teeth.

Despite dental formulas differing from lagomorph species, the dentition of guinea pigs is physiologically similar to rabbits, being full elodont. As true herbivores, the occlusal surface of cheek teeth of guinea pigs is rough and uneven due to enamel crests and dentinal grooves. Unlike rabbits, occlusal surfaces are flat and do not present a “zig-zag” pattern. A very important anatomical peculiarity of cheek teeth of guinea pigs is that they are curved; the mandibular with a buccal (lateral) convexity, and the maxillary with a palatal (medial) convexity. This results in a 30-degree oblique occlusal plane that slopes from dorsal to ventral, lateral to medial. The clinical crowns are much shorter than reserve crowns when compared to rabbits (Crossley, 1995; Capello and Gracis, 2005; Capello and Lennox, 2012).

### Pathophysiology of dental disease

Congenital malocclusion following prognathism of the mandible or brachygnathism of the maxilla is not recognized in rodent species. True dwarfism as recognized in pet rabbits has not been documented as rodent species have not been selectively bred for extreme size variation. Congenital dental abnormalities are seen in Lethal White guinea pig mutation. Abnormalities include microphthalmia, poorly developed or missing incisors and/or cheek teeth.

The primary cause of acquired dental disease in guinea pigs is insufficient or improper wearing of cheek teeth due to inappropriate diet, in particular lack of fiber. Metabolic bone disease as an underlying cause of dental disease has not been investigated and reported in rodent species. However, severe dental disease concurrent with secondary nutritional hyperparathyroidism with fibrous osteodystrophy has been reported in

guinea pigs (Hawkins, 2010).

### **Clinical signs and symptoms of dental disease**

Guinea pigs commonly present with symptoms directly related to and suggesting dental disease, such as reduced food intake, dysphagia, or anorexia. In multi-pig households owners may be unaware of decreased appetite in one individual, and the only presenting sign may be weight loss (Capello and Lennox, 2012).

While both guinea pigs and rabbits are herbivore prey species, the latter are much more capable of masking or hiding symptoms of dental disease and often tolerate significant dental abnormalities for longer periods of time. In guinea pigs, a slight alteration of the sloped occlusal plane of cheek teeth is enough to hamper chewing, and a slight overgrowth of clinical crowns is enough to interfere with movements of the tongue and swallowing. Therefore, guinea pigs are much more prone to apparent onset of anorexia due to dental disease than rabbits.

The history of guinea pigs with dental disease often includes improper feeding, most particularly lack of fiber (hay) and/or excess of fruits.

Malocclusion of incisor teeth is often present as excessive elongation or lateral deviation of the clinical crown of mandibular incisors. As primary incisor malocclusion is rare, dental disease of cheek teeth should be investigated and addressed as well.

### **Diagnosis of dental disease**

The small size and the natural behavior make safe restraint and effective oral examination much more difficult in non-anesthetized rodent species than in rabbits. Complete inspection and proper diagnosis of dental disease in guinea pigs should be performed under general anesthesia. Effective anesthetic protocols for induction and maintenance of general anesthesia are available in the literature.

The standard diagnosis of dental disease in guinea pigs includes two modalities: radiology and oral endoscopy. A very good to optimal complete radiologic study must include five basic extraoral projections of the head: lateral; oblique in two directions; ventrodorsal and rostrocaudal (Capello and Gracis, 2005; Capello and Lennox, 2008). Thorough inspection of the oral cavity is greatly enhanced by oral endoscopy (Capello and Gracis, 2005). While this is considered very useful in rabbits, in the author's opinion it is mandatory for guinea pigs. Other magnification devices are helpful but often not sufficient, and several abnormalities can be missed without the help of stomatoscopy. Documentation of lesions for comparison or client education is another added benefit.

Advanced diagnostic imaging modalities such as computed tomography (CT) and magnetic resonance (MRI) are capable of excellent details also in small species like guinea pigs. In particular, 3D volume and surface renderings of the skull can provide tremendous information for diagnosis of dental disease or related problems in this species, like abnormalities of the temporomandibular joint (Souza et al, 2018; Capello and Cauduro, 2008; Capello and Lennox, 2015; Capello et al., 2015).

### **Patterns of dental disease**

The most frequent cause of malocclusion of incisor teeth in the guinea pig appears to be coronal elongation and malocclusion of cheek teeth (Capello and Gracis, 2005). This may be due to their physiologic ability to compensate for any moderate primary incisor abnormalities through rostrocaudal movements of the jaw, which permits normal wearing of incisors. The two most common patterns of malocclusion in guinea pigs are excessive coronal elongation of the mandibular incisors or lateral deviation, with an oblique occlusal plane of about 45 degrees. Typical incisor malocclusion of rabbits, where mandibular incisors tend to elongate labially, is rarely seen in guinea pigs. Maxillary incisors are not prone to curve palatally as in chinchillas or other rat-like rodent species. Various fractures of incisor teeth can be faced.

Like in rabbits, excessive coronal elongation and malocclusion of cheek teeth is very common, but with different traits. Due to the peculiar orientation of the cheek teeth, mandibular cheek teeth crowns always elongate lingually, and maxillary crowns always laterally.

Overgrowth of clinical crowns is not so evident as it is in rabbits, and spike or spur formation is much less frequent. Mandibular cheek teeth tend to bend lingually over the tongue hampering movements. A typical “bridge-like” malocclusion occurs when the first mandibular premolars occlude or even cross each other. The sharp border of maxillary cheek teeth can create severe discomfort to the buccal mucosa. It should be kept in mind that even very early malocclusion and subsequent alteration of the sloped occlusal planes is enough to elicit reduced food intake or anorexia in this species. Elodontoma affecting a mandibular incisor and a maxillary cheek tooth has been reported in two guinea pigs (Capello et al., 2015)

### **Prognosis of dental disease**

The goal of the intraoral treatment is restoration of dental anatomy to as close to normal as possible. In many cases, complete restoration is not feasible, and owners must be aware that a reasonable goal can be palliative only, or simply management of dental disease (Capello and Lennox, 2012). For more severe clinical cases, euthanasia is a humane, reasonable option.

As a general consideration, prognosis for dental disease in guinea pigs is more guarded than in rabbits. However, since so many different pathologic patterns can be faced, prognosis should be formulated for every single case.

Unless the patient is presented in poor general conditions, prognosis for treatment of dental malocclusion of cheek teeth in guinea pigs is fair to good. Malocclusion of incisor teeth is usually addressed as a consequence, and extraction is rarely needed, even if feasible. Unlike rabbits though, guinea pigs may not improve immediately after a dental treatment, due to stretching of the masticatory muscles and associated pain and inflammation. Patients that do not immediately return to eating may not wear teeth down to the degree required to prevent repeated overgrowth. These patients may require additional dental treatment until the soft tissues heal and the patient is able to eat enough high fiber food to allow normal wearing. Involvement of the temporomandibular joint up to subluxation, coupled with stretching of masseteric muscles carries a poor prognosis in guinea pigs.

### **Specialized equipment for diagnosis and treatment of dental disease**

Oral inspection and treatment of dental disease in rodents requires specialized equipment. Most dental instruments described elsewhere for rabbits are useful for rodents. The “table top mouth gag and restrainer” is much easier to use than traditional mouth gags, which are difficult to keep in place due to the smaller patient size. Smaller, modified “open blade” cheek dilators are available and are much more effective than those used in rabbits as they provide more effective hold on cheek margins and inner mucosa. This is especially true for guinea pigs, where the well-developed buccal folds complicate the positioning of a “flat wing” traditional cheek dilator.

Appropriately contoured needles are used for extraction of incisor teeth and are shaped to match the size and curvature of the tooth. A rotating dental unit with a straight handpiece is used in guinea pigs as well, with the addition of smaller metal or silicon burrs (Capello and Lennox, 2012).

### **Medical treatment**

Medical therapy is an important adjunct to dental correction or even to surgical treatment of dental disease. The three key points of medical treatments are the use of antibiotics to control local infection and reduce the risk of systemic complications, the administration of analgesic drugs, and general supportive therapy for debilitated patients both before and after dental treatments. Established or potential toxicity of

many common antibiotics in rodent species should be considered (Capello and Lennox, 2012).

### **Treatment of dental disease**

Coronal reduction of incisor teeth is usually performed in conjunction with treatment of cheek teeth and should never be performed without complete inspection and evaluation of the cheek teeth. Reduction of the length of the crowns of incisors is performed with low/medium-speed dental equipment, as cutting instruments pose an unacceptably high risk of iatrogenic damage, in particular fractures of the clinical or reserve crowns.

Coronal reduction of cheek teeth in guinea pigs should be performed with the tip of a delicate, slightly abrasive bur. The goals are to shorten the elongated clinical crowns and restore the proper oblique occlusal plane as close as possible to the normal anatomy, which is a critical aspect of treatment in this species.

Due to the normal curvature of cheek teeth in guinea pigs, extraction is challenging, unless the tooth is loose because of periodontal infection. Unfortunately, diseased teeth fracture easily, making complete intraoral extraction extremely difficult. The extraoral approach for extraction of cheek teeth as described for rabbits is feasible, but more difficult due to decreased patient size (Capello and Gracis, 2005; Capello and Lennox, 2012).

### **Periapical infections and osteomyelitis**

Despite similar anatomy and physiology of teeth, guinea pigs seem to be much less prone to periapical infections and osteomyelitis than rabbits. Advanced diagnostic imaging is of paramount importance for detailed diagnosis in regard of both hard and soft tissues involved, and for surgical planning (Capello and Lennox, 2015). The general surgical guidelines (excision of the capsule, debridement, extraction of the tooth involved, flushing and marsupialization) are the same as described for the rabbit. Unlike rabbits, the cheek teeth of guinea pigs and subsequent abscess are always located beneath the masseteric muscle (Popesko et al, 1992), making both the surgical access and the marsupialization more difficult.

### **References**

1. Capello V, Gracis M. In: Lennox AM, ed. Rabbit and Rodent Dentistry Handbook. Lake Worth, FL, Zoological Education Network, 2005.
2. Capello V, Cauduro A: Application of computed tomography for diagnosis of dental disease in the rabbit, guinea pig and chinchilla. JEPM 2008, 17(2): 93-101.
3. Capello V, Lennox AM. Clinical radiology of exotic companion mammals. Ames, IA, Wiley-Blackwell, 2008.
4. Capello V, Lennox AM. Small mammal dentistry. In: Quesenberry KE, Carpenter JW, editors. Ferrets, Rabbits and Rodents Clinical Medicine and Surgery, 3<sup>rd</sup> edition. St Louis: Elsevier Saunders; 2012. p. 452-471.
5. Capello V, Lennox A. Advanced diagnostic imaging and surgical treatment of an odontogenic retromasseteric abscess in a guinea pig. Journal Small Anim Pract 2015;56(2):134-7
6. Capello V, Lennox AM, Ghisleni G. Elodontoma in Two Guinea Pigs. J Vet Dent 2015; 32 (2): 111-119
7. Crossley DA: Clinical aspects of rodent dental anatomy. J Vet Dent 1995 12(4): 131-135.

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Capello, V – Dentistry of Guinea Pigs



8. Hawkins MG. Secondary nutritional hyperparathyroidism with fibrous osteodystrophy in 3 guinea pigs. Proceedings of 31st Annual AAV Conference and Expo. San Diego (CA): 2010. p. 121.
9. Popesko P, RjtoVà V, Horàk J: A colour atlas of anatomy of small laboratory animals. Vol. I: Rabbit, Guinea pig. London, Wolfe Publishing Ltd, 1992.
10. Souza MJ, Greenacre CB, Avenell JS, et al. Diagnosing a tooth root abscess in a guinea pig (*Cavia porcellus*) using micro computed tomography imaging. J Exot Pet Med 2008; 15: 274-277

## **Diagnostic imaging of the head of pet rabbits (Radiography)**

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

Radiography provides critical information to complement the clinical examination and represents one of the most important diagnostic tools in veterinary dentistry (Capello and Gracis, 2005; Capello and Lennox, 2008; Jekl 2013). It is also important to consider that the clinical crown, visible above the gingival margin, represents a small portion of the rabbit tooth, and that most of the dental structure (the *reserve crown* of hypsodont/elodont teeth) is invisible on clinical inspection. Supporting bone and periapical structures, as well as other parts of the skull, should always be evaluated for diagnosis of dental disease (Capello and Gracis, 2005; Capello and Lennox, 2008).

### **Digital modalities**

Over the past few years, digital radiography (DR) has completely replaced conventional film radiography. The basics of radiography on standard films and high resolution films have been reported elsewhere (Capello and Lennox, 2008).

Conceptually, digital radiology (DR) is not an advanced technique and does not necessarily produce higher quality radiographs than good-quality conventional radiographs.

Most of the basic principles of traditional radiography on films apply to digital as well.

The most important of them is patient positioning to obtain proper diagnostic views.

Two digital imaging systems are available: computed radiography (CR) and direct digital radiography (DDR) (Capello and Lennox, 2008). In the case of CR, detectors are placed in a cassette, which does not include films and intensifying screens. The image plate is processed by a specific scanner, which is a stand alone unit similar to an x-ray film processor, but is faster and does not require a dark room. Data is converted into a digital format image and processed by a computer, with specific software. The greatest advantage of CR is the ability to be coupled with standard radiographic equipment.

DDR instead sends digital information directly to the computer without the intermediate scanning step. Advantages of DR include no need for x-ray films, dark room, or film storage; an immediate feedback (in case of DDR) and fewer retakes; immediate adjustment of the grayscale; flexibility of the digital format for storage, recording and distribution. Nevertheless, some potential advantages may not be so obvious when DR is applied to exotic patients.

The most important concern for use of any digital system in small exotic species is resolution. The area corresponding to the "film" has a fixed number of pixels (usually corresponding to standard resolution of approximately 250 pixels per inch with CR, and about 180 p.p.i. with DDR). Higher resolutions plates (commonly named "mammography plates") and scanners able to take and process at double resolution (500 p.p.i.) are available, but they are more expensive and not needed for a standard small animal practice dealing mostly with dog and cat patients.

Reduced time and increased efficiency are well recognized benefits of DR. However, the rabbit patient requires more time for anesthesia, monitoring, and positioning. Therefore, the advantage of reduced time may be less significant in this species. Teleradiology and increased interactivity with referral clinicians and colleagues is easier with DR.

### **Intraoral radiography**

The intraoral technique is usually preferred in veterinary medicine over the extraoral technique, as it produces images of optimal resolution and diagnostic quality. Intraoral films or digital plates are non-screen films that can be placed directly inside the

patient's mouth, reducing the object-to-film distance, and therefore minimizing the image size distortion. The use of intraoral film is reported in rabbits (Bohmer 2015, Regalado and Legendre, 2017). A mobile dental radiographic unit is needed to expose intraoral films, as it can be easily moved facilitating the positioning of the patient and the use of proper angles to obtain dedicated oblique views.

In the author's experience the correct placement of films within the oral cavity of rabbits and rodents is difficult due to patient size. In most patients, intraoral techniques can therefore be employed primarily for evaluation of anatomic structures such as maxillary and mandibular incisor teeth, rostral cheek teeth, and the rostral portion of the maxilla.

### **Extraoral radiography**

Because of difficulties obtaining good quality intraoral images, in particular of cheek teeth and surrounding structures, the extraoral technique is most commonly used in the evaluation of dental structures in rabbits by most exotic companion mammal veterinarians (Capello and Gracis, 2005; Capello and Lennox, 2008). Considering the complex dental disease syndrome in rabbits and related complications such as osteomyelitis of the mandible and other empyemas of the preformed cavities of the skull (nasal cavities, tympanic bullae), the radiographic exam of the entire skull is of paramount importance.

### **Radiographic projections and normal radiographic anatomy of the head**

The complete radiographic study of the head in rabbits should include one or two latero-lateral (LL), right-to-left and left-to-right latero-oblique (LO), dorso-ventral (DV) (or ventro-dorsal, VD) and rostro-caudal (RC) projections (Capello and Gracis, 2005; Capello and Lennox, 2008). Additional views such as LO with a different degree of obliquity, slight LO in the rostro-caudal direction rather than the standard dorso-ventral, slight obliques from the VD position, VD with the mandible shifted laterally, and intraoral (IO) projections may be useful or required for the radiographic study of a specific patient (Capello and Lennox, 2008). Also, contrast studies of the nasolacrimal duct may be performed if clinical indications are present. Most authors agree that LL is the most useful view (Capello and Lennox, 2008, Raftery, 2013) When evaluating a patient for dental disease, the author considers LL, right-to-left and left-to-right LO, and DV views as essential, and recommends additional oblique and RC views for assessment of specific areas. With the exception of preliminary test radiographs to obtain an overall evaluation, and in cases of extreme anesthetic risk, general anesthesia is mandatory for accurate patient positioning and to avoid motion artifacts. Radiographic anatomy of the head of the rabbit, guinea pig and chinchilla, as well as proper positioning to obtain the five standard projections with the extraoral technique, have been described in detail in the literature (Capello and Gracis, 2005; Capello and Lennox, 2008, Silverman and Tell, 2005). The reader is referred to those references on this subject, for further details.

### **Interpretation of radiographs of the skull**

Correct positioning and diagnostic quality of the LL view is confirmed by perfect superimposition of bilateral anatomic structures, such as the rostral margin of the right and left orbit, optic foramen, tympanic bullae, mandibular processes, and temporomandibular joints (Capello and Gracis, 2005; Capello and Lennox, 2008, Raftery, 2013). The ventral margin of right and left mandibles should appear superimposed. This view should be obtained with the mouth closed and is used to evaluate both the incisor and cheek teeth.

In the rabbit, the mandibular incisor teeth should occlude between the maxillary first and second (accessory) set of incisor teeth. Oblique views are required to determine abnormalities on one particular side.

The cheek teeth (CHT) of rabbits form a regular palisade, and their occlusal plane has a zigzag pattern, due to the interdigitation of mandibular and maxillary teeth and

presence of enamel ridges on their occlusal surface. The dental interproximal spaces of the occlusal surface are virtual, as these teeth are tightly packed together. The reserve crowns of maxillary CHT3-CHT6 are located inside a peculiar bony structure of the rabbit skull called the alveolar bulla, which lies cranial, ventral and medial to the orbital fossa. This anatomical feature plays an important role in the formation of retrobulbar and parabolbar abscesses following periapical infection of those maxillary cheek teeth. The apex of maxillary CHT3 is radiographically slightly dorsal to the apices of the other cheek teeth, following the dome of the alveolar bulla. All mandibular cheek teeth should be at some distance from the ventral cortex of the mandible, which should be visible as a smooth, thick, radiopaque line.

The latero-oblique (LO) views are obtained with the animal in lateral recumbency and the head slightly rotated to avoid superimposition between the tooth apices of right and left sides. The rotation should not be excessive to minimize image distortion. Normally a 15° to 20° rotation is sufficient, unless specific oblique views are necessary, in particular to display part of the masseteric fossa. Right-to-left and left-to-right views should always be obtained for comparison, even if dental disease is suspected only on one side. Right and left reference structures (tympanic bullae, mandibular processes and temporomandibular joints) should appear just dorsal and ventral to each other. If the head is incorrectly tilted in rostrocaudal direction as well (e.g. lifting the nose too much), these structures will appear out of line. A slight oblique projection in the rostrocaudal direction may be desired in selected cases. The LO view allows the evaluation of the reserve crowns and apices of the mandibular cheek teeth of one side (usually the side next to the digital plate) and the maxillary cheek teeth of the opposite side. Also, the apex of each incisor tooth can be better visualized than on LL projection.

Symmetry between right and left sides is critical for proper evaluation of VD or DV projections. These views allow the evaluation of the relationship between the mandible and the skull, and the integrity of the margins of mandibular and maxillary bones. Severe cheek teeth elongation and deformation, bone deformation and perforation may be visualized. The evaluation of the incisor teeth is difficult with this view. A slight oblique projection may be desired in selected cases. Also, the VD projection with the mandible shifted laterally prevents superimposition with part of the maxilla on the contralateral side. This view is useful to evaluate part of the nasal cavity and the maxillary recess.

An adequate rostrocaudal projection is the most difficult to obtain. However, it may give information on cheek teeth prior to intraoral inspection including the occlusal plane angle, presence of spikes and spurs, coronal and apical elongation, and cortical perforation by dental apices. Anisognathism, which is characterized by a narrow mandible and wider maxilla in the rabbit, is easily appreciated with this view.

### **Radiographic abnormalities**

Common radiographic abnormalities of the skull and teeth of the rabbit have been extensively reported, and are summarized below (Capello and Gracis, 2005; Capello and Lennox, 2008; Raftery, 2013). The reader is referred to those references for further detail.

The earliest stage of acquired dental disease (ADD) of cheek teeth in rabbits is elongation of the crowns. Since both the reserve crown and the clinical crown begin to take up more space, abnormalities related to increased pressure begin to occur. The zig-zag pattern of the occlusal plane of cheek teeth is still normal, but the radiolucent line is less visible when the mandible is at rest, even in a proper lateral projection. Pressure on the reserve crowns begins to increase when the animal chews. Since there is not another tooth cranial to the first premolars, they begin to curve, with increasing mesial convexity. In some early cases, slight deformation of the ventral mandibular cortical bone due to the increased pressure may be visible. Due to the



abnormal convexity, interproximal space of mandibular cheek teeth begins to widen. Malocclusion of incisor teeth is usually not present at this stage. Later stages of ADD of cheek teeth demonstrate marked deformation of the ventral aspect of the mandible. the lamina dura is no longer visible, and the radiolucent line representing ventral cortical bone of the mandible appears very thin, or is absent. This radiographic sign indicates that reserve crowns and apices have penetrated the cortical bone. Perforation most commonly involves CHT1 and/or CHT2. Perforation from the apex of CHT3 is possible. Elongation of the reserve crown and perforation from the apex of CHT4 usually involves the cranial part of the masseteric fossa. Detection of these abnormalities requires a proper oblique projection, which should be less than 30 degree oblique for the mesial teeth, and about 30 degree for CHT4. Oblique projections with a 30 degree obliquity or higher may produce an artifact giving a false impression of bone deformity.

In addition to abnormal elongation of crowns, deformities of both clinical and reserve crown become apparent. The crowns curve in both rostro-caudal and in latero-lateral directions, and the tooth may rotate within the alveolus.

A common sequela of excessive coronal elongation of cheek teeth is fracture, especially of mandibular cheek teeth. A common and peculiar lesion is the longitudinal fracture of the mandibular first premolar (CHT1). This often occurs when the rabbit chews inappropriate foods such as seeds or nuts.

The very advanced stage of ADD may be defined as “end stage”. At this stage, the normal radiographic anatomy of the cheek teeth is no longer visible due to advanced dentinal resorption. When present, marked radiolucency of the mandible is due to bone resorption following metabolic bone disease. Clinical crowns of the mandibular cheek teeth are often retained as non-growing remnants. Overgrowth of mandibular cheek teeth still capable of growth occurs due to lack normal occlusion and wearing.

Many rabbits are able to chew and eat soft foods and can survive in good health for years with this severe condition. In these cases, frequent restoration and approximation of a normal cheek teeth occlusal plane is necessary for the rest of the patient's life.

Marked irregular bone calcification may occur in an attempt to counteract abnormal bone resorption. In some cases, root deformation causes painful compression of adjacent nerves. Symptoms range from none to evidence of severe discomfort. Periapical infection is a common sequela of advanced dental disease. One of the most frequently affected site is mandibular CHT1. Due to the proximity of the apex of the lower incisor (mesial) and of CHT2 (distal) to mandibular CT1, one or both of those teeth can be involved as well. Radiographic abnormalities are represented by deformation or rarefaction of the tooth root and/or its apex, deformation of the cortical bone, and radiolucency around the apex of the tooth. The latter sign is consistent with infection and presence of purulent material. A retained fragment of the reserve crown may also be present.

Objective interpretation of dental disease in rabbits, guinea pigs and chinchillas with the use of anatomic reference lines has been described (Boehmer and Crossley, 2009; Boehmer 2015). The use of lines may facilitate diagnosis in selected cases. However, they should only be applied to optimal projections in order to be reliable. In rabbits, frequent exceptions do exist depending on the morphology of the skull in different breeds.

## References

1. Boehmer E. Dentistry in Rabbits and Rodents. Philadelphia: Wiley-Blackwell; 2015.
2. Capello V, Gracis M, Lennox AM (ed). Rabbits and rodents dentistry handbook. Lake Worth, FL, Zoological Education Network; 2005.

3. Capello V, Lennox AM. Clinical radiology of exotic companion mammals. Ames: Wiley Blackwell 2008.
4. Jekl V. Principles of radiography. In: Harcourt-Brown F, Chitty J, eds. Manual of rabbit surgery, dentistry and imaging. 1st ed. Quedgeley, Gloucester British Small Animal Veterinary Association, 2013; 3: 39-58
5. Raftery A. Radiographic interpretation of the skull. In: Harcourt-Brown F, Chitty J, eds. Manual of rabbit surgery, dentistry and imaging. 1st ed. Quedgeley, Gloucester British Small Animal Veterinary Association, 2013; 4: 59-68.
6. Regalado A, Legendre L. Full-mouth intraoral radiographic survey in rabbits. Journal of Veterinary Dentistry 2017, 34(3) 190-200
7. Silverman S, Tell LA. Radiology of rodents, rabbits and ferrets. An atlas of oral anatomy and positioning. St. Louis: Elsevier Saunders; 2005.

## **Orthopaedic techniques and fracture repair in exotic companion mammals**

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

### **Introduction**

Orthopedic lesions are common in small exotic mammals such as rabbits, rodents and mustelids (ferrets and skunks), which are increasing in popularity as household pets (Helmer and Lightfoot, 2002; Capello, 2006). Most lesions are traumatic in origin, typically the result of having been dropped by the owner, stepped on, or sat on. Falls from heights are common and are often a result of improper handling and restraint. Injuries can also result from attacks from other animals (Capello, 2006).

Rabbits, chinchillas, and other small rodents like hamsters suffer injuries secondary to entrapment in cages (Helmer and Lightfoot, 2002; Capello, 2006; Mans and Donnelly, 2012). The inquisitive nature of the pet ferret can lead to “high rise syndrome” following falls from apartment terraces (Capello, 2006; Capello 2009).

Most traumatic lesions are bone fractures, occurring most frequently to long bones (Capello, 2006).

### **Clinical exam of the orthopaedic patient**

If an overall body trauma occurred, the presenting animal should be considered a trauma patient. Shock, any thoracic and/or abdominal lesions and potential bleeding must be addressed and treated immediately before the orthopedic evaluation (Capello, 2006).

With the exceptions of orthopedic injuries directly impacting the central nervous system (spinal fractures), respiratory system (severe fractures of the ribs), and/or open fractures, bone and articular lesions are not a true emergency, and the owner must be advised that primary repair may be delayed until the patient is stabilized (Capello, 2006).

Fractures of the distal portions of the limbs are often open fractures due to the lack of significant soft tissue, especially in rabbits and rodents (Capello, 2006; Zehnder and Kapatkin, 2012). Open fractures are often hidden by thick fur, which necessitates careful examination, especially in the case of grade I and grade II open fractures. Grade III open fractures are prone to osteomyelitis, and the risk for nonunion or other complication post-fixation is higher.

Open fractures must be managed with strict aseptic technique, even in cases of highly contaminated wounds. Careful fur clipping around the wound is mandatory before the evaluation (Capello, 2006; Zehnder and Kapatkin, 2012).

In unstable trauma patients, survey radiographs in the unanesthetized animal can be performed to rule out other lesions and to confirm the presence of fractures. When the patient is stable, complete evaluation of the fracture is performed with at least two basic projections (lateral and antero-posterior) (Capello, 2006; Capello and Lennox, 2008). Additional oblique projections may often be helpful.

Due to smaller size, good to excellent quality radiographs are essential and they should be accomplished with the patient under general anesthesia (Capello, 2006; Capello and Lennox, 2008; Zehnder and Kapatkin, 2012).

Temporary external coaptation with splints or padded bandages may be indicated for some fractures (Zehnder and Kapatkin, 2012). However, in certain species, body type and location, some open fractures cannot be aseptically bandaged until primary repair is performed. In these cases, strict cage confinement is often the only reasonable option. Patients are best confined in wireless cages such as plastic containers to prevent climbing and further entrapment and damage to the fractured limb (Capello, 2006).

### **Common fractures in rabbits**

The most common fractures of pet rabbits are fractures of the hindlimb (Helmer and Lightfoot, 2002; Rich 2002; Capello, 2006). Among these, fractures of the tibia and fibula are the most frequent. These usually occur when the foot becomes trapped in the cage, or while the animal is running on smooth surfaces such as indoor flooring. Diagnosis of complete fractures of the tibia is straightforward, because lameness and foot deviation are usually very obvious at the clinical exam.

Rabbit cortical bone is thinner than in dogs or cats (Zehnder and Kapatkin, 2012). Bones are brittle, and comminuted fractures of the tibia are common (Varga, 2014), especially distal fractures (Capello, 2006; Capello and Lennox, 2008). The short distal fragment makes fixation of these fractures challenging.

Femoral fractures in pet rabbits are frequent as well (Zehnder and Kapatkin, 2012). They usually occur after a fall or when the rabbit is inadvertently stepped on. Main proximal and distal bone fragments are usually significantly displaced because of the strong musculature (Zehnder and Kapatkin, 2012). In case of distal fractures, A cranio-caudal projection is mandatory to diagnose or rule out condylar or bicondylar fractures (Capello and Lennox, 2008), as articular fractures are particularly severe.

Fractures of the radius and ulna in pet rabbits usually occur after improper handling (when the rabbit is lifted held by the forelimbs), after jumping down, or after a fall from height. These fractures are more likely to be open because of the limited soft tissue coverage in that area (Zehnder and Kapatkin, 2012).

Humeral fractures in pet rabbits usually occur after a fall from a height or other blunt trauma. Patients with this fracture type should always be checked for the presence of thoracic trauma.

Many other common fractures occur in pet rabbits, such as fractures of the pubis and of the ischium, vertebral fractures and fracture of the phalanxes. Surgical repair of most of them is from very difficult to impossible.

Repair of fractures secondary or concurrent to metabolic bone disease should be carefully considered, as the bone cortices are unable to support insertion of pins. In most cases, fixation by splinting or simple cage rest are the only options.

### **Common fractures in rodents**

The most common fractures in pet rodents are fractures of the tibia and fibula (Conn 2000; Capello, 2003; Hollamby, 2009; Mans and Donnelly, 2012; Zehnder and Kapatkin, 2012). Similar to rabbits, these usually occur when the foot is trapped in cage wires.

Clinical signs of lameness in pocket rodents are not easily detected by the owner. Therefore it is not uncommon to diagnose an old fracture long after the bone has healed.

### **Common fractures in mustelids**

Events leading to fractures of the limbs in pet ferrets and skunks are very similar to those occurring in dogs and cats and in most cases the fractures are similar as well (Ritzman and Knapp, 2002; Capello 2009). The most frequent are complete fractures of the femoral shaft, comminuted or non-comminuted.

Fractures of the forelimb are also encountered in ferrets, especially following falls from height. Fractures of the radius and ulna are more frequent than humeral fractures.

### **Treatment of fractures and methods of fixations**

External coaptation may be used effectively as a definitive orthopedic treatment for closed fractures (Zehnder and Kapatkin, 2012). This method works better for simple fractures affected by bending and rotational forces because bone fragments may remain in contact and reduced. Fractures affected by compressive forces such as oblique and comminuted fractures are poorly immobilized with external coaptation



(Zehnder and Kapatkin, 2012). Splinting of tibial fractures in chinchillas may or may not provide adequate stability (Mans and Donnelly, 2012; Zehnder and Kapatkin, 2012). Malleable materials (when heated in boiling water) available for dogs and cats adapt to any shape and work best when used in a half cast with a light modified Robert-Jones bandage (Zehnder and Kapatkin, 2012).

Among the methods of definitive stabilization, intramedullary pinning rarely provides enough rigidity because they primarily resist bending forces but do not counteract other forces, in particular rotation forces (Zehnder and Kapatkin, 2012). However, it may be the only effective option for small rodents such as hamsters (Capello, 2003; Capello and Lennox, 2008). The intramedullary pin should fill about 70% of the diameter of the medullary cavity.

Bone plating is not frequently feasible due to the small size of the bones and the thin cortices when compared to the screws available (especially in rabbits and rodents) (Capello, 2006; Zehnder and Kapatkin, 2012), and the high costs. A study demonstrated that screw insertion caused cortical fractures in a rabbit model (Barron et al, 2010).

External skeletal fixation (ESF) is the most common method of fracture repair in small mammals (Capello, 2006; Zehnder and Kapatkin, 2012). As this method of fixation allows stability without involving the fracture site, the main indications for ESF are comminuted or highly comminuted fractures where intramedullary pinning is not feasible, and open fractures. In general, external fixation allows proper stabilization against all the forces acting on the fragments in the three directions of the space: both latero-lateral and cranio-caudal bending forces, and rotational forces.

These advantages are particularly important in small mammals, where postoperative control of excessive movement is much more difficult than in dogs and cats.

### **Basic principles of external fixation and insertion of pins**

Basic principles for applying external fixators are similar in all species (Brinker et al., 1990; Capello, 2006; Zehnder and Kapatkin, 2012). Dealing with small mammal orthopedic surgery, the surgeon must have an excellent knowledge of surgical anatomy of the exotic species treated (Capello, 2006).

The pins should be inserted into the bones in such a way to minimize negative impact on soft tissues such as vascular and nervous structures. Pins must also not interfere with the body wall.

Due to the normal physiologic hyperflexed position of the hindlimb in rabbits and chinchillas, a unilateral external fixator is better placed on the lateral aspect of the tibia rather than the medial side, where it can interfere with the lateral abdominal wall and the genitalia of male animals.

Strict aseptic technique is mandatory, despite the fact it is often more difficult in small animals. Shaving of fur and surgical scrubbing must be performed very carefully in rabbits and rodents to prevent damage of the very thin and delicate skin in these species. Excessive scrubbing can lead to severe inflammation of the skin, which could result in postoperative complications.

The proper insertion of pins has to be performed according to accepted basic principles:

- pins must be inserted through at least two cortices. The ideal angle of insertion should be 70 degrees to the longitudinal axis of the bone, toward the center of the bone fragment. This angle increases the resistance of the pin, when compared to pins inserted perpendicularly to the axis.
- This angulation is often not feasible in small exotic mammals, and parallel insertion of pins may be the only option.
- Pin size should not exceed 30% of the bone diameter. This necessitates the use of pins often as small as 0.8 to 1.5 mm in small exotic mammals.
- Pins must be inserted along a single plane to allow connection with a single external rod.

- A minimum of two pins is needed for each fragment, and three is even better. However, it is often impossible to insert more than two pins per fragment in small exotic mammals.
- Maximal stability is accomplished by inserting the pins proximally and distally in each fragment. The insertion too close or too far to the fracture site is incorrect.

### **Configurations of external fixators**

Pins can be inserted and connected with external rods forming a number of different configurations. Each of them provides different types and levels of stabilization (Ritzman and Knapp, 2002; Capello, 2006; Barron et al, 2010). The basic configurations are: monolateral, bilateral on the same plane, biplanar, and tridimensional.

ESF can be used in conjunction with other methods of fixation (pins, screws, cerclage wires). The most common combined technique is external fixation with intramedullary (IM) pinning. Since in this configuration the goal of the EF is to provide anti-rotational stability, a single pin per fragment is adequate. The use of an IM-pin-tie-in technique is useful in some of the larger small mammals, and has been reported in rabbits (Pignon, 2015) and ferrets (Capello, 2006; Capello 2009).

### **Instruments and materials**

Kirschner wires (commonly called pins) can be smooth or threaded. Threaded pins are much more secure and are extremely unlikely to become loose during the postoperative period (Capello, 2006; Zehnder and Kapatkin, 2012). The sizes commonly used in small exotic mammals ranges from 0.8 mm. to 1.5 mm. Pins used as a connection bar are usually 2.0 mm or larger.

A low-speed power drill (about 150-300 rpm/min) is the best option for insertion of pins (Capello, 2006; Zehnder and Kapatkin, 2012). The risk of thermal injury to cortical bones is less than the risk of excessive mechanical forces applied using a hand chuck. Also, manual insertion causes wobble and leads to premature loosening of the pins (Zehnder and Kapatkin, 2012). However, hand chucks can be useful in very small exotic mammals where the weight of the power drill alone can produce excessive, harmful movements to the whole limb, not to mention the whole patient during the insertion of pins.

Many different types of clamps for connection of the pins to the bar are currently available. Each size clamp usually matches one rod size, and two or three different pin sizes.

Clamps weight differently according to its composition metal alloy, therefore the lightest should be chosen for exotic mammals.

A combination wrench and angled open socket wrench are needed to tighten the screw bolts of the clamps.

Shears are needed to cut Kirschner wires and rods to the proper length.

Polymethylmethacrylate is frequently used in exotic animal orthopaedics to connect the pins to the bars. The paramount advantage is to significantly reduce the weight of the ESF implant.

A tubular, very light external fixator device has gained popularity for orthopedics of small exotic patients (Hernandez-Divers, 2017). The *Fixateur du Service de Santé des Armées* (F.E.S.S.A.) was developed by the French Army as a lightweight external fixator for repair of human metacarpal and phalangeal fractures. The F.E.S.S.A. connection bars are made of lightweight, autoclavable and reusable stainless steel. The tubular bars present many holes serving as a guide for accurate insertion of pins even a few millimetres apart, in both parallel or angled fashion. Pins are then secured to the bars using small screws instead of traditional bolts.

### **Insertion of pins and positioning of clamps**

According to the basic principles of external fixation, proper insertion of pins must follow certain guidelines (Brinker et al., 1990; Capello, 2006).

- The first pin is inserted through the lateral and medial bone cortices in the proximal end of the proximal fragment.
- The fracture is then reduced, and the second pin is inserted at the distal end of the distal fragment. It is mandatory to insert these two pins on the same plane of the femoral shaft.
- The two pins are connected to the rod with two clamps. This way, primary stabilization of the fracture can be accomplished, facilitating the insertion of the other two pins.
- The third pin is inserted at the distal end of the proximal fragment, not too close to the fracture site. The rod helps to insert the pin on the same plane as the other two pins.
- The fourth pin is inserted at the proximal end of the distal fragment, not too close to the fracture site.

Another option is to pre-place two other clamps; this will allow the perfect insertion of the first two pins on the same plane.

### **Follow-up**

Adequate post-surgical recheck examinations are of paramount importance. Owners should be clearly instructed about husbandry and management, and patients should be closely monitored after application of an EFS device. Many factors (such as patient's age, type of fracture and anatomical position, and damage to the vascular support) affect bone healing and optimal removal time of an external fixator. Control radiographs should be taken during the postoperative period. The ideal time to remove external fixators is 6 weeks (Zehnder and Kapatkin, 2012).

### **Complications**

The most common complications of external fixation are similar to those experienced in non-exotic mammals, such as delayed union and nonunion, and osteomyelitis (Capello, 2006; Zehnder and Kapatkin, 2012). In small exotic mammals other complications include injuries to soft tissues caused by the EF device, and fractures or other severe lesions due to the entrapment of the device itself with furniture. Those usually happen when the EF is not adequately protected, or when the protective bandage is removed by the pet.

Loosening of the pins and/or the rod can occur with improper placement of the EF device, weak fixation with clamps or methacrylate, and/or improper post-operative management. Inadequate stabilization is usually a consequence of loosening of the pins and the rod, which can result in delayed union, nonunion, or break down of the healing fracture site. Because of their small size and light weight, most exotic mammals seem to tolerate limb deformities very well (Zehnder and Kapatkin, 2012), as long as they do not represent a predisposing factor for pododermatitis or other skin lesions.

### **Amputation**

Limb amputation in exotic companion mammals may be necessary when bony or soft tissue lesions cannot be managed with orthopedic surgery or splinting; when osteomyelitis following open fractures or surgical failure would occur; and in case of neoplasia (Helmer and Lightfoot, 2002; Capello 2009; Mans and Donnelly, 2012; Zehnder and Kapatkin, 2012; Varga, 2014). Amputation has been successfully reported and well tolerated in many different species (Capello, 2003; Kottwitz, 2005; Burcham, 2006), either for the forelimb and hind limb, even if the latter is more frequent. Prognosis of every single case should be discussed depending on the species, husbandry, and patient conditions. Amputation of the forelimb in rodent

species having cheek pouches might lead to impaction of the ipsilateral cheek pouch. The level of amputation depends on the injury, and surgeon's preference. Usually cosmetic appearance is not a concern for very small and fully furred mammals.

### **Miscellaneous orthopaedic conditions**

Elbow luxation is a relatively common condition seen in pet rabbits and ferrets (Zehnder and Kapatkin, 2012). In rabbits, most cases can be treated with simple reduction under general anaesthesia and rest in cage; in ferrets splinting or surgical reduction may be necessary.

Luxation of the hip joint is relatively frequent in rabbits, both primarily traumatic and secondary to hip dysplasia. The latter is probably due to underlying metabolic bone disease. Both conservative and surgical treatment have been reported (Capello, 2008; Coleman and Palmer, 2015). Fracture of femoral head and neck, and related surgical ostectomy has been reported by the author in a ferret and a guinea pig (Capello, 2008). Various degrees of degenerative joint disease is frequent in guinea pigs, especially in young patients suffering from vitamin C deficiency.

### **References**

1. Barron HW, McBride M, Martinez-Jimenez D et al. Comparison of two methods of long bone fracture repair in rabbits. *J Exot Pet Med* 2010;19:183-188.
2. Brinker WO, Piermattei DL, Flo GL, Handbook of Small Animal orthopedics and fracture treatment, 2nd ed. Saunders, 1990.
3. Burcham JC. Hindlimb amputation in a gerbil. *Exotic DVM* 2006, 8(4): 11-12.
4. Capello V. Surgical techniques in pet hamsters. *Exotic DVM* 2003, 5(3): 32-37.
5. Capello V. External fixation for fracture repair in small exotic mammals. *Exotic DVM* 2006, 7(6): 21-37.
6. Capello V, Lennox AM. Clinical radiology of exotic companion mammals. Ames: Wiley Blackwell 2008.
7. Capello V. Femoral head and neck ostectomy in selected exotic mammal species. *Exotic DVM* 2008, 10(1): 21-26.
8. Capello V. Ferrets: common surgical procedures. In: BSAVA Manual of Rodents and Ferrets, Keeble E, Meredith A (Eds.). Gloucester, UK: BSAVA, 2009. pp. 254-268.
9. Coleman KA, Palmer RH. Femoral head and neck ostectomy for surgical treatment of acute craniodorsal coxofemoral luxation in rabbits. *J Exot Pet Med* 2015;24:178-182.
10. Conn M. Tibial fracture in a Guinea Pig. *Exotic DVM* 2000, 2(5): 5.
11. Helmer PJ, Lightfoot TL, Small exotic mammal orthopedics. *Vet Clin North Am Exot Anim Pract*, 2002; 5:1, 169-182.
12. Hernandez-Divers SJ. Application of F.E.S.S.A. External fixation for long bone fractures in birds. In: Proceedings of the Association of Avian Veterinarians. Providence (RI): 2007, p. 43-47.
13. Hollamby S. Rodents: neurological and musculoskeletal disorders. In: BSAVA

Manual of Rodents and Ferrets, Keeble E, Meredith A (Eds.). Gloucester, UK: BSAVA, 2009. pp. 161-168.

14. Kottwitz J. Midfemoral pelvic limb amputation in a chinchilla. *Exotic DVM* 2005, 7(4): 31-34.

15. Mans C, Donnelly TM. Disease problems of chinchillas. Quesenberry KE, Carpenter JW, eds. *Ferrets, Rabbits and Rodents: Clinical Medicine and Surgery*. 3rd ed. St. Louis, MO: Elsevier/Saunders; 2012:311–325.

16. Pignon C, Parent A, Moissonnier P. Use of Tie-In Technique to Repair Tibia Fracture in Rabbits. *Proceedings of the 3rd ExoticsCon*. San Antonio, TX: 2015, p. 383.

17. Rich GA, Rabbit orthopedic surgery: *Vet Clin North Am Exot Anim Pract*, 2002; 5:1, 157-168.

18. Ritzman TK, Knapp D, Ferret orthopedics. *Vet Clin North Am Exot Anim Pract*, 2002; 5:1 129-155.

19. Varga M. Neurological and Locomotor Disorders. In Varga M (ed): *Textbook of rabbit medicine*. Butterworth Heinemann Elsevier; 2014, pp 467-389.

20. Zehnder A, Kapatkin AS. Orthopedics in small mammals. Quesenberry KE, Carpenter JW, eds. *Ferrets, Rabbits and Rodents: Clinical Medicine and Surgery*. 3rd ed. St. Louis, MO: Elsevier/Saunders; 2012:472–484.

## **Surgical treatment of odontogenic abscesses in pet rabbits**

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

### **Anatomy and surgical anatomy**

#### *Mandible*

The topographic anatomy outlines three portions of the rabbit mandible (Popesko et al, 1992; Capello, 2016).

The incisive part, where the two mandibles are joined rostrally by the mandibular symphysis. This portion includes the reserve crown and apex of the incisor teeth.

The body of the mandible. It includes the reserve crowns and apices of the premolar and molar teeth.

The masseteric fossa and the branch of the mandible, with the condylar process. The area of the masseteric fossa is very thin, because it accommodates the masticatory muscles in a double groove both laterally and medially. The masseter muscle, positioned laterally, is composed of two main layers (the superficial and the deep part) and is of particular surgical interest.

#### *Maxilla and skull*

The alveolar bulla is a unique bony structure specific to rabbits, which includes the reserve crowns and apices of the four distal (caudal) maxillary cheek teeth (the 3rd premolar, and the three molar teeth, i.e. CHT3 through CHT6) (Capello and Gracis, 2005). Reserve crowns of the first two premolars (CHT1 and CHT2) are located more rostrally and outside the alveolar bulla. The dome of the alveolar bulla is adjacent to the cranioventral aspect of the orbital fossa, and caudolaterally adjacent to the lacrimal bone (Capello, 2016).

Rabbits have three main lacrimal glands (gland proper, accessory lacrimal gland, and the gland of the nictitating membrane) of which two are divided into multiple lobes (Popesko, 1992; Harcourt-Brown, 2002; Capello 2016). The lacrimal gland proper is located in the caudodorsal area of the orbit. The accessory lacrimal gland is much larger and divided into three lobes: the orbital, the retro-orbital, and the infraorbital. The gland associated with the nictitating membrane is commonly referred to as the Harderian gland and is divided into the superficial gland and the deep gland (Capello, 2016).

The nasolacrimal duct runs from the orbital fossa to the nasal cavity. It curves medially, passes through the infratrochlear incisure and the foramen of the lacrimal bone, and enters the bony nasolacrimal canal medial to the maxillary bone, being adjacent to the maxillary recess (Van der Woerd, 2004; Capello, 2014).

The conchae, also called nasal turbinates, are highly convoluted cartilaginous membranes covered by mucosa filling the nasal cavities. They outline empty spaces (meatuses) and blind cavities (recesses) (Capello, 2014). The paranasal cavities of rabbits are represented by the paired dorsal conchal, the sphenoidal, and the large, double-chambered maxillary recesses (Casteleyn et al, 2010; Capello, 2014).

The tympanic bulla is well developed in rabbits. Unlike the alveolar bulla, it is a normally cavity bone located caudally and laterally at the base of the skull (Popesko, 1992; Capello et al, 2015). The tympanic bulla communicates laterally with the ear canal entering the alveolar bulla through the external acoustic meatus (but separated by the tympanic membrane); and medially with the pharynx through the Eustachian tubes.

## **Clinical presentation**

Facial abscesses appear as large masses usually located at the ventrolateral aspect of the mandible or the lateral aspect of the maxilla (Capello and Lennox, 2012, Capello 2016). Some rabbits may exhibit an obvious unilateral exophthalmos. Abscesses are typically cool and non painful upon palpation. Early small masses are usually missed by the owners because of their location and the presence of fur, especially in long-haired rabbits. However, they may increase to considerable size. Occasionally, part of the overlying skin can be necrotic, and a fistula or rupture may occur.

## **Pathophysiology and clinical considerations**

Periapical infections represent the most common complications of acquired dental disease in pet rabbits. They comprise a considerable portion of the acquired and progressive dental disease syndrome (ADD). Due to the specific anatomy of rabbit teeth, and the relationship between the reserve crown and the adjacent alveolar bones, periapical infections may often quickly involve surrounding bone and adjacent soft tissues, producing abscess(es) and osteomyelitis.

Facial abscesses can be single or multiple, or multilobulated within a single entity. They are typically surrounded by a thick and well developed capsule, and contain white, creamy pus (Capello and Lennox, 2012, Capello 2016).

Patients lacking intraoral lesions and evident malocclusion are usually able to eat normally. Pain can be elicited on palpation at the bony infection site but is usually absent upon palpation of the mass. In regard to further complications such as extensive osteomyelitis or exophthalmos, the range of clinical signs and symptoms is even broader. Most patients with end stage dental disease complicated by chronic, extensive osteomyelitis may produce very large and multiple facial abscesses which can rapidly progress to weight loss and emaciation if aggressive treatment is not pursued. However, other animals with single or multiple foci of osteomyelitis and/or empyemas may live for several years in fair overall health.

Periapical infections and osteomyelitis represent a septic inflammatory process; however, they do not elicit hyperthermia. Also, the local infection tends to be encapsulated (while it progressively destroys the surrounding bone), and this likely plays a critical role for the antimicrobial treatment alone being ineffective.

Advanced ADD (coupled with specific anatomic features of the rabbit skull) may also elicit the formation of empyemas (Capello, 2016). An empyema is defined as a collection or gathering of pus within a naturally existing anatomic cavity. It is different from an abscess because the latter is a collection of pus in a newly formed cavity surrounded by a capsule. The rabbit skull has at least three preformed anatomic cavities that may be involved following ADD and bacterial complications: the nasal cavity with its meatuses, the maxillary recess, and the tympanic bulla. A fourth bony cavity of the skull can also be affected by empyema: the alveolar bulla. Although this preformed cavity is not normally empty, as it includes the reserve crowns of maxillary CHT3-CHT6, in the case of dental disease or tooth extraction, it can be enlarged and/or partially empty, acting as a pathologic cavity (without a capsule) and therefore be affected by an empyema. The anatomical features and the small size of the skull and teeth of rabbits make the dental and/or the surgical treatment difficult in general. In select advanced or complicated cases, it can be very challenging. The presence of the orbit and the eye globe makes surgical access especially more difficult when treating certain maxillary abscesses.

## **Prognosis**

The vastness of complications leading to facial abscesses, empyemas, and possible further involvement of facial structures makes discussion of prognosis in general, virtually limitless and impossible. Prognosis should therefore be tailored to the specific patient and case (Capello, 2016).

The first critical element for a proper prognosis is diagnostic accuracy (Capello and Cauduro, 2016). The diagnosis must be correct and as detailed as possible, specifically in regard to dental and bony involvement. Therefore diagnostic imaging, both standard (radiography, oral endoscopy) and advanced (computed tomography, magnetic resonance) is of paramount importance.<sup>6</sup>

Several practical, even non-medical, factors should be considered when formulating the prognosis. They include the management during the postoperative period, the owner's understanding and compliance (in particular with regard to advanced and chronic disease), and cost.

Because of enhanced diagnostic imaging, improved surgical techniques, and overall treatment advances, prognosis is much more favorable even for complex cases, than it was believed just a few years ago. Rabbits can show surprising improvements after facial surgery, and even chronic cases can be managed for years with a good quality of life (Capello 2016).

### **Medical treatment vs. surgical treatment. The role of the osteomyelitis**

Because periapical infection, osteomyelitis, and abscesses are bacterial infections, antimicrobial therapy is indicated (Capello and Lennox, 2012). The best therapeutic choices come from culture/sensitivity, keeping in mind that the core of the abscess is usually sterile and that a portion of the capsule should be submitted for sensitivity; that anaerobic organisms are frequently involved therefore different culture techniques should be pursued; and taking into consideration the potential toxicity of many common antibiotics in rabbits (Tyrrel et al, 2002; Gardhouse, 2015).

Nevertheless, with the exception of some anecdotal reports, no clinical trials have demonstrated that medical therapy alone is effective. In addition to antibiotic therapy, the key points of medical treatment should include supportive (fluids and nutrition with assisted feeding formulas for herbivores) and analgesic therapy when indicated. Both should be tailored for every patient, as many of them have a normal appetite even in the presence of an abscess, and may exhibit little to no symptoms of pain. Medical and supportive treatment is critical for debilitated patients prior to surgical intervention, and in general when gastrointestinal complications are present following reduced food intake. Rabbits typically resume eating well soon after a dental or extraoral surgical treatment, and exhibit noticeable improvement even after an aggressive surgery, as compared to the clinical conditions prior to the surgical treatment of the abscess.

### **Principles of surgical treatment**

The surgical treatment of facial abscesses has been extensively reported in the literature. All the three distinguishing traits of periapical infections and abscesses of rabbits (the presence of a capsule, the osteomyelitis, and the diseased dental and bony tissue acting as a sequestrum) must be pursued and addressed in order to obtain a long-term therapeutic success and prevent frequent recurrence. The combined dental and surgical treatment is designed to remove the entire capsule, the affected tooth/teeth, and to thoroughly debride the osteomyelitic bone (Capello and Gracis, 2005; Capello and Lennox, 2012; Capello 2016). This ultimately facilitates the efficacy of antibiotic therapy.

Various surgical options have been reported beyond the simple (and usually ineffective) incision of the abscess followed by flushing of the purulent content. Minimal surgical debridement, without removing the entire capsule, has been reported as an effective treatment option in rabbits with dental abscesses (Taylor et al, 2010). This technique involves the incision of the abscess, minimal debridement and cleaning of the abscess cavity, and packing the cavity with strips of 3- to 5- mm-diameter sterile gauze impregnated with antibiotics, most commonly ampicillin or clindamycin. Rabbits are concurrently treated with systemic antibiotics such as trimethoprim and metronidazole, enrofloxacin and metronidazole, or azithromycin. This procedure may



be an option in rabbits with minimal osteomyelitis. However, efficacy in rabbits with extensive bony involvement is not known.

Excision of the entire abscess may be followed by either primary closure after packing of the surgical site with AIPMMA beads (Divers, 2000) or marsupialization (Capello and Gracis, 2005; Capello and Lennox, 2012; Capello 2016). Additional local treatment of the open site has been reported in many different ways including packing with calcium hydroxide (Remeeus and Verbeek, 1995), honey (Harcourt-Brown, 2002) or Intrasite gel (Smith&Nephew, London, UK) (Harcourt-Brown and Chitty).

Marsupialization of the soft tissues around the area of the affected bone is the author's treatment of choice for more than 20 years because this procedure is associated with a high percentage of successful outcomes and long-term postoperative follow-up, particularly in cases of deep or severe osteomyelitis, which are common. Ideally, the surgical technique should allow postoperative flushing and debridement of the surgical site, application of antiseptics or other products to promote healing, and allow constant direct monitoring of healing. This method is based on the same basic principles of orthopedics when a grade III open fracture and an osteomyelitic site are present. The fracture repair is usually performed with an external fixation technique and the infected site left partially exposed. Marsupialization of the surgical site allows these same surgical principles in cases of osteomyelitis of the maxilla and mandible.

Hospitalization for management of the wound during the first days, a longer postoperative period, frequent rechecks, temporarily unattractive cosmetic appearance, and significant owner commitment should be discussed with the owner prior to surgery (Capello, 2016)

### **Abscesses and osteomyelitis of the Mandible**

#### *Periapical infection of mandibular premolar teeth and focal osteomyelitis of the body of the mandible*

Following induction of general anesthesia, the patient is maintained via orotracheal intubation and positioned in dorsal or lateral recumbency, depending on the location of the abscess. Adjunct local anesthesia can be achieved by performing local nerve blocks of the mental and the inferior alveolar nerves (Lennox, 2008). The surgical site is shaved, aseptically prepared and draped. Transparent or semitransparent drapes are preferred as they facilitate visualization of the orientation of the head. A skin incision is made over the mass, preserving the capsule and taking care to not enter the underlying abscess. The subcutaneous tissue and muscle layers are bluntly dissected to expose the capsule of the abscess. The junction between the capsule and the underlying cortical bone is dissected with a scalpel blade or sharp scissors. The wall of the abscess is entirely removed, including thin bone when cortical reaction is present. A small portion of the capsule is submitted for culture and sensitivity testing, as the purulent material inside is often sterile. The purulent exudate is removed using cotton tip applicators, and the bone cavity is thoroughly flushed using saline or 0.1% chlorhexidine solution. The infected or necrotic cortical bone is debrided using a bone curette. If present, the fragment of the diseased tooth/teeth is meticulously worked with small dental elevators or contoured needles to free the attachment to the bone, and extracted. In some cases, the tooth fragment is ankylotic to a small piece of necrotic alveolar bone. The bone cavity is again flushed as described above. Marsupialization of the soft tissues around the surgical site is performed using 3-0 or smaller non-absorbable suture material.

#### *Periapical infection of mandibular incisor teeth and osteomyelitis of the incisive portion of the mandible*

The involvement of the incisive portion of the mandible is usually less frequent because both inspection and extraction of incisor teeth are easier than for premolar teeth. The surgical technique is similar to the previous description; however the approach is

slightly more cranial. Due to anatomic proximity, periapical infection of a mandibular incisor tooth may be associated with periapical infection of the ipsilateral first premolar (CHT1), making the approach combined.

Extensive osteomyelitis involving the incisive portion (uni- or bilaterally) may create large and challenging ventral abscesses firmly attached to underlying bone. They require deep and thorough debridement.

#### *Periapical infection of distal molar teeth and osteomyelitis of the masseteric fossa*

The most distal (caudal) mandibular cheek teeth (CHT4 and CHT5) can be affected by abnormal elongation of the reserve crown and periapical infection. CHT5 is rarely primarily involved but is frequently involved in conjunction with CHT4. Due to the normal curvature of their reserve crown, the apices of those teeth lie just cranial to the borderline between the body of the mandible and the masseteric fossa. In the case of dental disease of those teeth, caudal elongation of the reserve crown and perforation of the cortical bone occurs at the cranial aspect of the masseteric fossa. The periapical infection and the abscess develop beneath the masseter muscle, leading to a retromasseteric abscess.

The surgical treatment of a retromasseteric abscess is more challenging than a standard mandibular abscess involving the two more cranial portions of the mandible. The basic principles are similar, but in this case the abscess capsule lies beneath the double layered masseter muscle, and the underlying thin bone is often lytic and perforated. Deep and thorough debridement of the diseased bone is not always feasible, and the risk of intraoperative complications (i.e. fracture of the mandible during the debridement of the osteomyelitic bone) is higher. Computed tomography (CT) is highly recommended before this surgery to evaluate the position of the diseased reserve crown, the extent of the lysis, and to rule out possible fracture of the branch of the mandible. Intraoral extraction of CHT4 and CHT5 should be attempted before the extraoral surgical procedure. However, complete extraction is unrewarding in most cases because the clinical or the reserve crown usually fracture due to ankylosis of the elongated reserve crown.

The skin incision over the swelling is performed with an oblique dorsoventral and craniocaudal direction. After gentle retraction of the skin, the superficial zygomatic muscle is exposed. Blunt dissection and retraction allows exposure of the aponeurosis covering the superficial part of the masseter muscle. The aponeurosis is then dissected and retracted to expose the body of the superficial masseter. The superficial and the deep part are then dissected and retracted as well, until the white capsule of the abscess is exposed. The retromasseteric capsule is usually thinner than in other abscesses. The capsule is opened and removed along with the abundant pus. The diseased tooth or its remainder is extracted, while thorough debridement of the surrounding bone may not be feasible because it may be very thin and lytic. Although the function of the masseter muscle would be affected after the complete incision and marsupialization, chewing does not seem to be affected. Food is masticated primarily in a horizontal or lateral plane by only one side of the cheek teeth at a time; therefore, the rabbit is able to chew with the contralateral muscle/teeth functional unit.

#### *Extensive osteomyelitis of the mandible*

Rabbits affected by advanced to end stage dental disease may be presented with extensive osteomyelitis of the mandible. Typically, two different stages of this condition can be encountered: (1) extensive osteomyelitis of the mandible involving the incisive portion and the body of the mandible, without involvement of the masseteric fossa, or (2) extensive osteomyelitis of the mandible involving the incisive portion, the body of the mandible, and the masseteric fossa.

In those cases where most of the supporting bone is lytic and “moth-eaten”, usually with additional multi-lobed abscesses, thorough debridement would not be sufficient to stop the infection. The involved portions of the mandible should be removed en-bloc. In

the most common cases where the masseteric portion of the mandible is still unaffected and intact, unilateral rostral (partial) mandibulectomy can be a feasible treatment option, even if challenging. In the second case, the surgical options can be subtotal unilateral mandibulectomy with transverse resection of the branch of the mandible, or total mandibulectomy. For these cases, CT is mandatory to make a proper prognosis and a surgical plan. Mandibulectomy has also been reported in case of mandibular neoplasia (Miwa, 2006).

### **Postoperative care**

Marsupialization allows postoperative flushing and treatment, and will facilitate healing by second intention, reducing the risk of recurrence. Despite exposure of part of the deep bone, marsupialization is well tolerated by rabbits, and typically they do not need an elizabethan collar or assisted feeding, being usually able to eat the day after surgery. Antibiotics and analgesics are administered as routine. Occasionally, anorexic rabbits must be encouraged to eat. Commercially available assist feeding products for herbivores are excellent for this purpose. Adjunct fluid therapy may be necessary in some patients.

The local postoperative treatment consists of flushing the surgical site twice daily with further gentle debridement, applying antiseptics or other products to promote healing (Capello and Gracis, 2005; Capello, 2016). This wound care can be performed with gentle restraint and without the use of sedation or anesthesia. Most owners, following adequate instructions from the veterinarian, are able to perform part of the local treatment at home.

When a layer of granulation tissue begins to cover the exposed bone, the marsupialization suture is removed from the marsupialization site (typically 4-7 days postoperatively). At 3 weeks post surgery, the bone cavity fills with new connective tissue and other deep soft tissues are usually healed. Approximately 4 weeks after surgery, the overlying skin will completely heal. Slow healing by secondary intention is also critical in cases of simultaneous extraction of one or two cheek teeth, where suturing the gingiva may be very difficult to impossible. In these cases, the alveolus may become impacted with food if the extraoral access is completed with a suture. Marsupialization actually allows flushing of the intraoral-extraoral fistula through the cutaneous opening, until the fistula will close after healing of the gingiva, of extraoral soft tissues, and apposition of new bone.

Intensive postoperative care of the wound should be performed with special care after marsupialization of the masseter muscle. Temporary exposure of the masseteric fossa leads to formation of a fistula that eventually heals by second intention.

Edema of surrounding tissues expected to some extent during the first days after rostral mandibulectomy. Complications include edema of tongue or dehiscence of the buccotomy suture. The author has experienced several cases where rabbits were able to eat soft food on their own within a few days after this surgery.

### **Follow-up**

Periapical abscesses and osteomyelitis are associated with a high rate of recurrence. Short term follow-up demonstrates healing of the surgical site and the surrounding soft tissues. Medium-term follow up (8-12 weeks post surgery) includes radiographic evaluation to demonstrate remodeling and apposition of new bone in previous sites of osteomyelitis, even if the bone defect may never be filled completely.

### **Abscesses of the Maxilla and empyemas the skull**

#### *Odontogenic non periapical abscesses*

Most odontogenic abscesses are periapical. However, exceptions can be encountered. Coronal spikes of cheek teeth creating a wound on the buccal mucosa can develop into a facial abscess. Due to typical pathophysiology of dental spikes those abscesses

are more likely to originate from maxillary cheek teeth. Extraction of the affected tooth is usually intraoral, then complete surgical excision is performed as routine.

*Periapical infection of maxillary mesial (rostral) premolar teeth (CHT1 and CHT2)*

Typical presentation of this abscess is the swelling of the rostral maxillary area and epiphora. Pathophysiology and combined intraoral dental/extraoral surgical treatment are similar to the corresponding abscess of mandibular premolars. Adjunct local anesthesia can be achieved performing a local nerve block of the rostral infraorbital nerve. Due to different anatomy as compared with the mandible, focal osteomyelitis may not be present. However, in advanced cases, it may also be complicated by dacryocystitis or by involvement of the maxillary recess. Exophthalmos is usually absent.

*Bacterial dacryocystitis*

Bacterial infection of the nasolacrimal duct is usually odontogenic because secondary involvement (subocclusion or obstruction) follows overgrowth of reserve crown and apical deformity of the ipsilateral primary incisor tooth (more commonly), or of the rostral premolar teeth (less commonly). It may or may not be associated with a periapical infection of those teeth, but even in the latter case it may develop into a facial abscess. Presentation is very similar to the above mentioned maxillary or zygomatic abscess.

Surgical treatment is aimed at debridement and marsupialization, but abscess of the distal portion of the nasolacrimal duct involving the nare or the upper lip might require cosmetic surgery.

*Periapical infection of molar teeth*

Bacterial involvement of several periocular structures (maxillary teeth, alveolar bulla, lacrimal glands), single or combined, can lead to the clinical sign of exophthalmos. Those etiologies have all been generally reported as retrobulbar abscess. Even if this pathologic condition is relatively common in pet rabbits as a complication of dental disease, a proper classification is useful not only because exophthalmos may exhibit slightly different traits, rather because several different surgical approaches can be pursued, depending on the type of abscess. Advanced cases presenting late in the course of the disease result in loss of the eye globe and necessitate enucleation. This procedure allows dorsal surgical access to the alveolar bulla, but also risks exposure of the optic nerve and the optic foramen, and is also not ideal for cosmetic reasons. Detailed diagnosis and appropriate surgical access can allow resolution saving the affected eye.

*Deformity and empyema of the alveolar bulla*

The alveolar bulla is a virtual cavity, because it is a preformed bony structure including the reserve crowns of maxillary CHT3-CHT6. In the case of elongation of reserve crowns or widened interproximal space and apical deformity, the dome of the alveolar bullae can enlarge. In other cases a real cavity can form within the alveolar bulla, in particular when a single cheek tooth has been previously extracted. It may partially fill with food debris and an empyema may follow. The result of this pathologic change is mild to intermediate exophthalmos, but a retrobulbar abscess is not present at this stage. Dedicated oblique projections, or advanced diagnostic imaging (CT, MRI) are needed for differential diagnosis. At least three different options can be considered to prevent formation of a retrobulbar abscess: (a) flush the empyema intraorally. This may not be very practical, because repeated anesthesia is necessary and the empyema may not be resolved; (b) extract all the cheek teeth and allow the inner surface of the alveolar bulla to heal by second intention (c) perform a lateral maxillotomy via a partial ostectomy of the zygomatic arch to access the alveolar bulla, and fill the defect with AIPMMA beads.

However, in the author's experience, conservative treatment and monitoring of the deformity and/or empyema of the alveolar bulla can be an option alternative to the surgical approach, being prepared to address the retrobulbar abscess should the empyema progress to a further stage.

#### *Retrobulbar abscess*

A retrobulbar abscess originates from periapical infection and perforation of the dome of the alveolar bulla. The size can be as large as that of the eye globe itself, and the position is exactly at the bottom of the orbital fossa, therefore ventromedial to the eye globe. Pressure usually elicits a very evident and severe exophthalmos that can rapidly evolve to panophthalmitis, with possible damage to the optic nerve. Radiography including several oblique views are diagnostic in regard of the involvement of teeth and the alveolar bulla, but they provide very little information about the size and position of the abscess. CT and/or MRI are very important for diagnosis and surgical planning. CT allows detection of the cheek teeth involved and more details about the alveolar bulla, while MRI provides the precise size and position of the retrobulbar abscess, including the optic nerve. Ideally they should be performed in combination; however, when only one is an option, MRI is more specific.

A combined intraoral and extraoral surgical approach is needed for a salvage procedure of the eye. Extraction of the affected cheek teeth (sometimes involving the entire maxillary arcade) is mandatory. Following extraction, the access to the retrobulbar abscess may (Martinez-Jimenez, 2007) or may not be feasible (Capello, 2016), because the top of the alveolar bulla may not be reached through the intraoral approach. The extraoral approach is performed with lateral maxillotomy via a partial osteotomy of the zygomatic arch to access the alveolar bulla. When the retrobulbar abscess is very large and dislocation of the eye globe is very dorsal, a lateral approach just a bit dorsal to the lateral margin of the orbital fossa can be attempted, as described below for the lateral parabolbar abscess. Depending on periorbital edema, immediate reposition of the eye globe may or may not be possible. Even in the latter case, postoperative anti-inflammatory treatment can be effective to reduce the exophthalmos and restore the normal position of the eye globe in a few days.

#### *Parabolbar abscesses*

Periapical infection with subsequent involvement of the accessory lacrimal gland leads to a lateral (or infraorbital) parabolbar abscess. Since exophthalmos is evident and severe, these abscesses have been usually reported as retrobulbar. However, the difference is critical because the abscess is not located at the bottom of the orbital fossa, and surgical access can be successfully achieved with a ventrolateral approach to the exophthalmic eye globe. Repositioning of the eye globe is accomplished after removal of the pus, debridement, and thorough flushing. Marsupialization of this surgical site is not a practical option because the small linear opening is prone to closure. However, part of the incision may be left open, allowing flushing for a few days postoperatively.

Periapical infection with subsequent involvement of the main lacrimal gland leads to a caudal parabolbar abscess. Surgical debridement is straightforward, with a caudal approach to the eye globe.

#### *Empyema of the maxillary recess*

Depending on individual patients and further development, clinical signs can be more consistent with an ipsilateral rhinitis, or with a swelling of the infraorbital area. The empyema of the maxillary recess may require a double or triple combined surgical access: intraoral extraction of diseased cheek tooth/teeth; an extraoral approach through the perforated area of the maxilla (pararhinotomy), or may be combined with a dorsal approach via a rhinotomy. The pararhinotomy and rhinotomy techniques have been reported in the literature (Lennox, 2013; Capello, 2014).

#### *Empyema of the nasal cavity and odontogenic septic rhinitis*

Chronic septic rhinitis secondary to severe or end stage dental disease can be a sequela of empyema of the alveolar bulla and/or empyema of the maxillary recess. Long-term medical treatment is usually unrewarding, can provide temporary and palliative improvement. The rhinotomy approach followed by temporary or permanent rhinostomy have been reported in the literature (Lennox, 2013; Capello, 2014).

#### *Empyema of the tympanic bulla/Otitis media*

Empyemas of the alveolar bulla, maxillary recess and/or nasal cavities, can spread the infection to the tympanic bulla through the pharynx and the Eustachian **tubes**.

Empyema of the tympanic bulla may or may not be clinically exhibited as otitis media with neurologic signs and symptoms, and these patients may or may not be affected by concurrent otitis externa. The surgical approaches and techniques for treatment of the tympanic bulla have been extensively reported (Eatwell et al, 2013; Capello et al, 2015).

#### **References**

1. Capello V, Gracis M, Lennox AM (2005). Rabbits and rodents dentistry handbook. Lake Worth, FL, Zoological Education Network; 2005.
2. Capello V, Lennox AM. Small mammal dentistry. In: Quesenberry KE, Carpenter JW, editors. Ferrets, Rabbits and Rodents Clinical Medicine and Surgery, 3<sup>rd</sup> edition. St Louis: Elsevier Saunders; 2012. p. 452-471.
3. Capello V. Rhinostomy as surgical treatment of odontogenic rhinitis in three pet rabbits. J Exotic Pet Med 23(2):172-187, 2014
4. Capello V, Mancinelli E, Lennox A. Anatomy of the ear. In: Ear surgery of pet rabbits. ebooksdynamic.vet; 2015. p. 1-6.
5. Capello V. Surgical treatment of prolapse of the deep lacrimal gland in a pet rabbit. J Exotic Pet Med 25(1):44-51, 2016
6. Capello V, Cauduro A. Comparison of diagnostic consistency and diagnostic accuracy between survey radiography and computed tomography of the skull in 30 rabbits with dental disease. J Exotic Pet Med 25(2): 115-127, 2016
7. Capello V. Surgical treatment of facial abscesses and facial surgery in pet rabbits. Vet Clin Exot Anim. 2016;19(3):799-823.
8. Casteleyn C, Cornillie P, Hermens A, Van Loo D, Van Hoorebeke L, Van den Broeck W, Simoens P. Topography of the rabbit paranasal sinuses as a prerequisite to model human sinusitis. Rhinology, 48: 300-304, 2010.
9. Divers SJ. Mandibular abscess treatment using antibiotic-impregnated beads. Exot DVM 2000;2:15-18.
10. Eatwell et al. Partial ear canal ablation and lateral bulla osteotomy in rabbits. J Small Anim Pract 2013;54:325-330.
11. Gardhouse S, Sanchez-Migallon Guzman D et al. Microbiology and antimicrobial susceptibilities of odontogenic abscesses in domestic rabbits. Proceedings of theExoticsCon. San Antonio, TX: 2015, p. 357.

12. Harcourt-Brown FM. Honey to treat rabbit abscesses. *Exot DVM* 2002; 3:13-14. 53-60.
13. Harcourt-Brown FM. Ophthalmic diseases, in: Harcourt-Brown FM. *Textbook of Rabbit Medicine*. Oxford, UK, Butterworth-Heinemann, pp 292-306, 2002
14. Harcourt-Brown F, Chitty J. Facial abscesses. In: Harcourt-Brown F, Chitty J, eds. *Manual of rabbit surgery, dentistry and imaging*. 1st ed. Quedgeley, Gloucester British Small Animal Veterinary Association, 2013; 29: 395-422
15. Lennox AM. Small exotic mammal dentistry-anesthetic considerations. *J Exot Pet Med* 2008;17:102-106.
16. Lennox A. Rhinotomy and rhinostomy for surgical treatment of chronic rhinitis in two rabbits. *J Exotic Pet Med* 22(4):383-392, 2013
17. Martinez-Jimenez D, Hernandez-Divers SJ, Dietrich U, et al. Endosurgical treatment of a retrobulbar abscess in a rabbit. *J Am Vet Med Assoc* 2007; 230:868-872.
18. Miwa Y. Mandibulectomy for treatment of oral tumors (cementoma and chondrosarcoma) in two rabbits. *Exot DVM*. 2006; 8:18-22.
19. Popesko P, Rjtová V, Horák J. A colour atlas of anatomy of small laboratory animals. Vol. I: Rabbit, guinea pig. Vol. II: Rat, mouse, hamster. London, Wolfe Publishing Ltd, 1992.
20. Remeus PG, Verbeek M. The use of calcium hydroxyde in the treatment of abscesses in the cheek of the rabbit resulting from a dental periapical disorder. *J Vet Dent* 1995;12: 19-22.
21. Taylor WM, Beaufrère H, Mans C, et al. Long-term outcome of treatment of dental abscesses with a wound packing technique in pet rabbits: 13 cases (1998-2007). *J Am Vet Med Assoc* 2010; 237:1444-1449.
22. Tyrrel KL, Citron DM, Jenkins JR, et al. Periodontal bacteria in rabbit mandibular and maxillary abscesses. *J Clin Microbiol* 2002;40:1044-1047.
23. Van der Woerd A. Ophthalmologic diseases in small pet mammals. In: Quesenberry KE, Carpenter JW, eds. *Ferrets, rabbits and rodents: clinical medicine and surgery*. 2nd ed. St. Louis: Saunders, imprint of Elsevier, 2004;421-428.

## Ear and nasal surgery of pet rabbits

Vittorio Capello, DVM, Dip. ECZM (Small Mammals), Dipl. ABVP (ECM)  
Clinica Veterinaria S.Siro, Clinica Veterinaria Gran Sasso  
Milano, Italy

### Ear surgery

#### Introduction

Otitis in pet rabbits can be difficult to diagnose due to a number of unique features of anatomy and pathophysiology; and because clinical symptoms can be subtle. A number of surgical techniques have been reported and vary depending on the type and location of the disease. Surgery of the ear pinna includes partial amputation and surgical treatment of otohematomas. Surgery of the external ear (acoustic duct) and of the middle ear (tympanic bulla) include lateral ear canal resection (LECR) with different variations, total ear canal ablation (TECA), lateral otostomy or partial ear canal resection (PECR), osteotomy of the tympanic bulla with lateral (LBO) or ventral (VBO) approach.

#### Anatomy of the ear

Similar to other mammal species, the ear system in rabbits is a sensory and neurologic organ. It is anatomically divided into three portions: the external ear, the middle ear, and the inner ear (including the vestibular system) (Capello et al., 2015).

#### *External ear*

The external ear includes the ear pinna, the ear canal and the tympanic membrane. The ear pinnae represent a large portion of the body surface in rabbits and have high vascular support. Ear functions are perception of noise with specific regard to escape from predators, and thermoregulation (Vella and Donnelly, 2012). However, size of the ear pinna is remarkably different in various breeds of pet rabbits. True dwarf rabbits weighing 1 Kg or less have typical short and more round ear pinnae (Capello et al., 2015). The ear canal is composed by the cartilaginous acoustic duct and the external acoustic meatus (which is a short portion of the bony acoustic duct) (Popesko et al., 1992). Since most part of the ear canal is cartilaginous, the ear canal may commonly be considered as the cartilaginous acoustic duct only (Capello et al., 2015). The vascular support of the ear pinna is provided by the auricular artery which is visible as a median vessel both on the dorsal and the inner aspect of the pinna (Popesko et al., 1992). The auricular artery originates from the rostral and caudal auricular arteries, which are branches of the external carotid artery (Popesko et al., 1992). There are arteriovenous shunts at the apical portion of the ear pinna, between the auricular artery and the auricular veins (Vella and Donnelly, 2012). There are three auricular veins, all merging in the maxillary vein, and then in the external jugular vein (Popesko et al., 1992). The rostral and the caudal auricular veins run along the margins of the ear pinna and are also commonly known as marginal veins. The intermedial branch of the caudal auricular vein runs along the auricular artery, or slightly separated and parallel to the artery. All those vessels may not be clearly visible in standard dwarf rabbits, and individual differences may also be present. The main cartilage of the pinna is simply named cartilage of auricle (Popesko et al., 1992). It has an external convex surface covered by normal skin with rare fur, and an internal concave surface covered by modified skin with no fur. The concave surface is named *scapha* (Popesko et al., 1992). The proximal part of the margins of the cartilage of the pinna is the helix. Both helices are highly convex/concave and represent part of the walls of the ear canal.



Most part of the lateral wall of the cartilaginous acoustic duct is represented by the tragus. This is a complex cartilaginous plate with a ventromedial part (antitragus) forming the dead end diverticulum of the ear canal, and a proximal appendix (the scutiform cartilage) which is an important point of insertion for auricular muscles. The intertagic incisure is present between the tragus and the antitragus. The dorsal and ventral lateral margins of the tragus are joint with the free margins of the dorsal and the ventral helices. In summary, the longest part of the cartilaginous acoustic duct is outlined by the proximal portion of the scapha medially, by the dorsal helix dorsolaterally, by the ventral helix ventrolaterally, and by the tragus laterally. The cartilaginous acoustic duct is completed by the cartilage of acoustic meatus (CAM), an annular cartilage forming a ring (or short cylinder). The ring is incomplete because of the presence of the cartilaginous incisure of acoustic meatus. This cartilage represents the most proximal cartilaginous portion of the ear canal, and its junction with the external acoustic meatus.

The ear canal includes a short tract within the petrous part of the temporal bone (Popesko et al., 1992). This tract is the external bony acoustic duct (or meatus). The tympanic membrane is located a few millimeters within the bony acoustic duct. It represents the separation between the external ear and the middle ear, and the separation between the external bony acoustic duct and the proximal portion of the bony acoustic duct, beyond the tympanic membrane, which is part of the middle ear. The whole ear canal is covered by modified skin rich of sebaceous gland normally producing white waxy secretion.

Unlike selected carnivore species, standard rabbits of any size including dwarfs do not have the horizontal portion of the ear canal (Chow, 2011). The ear canal is vertical and straight from the distal (external) opening to the tympanic membrane. However, lop-eared breeds have anatomic variations of the ear canal. There is a flexion point at the level of the tragus and/or at the junction between the proximal end of the tragus and the cartilage of acoustic meatus. This flexion actually creates a distal vertical portion and a proximal horizontal portion of the ear canal, giving the peculiar aspect of bent down ear pinnae (Capello et al., 2015).

The horizontal portion of the ear canal in lop rabbits includes the very proximal part of the tragus, the cartilage of the acoustic meatus, and external bony acoustic duct.

Also, the ear canal is generally narrower than the ear canal of standard rabbits. In many cases, it is narrower than the ear canal of smaller standard rabbits.

Crossbred standard/lop rabbits may have intermediate anatomic changes of the ear canal; or show standard anatomy of a single ear canal, and modified anatomy of the contralateral ear canal (Capello et al., 2015).

These anatomic differences predispose lop rabbits to accumulation of waxy debris along the whole ear canal, in particular at the flexion point. The different junction between cartilage may also predispose for ectasia of the ear canal at the flexion point. This modified anatomy has a great impact on patterns of ear disease, and related surgical techniques.

#### *Middle and inner ear*

The middle and the inner ear are located within the petrous bone, which is part of the temporal bone. This bone is commonly named tympanic bulla because it is a cavitary bone with a round shaped ventral aspect. The middle ear includes the bony acoustic duct proximal to the tympanic membrane, and the tympanic bulla.

The rostral and caudal auricular arteries originate from the external carotid artery and surround the tympanic bulla ventrally (Popesko et al., 1992).

The facial nerve exits the skull through the stylomastoid foramen, and courses rostrally, ventrolaterally to the tympanic bulla (Popesko et al., 1992; Chow, 2011).

The inner ear is located on the medial aspect of the petrous bone and of the tympanic bulla and includes the cochlea and the vestibular system (Popesko et al., 1992).

## **Pathophysiology**

Otitis externa, including bacterial and parasitic, has been reported in rabbits (Eatwell et al., 2013; Capello et al., 2015). Purulent otitis externa results in empyema and ectasia of the ear canal (especially in lop rabbits) which is commonly and improperly defined as “ear abscess” (Eatwell et al., 2013; Capello et al., 2015).

Empyema of the tympanic bulla and/or otitis media can result from otitis externa after rupture of the tympanic membrane, but pathophysiology in the opposite direction can occur as well (Eatwell et al., 2013; Capello et al., 2015).

Chronic rhinitis (including infection or empyema of the maxillary recess) can also lead to otitis (Capello, 2014). The rhinopharynx communicates with the middle ear and the tympanic bulla through the Eustachian tubes (Deeb, 2004; Popesko et al., 1992).

## **Clinical signs and symptoms**

Otitis in pet rabbits can be difficult to diagnose due to a number of unique features of anatomy and pathophysiology; and because clinical symptoms can be subtle (Capello et al., 2015).

More commonly reported symptoms include head shaking, scratching at the ear, pain on palpation of the ear canal, lethargy, and reduced food intake. However, these may also be mild to absent. Ataxia, head tilt, nystagmus are symptoms related to vestibular syndrome as a result of otitis media or interna (Chow, 2011; Capello et al., 2015).

Other clinical signs include collection of purulent exudate within the ear canal, thickening or swelling at the base of the ear canal, or larger swellings located in the preauricular area (Capello et al., 2015).

## **Diagnosis**

A number of tests aid diagnosis. In cases of otitis externa, cytology helps differentiate cerumen vs. purulent debris. Culture and sensitivity identify specific bacterial pathogens. Otoscopy is an excellent tool to identify abnormalities of the external ear canal, but it is often not helpful due to stenosis or empyema of the external ear canal (Capello et al., 2015).

Otitis media may produce bony abnormalities of the tympanic bulla identified radiographically. Radiographic views include VD and oblique projections and require optimal positioning and excellent technique (Capello and Lennox, 2008). Early or mild cases may not produce detectable radiographic abnormalities. Computed tomography is the best diagnostic imaging modality for identification of specific lesions such as filling of the tympanic bulla, and osteolysis. Both axial and three-dimensional (3D) rendering is useful for this purpose (Capello et al., 2015).

## **Medical treatment**

Medical therapy has been reported as poorly effective, especially in case of otitis media that cannot be treated topically (Chow, 2011; Capello et al., 2015). In the author's experience it is unrewarding in all but the mildest cases. Pus in rabbits is thick and difficult to remove, and many cases of otitis media involve empyema of the tympanic bulla and osteolysis, both of which are unlikely to resolve without surgical intervention. Medical therapy may involve long-term antibiotics, ideally chosen with the aid of culture and sensitivity, and flushing of the external ear canal under sedation or general anesthesia in case of otitis externa (Capello et al., 2015). Analgesic therapy is an adjunct to antibiotic treatment (Chow, 2011; Capello et al., 2015).

## **Surgical treatment**

A number of surgical techniques have been reported and vary based on the type and location of the disease. Surgical procedures are classified depending on the topographic anatomy:

- Surgery of the external ear

- Surgery of the ear pinna
- Surgery of the ear canal
- Surgery of the middle ear (tympanic bulla)

### *Surgery of the external ear*

#### **Surgery of the ear pinna**

##### **Amputation of the ear pinna**

Indications for partial amputation of the ear pinna (not including the ear canal) are mostly represented by trauma and neoplasia (Capello et al., 2015; Csomos et al., 2016). Blood vessels included in the portion of the ear pinna to be removed are ligated. Skin incisions are performed on both sides of the ear pinna, and the skin is bluntly separated from the surrounding cartilage of the auricle. Condotomy is performed with scissors slightly more proximal than the skin, in order to allow a skin-to-skin suture of the margins. Suture is routine in an interrupted pattern with non-absorbable material.

##### **Treatment of otohematoma**

Otohematoma is not frequent in rabbits, but it may follow repeated shaking and scratching of the ear pinna because of bacterial or parasitic otitis externa. The surgical approach is from the *scapha*, where a S-shaped skin incision is performed over the hematoma. Serum is drained and absorbed with sterile gauze, and blood clots are removed with gentle pressure over the ear pinna (Welch Fossum, 2007; Capello et al., 2015; Csomos et al., 2016). The site is then thoroughly flushed to remove additional fibrin clots. In order to prevent that pockets are left, in which fluids can accumulate, several mattress sutures are placed full thickness, transfixing the cartilage of auricle and the skin on both sides of the ear pinna. Sutures should be placed vertically rather than horizontally (Welch Fossum, 2007; Capello et al., 2015; Csomos et al., 2016). The skin incision is not sutured. Bandage of the ear pinna is not necessary.

### *Surgery of the ear canal*

##### **Lateral ear canal resection**

The Lateral Ear Canal Resection (LECR) is aimed to create a wide and more proximal lateral opening of the ear canal for treatment and management of the otitis externa, by removing exudate and performing flushing of the ear canal (Capello et al., 2015).

Indication is otitis externa non associated with otitis media or severe disease of other ear canal structures. This is particularly important in the lop rabbit because of the different anatomy of the ear canal. From the surgical point of view it represents a permanent otostomy, where the cavity is represented by the ear canal. For this reason it is also commonly "otostomy". However, this terminology is generic, and it may be applied also to other different techniques and approaches of surgery of the ear. The standard LECR is performed removing most of the lateral wall of the ear canal (usually, the entire cartilage of the tragus via a total condrectomy of that specific cartilaginous plate) (Capello et al., 2015).

Two parallel skin incisions are made on the lateral aspect of the ear canal, parallel to the long axis of the ear pinna and canal. Additional local anesthetic block can be performed before skin incisions. In case of standard LECR, the skin incisions start from the border of the opening, to the proximal aspect of the ear canal. The flap of skin between the two incisions and associated subcutaneous tissue are bluntly dissected free from the underlying cartilaginous plates and reflected rostrally, in order to expose the tragus and part of the helices. The flap is then resected transversely at the proximal end and removed. The tragus is separated from the two helices and removed, including the scutiform cartilage. Haemorrhage is usually minimal and it can be easily

controlled with cotton tip applicators, radiosurgery or other hemostatic devices. The normal anatomy may be significantly altered in cases of empyema and dilation of the ear canal, in particular in lop rabbits where the flexible tragus can be ruptured. When the purpose of standard LECR is to treat (or to prevent) otitis externa only, and when involvement of the proximal portion of the ear canal within the CAM and of the bony acoustic meatus are not present, the CAM is not removed, in order to use it for the suture to the adjacent skin, and keep the acoustic duct well patent. Skin is sutured over the free margins of the helices, and to the margins of the cartilage of the acoustic meatus, creating a stoma over the bony acoustic meatus. However, different variations of this surgical technique can be performed depending on one or more of the following elements: kind of patient (standard or lop rabbit); extension of the otostomy; presence of empyema of the ear canal; deformity, ectasia or rupture of the ear canal; final cosmetic appearance; and surgeon's preference. When wider otostomy in a proximal direction is pursued (more frequently in the lop rabbit) the annular cartilage of the acoustic meatus is removed as well, dissecting it from the bony acoustic meatus of the tympanic bulla. The LECR is therefore performed via a double, total condrectomy (tragus, and CAM). This technique would be properly named Total Lateral Ear Canal Resection, because the lateral wall of the ear canal is removed from the distal natural opening to the most proximal end possible. Another option is to avoid the excision of the tragus, just flexing and suturing it to the dorsal helix and the adjacent skin. In this case, the permanent otostomy is performed via a single condrotomy, rather than the condrectomy of the tragus. This surgical technique is not associated with excision of the cartilage of the acoustic meatus. The LECR may also be partial, performing the partial condrectomy of the tragus. This technique undergoes a different terminology and is reported below. This approach is usually combined with excision of the cartilage of the acoustic meatus. In case of empyema of the tympanic bulla or otitis media, most LECRs can also be combined with the surgical approach to the tympanic bulla, in particular with the Lateral Bulla Osteotomy/Ostectomy (LBO). The standard LECR and the LECR via simple condrotomy represent an exception because they do not include the excision of the cartilage of the acoustic meatus. Instead, the combined surgical technique LECR+VBO must include condrectomy of that annular cartilage.

### **Total ear canal ablation**

Indication is for cases of severe infection, stenosis of the entire ear canal, or neoplasia. Total Ear Canal Ablation (TECA) includes removal of all the cartilages of the external ear canal (Chow, 2011; Eatwell et al., 2013; Capello et al., 2015; Csomos et al., 2016). A single skin incision is made on the lateral aspect of the dilated ear canal, parallel to the long axis of the ear pinna and canal. The subcutaneous tissue is bluntly dissected from the lateral cartilages of the ear canal (the tragus, and part of the helices). In lop rabbits, the flexion of the tragus may be ruptured, and the ectasia of the ear canal may be represented by the modified skin of the ear canal. The vertical tract of the ear canal is dissected from surrounding tissues (including the skin of the scapha on the medial side) without being entered. Dissection is continued proximally to include the CAM, which is dissected from the bony acoustic duct. After the tympanic bulla is surgically addressed (lateral bulla osteotomy is described below) the subcutaneous tissue and the skin are sutured over the vertical portion of the ear canal. Instead, marsupialization is performed over the tympanic bulla, creating a new opening for postoperative flushing.

### **Partial ear canal resection**

Partial ear canal resection (PECR) represents a lateral otostomy. Also reported as partial ear canal ablation (PECA) (Eatwell et al., 2013; Csomos et al., 2016), this

surgical technique is actually a partial lateral resection of the ear canal, and approaches the empyema of the external ear canal and the otitis similarly to other thick, encapsulated abscesses in the rabbit (Capello et al., 2015).

In many rabbits, especially lop rabbits, pus accumulates at the base of the ear canal at the junction of the tragus with the cartilage of the acoustic meatus. In case of PECR, only the proximal portion of the tragus is removed, along with the cartilage of the acoustic meatus. While seldom performed in standard (non-lop) rabbits, this technique results in a slightly better cosmetic outcome than lateral ear canal resection or TECA. For PECR, the skin is incised over the swelling. The soft tissues delimiting the empyema are separated from adjacent tissues using blunt dissection. Once isolated, the proximal portion of the tragus with the scutiform cartilage, and the cartilage of the acoustic meatus are removed. Lateral bulla osteotomy is performed if indication is present. Once surgery is completed, a stoma is created by suturing skin to subcutaneous tissue and surrounding remaining cartilage for postoperative flushing and healing of margins by secondary intention.

### **Surgery of para-auricular abscesses**

In case of severe lysis of the tympanic bulla subsequent to chronic empyema, para-auricular abscesses can be present around the base of the ear canal (Capello et al., 2015). They may or may not be associated with otitis externa and empyema of the ear canal and are surgically addressed with the standard technique for abscesses. Adjunct surgical technique for the ear canal may be necessary, as well, cleaning and flushing of the ruptured tympanic bulla followed by marsupialization.

### **Surgery of the middle ear (tympanic bulla)**

#### **Lateral bulla osteotomy**

Indication is for empyema of the tympanic bulla with or without severe otitis media (Eatwell et al., 2013; Capello et al., 2015; Csomos et al., 2016). It can be combined with lateral (standard, or partial) ear canal resection, or with total ear canal ablation. The lateral aspect of the bulla is approached from the bony acoustic meatus. The minimal lateral osteotomy is aimed to slightly open and enlarge the bony acoustic duct, allowing intraoperative flushing of the exudate. While some references describe osteotomy using rongeurs or other cutting instruments (Eatwell et al., 2013), the author recommends careful burring with the use of a high-speed dental drill and fine burs. In severe cases, the bulla is already lytic and ruptured; therefore wide osteotomy is performed via a thorough, deeper debridement. After accessing the bulla, pus is gently removed and the bulla flushed carefully. More aggressive debridement and the use of a curette may result in damage, especially to the medial aspect of the bulla, with production vestibular disease or worsening of clinical signs, if already present. The surgical procedure is completed suturing the skin to the subcutaneous tissue around the opening of the bulla, for continued postoperative drainage and flushing.

#### **Ventral bulla osteotomy**

The ventral approach is medial and parallel to the mandibular angle. Reported advantages include improved exposure, less risk of damage to the hypoglossal and facial nerves, and improved drainage. Since drains for postoperative flushing are difficult to place and maintain in rabbits, the bulla can be filled with AIPPMA beads. This approach may or may not be associated with other surgical treatment of the ear canal (Chow, 2011).

## **Nasal surgery**

### **Introduction**

Disease of the upper airways is common in pet rabbits, and it is caused by a number of primary and secondary etiologies. Infectious disease, complications of advanced dental disease, traumatic injuries, neoplasia, foreign bodies and other miscellaneous conditions have been reported (Capello, 2014; Lennox, 2013). Chronic rhinitis is debilitating in this obligate nasal breathing species, and medical treatment alone may be unrewarding. Surgical treatment is an effective option, in particular for severe cases leading to empyema of the nasal and paranasal cavities. Advanced diagnostic imaging is critical to diagnose the extent of the disease process and related patency of the upper airways, and to guide the surgical technique and approach (Capello, 2014). Rhinotomy and pararhinotomy, uni- or bilateral, followed postoperatively either by a temporary or permanent stoma are well tolerated by rabbits, and carry a good prognosis.

### **Anatomy and physiology**

The nasal cavity is separated into two paired nasal cavities by a thick cartilaginous longitudinal septum. The paranasal cavities of most domestic mammals are represented by the true sinuses (which are preformed cavities within pneumatic skull bones, in communication with the nasal cavities) and recesses (which are dead end spaces created by turbinates within the nasal cavity). In addition to the frontal and sphenoidal sinuses, paranasal cavities in dogs include also paired maxillary recesses not included within the maxilla (Evans, 1993).

Each nasal cavity of rabbits contains five conchae, also called nasal turbinates due to the presence of highly convoluted cartilaginous membranes covered by mucosa. They are reported in a rostro-caudal direction as the ventral, dorsal, middle nasal concha; and the third and the fourth endoturbinate. The latter are also reported as ethmoidal nasal conchae (Popesko et al., 1992; Varga, 2014). Nasal turbinates (in particular the ventral nasal concha) have a very complex arboreal structure (Capello, 2014). With skull bones, the nasal conchae delineate the dorsal, middle, ventral, and ethmoidal nasal meatuses (Casteleyn et. al, 2010). The nasopharyngeal meatus continues the nasal cavity ventrocaudally. The paranasal cavities of rabbits are represented by the paired dorsal conchal, the sphenoidal, and the large, double chambered maxillary recesses (Capello, 2014; Varga, 2014; Casteleyn et. al, 2010). These structures were commonly referred to as sinuses in the literature (Harcourt-Brown, 2002; Chitty and Raftery, 2013).

The anatomy of the nasolacrimal duct (Van der Woerd, 2012), of the cheek teeth and the alveolar bulla (Capello and Gracis, 2005), of the tympanic bulla (Popesko et al., 1992) and of the Eustachian tubes (Deeb, 2004), have been reported in the literature. Rabbits are obligate nasal breathers as the epiglottis is normally engaged over the caudal margin of the soft palate. This important physiologic feature compounds the severity of upper respiratory disease in this species. Mouth breathing is non physiologic and represents a symptom of dyspnea in rabbits with severe rhinitis (Capello, 2014 and Lennox, 2013).

### **Etiology and pathophysiology**

Upper respiratory disease is most frequently associated with infectious agents. Most of them are bacterial agents (*P. multocida*, *Bordetella bronchiseptica*, *Pseudomonas* spp., *Staphylococcus* sp. or mixed infections), but in rare cases can include fungal, viral or parasitic pathogens as well (Lennox, 2013).

Oral infections associated with severe or end-stage dental disease may indirectly spread to the upper respiratory tract because of the close anatomic relationship of

certain dental structures with the nasal and paranasal cavities, and with the nasolacrimal duct (Capello, 2014).

Otitis media is associated with respiratory disease in rabbits, as infection can spread via the eustachian tube to the tympanic bulla and middle ear (Capello et al., 2015). However, the opposite pathophysiologic route may occur from otitis externa and media. Traumatic injury to the nasal cavities includes blunt trauma, predator injury and iatrogenic trauma to the nasal mucosa following rhinoscopy or nasotracheal intubation (Lennox, 2013).

Foreign materials such as hay and neoplasia have also been reported (Lennox, 2013; Lennox and Reavill, 2014).

### **Diagnostic imaging**

Thorough diagnostic imaging is essential for detailed diagnosis, proper prognosis, and to help identify those patients that may benefit from surgical treatment (Capello and Lennox, 2011). Diagnostic imaging modalities for investigation of rabbit nasal cavities include radiography, computed tomography (CT), rhinoscopy, and magnetic resonance imaging (MRI).

The use of CT for diagnosis of dental disease and for diseases of the nasal cavities, turbinates, recesses, and tympanic bullae in rabbits has been extensively described (Lennox, 2013; Capello, 2014). CT is ideal for visualization of hard tissues, and allows additional volume rendering, emphasizing internal anatomic structures. A particular volume rendering modality displays empty spaces as a cast. This is particularly advantageous for the evaluation of patency of nasal cavities, the related recesses, the tympanic bullae and the upper airways in general (Capello, 2014).

Unlike other diagnostic imaging, endoscopy provides direct visualization of internal anatomic structures. The extent of the accessible nasal cavity in most rabbits is limited to the ventral and middle meatuses and adjacent turbinates, although in larger rabbits it is possible to visualize the rhinopharynx more caudally (Divers, 2010). Diagnostic benefits of rhinoscopy include magnification of visualized structures and the potential for collection of biopsy samples. Potential treatment benefits include removal of foreign bodies from the nasal cavities. Rhinoscopy can also be performed from sites other than the natural nasal openings, including through a dorsal or lateral rhinostomy site.

### **Indications**

The most important criteria for patient selection are lack of response to aggressive medical therapy following bacterial culture and sensitivity test, and identification of granulomatous disease, lysis of the turbinates, empyema of the nasal and/or paranasal cavities (Capello, 2014; Lennox, 2013).

### **Surgical techniques and approaches**

Rhinotomy is the surgical access to the nasal cavity via osteotomy, associated with minimal or no removal of bone tissue, aimed to close the rhinotomy site at the end of the surgical procedure. Rhinostomy is used to describe a similar surgical access, associated with removal of bone tissue, with the goal of eventual closure (temporary rhinostomy), or creating a permanent stoma (permanent rhinostomy). Pararhinotomy and pararhinostomy are the same surgical access applied to paranasal cavities.

#### *Dorsal rhinotomy and rhinostomy*

All patients undergoing surgery of the nasal and paranasal cavities must be under general anesthesia and maintained via orotracheal intubation. With the dorsal approach, rhinotomy may be unilateral or bilateral, wide or narrower depending on selected cases and topographic indications provided by diagnostic imaging modalities (Capello, 2014; Lennox, 2013).

The rabbit is placed in sternal recumbency with the head lifted in a steady horizontal position. The dorsal area of the frontal and nasal bones are shaved, aseptically prepared and draped. A longitudinal incision of the skin and subcutaneous tissue is performed on the midline when bilateral exposure of the nasal bones is desired, or paramedian to the midline when aimed to exposure of a single nasal bone. Modality, exact position and extent of the osteotomy can vary depending on the case and on the goal of surgery (e.g. rhinoscopy, collection of biopsy sample for histopathology, microbial culture and sensitivity test, exploratory rhinotomy, debridement, or placement of a catheter or a flushing tube). When rhinotomy is small or performed step by step from small to large, it can be performed using a small ball-tipped rotating dental burr. The nasal bone is burred creating a fenestration while minimal haemorrhage is controlled with cotton tip applicators. When treating for nasal empyema and necrosis of turbinates, the site should be large enough to allow exploratory rhinotomy. When extensive removal of the nasal bone(s) is pursued, the lateral osteotomy may be performed along the syndesmosis between the nasal bone and the nasal process of the incisive bone. The rostral incision is made between the cranial border of the nasal bone and the cartilage of the nose. In case of unilateral rhinotomy (i.e. removal of a single nasal bone), the medial osteotomy should avoid the midline syndesmosis between the two nasal bones, where the nasal septum lies beneath. In the author's experience, reposition of the bony flap as described in dogs was unsuccessful, and would lead to avascular necrosis of the nasal bones. Osteotomies can be performed using a small ball-tipped rotating dental burr, or with a scalpel blade along the lateral syndesmosis.

Following rhinotomy, the nasal cavity is thoroughly inspected, flushed with sterile saline solution, gently debrided and cleaned from necrotic turbinates and pus. The rhinotomy site should be large enough to allow inspection and flushing of the ipsilateral maxillary recesses. Also, a cotton tipped applicator is passed from the rhinotomy site through the ipsilateral nare in order to clean and to assess patency of the cranial portion of the nasal meatuses. Haemorrhage is usually minimal and can be controlled using cotton tip applicators. Small suction devices may also be beneficial. If the presence of a foreign body is suspected, it should be thoroughly and patiently searched to prevent missing it, or partial removal. The exploratory rhinotomy is complete when visual and endoscopic inspection reveals a clean nasal cavity.

When performing a simple rhinotomy procedure, the periosteum and the skin are sutured over the rhinotomy site. Since continued postoperative flushing is important for complete resolution, this can be performed with implantation of a fenestrated catheter (Lennox, 2013). In case of temporary or permanent rhinostomy, the skin is sutured over the stoma. Healing of the subcutaneous tissue to the underlying bone does occur, in particular when a healing ointment is applied locally (Capello, 2014).

#### *Lateral pararhinotomy and pararhynostomy*

Indications for the lateral approach to the maxillary recess is usually represented by empyema of this paranasal cavity (Capello, 2014). It is usually associated with a facial abscess on the craniolateral aspect of the maxilla, which may or may not involve the nasolacrimal duct as well. Because it is a recess, the surgical access to the maxillary paranasal cavity allows an indirect access to the other nasal structures and meatuses. However, this approach allows limited exposure. CT is therefore critical for selection of the patient and to rule out indications for complete exploratory rhinotomy via a dorsal approach. Depending on selected cases, lateral pararhinotomy can be combined with dorsal rhinotomy.

The rabbit under general anesthesia and intubated is placed in lateral recumbency. The rostral maxillary area is shaved, aseptically prepared and draped. If a maxillary abscess is present, it is addressed as routine following incision of the skin, blunt dissection of the subcutaneous tissue, exposure of the capsule of the abscess,



excision of the capsule and debridement of the underlying tissue. A delicate retractor such as the Lone Star retractor is used to expose the lateral aspect of the maxillary bone, in particular the thin perforated surface (facies cribrosa) which is entered with scissors or other sharp surgical instruments. Alternatively, a small tipped rotating bur can be used. The maxillary recess is explored, cleaned from pus using a small Williger bone curette, and flushed with saline solution. The author prefers to maintain the pararhinostomy site open with marsupialization of the soft tissues.

### **Postoperative treatment and follow-up**

Rhinotomy followed by placement of a catheter, dorsal rhinostomy and pararhinostomy are critical to continue postoperative medication of the nasal cavities and recesses through flushing, and local antibiotics. These procedures and gentle debridement can be performed without sedation. Following permanent rhinostomy, natural healing of the skin eventually results in significant reduction of the stoma. In cases of chronic rhinitis following advanced dental disease which do not completely resolve, a brief surgical procedure may be necessary to remove part of the cutaneous flap to increase patency of the stoma (Capello, 2014).

### **References**

1. Capello V, Gracis M, Lennox AM (ed): Rabbit and Rodent Dentistry Handbook. Ames, IA, Wiley-Blackwell, (formerly Zoological Education Network), 2005.
2. Capello V, Lennox AM. Rabbit. In: Capello V, Lennox AM, Widmer WR. Clinical Radiology of Exotic Companion Mammals. Ames, IA: Wiley-Blackwell; 2008:54-87.
3. Capello V, Lennox AM. Diagnostic imaging of the respiratory system in exotic companion mammals. Vet Clin Exot Anim 14(2):369-89, 2011.
4. Capello V. Rhinostomy as surgical treatment of odontogenic rhinitis in three pet rabbits. vJ Exotic Pet Med 2014;23(2):172–87.
5. Capello V, Mancinelli E, Lennox A, Kling M (editor). Ear surgery of pet rabbits. Milano, Italy: ebooksdynamic.vet; 2015.
6. Casteleyn C, Cornillie P, Hermens A, Van Loo D, Van Hoorebeke L, Van den Broeck W, Simoens P. Topography of the rabbit paranasal sinuses as a prerequisite to model human sinusitis. Rhinology, 48: 300-304, 2010
7. Chitty J, Raftery A: Ear and sinus surgery, in F Harcourt-Brown, J Chitty (Eds): BSAVA Manual of rabbit surgery, dentistry and imaging. British Small Animal Veterinary Association, Gloucester, UK. Chapter 16: pp 212-232, 2013
8. Chow EP. Surgical management of Rabbit Ear disease. J Exotic Pet Med. 2011;20(3):182-187.
9. Csomos R, Bosscher G, Mans C et al. Surgical management of ear diseases in rabbits. Vet Clin Exot Anim. 2016;19(1):189-204.
10. Deeb BJ. Respiratory disease and Pasteurellosis. in Quesenberry KE, Carpenter JW. Ferrets, Rabbits and Rodents Clinical Medicine and Surgery 2<sup>nd</sup> ed. Philadelphia, PA: Saunders; 2004:172-182.
11. Divers SJ. Exotic Mammal Diagnostic Endoscopy and Endosurgery. Vet Clin Exot Anim 13(2):255-72, 2010

12. Eatwell K et al. Partial ear canal ablation and lateral bulla osteotomy in rabbits. *J Small Anim Pract* 2013;54:325-330.
13. Evans HE. The respiratory system. In: *Miller's Anatomy of the dog*, 3<sup>rd</sup> ed. Saunders, Philadelphia, 1993. 463-493.
14. Harcourt-Brown F. *Textbook of rabbit medicine*. Oxford, UK: Butterworth-Heinemann; 2002.
15. Lennox AM. Rhinotomy and rhinostomy for surgical treatment of chronic rhinitis in two rabbits. *J Exotic Pet Med* 2013;22(4):383–392.
16. Lennox AM, Reavill D. Nasal mucosal adenocarcinoma in a pet rabbit. *J Exotic Pet Med* 2014;23(4):397–402.
17. Popesko P, Rjtová V, Horák J. *A Colour Atlas of Anatomy of Small Laboratory Animals Vol. 1: Rabbit, Guinea pig*. London, UK: Wolfe Publishing Ltd; 1992.
18. Van der Woerd A. Ophthalmologic diseases in small pet mammals. In: Quesenberry KE, Carpenter JW: *Ferrets, Rabbits and Rodents: Clinical Medicine and Surgery* (3<sup>rd</sup> ed.). Philadelphia, PA, Saunders, imprint of Elsevier Science, pp 523-531, 2012.
19. Vella D, Donnelly TM. Basic anatomy, physiology and husbandry. In: Quesenberry KE, Carpenter JW, eds. *Ferrets, Rabbits and Rodents Clinical Medicine and Surgery*. 3<sup>rd</sup> ed. St. Louis MO: Elsevier Saunders; 2012:157-173.
20. Welch Fossum T. Surgery of the ear. In: Fossum TW, ed. *Small Animal Surgery*, 3<sup>rd</sup> ed. St. Louis, MO: Mosby Elsevier; 2007:260-288.

## Sevoflurane/Isoflurane gel anaesthesia in frogs

Sarah Frith BVSc MVS (Conservation medicine)  
Melbourne Zoo  
Elliott Ave, Parkville VIC 3052

The author's aim is to describe a simple method used to anaesthetise frogs in a small animal clinic setting without specialised equipment. An isoflurane or sevoflurane gel is compounded in-clinic by mixing either agent with a water-based sterile lubricant and tap or sterile water to create a stable gel. The use of an anaesthetic gel appears to reduce vaporisation and increase skin contact compared to the use of undiluted isoflurane/sevoflurane topically or either agent mixed with only water (Sladakovic and Divers, 2019). The technique is particularly useful for anaesthetising amphibian patients for minimally invasive medical procedures, such as minor surgery, placing microchips, venepuncture and allowing optimal positioning for radiology and ultrasound. The author's preference is to use sevoflurane over isoflurane as the author has seen transient dark skin discolouration with the use of isoflurane gel. This may represent skin irritation. Skin lesions were also reported in four American Green Tree Frogs (*Hyla cinerea*) tested with isoflurane gel and two of these frogs subsequently died (Zec *et al*, 2014). None of the frogs receiving sevoflurane jelly in this study developed skin lesions.

Melbourne Zoo vets have noticed that there is species variability in response to anaesthetic gels, in particular stuttering barred frogs (*Mixophyes balbus*) appears to be sensitive to the sevoflurane gel. There has been one death in a stuttering barred frog at Melbourne Zoo following anaesthesia with sevoflurane gel but others of this species have responded well. Species commonly anaesthetised with sevoflurane gel at Melbourne Zoo include giant green tree frog (*Litoria caerulea*), white-lipped tree frog (*Litoria infrafrenata*), dainty tree frog (*Litoria gracilentia*), Baw Baw frog (*Philoria frosti*), Southern corroboree frog (pseudophryne corroboree), stuttering barred frog (*Mixophyes balbus*).

Other studies have used anaesthetic gels in cane toads (*Rhinella marina*), American green tree frogs (*Hyla cinerea*), various *Xenopus* and *Bufo* species.

An anaesthetic gel is made by mixing 3 parts of isoflurane or sevoflurane with 3.5 parts sterile water-soluble lubricant and 1.5 parts water. Vigorous mixing is needed to allow formation of a stable gel. The author has found that mixing is best achieved between two syringes using a double syringe adaptor or mixing in a 20ml syringe with syringe cap and shaking vigorously for approximately 10 minutes until no liquid component remains. Precautions should be taken to limit human exposure to the vaporised anaesthetic when mixing or using either gel formulation. It is important to note that vaporised isoflurane and sevoflurane were detected in the test chambers used in one study by Zec *et al* (2014).

When using an anaesthetic gel in a previously unstudied species consider starting with a dose of 0.05ml per gram of body weight, then top up with the same amount every five minutes until loss of the righting reflex. Total doses of 0.1-0.15ml per gram of body weight are commonly required. Application can be to the ventrum and/or dorsum although Foxon (1964) reports the dorsum may be more appropriate physiologically, as it plays an important role in cutaneous gas exchange in anurans. Anurans have a dedicated blood supply to the skin from two large cutaneous arteries that originate from the same source as the pulmonary arteries and the greatest concentration of capillaries associated with these arteries is found in the skin of the back and thighs (Foxon, 1964). Toads and other terrestrial species with thicker skin may require higher doses of gel.

whereas thin-skinned, aquatic species may require lower doses of gel (Stetter *et al*, 1996, Sabrina *et al* 2013). Toads and frogs with more granular, irregular skin may have an increased surface area over which the gel is absorbed so gel may need to be removed rapidly after first effects of sedation to prevent undesirably deep anaesthesia (Sladakovic and Divers, 2019).

Frogs may be placed inside a small resealable plastic bag while induction of anaesthesia occurs. This is preferable to hard containers as frogs appear less likely to injure themselves if they jump during induction when in plastic bags compared to hard containers. Once the righting reflex has been lost (usually within 3-5 minutes of gel application) the gel should be gently rinsed off with copious water at a temperature appropriate to the species. Gauze or cotton wool is used to gently wipe off gel under flowing water.

The respiratory rate, heart rate (via Ultrasonic Doppler or foetal doppler), palpebral and withdrawal reflexes may be monitored during anaesthesia. If a deeper plane of anaesthesia is required for invasive surgery (e.g. fracture repair, exploratory coeliotomy) a frog may be intubated and maintained on gaseous anaesthesia.

A frog is recovered from anaesthesia when it has regained the righting reflex and is moving in a coordinated way. The author suggests keeping frogs away from water bodies for at least two hours post-anaesthetic.

## References

1. Foxon GEH (1964). Blood and respiration. In: Moore JA, ed. *Physiology of the amphibia*. New York: Academic Press, 151–209.
2. Sabrina MS *et al* (2013). Evaluation of righting reflex in cane toads (*Bufo marinus*) after topical application of sevoflurane jelly. *AJVR* 74(6), 823-827.
3. Sladakovic I and Divers SJ (2019). Amphibian Anaesthesia. In: Mader's Reptile and Amphibian Medicine and Surgery 3<sup>rd</sup> Ed. Elsevier St Louis 480-485.
4. Stetter M, *et al* (1996). Isoflurane anesthesia in amphibians: comparison of five application methods. *Proceedings Am Assoc Zoo Vet Annu Conf*, 255–257.
5. Zec S *et al* (2014). Loss and Return of Righting Reflex in American Green Tree Frogs (*Hyla cinerea*) after Topical Application of Compounded Sevoflurane or Isoflurane Jelly: A Pilot Study  
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## **A whole 'lotl problems: Common issues, diagnostics, treatment, and management of the axolotl patient.**

Dr Oliver T C Gadsden BSc DVM  
Melbourne, VIC, Australia

### **Introduction**

Axolotl (*Ambystoma mexicanum*) are the only legal salamander permitted as a pet in Australia. Despite being the centre of much scientific publication and research for their impressive regenerative abilities, there appears to be little clinical data for their management and treatment as veterinary patients. Husbandry, common issues, and illnesses are well described through their tenure as laboratory animals, however comparatively little is offered for diagnosis, management and treatment of these cases.

### **Husbandry**

For the purpose of this talk knowledge on basic husbandry and parameters is assumed and will not be explored in detail, instead the focus will be on a collection of common issues encountered as a means to highlight diagnostics, treatment and management.

Some excellent resources for husbandry of axolotl are [www.axolotl.org](http://www.axolotl.org) and the former Indiana University Axolotl Colony (much of which has been merged into [axolotl.org](http://axolotl.org) since it's shutdown.) For a definitive compilation of much of the laboratory standards, husbandry and some medical issues encountered 'Developmental Biology of the Axolotl – Armstrong et al' is recommended.

### **Summary of Husbandry requirements**

- Water temperature: 16 - 18°C ideal (may tolerate up to 20-24°C in short term)
- Tank size: minimum 2ft for single axolotl
- Feeding: adults 2-4 small volume feeds a week, juveniles every two days, tadpoles daily
- Water changes: 25% weekly change (less if in understocked/ very large tank)
- Water testing: every 1-2 weeks
- pH: 7.6
- Ammonia: 0ppm
- Nitrite: 0ppm
- Nitrate: 0 - 20ppm
- General hardness (GH): 140-210 ppm (moderately hard)
- Special considerations: Low light intensity, incompatible tankmates, low water flow, appropriate substrate

### **General signs of disease**

- Anorexia
- Lethargy/nonresponsive
- Body condition loss, curling of tail membrane (possibly atrophy of tail membrane)
- Floating/ abnormal buoyancy
- External gill atrophy/degeneration
- Anaemia (gill filaments)
- Skin lesions
- Development of dull skin colour or yellow tinge (in non-yellow colour morphs)
- Exophthalmos, opacities, or spontaneous cataracts

## **Environmental temperature control**

Axolotl biology, metabolism and body function in response to environmental temperature, particularly low temperatures, simultaneously offers many challenges to case management as well as some interesting techniques and solutions. Precise control of water temperature and ability to actively cool are not only required to meet basic husbandry parameters, but also form an integral part of the author's case management and therapy. It has been suggested that chilling axolotl to 5-15°C may prove beneficial in sick axolotl, (Bjorklund and Duhon, n.d., Clare, 2019) can initiate a regurgitation reflex, (National Research Council (US) Subcommittee on Amphibian Standards, 1974) and purposefully slowing their metabolism may also prove useful in buying the clinician time for treatment of serious disorders.

Similarly to how one can attempt to manage reptile patients without appropriate temperature control, it is still possible to manage axolotl cases without this ability. In the author's opinion and case experience, however, not being able to meet basic husbandry requirements of sick axolotl (let alone the more involved techniques in environmental temperature control that one can use) place the clinician at a disadvantage in managing these cases. It is therefore the author's recommendation to invest in an aquarium chiller or appropriate 'fridging' setup if you are serious about managing a number of axolotl patients through your hospital, although the cost of such units may be prohibitive.

## **Common issues**

### **Internal parasitism:**

Clinical signs: Anorexia, weight loss, lethargy

As with other amphibian species internal parasites can be screened for with faecal examinations; wet prep, float, gram stain. Although, getting a sample before it dissolves can prove challenging. Most well managed colonies should not have issues with internal parasitism unless there have been recent introductions or other underlying stressors (husbandry or disease process) (Bjorklund and Duhon, n.d.).

Treatment should be directed by identification of any causative organisms.

### **External skin disease (parasitic, bacterial):**

Clinical signs: skin discoloration, excessive mucus production, high skin turnover/shedding, pruritus, anorexia, lethargy (severe cases)

Increased skin turnover and mucus production is much more apparent in the darker colour morphs than lighter shades such as leucistic (white), albino (yellow) and copper colours. Axolotl may actively 'itch' areas with extremities or use the environment to address pruritus. Skin issues may be a primary cause of disease or a secondary side effect of underlying immunosuppression/stressors. Diagnostic testing includes making skin scrapes of affected and sentinel areas as well as performing gill filament clippings.

Cytology and demonstration of causative organisms should direct treatment as in other aquatic cases, while also ensuring treatments are not contraindicated or toxic in this species. A list of reportedly toxic compounds is included at the end of the document.

In general, salt bathing is a relatively non-invasive and broad treatment for a range of conditions should diagnostics not be able to be performed or if they are inconclusive. Weak tea baths (black tea without additional aromas or additives – tannin therapy) are also an option for less serious conditions with a lesser degree of action but less damage to skin and gills.

Salt baths will also temporarily increase mucus production as in fish species and owners should be warned about this. Salt baths can, however cause damage to the gills and skin if done at higher concentrations or if left too long. Recommended bath concentration is 10-15g/L (non-iodinated salt) for 10 minutes (Loh, 2015).

### **Fungal infections:**

Fungal skin, and gill disease is a common finding in axolotl. Most commonly involved species are saprolegnia (Bjorklund and Duhon, n.d.). Axolotl often present with white hair like structures coming from areas of the gills, skin and occasionally necrotic digits and limbs. Another presentation for species other than saprolegnia are raised wart like lesions (Bjorklund and Duhon, n.d.). Fungal hyphae may be demonstrated by cytology. Supportive treatments exist and may be pursued however, cases of primary fungal disease are exceedingly rare and clinicians should always aim to diagnose and address the underlying health or husbandry issues that have led to the condition.

Supportive care generally includes salt bathing or other means of general antiseptic treatment appropriate for axolotl, as well as strict adherence to basic husbandry requirements. The clinician may opt to include specific antifungal treatment for moderate to severe cases. Broad spectrum antibiotics are recommended in severe cases, especially with active tissue necrosis or indicators of developing septicemia. Eventual debridement of necrotic tissues may need to occur in severe cases. Chilling the axolotl has been suggested to improve immune function and healing. Cooling to 15°C for mild to moderate cases is recommended and cooling between 5-15°C for severe cases if there are concerns over developing septicemia.

Note: While cooler temperatures are preferred for saprolegnia growth, the benefits to axolotl patients seem to outweigh the drawbacks of maintaining a lower water temperature during treatment (5-15°C.)

### **Trauma:**

Axolotl possess quite delicate skin and are prone to injury. Most common causes of trauma are tankmate injuries or environmental trauma. Minor cuts, abrasions and wounds may be managed with appropriate general antiseptic treatments such as salt bathing or general antibiotic treatment. In water medications are usually sufficient.

In cases of severe fractures, septic joints/limbs, or compromised blood supply, amputation of limbs or digits may be considered. In comparison to other species amputation in axolotl is a quite simple and accessible treatment due to its novel approach incorporating their native abilities to regenerate portions of their body. Amputation should, still, always be considered with caution. While regeneration of lost digits, limbs and other sections of their body are possible they will carry a not-insignificant metabolic loss to the animal over time and will incorporate a new open wound to manage. In many of the situations described above, however, this is preferable in terms of management, prognosis, and simplicity.

If amputation or significant debridement is to occur, one should maximise the potential for healing by secondary intention; sutures and primary closure are often not indicated as they will likely inhibit the natural regenerative abilities of the animal. Regeneration of limbs is not always a perfect process; it is not uncommon for potential complications during regeneration to occur including undersized limbs with limited functionality or regeneration of multiples of the injured anatomy.

One of the few areas where there is significant literature is in the methodology used in limb and tail amputations (Bryant et al., 2017, Kragl and Tanaka, 2009). A summarised method is given below, the aim of which is to produce the largest possible limb bud to give the patient the highest chance at regenerating a fully sized and functional limb.

**Suggested methodology - Limb and tail amputation:**

On an anaesthetised patient to a surgical plane.

- Scrub site using preferred scrub of 0.75% chlorhexidine solution; if this is not available use irrigation of sterile isotonic fluids (Surgical scrubs that contain soaps, detergents, isopropyl alcohol, or iodine products are contraindicated in amphibians (Gentz, 2007)).
- Leave ideally a minimum of 0.5-1cm of healthy tissue from the nearest proximal joint depending on patient size.
- Amputate at the desired point cutting through limb with blunt-sharp scissors (thought to aid in stimulation of regeneration through crushing trauma of tissues).
- Trim back any bone by 2-5mm to account for muscle contracture.
- Apply topical pressure until adequate haemostasis is achieved.
- Trim skin from periphery of amputation site to leave as large an area of exposed muscle tissue at the site as possible.

Post-operative care includes managing open wounds via general antiseptics or antimicrobial therapy as for cases of minor trauma. Recovery from anaesthesia, healing, and regeneration are aided by water temperatures of 5-15°C. (Bryant et al., 2017).

**Gastrointestinal foreign bodies:**

Foreign bodies (FB) are again a frequent issue in axolotl due to the way that they 'inhale' their food. For this reason, they should be housed on substrate that is unable to be swallowed, able to be digested, or pass through the entirety of the GIT without issue.

Presenting signs include anorexia, body condition loss in chronic cases, regurgitation and abdominal distention.

In mild cases of small FBs axolotl may spontaneously expel them given time, (Bjorklund and Duhon, n.d.), however most cases showing clinical signs have passed this point and should mainly be considered in cases where small FBs are an incidental finding. Palpation, and sometimes in smaller patients, visualisation (particularly of coloured FBs) should be the main tools used on physical examination. For appropriate diagnosis and choice of management strategies, imaging should be performed to quantify and localise any FBs, as the location and number may significantly change the clinical approach.

**Radiography:**

Radiology or other imaging such as ultrasound should be performed to quantify and localise the foreign bodies within the gastrointestinal tract. Axolotl may be imaged in shallow water if needed, however, this will affect the quality of the image as x-rays will be attenuated by the surrounding water. Imaging inside of containers (plastic or perspex) is preferred as those materials only attenuate x-rays opposed to glass that will reflect.

**Therapeutic temperature control:**

A novel solution for management of gastric foreign bodies in axolotl (and a few other scattered amphibian and reptile species) includes temperature control to stimulate a natural regurgitation reflex. If the environmental temperature is rapidly dropped (over the course of a few hours) some axolotl may be stimulated to regurgitate their stomach contents in preparation for hibernation (National Research Council (US) Subcommittee on Amphibian Standards, 1974).



This can be a useful tool in management of gastric foreign bodies, in some cases saving the patient the need to go onto removal under sedation or surgery and should always be attempted before moving onto more invasive techniques.

#### **Manual retrieval options:**

In cases of gastric FB that do not respond to rapid cooling, the retrieval option of choice is as a minimally invasive procedure under general anaesthesia. Lubricated forceps are inserted through the oral cavity into the stomach for manual removal. Failing this, or for a FB more distal to the stomach and unable to pass naturally, an exploratory laparotomy is the next option.

#### **Septicaemia:**

*Pseudomonas* and *Aeromonas* have been stated to be common species involved in bacterial infection of axolotl and, again, many of these infections are thought to be secondary to other underlying chronic disease or stressors (Bjorklund and Duhon, n.d.). In clinical practice septicaemia appears a common end stage of many disease pathways, supporting the above suggestion.

Clinical signs include: anorexia, skin changes, advanced cases are reported to develop ascites.

Diagnostically, septicaemia is rarely confirmed in live patients and treatment is often started on the basis of clinical signs and history. Once clinical signs of septicaemia are apparent, prognosis is often poor. Treatment involves broad spectrum empirical antibiotic use, and supportive care. Ideally obtain a fluid sample (coelomic, blood, other) for culture and sensitivity to confirm treatment is appropriate. Successfully used antibiotics include enrofloxacin 5mg/kg q24 ICo (diluted with water for injection or saline,) Gentamycin/amikacin 5mg/kg q48 ICo (diluted with water for injection or saline,) Trimethoprim sulpha's PI/in water (Bjorklund and Duhon, n.d., Loh, 2015). If the patient survives, addressing the root cause of immunosuppression is key to a full recovery.

The author prefers therapeutic cooling of suspect septicaemia cases to 5°C until the patient is stable (often multiple days – week). This appears to buy the clinician time to administer treatments and slows down the progression of clinical signs compared to keeping at 15°C, however, supportive evidence for this practice is purely anecdotal.

#### **Euthanasia:**

Euthanasia of axolotl should be performed by an anaesthetic overdose (MS-222, benzocaine or Alfaxan,) or sedation followed by pentobarbital injection. The most accessible IV access in a sedated patient for euthanasia is intracardiac. The heart is located central to and directly underlying the thoracic girdle.

#### **Clinical techniques**

IM injection – Epaxial muscles

ICo/Intraperitoneal injection – Insert needle at a shallow angle just cranial of the hind limb, ventral to the epaxial muscles to avoid the kidney.

IV blood draw – Ventral coccygeal tail vein, femoral vein, intracardiac (sedation recommended)

Salt baths – 10-15g/L (non-iodinated salt) for 10 minutes.

#### **Known toxicities**

- Malachite green
- Copper based products
- Tetracyclines (poorly tolerated – irritant to skin)

## References

1. Bjorklund, N. and Duhon, S. (n.d.). *The Mexican Axolotl as a Pet and a Laboratory Animal*. [Newsletter] Indiana Axolotl Colony Newsletter Archive, Indiana University Axolotl Colony Newsletter.
2. Bryant, D., Sousounis, K., Payzin-Dogru, D., Bryant, S., Sandoval, A., Martinez Fernandez, J., Mariano, R., Oshiro, R., Wong, A., Leigh, N., Johnson, K. and Whited, J. (2017). Identification of regenerative roadblocks via repeat deployment of limb regeneration in axolotls. *npj Regenerative Medicine*, [online] 2(1). Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5677943/#Sec12title> [Accessed 20 Aug. 2019].
3. Clare, J. (2019). *Axolotls: The Fascinating Mexican Axolotl and the Tiger Salamander*. [online] Axolotl.org. Available at: <http://www.axolotl.org> [Accessed 20 Aug. 2019].
4. Gentz, E. (2007). Medicine and Surgery of Amphibians. *ILAR Journal*, [online] 48(3), pp.255-259. Available at: <https://academic.oup.com/ilarjournal/article/48/3/255/664076> [Accessed 20 Aug. 2019].
5. Kragl, M. and Tanaka, E. (2009). Axolotl (*Ambystoma mexicanum*) Limb and Tail Amputation. *Cold Spring Harbor Protocols*, [online] 2009(8), pp.pdb.prot5267-pdb.prot5267. Available at: <http://cshprotocols.cshlp.org/content/2009/8/pdb.prot5267.abstract> [Accessed 20 Aug. 2019].
6. Loh, R. (2015). Common Disease Conditions in Axolotls. In: *World Small Animal Veterinary Association World Congress 2015*. [online] World Small Animal Veterinary Association, pp.1-4. Available at: <https://www.vin.com/apputil/content/defaultadv1.aspx?id=7259254&pid=14365&print=1> [Accessed 20 Sep. 2019].
7. National Research Council (US) Subcommittee on Amphibian Standards (1974). *Amphibians: Guidelines for the breeding, care, and management of laboratory animals*. Washington (DC): National Academies press (US), p.Chapter IV: Amphibian Management and Laboratory Care.

## Care and husbandry of sugar gliders (*Petaurus breviceps*)

Dr Jaclyn Gatt BVSc MVS (Conservation Medicine) MANZCVS (Unusual Pets)  
Bird & Exotic Animal Clinic  
19 Ponting Street, Williamstown VIC 3016

### Introduction

Sugar gliders (*Petaurus breviceps*) are a small native Australian marsupial that is becoming increasingly popular as pets both internationally and locally. As a native species they are somewhat more regulated in Australia than in other locations, with most states either requiring a wildlife licence or not allowing them as pets at all. Despite their adorable, fluffy appearance these marsupials are actually highly specialised mammals with unique feeding, housing and social requirements that must be met in order to provide them with a healthy and fulfilling life. As with any non-traditional pet it is essential to understand the needs of the species free-living counterparts and replicate this as closely as possible if we are to successfully keep them as pets.

### Biology 101

Sugar gliders are a nocturnal species of diprotodont marsupial, being closely related to possums and other glider species. By day, they sleep in tree hollows, then venture out at night to forage for food. They are social animals that will typically live in groups of

### Digestion

Sugar gliders are omnivorous diprotodonts and possess sharp upper and lower incisors, upper canines, and opposing sets of premolars and molars (3 and 4 teeth, respectively). This allows them to gnaw branches and leaves to obtain gum, sap and pollens but also to crunch insects and small invertebrates for protein. Further details of their nutrition will be discussed later.

Gliders are hindgut fermenters that have adapted to use bacteria in their caecum to digest the complex sugars found in tree sap and gum. The digestive tract terminates at the cloaca, a shared chamber with the reproductive and urinary tracts that exit through the single common opening known as a 'vent'.

### Reproduction

Females are seasonally polyoestrous and have two lateral vaginas, a central vaginal canal, two uteri, and a ventral abdominal pouch containing four teats. They give birth to tiny joeys that ascend from the cloacal opening into the pouch where they stay for 70-74 days. On emerging from the pouch they stay in the nest/hollow until weaning at 110-120 days old, eventually leaving their colony in search of a new one at 7-10 months of age.

Males have a long, forked penis with 2 openings (proximal for urine, distal for seminal fluid) and a pedunculated scrotum containing 2 testicles. Prominent scent glands that produce dark brown, musky scented secretions are positioned on top of the head (frontal gland), under the chin, throat and cranial thorax (sternal gland) and adjacent to the vent (paracloacal gland, also found in females). The scent glands are used for marking territory and mates, along with urine spraying, making gliders quite fragrant a lot of the time!

Table 1. **Physiologic Data for Sugar Gliders**

Life span	9–12 years
Adult male body wt	100–160 g
Adult female body wt	80–135 g
Respiratory rate	16–40/minute
Heart rate	200–300 bpm
Body temperature	36.3°C
Thermoneutral zone	27°–31°C
Food consumption	15%–20% bodywt/day
Dentition	Diprotodont
Dental formula	2 (I 3/1-2 C 1/0 P 3/3 M 4/4)
Puberty	8–12 months in females, 12–15 months in males
Oestrous cycle	29 days
Gestation period	15–17 days
Litter size	2 (81%)
Birth weight	0.2 g
Pouch emergence	70–74 days
Weaning	110–120 days

(From MSD Veterinary Manual, <https://www.msdvetmanual.com/exotic-and-laboratory-animals/sugar-gliders/sugar-gliders> )

### **Behaviour**

These are highly social animals that prefer to live in harem-style groups, with one dominant male and several females that may or may not be related cohabitating. In a captive situation, this means sugar gliders are best kept in small groups, though at a minimum a pair of animals. The author generally does not recommend keeping a single individual as a pet as it is so far from the 'normal' way of life for this species. This is arguably a source of chronic stress for a lone animal and housing them at least in a pair should be considered imperative to good glider welfare.

These intelligent and social creatures form strong bonds to cage mates and can become very trusting and tolerant of regular handling and interaction with their humans. Positive reinforcement through regular, gentle handling during the animals active hours (evening, night or dawn) and offering treats such as meal worms can help build on this relationship. Distressed or scared gliders make a chattering sound called “crabbing”, which should signal to the handler to slow down and give the animal time to adjust to what is happening. A frightened glider that feels trapped will likely try to scramble away and escape, causing many scratches and the occasional bite.

## **Housing**

The native habitat of the sugar glider is comprised of dense woodland and scrub, allowing them to lead an arboreal lifestyle. Their very specialised anatomy and gliding membrane (patagium) allows them to save energy by gliding between trees whilst hunting insects for food. In a captive setting, a large aviary style enclosure (PVC-coated stainless steel wire) or tall wire sided cage can be used to provide space for climbing and jumping. A maximum width of 10mm between bars is advised, with horizontal bar position preferred, making many of the standard large parrot cages useful for gliders too.

Cages should be placed on a stand or elevated to eye level to mimic a raised position within a tree and placed away from direct sunlight and drafts. Given these are nocturnal animals it is also suggested to keep the cage away from thoroughfares within the home to avoid disturbing their sleep pattern.

Furniture within the cage should include a number of nesting boxes and pouches anchored at various heights and positions, with wood, plastic, wicker and fleece fabrics all being suitable. Shredded paper, strips of fabric or even old socks can serve as bedding within these spaces. Wood shavings should be avoided due to its moisture absorbing and ammonia releasing properties, which may predispose gliders to respiratory disease.

Climbing branches and ledges can be put together using native tree branches, rope perches (sisal fibre), sea grass mats and non-treated pine shelves. Generally, bird-safe toys made of natural, non-toxic materials make good sugar glider equipment with items such as ladders, hanging paper toys and colourful plastic beads being popular choices. It is important to note that no matter how large and well equipped the enclosure is, sugar gliders should also be provided with supervised time outside of their cage to explore and exercise. For those who are really committed, there are a number of excellent climbing frames and suspended play gyms that can be constructed to hang from the ceiling and mimic an arboreal canopy for gliders. Pinterest has some fabulous ideas!

## **Nutrition**

Perhaps the most crucial thing to get right with sugar gliders is their diet, which is also the subject of extensive research and debate as to the best way to deliver the required nutrients to these animals whilst avoiding issues with obesity and nutritional deficiencies. The diet of wild sugar gliders is complex, consisting of a combination of eucalyptus sap, acacia gum, manna, nectar, pollen and insects, and the captive diet needs to mirror this. The wild diet also varies with the season, as flowering plants emerge and insect abundance varies, which further adds to the difficulty of getting a captive diet right.

The basic components of the sugar glider diet are:

- Protein- derived from insects and arachnids
- Carbohydrates- sugars as complex polysaccharides in tree sap, gum and secretions of sap-sucking insects
- Fibre – leafy greens and plant matter

An example of a balanced captive diet includes:

- 65% Vegetable and Fruit mix (carbohydrates) of which 25% fruit, 25% leafy greens and 50% vegetables.
- 20% Nectar mix (sugars)
- 15% Insects and Carnivore mix (protein)

The above diet can be formulated using a combination of Wombaroo products to try and replicate the natural diet of the sugar glider in a captive setting.

Historically, the Leadbeater's formula (*below*) has been a popular base diet that was developed by Australian zoos to help provide the variety of nutrients needed for their captive gliders. Various items of fresh food and insects can be added to this to achieve a similar goal, though the precise nutrition is less well documented with non-commercial products.

#### Leadbeater's formula

- 150ml warm water
- 150ml honey
- 1 shelled hard-boiled egg
- 25g high protein baby cereal
- 1 tsp multivitamin/ mineral supplement

1. Mix warm water and honey. Blend egg in a separate container until evenly mixed.
2. To the egg, gradually add the honey/water and blend until smooth.
3. Repeat for multivitamin supplement, then baby cereal, blending after each addition.
4. The formula can be refrigerated (use within 2-3 days) or frozen in ice cube trays for use later.

It goes without saying, but fresh, clean water should be available at all times and offered in a bowl or sipper bottle, depending on the glider's preference. It is advisable to have more than one water station available as active animals may accidentally knock things over during the course of their nightly adventures.

#### **Wellness care**

In the absence of any vaccinations it is important that veterinarians recommend annual health checks as part of routine wellness care for this species. The purpose is to review the diet and husbandry of the gliders, as well as perform a physical exam (including a weight check!), dental check and faecal exam (float and direct smear) for parasites. For animals 5 years and over, 6 monthly wellness checks are advised including annual blood tests to monitor for underlying issues and provide a baseline for the individual should future issues arise. Depending on the patient and any other concerns, urinalysis and radiographs could also be considered as part of the patient's database.

#### **Conclusion**

Vets and owners are responsible for meeting the specialised needs of the sugar gliders in their care, and ultimately ensuring their welfare is maintained. It is essential that the veterinary practitioner understands the basic biology and needs of the wild sugar glider in order to guide their clients on how best to adapt them for a captive lifestyle. Only by providing adequate care and husbandry to these pets will we be able to mitigate the onset of captivity-induced disease.

## References

1. Booth R (2003). Sugar gliders. *Seminars in Avian and Exotic Pet Medicine* Oct 1;12(4):228-231.
2. Dierenfeld ES (2009). Feeding behavior and nutrition of the sugar glider (*Petaurus breviceps*). *Veterinary Clinics of North America: Exotic Animal Practice* May 1;12(2):209-15.
3. Dierenfeld ES & Whitehouse-Tedd KM (2018). Evaluation of three popular diets fed to pet Sugar Gliders (*Petaurus breviceps*): Intake, digestion and nutrient balance. *Journal of animal physiology and animal nutrition*, 102(1):193-208.
4. Handasyde K, Holz P, Kelly D, Renfree MB and Webb C (2014). A Guide to the care and use of Australian native mammals in research and teaching. National Health and Medical Research Council, 70-83.
5. Hess L (2019). Sugar Gliders. MSD Veterinary Manual. Merck & Co, NJ, USA (Cited November 2019). Available from: <https://www.msdsvetmanual.com/exotic-and-laboratory-animals/sugar-gliders/sugar-gliders#v3310938>
6. Wombaroo Food Products (2018). Sugar Glider Feeding Guidelines. Adelaide, Australia. (Cited August 2019). Available from: <http://www.wombaroo.com.au/resources/Sugar%20Glider%20Feeding%20Guidelines%20A4.pdf>
7. Wombaroo Food Products (2018). Young Sugar Glider Growth and Feeding Chart. Adelaide, Australia. (Cited August 2019). Available from: <http://www.wombaroo.com.au/resources/Sugar%20Glider%20Growth%20&%20Feed%20Chart.pdf>
8. Quesenberry K & Carpenter JW (2011). Chapter 29 Sugar Gliders. *Ferrets, Rabbits, and Rodents: Clinical Medicine and Surgery*. Elsevier Health Sciences, 393-410.

## Intralipid: A novel treatment of fipronil toxicity in a rabbit

Kelly Giles BVSc BVMS Hons.  
Veterinarian at Unusual Pet Vets  
Murdoch, Western Australia 6150

### Case report

"Lucky", a 3-month-old entire male dwarf lop rabbit (*Oryctolagus cuniculus*), presented as an emergency for acute onset of generalized seizures which had first occurred that morning. The owner reported her son had applied an unknown amount of a flea treatment containing Fipronil to the patient two days earlier. Lucky had appeared normal at home until this morning, when he became quieter, inappetent and then started to seizure.

On physical exam the patient was bright, euthermic and in good body condition. However, mild-moderate dehydration was detected on skin tent and reduced borborygmi was noted on abdominal exam. Within five minutes of arrival the patient exhibited a grand mal seizure of approximately 15-20 seconds duration.

Midazolam was administered intramuscularly at dose rate of 0.2mg/kg, in conjunction with the patient being placed in a darkened oxygenated box for monitoring.

At this point the owner was advised the prognosis for recovery was guarded, however aggressive anticonvulsant therapy and supportive care was offered. The owner consented to hospitalisation and the recommended treatment for the next 24 hours.

The patient was started on the following:

Treatment	Dose / Route / Frequency	Intended purpose
Buprenorphine	0.03mg/kg IM q8h	Analgesia
Ranitidine	5mg/kg PO q12h	Prokinetic
Midazolam	0.2mg/kg IM q4h	Anticonvulsant
Levetiracetam	20mg/kg IV q8h	Anticonvulsant
Crystalloid fluids	10ml/kg/hr IV for 1hr then; 2ml/kg/hr IV for 5hrs	Rehydration
Intralipid rescue therapy	1.5ml/kg IV over 3 minutes then; 10ml/kg/hr CRI	Chelation
Critical care feeding	4-6ml/kg PO q2h	Nutritional support

The intralipid rescue therapy was monitored by collecting blood samples into capillary tubes every two hours and monitoring the opacity of the serum. Once the serum was observed to be completely opaque for four hours, the intravenous infusion was stopped. The serum and patient were monitored overnight for any seizure activity, and when the serum was observed to be transparent, the intravenous infusion was re-started. The patient was observed experiencing a small seizure once during the treatment, approximately two hours into the intralipid administration.

Once the patient demonstrated no further seizure events for a 16-hour period and had also re-established normal eating and toileting behaviour, the owner elected to manage the patient at home. Levetiracetam (20mg/kg PO TID x 14 days) and Ranitidine



Image 1: Patient receiving an IV loading dose of intralipid rescue therapy.



(5mg/kg PO BID x 5 days) were dispensed for at-home use, with instructions to monitor for any signs of inappetence or seizure activity.

The owner was contacted 24-hours after hospitalisation and reported no concerns. The patient came in for a recheck four days after discharge and the owner reported the patient's right distal ear had become desiccated and necrotic. This was observed as the distal marginal auricular vein, which was used as the site of intralipid infusion. A partial ear amputation and Pentoxifylline (30mg/kg PO BID x 4 days) were both declined by the owner, however, several days later the affected ear tissue fell off and the owner reported the patient had returned to normal.

## **Discussion**

Fipronil is on label as a treatment for fleas, ticks and mites in cats and dogs. The drug blocks GABA receptors in the central nervous system by inhibiting the uptake of chloride ions, which leads to excitation of the central nervous system. Fipronil has a greater affinity for these receptors in insects than mammals, which has led to its widespread use as an antiparasitic. However, rabbits appear to be more sensitive than other mammals (Petritz, 2018).

Fipronil has widely been reported to have a narrow margin of safety in rabbits, which has led many products containing the drug to be labeled as toxic in rabbits. Initially the drug had been recommended at 5mg/kg topically in rabbits, however further studies found that ingestion of the drug, potentially through rabbits licking the area the drug was applied, resulted in severe adverse reactions (Gupta R, 2018). It is thought that the increased bioavailability of the drug when given orally may be the reason behind this (Gupta R, 2018 and Petritz 2018).

Clinical signs of fipronil toxicosis in rabbits have been reported to include inappetence, lethargy and seizures. The onset of these clinical signs appears to peak three days post-application (Stern, 2017). The prognosis is guarded in rabbits once signs of seizures have developed (Petritz, 2018 and Johnston, 2008). Current treatment protocols recommend the use of anticonvulsants such as midazolam and levetiracetam, along with nutritional and fluid support (Petritz, 2018). The use of intralipid rescue therapy has been theorized in fipronil toxicity, but not yet reported in rabbits (Huynh M, 2016).

Intravenous intralipid therapy first gained attention in human medicine for its superior resuscitation effects in local analgesia toxicity (Rothschild L, 2010). Later studies have shown intralipid to be an effective rescue therapy for overdoses of calcium channel blockers, macrocyclic lactones, antipsychotics and antidepressants (Plumb, 2019 and Johnson, 2017). Fewer reports of its veterinary clinical application exist; however it has been shown to be effective in the laboratory setting with propranolol and chlorpromazine toxicosis in rabbits (Martyn H, 2008 and Cave G, 2008).

There are several theories as to intralipid's mechanism of action, with the 'lipid sink' mechanism most widely reported (Rothschild L, 2010 and Plumb, 2019). This theory suggests that the drug can sequester lipophilic compounds whilst in the intravascular space, which reduces the amount of drug available to other tissues (Lee, 2012). As such, intralipid has been recommended in cases of toxicity with lipophilic drugs. As most recommendations for intralipid use are largely derived from case reports, veterinary medicine has relied on doses extrapolated from human medicine. Veterinary clinicians are advised to use these recommendations with care as reliable safety data hasn't been established (Lee, 2012). Risks associated with use of intralipid are not widely established, however several common risk factors have been suggested to

include; pancreatitis; unilateral facial pruritus; pain on extravasation; suspected corneal opacity and thrombophlebitis (Plumb, 2019).

The dose recommended in canine veterinary medicine is a loading dose of 1.5ml/kg – 4 ml/kg over one minute, followed by a CRI of 15ml/kg/hr for two-six hours (Lee, 2012 and Plumb, 2019). The CRI can be repeated if the patient is still symptomatic and a serum sample is clear of lipaemia. It is recommended to cease intralipid therapy if the patient does not respond after three treatments, or if the serum is lipaemic (Plumb, 2019).

## Conclusion

This case demonstrated the successful use of intralipid rescue therapy in a rabbit with fipronil toxicosis. The patient presented with active seizing, which typically carries a guarded prognosis for rabbits when associated with this condition. The patient did, however, experience necrotic loss of the distal ear tip following administration of intralipid into his marginal auricular vein, suggesting that there may have been development thrombophlebitis or a fat embolism as a consequence of the drug's use. Therefore the author would advise the use of larger vessels, such as the cephalic or lateral saphenous veins, as the infusion site.

The other complication encountered in this case was the potential for fluid overload. The dose used was initially extrapolated from canine medicine, however, the patient's size and hydration status prevented a 15ml/kg/hr CRI of intralipid in this case. Instead a 10ml/kg/hr CRI of intralipid was used in conjunction with crystalloid fluid infusion at 2-10ml/kg/hr IV, depending on the patient's level of dehydration.

Intralipid is a stable product with an unrefrigerated shelf life of approximately one year prior to opening of the bottle. It is also a relatively inexpensive drug that can be purchased through most veterinary suppliers in Australia. This paper suggests that intralipid may be an effective rescue therapy for rabbits with fipronil toxicity and can improve the prognosis of rabbits presenting with this condition.

## References

1. Cave G, H. M. (2008). Intralipid Infusion Ameliorates Propranolol-Induced Hypotension in Rabbits. *Journal of Medical Toxicology*, 71-76.
2. Gupta R, A. A. (2018). Fipronil. In G. R, *Veterinary Toxicology Basic and Clinical Principles* (pp. 535-536). United States: Elsevier.
3. Huynh M, B. A. (2016). Assessment and Care of the Critically Ill Rabbit. *Veterinary Clinics: Exotic Animal Practice*, 379-409.
4. Johnson, T. (2017). Lipid Therapy for Selected Toxins. *Southwest Veterinary Symposium*. Davis: Veterinary Information Network.
5. Johnston, M. S. (2008). Clinical Toxicoses of Domestic Rabbits. *Veterinary Clinics: Exotic Anima Practice*, 315–326.
6. Lee, J. A. (2012). Lipid Rescue: What is the Evidence? *International Veterinary EMergency and Critical Care Symposium*. Minneapolis: Pet Poison Helpline.
7. Martyn H, C. G. (2007). Intralipid Outperforms Sodium Bicarbonate in a Rabbit Model of Clomipramine Toxicity. *Toxicology*, 178 - 185.

8. Petritz, O. (2018). Therapeutic Contraindications in Exotic Pets. *Veterinary Clinics: Exotic Animal Practice*, 327–340.
9. Plumb, D. (2019). Plumb's Veterinary Drug handbook. Stockholm, Wisconsin.
10. Rothschild L, B. S. (2010). Intravenous lipid emulsion in clinical toxicology. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 1-8.
11. Stern, L. (2017). Managing Toxicoses in Exotic Species. *Atlantic Coast Veterinary Conference*.

## **Pancreatic mass in a seizing guinea pig, *Cavia porcellus***

Sasha Herbert  
UVet Exotics Central  
University of Melbourne  
250 Princes Highway  
Werribee, Victoria, Australia

### **Summary**

Insulinomas are well documented in humans, domestic ferrets, domestic dogs and less often in domestic cats. Multiple endocrine neoplasia is reported, and common presentations are classified in humans. They are less commonly reported in domestic animals. This report describes a case of insulinoma in a guinea pig that was found on necropsy to also have thyroid neoplasia. Clinical signs were predominantly neurological progressing from facial twitches, hind limb weakness and periods of vacant staring, to generalised tremours and seizures within two weeks. Tachypnoea and dyspnoea were also observed during and after episodes of collapse. There were no changes to the hair coat or to the body condition of this guinea pig. Serum biochemistry displayed blood glucose of 1.1mmol/L to 4.5mmol/L during episodes of general tremouring and after seizures. Ionised calcium was elevated. Signs resolved with administration of oral dextrose or honey.

### **Clinical presentation and progression**

24<sup>th</sup> May: Adult entire female guinea pig estimated as 3 years old but adopted as an adult so uncertain of exact age. Presented by owner due to grunting and sitting in a hunched posture. An hour later she started twitching and urinated, and then stopped grunting. 20 minutes later when she arrived at the emergency centre this had progressed to a loss of ability to stand. Previous history included a change in behaviour. She had become more aggressive to the other guinea pigs over the last 3 months. Over these same three months she had been treated elsewhere for a respiratory tract infection and a urinary tract infection. Her appetite, drinking, faecal production and urination had been normal. Her levels of activity had been normal and vigorous.

Over the next two hours in the emergency centre the guinea pig was found to have difficulty rising, and tachypnoea, crackles and wheezes on auscultation. She was given flow by oxygen and gradually regained strength and at this stage was transferred to the exotics department.

### **Investigation and treatment**

Thoracic focused assessment with sonography for trauma (TFAST) showed no pleural effusion.

Blood collected from the cephalic vein showed glucose to be 1.7mmol/L.

Haematocrit, plasma total solids, sodium, potassium, chloride and ionised calcium were all within reported normal limits. A blood smear was reviewed showing many degranulated heterophils and low lymphocyte numbers.

Hypoglycaemia differentials were considered to include insulinoma, liver disease or a septic process.

Nutrigel was given orally which she licked happily. She was also given 10ml of 5% glucose subcutaneously but she was already moving around normally again by this stage.

An investigation including abdominal ultrasound and thoracic radiographs was scheduled for five days later if signs continued.

Her owner reported that over the next four days she showed no further twitching, grunting or hunching and no difficulty breathing and did not lack energy. She did

develop a red colour to her urine. On some occasions she did seem to stumble or lack strength in her back legs. She continued to eat normally.

29<sup>th</sup> May: An abdominal ultrasound, blood glucose and urine culture and sediment examination were performed. Generalised twitching developed during the ultrasound. It continued for two minutes, abating after administration of midazolam. Blood glucose at this point was 4mmol/L. No pancreatic mass was noted on the ultrasound at this stage. The kidneys showed hyperechoic foci in the renal cortices, reduced corticomedullary distinction, bilateral ovarian cysts and mildly enlarged irregular uterus. The urine sediment examination showed no bacteria, blood, white blood cells or epithelial cells and normal calcium carbonate crystals. The urine culture was negative. Insulinoma was still suspected but not confirmed. Renal pathology was not further defined. There were no further neurological signs that day. The owner was asked to offer sweet food if the twitches and generalised tremours recurred and to video her signs at home.

Over the next few days at home the guinea pig continued to eat well but hind limb weakness and facial twitches became more frequent. The owner reported administering glucose orally at home which resolved each episode but didn't prevent them recurring.

2<sup>nd</sup> June: A sudden neurological decline with generalised tremours and then seizing occurred on day 9 since the initial presentation. Blood glucose was 3.3mmol/L. Glucose was administered. Antibiotic therapy was commenced as urine culture results were not yet returned. An insulin assay was discussed but a definitive safe treatment for Guinea Pig insulinoma has not been developed so it was decided against.

3<sup>rd</sup> June: Seizuring becoming more frequent and glucose orally no longer effective. Phenobarbitone syrup commenced.

4<sup>th</sup> June: The patient was euthanised.

### **Necropsy findings**

Pancreas: Pancreatic endocrine neoplasm 6mm, with marked islet hyperplasia

Thyroid: Thyroid endocrine neoplasm (suspected C-cell neoplasm)

Liver: Moderate, subacute, multifocal, hepatic necrosis

Kidney: Moderate tubular nephrosis with proteinosis

Lung: Mild multifocal lymphoplasmacytic interstitial pneumonia

A retrospective review of the ultrasound images found an image that matched the shape, size and location of this pancreatic mass.

Definitive identification of the suspected thyroid C-cell or chief cell neoplasm would require the use of immunohistochemical markers.

### **Discussion**

It is possible this was a case of multiple endocrine neoplasia with multiple comorbidities. Retrospectively we believe most of the signs were caused by the insulinoma but cannot be certain. Further diagnostics could have included an insulin assay, T4 assay, and full biochemistry for renal function. We need to do further work to establish normal values on different equipment for blood glucose measurements, and T4 measurements.

Treatment with diazoxide has been reported but the improvement in clinical signs was short lived. Prednisolone is used in ferrets but the use of this drug historically in Guinea pigs has been avoided due to an expectation of high sensitivity to its immune suppressive effects as in rabbits. Further work is needed in this area.

Had the nodule been identified on the initial ultrasound surgical excision could have been attempted.

## References

1. Brandão, J., Vergneau-Grosset, C., Mayer, J., 2013. Hyperthyroidism and Hyperparathyroidism in Guinea Pigs (*Cavia porcellus*). *Veterinary Clinics of North America: Exotic Animal Practice* 16, 407–420.  
<https://doi.org/10.1016/j.cvex.2013.01.001>
2. Hess, L.R., Ravich, M.L., Reavill, D.R., 2013. Diagnosis and treatment of an insulinoma in a guinea pig ( *Cavia porcellus* ). *Journal of the American Veterinary Medical Association* 242, 522–526. <https://doi.org/10.2460/javma.242.4.522>
3. Künzel, F., Mayer, J., 2015. Endocrine tumours in the guinea pig. *The Veterinary Journal* 206, 268–274. <https://doi.org/10.1016/j.tvjl.2015.08.016>
4. Rosenthal, K.L., Wyre, N.R., 2012. Endocrine Diseases, in: *Ferrets, Rabbits, and Rodents*. Elsevier, pp. 86–102. <https://doi.org/10.1016/B978-1-4160-6621-7.00007-5>
5. Vannevel, J.Y., Wilcock, B., 2005. Insulinoma in 2 guinea pigs (*Cavia porcellus*). *Can Vet J* 46, 339–341.

## Ecology of the Central Bearded Dragon (*Pogona vitticeps*)

Dr Jonathon Howard  
Exovet Pty Ltd  
East Maitland NSW 2323

### Introduction

The Central Bearded Dragon (*Pogona vitticeps*) is a medium sized, diurnal, heliothermic lizard that is endemic to the semi-arid interior of eastern Australia. It is the most popular pet reptile species kept in Australia and around the world. Therefore, it is the most common reptile presented to the veterinarian. Being an "exotic pet" species, it is important to understand their natural ecology to provide correct husbandry requirements in order for them to be kept healthy and thrive in the captive scenario. Knowledge of both the extreme environment which they inhabit and their resulting behavioural adaptations guides optimal terrarium setup and care. From 2017 to 2019 over 150 *Pogona vitticeps* were observed and captured in the wild to assess behaviour, diet, basking temperature, humidity and basking Ultraviolet Index (UVI). This information and data will help reptile keepers to provide better husbandry and welfare for captive pet dragons. The data will also help the reptile veterinarian identify any husbandry shortcomings that may be contributing to diseases in the sick dragon presented in practice.

### Habitat and distribution

*P. vitticeps* are a species that is endemic to semi-arid eastern central Australia. Its general distribution ranges in from Bourke, Western New South Wales, in the east, Mt Isa in Western Queensland to the north, Alice Springs, Northern Territory, to the west and Adelaide, South Australia, to the south. All the animals sampled for this paper were located in Western New South Wales covering an area of approximately 118,000 square kilometres.

Bearded dragons are a generalist species that will occupy any suitable habitat within this large distribution. The habitat type includes temperate to tropical semi-arid woodland, shrubland and hummock grassland (Wilson and Swan, 2003). Typical annual rainfall within this distribution is between 200-400mm (BoM, 2010).

### Size and weight

The average weights and snout to vent lengths (SVL) are presented in Table 1. These weights were measured using readily available digital scales which are commonly used in clinical practice to weigh smaller exotic species. The length of each lizard was measured using a standard industrial tape measure available at any hardware store. Length was rounded to nearest 0.5cm.

	Snout to Vent Length (cm) n=162	Weight (g) n=160
All animals	23.3	341
Male	24.0	372.8
Female	21.5	254
Gravid Female	22.0	315
Maximum	28.5	553

Table 1. Snout to Vent Length and Weight

The wild dragons captured in this study were observed to be leaner and had significantly more musculature compared to their captive counterparts. With obesity and diseases such as hepatic lipidosis prevalent amongst captive dragons, these weight to length ratios can be used to somewhat assess appropriate weights in the

captive dragon. Seasonal variation in body weight was observed, with male dragons being heavier in autumn compared to spring and summer. This matches the findings of another study (Badham, 1971) and can be correlated with the cease of breeding activity and preparation for Winter brumation.

### Basking behaviour and temperature

*P. vitticeps* are a diurnal heliothermic species, actively seeking out the sun to attain heat for metabolic function.

Observations of captured animals found them preferring an exposed, elevated basking position with a clear, minimally obstructed view of the surrounding area. These preferences aid in predator and prey detection as well as observing and maintaining territory (Brown, 2014).

The basking pattern is largely dependent on the season and temperatures. Observed basking behaviour in Spring was a mid-morning period lasting for 2-3 hours, followed by absence of basking during the hottest part of the early afternoon. Bearded dragons would then re-emerge mid-afternoon and bask until early evening. Gravid females were found to utilise the warmed surfaces longer, being found until the late part of the day, close to dusk.

During summer, when day time temperatures exceeded 38 degrees Celsius, basking would be restricted to as little as one hour in the mid-morning. They sought shelter during most of the day and did not re-emerge unless consuming food in the early evening. During the hottest weeks of summer, when night-time temperatures did not drop below 30 degrees, dragons were not witnessed basking at all, seeking shelter from the heat. In Autumn the basking pattern followed that of spring, with once again females seeming to bask later and longer in the day.

In spring and early summer, numerous males were observed basking negatively orientated to the sun or even in shade. These males were maintaining a dominant basking position to survey their territory. Understanding the relevance of basking positions not only for the need to thermoregulate but also in regards to territorial behaviour means that in a terrarium, multiple elevated basking sites away from the heat source are essential.

The temperature of body surface, ground surface and air at time of basking were measured to give an indication of thermoregulatory requirements of bearded dragons (Table 2).

	Body Surface Temperature (°C) n=159	Ground Surface Temperature (°C) n=127	Air Temperature (°C) n=159
All animals (S.E.)	36.3 (0.34)	37.6 (0.61)	29.2 (0.29)
Male	36.6	37.5	29.3
Female	35.1	37.3	28.4
Gravid Female	36.6	39.4	30.6
Maximum	46.5	58.9	38.6

Table 2. Body Surface Temperatures, Ground Surface Temperatures and Air Temperatures of basking dragons.

The body surface temperature was measured with an infrared thermometer with a distant to spot ratio of 12:1 and emissivity set to 0.95. This tool was chosen as these thermometers are frequently used by the reptile keepers to obtain temperatures of areas in the terrarium and the animal itself, in the latter by measuring approximately 5cm from the dorsal basking surface of the animal's body. This technique does not tell the true preferred optimal body temperature of the lizard as a rectal temperature is required but somewhat unrealistic for the pet keeper to obtain.

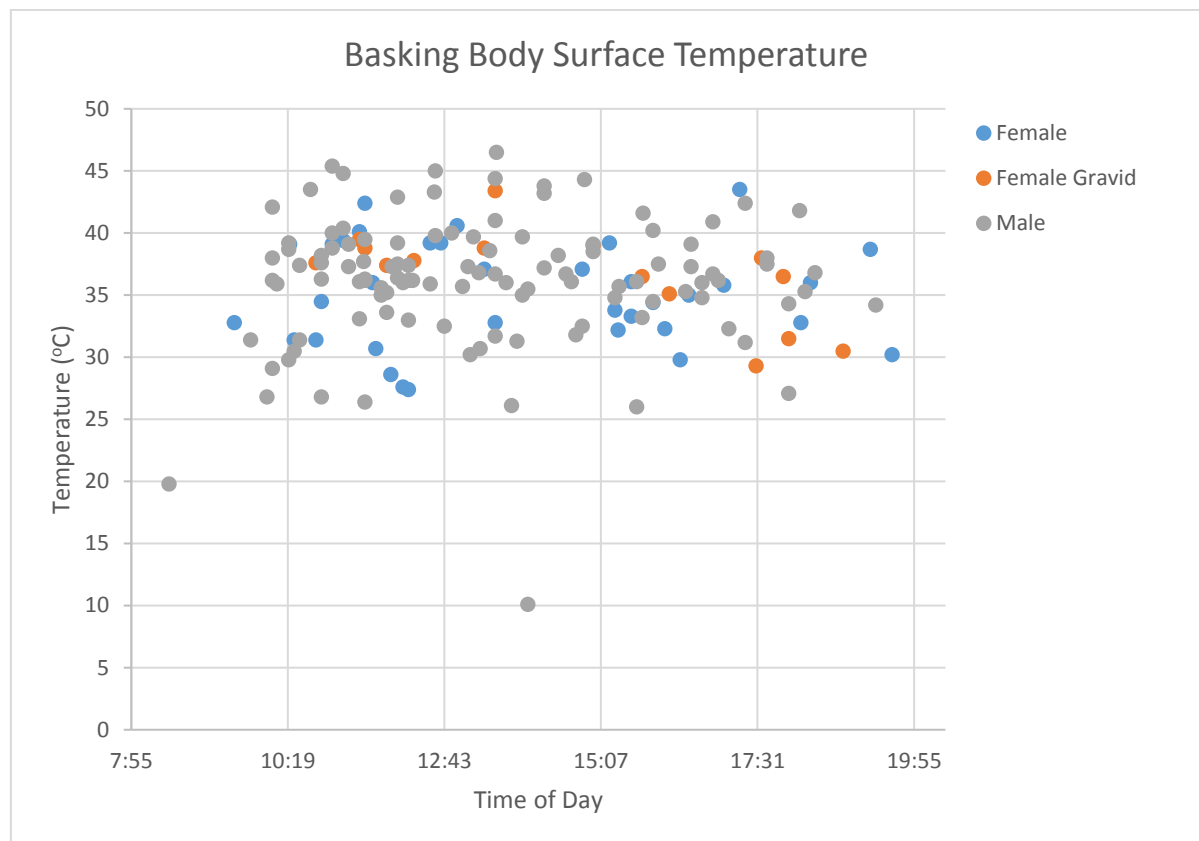


At the time of capture and temperature measurement, the animals may not have been at their preferred optimal body temperature yet. Despite this, the results are similar to the preferred average optimum body temperature of 36.3 degrees Celcius determined by the Badham study - through measuring rectal temperatures at the time of the animal changing position from a positive to a negative orientation to the sun.

The body surface temperature of the dragons is required to be at this higher temperature to allow heat transmission in order to attain a core body temperature to the POBT of 36.3 degrees Celcius (Badham, 1971).

The highest readings were measured at 42-45 degrees Celcius (Graph 1).

These results are useful to guide basking temperatures required for captive dragons in the terrarium.



Graph 1. Basking body surface temperature of *Pogona vitticeps*

The ground surface temperature was measured using the infrared thermometer described above. The reading was taken of the exposed ground surface next to the basking dragon at the approximate distance of 5cm. This data was collected to determine the radiant heat available in the environment at time of basking. A common mistake in reptile husbandry is the belief that the heat available to the animal correlates with the locally recorded air temperature. However, coupling air temperatures with surface temperatures illustrates that the dragon thermoregulates in significantly higher ranges of temperatures and therefore these conditions must be provided in the terrarium.

The air temperature was measured with a handheld digital air temperature and humidity hygrometer thermometer at the level of approximately one meter off the ground surface. This gives an indication for the ambient temperatures during the time

the bearded dragons are actively heating. These temperatures should be used as a guide to the air temperatures in the middle of the terrarium. There is still a requirement to have a cooler area in the terrarium as dragons have been observed placing their bodies on shaded surfaces to cool themselves when high ambient temperatures are present (Badham,1971).

Night-time temperatures within the field study area regularly dropped below 10 degrees Celcius during the spring when animals were active. While dragons would shelter in burrows and under logs during this time, one healthy male was found in a burrow with a body temperature of 11 degrees Celcius. A drop in night time temperatures in the terrarium is recommended to simulate natural daily temperature variation in the wild but it is not recommended to drop below 15 degrees Celcius.

### Humidity

Humidity is a parameter greatly emphasised within the bearded dragon keeping community. It is the amount of water vapour present in the air expressed as a percentage of the amount needed for saturation at the same temperature.

	Relative Humidity % n=132
All animals	26.0
Male	25.4
Female	30.7
Female Gravid	16.5
Maximum	83.2

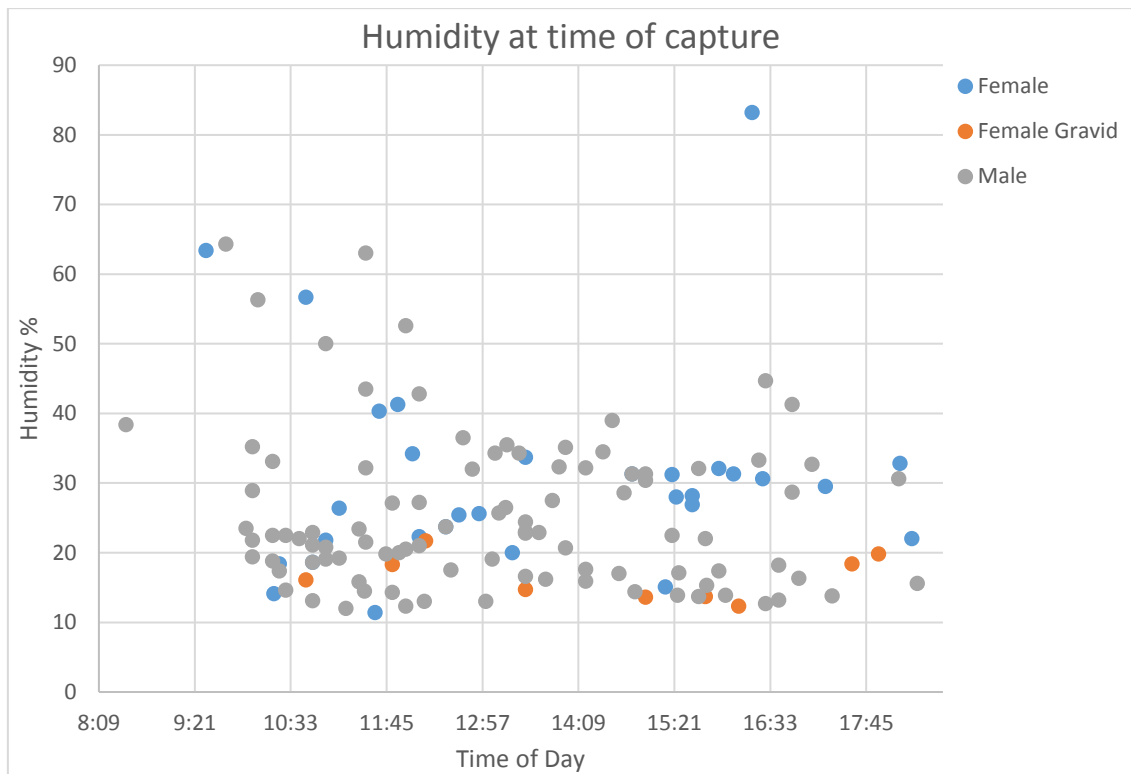
Table 3. Average relative humidity of basking *Pogona vitticeps*

It was observed that increases in humidity in the field, such as prior or post rainfall, brought animals out to bask. This is due to increased availability of their staple food source, subterranean termites, which emerge in higher humidity.

The typical humidity pattern in early spring and autumn in the area of the field study was 60% at 9am, dropping rapidly to under 30% by 11am, then below 20% at the hottest time of the day in mid to late afternoon, rising again to 60% overnight. During late spring and summer, the humidity starts at 50% at dawn and rapidly drops to 10-20% by 10am, increasing once again after sunset when temperatures begin to drop.

Most of the dragons in the field study were captured at humidity levels between 10 and 40% (Graph 3).

However, measuring the humidity at the time of basking alone is not a reliable method to determine levels to be provided in the terrarium, as a single measurement in an exposed position disregards the variation of humidity in a 24hour period and does not take into account the microhabitat at which the dragon will spend other hours of activity.



Graph 3. Relative humidity of basking *Pogona vitticeps*

### Ultraviolet Index (UVI)

Bearded dragons require UV-B light for the production of vitamin D3 for calcium metabolism (Baines et al., 2016). Even though vitamin D3 can be supplemented through diet, it is not as natural and much less effective in bearded dragons (Oonincx et al., 2010). The ultraviolet index (UVI) is an international standard measurement of the strength of sunburn producing UV-B radiation. It almost directly overlaps with the Vitamin D3 producing spectrum of UV-B making it a very useful measurement of Vitamin D3 producing power of artificial lighting sources (Baines et al., 2016).

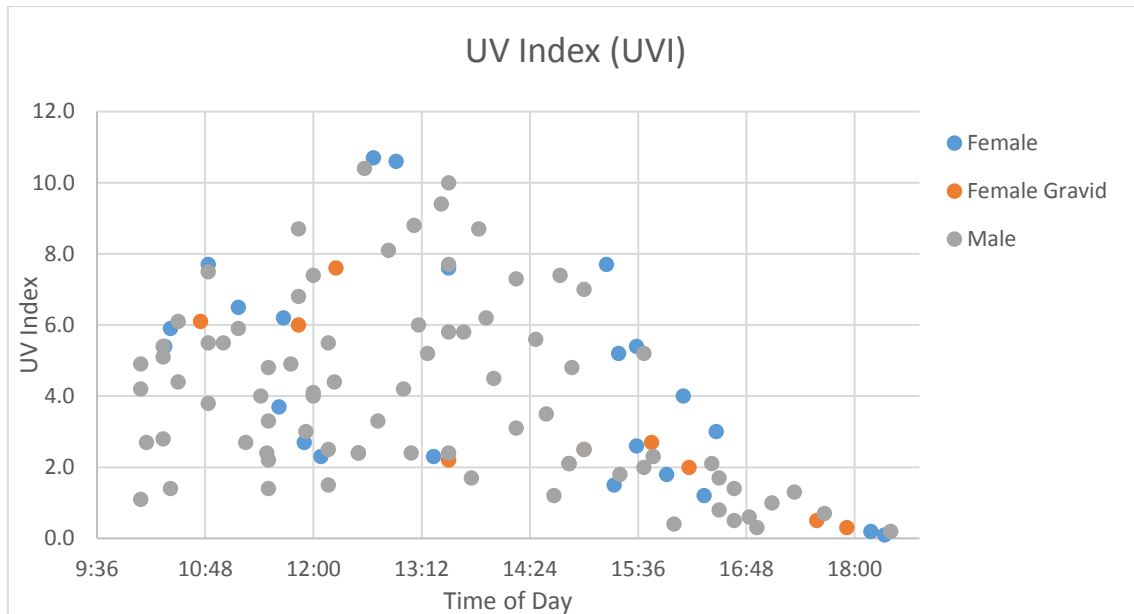
The UVI in areas where bearded dragons inhabit can peak at 12-14 during the active summer months (BoM, 2008). This does not consider the basking behaviour and the microhabitat in which this species occupies. To define an appropriate basking UVI for this species, a measurement was taken with a Solarmeter 6.5 UV Index Meter at the position of each basking dragon. Animals were captured within a UVI range between 0 and 10.7 (Graph 4). The average UVI during basking was 4.1 (Table 4).

This likely means that within the terrarium, a UVI of 4-5 at the basking spot with a reducing gradient to a UVI as low as 0 in the other areas is more than sufficient to produce adequate amounts of Vitamin D3. This is taking into account that the UVI in the natural habitat does not stay constant but peaks at midday when the sun is at its highest point.

With recent technological advances, there are many ultraviolet T5 high output (HO) fluorescent lamps that provide safe, long lasting and good quality UV-B light. Once these high UV-B producing lamps are utilised, caution must be used when supplementing with exogenous sources of vitamin D3, due to risk of vitamin D toxicity.

	Ultraviolet Index (UVI) n=112
All Animals (S.E.)	4.1 (0.3)
Males	4.1
Females	4.4
Gravid Females	3.3
Maximum	10.7

Table 4. Average UVI of basking *Pogona vitticeps*



Graph 4. UVI of basking *Pogona vitticeps*

### Diet

Bearded dragons are opportunistic omnivores feeding on insect and plant matter. Food items were noted by in situ observation and when examining the mouths of the captured animals. Insect species observed were termites, ants, wood roaches and wasps. Plant species observed were *Salvia verbanica*, flowers of *Wahlenbergia sp.*, *Hibiscus krichauffianus*, *Abutilon sp.*, *Chenopodium desertorum*, flowers of *Senna artemisioides*.

There is much debate on the percentage of plant material versus animal material in the captive setting. A study found that the diet of *P. vitticeps* consisted of 61% animal matter (Oonincx et al., 2015). Unfortunately, this study only sampled 14 animals over 12 days during the summer and does not account for seasonal variation and availability of food. Badham's study sampled 60 animals over three years in various seasons. It was concluded that the percentage dry weight of plant matter in the diet is 68.4% (adult males); 48.4% (adult females) and 20.2% (juveniles). A note was made that the chitinous exoskeleton of insects consumed contained less water content. Therefore, the plant material of the diet is underrepresented in the values above and could be significantly higher.

### Reproduction

Reproduction season is from August to December with almost every female captured during this time gravid or showing evidence of egg laying activity. During the early part of the season males fight for dominance within a territory. Male dragons will face off head to tail and lunge to bite the opponent's tail. Males captured had tail bite injuries and facial wounds.

Ovulating females invite copulation with the dominant male in the territory with a nudge or a tongue touch, run off a short distance and head bob slowly (Badham, 1971). Egg laying occurs approximately 37 days after mating. The average number of clutches is 2.6 per season with peak egg laying season in mid-October. On one field trip during this study in 2018, females within a study area did not show evidence of egg laying activity on clinical exam or plasma biochemistry. The area was particularly dry with no edible vegetation present in the environment. The animals appeared to be of good body condition. It is the author's impression that negative or neutral calorie intake during this time ceased reproductive activity. Avoiding excessive feeding has been a successful means in the author's experience of preventing captive bearded dragons from laying infertile clutches.

Numerous hatchlings were found from late summer. These animals were found under debris and hidden in the branches of shrubs. They were reluctant to expose themselves when basking, preferring to thermoregulate through filtered light through the leaves and bushes. This is something to consider when setting up a basking spot for a captive hatchling pet dragon.

In the wild, male hatchlings can reach sexual maturity in the first year at approximately 11.4cm SVL, while females do not reach sexual maturity until the second year of life at 14.3cm (Badham, 1971). This is in contrast with captive animals, which are often reproductive as early as at eight months of age. This is contributed to excessive feeding and not providing a natural brumation period as in the wild.

### **Brumation**

Bearded dragons undergo a period of brumation in the cooler months of the year. This is usually from April until August. During this time, they will seek shelter in excavated burrows and under fallen debris. They may still be found basking during this time on warmer, clear days (Australian Museum, 2019). During this study, two animals were uncovered while brumating in early spring with body temperatures of 10.1 degrees Celsius and 19.8 degrees Celsius. Despite air temperatures in winter approaching 0 degrees Celsius, burrows are well insulated and usually stay well above these freezing temperatures. Burrow studies in native mammals in the same habitat have recorded a winter average temperature of 15.5 degrees Celsius with very little daily fluctuation (Körtner et al., 2008).

The environmental cues to emerge from brumation may include increasing temperature, increasing daylight length, changes in humidity and barometric pressure. The Badham-study found that *P. vitticeps* did not move to actively bask until the body temperature reached 22 degrees C.

### **Life expectancy**

Badham's study found the mortality rate of central bearded dragons within their first year of life is 98.6% succumbing to predation, dehydration and cold. After the first year of life the mortality rate reduces to 29.1% with a life expectancy of 3.94 years.

The predators within their environment are various venomous and nonvenomous snakes, monitor lizards, birds, dingoes and introduced predators such as feral cats and foxes. A field study on *P. vitticeps* in western Queensland is currently experiencing significant predation problems with birds of prey and feral cats (Kristoffer Wild, personnel communication, May 6, 2019). Cannibalism of hatchling bearded dragons by larger dragons also occurs (Badham, 1971).

## Parasites

Wild dragons are hosts to numerous internal and external parasites. Dragons captured commonly had reptile ticks (*Ixodes* spp.) attached in ears, eyelid margins and folds of skin around the neck and legs. These did not seem to cause irritation or ill health.

The gastrointestinal content from a single road kill dragon on the outskirts of White Cliffs, NSW was collected and analysed. The stomach contained numerous oxyurid worms (pinworms) which are a natural parasite and are thought to aid with the breaking down of indigestible parts of the diet (Davies, 2008). These pin worms are species specific and have a direct life cycle (Mader, 2005). Feeder insects are incorrectly blamed within the hobby for spreading this parasite in captivity.

Two species of coccidia were also found within the gastrointestinal contents of the above-mentioned dragon, *Isospora amphiboluri* and *Eimeria* sp. These two species of coccidia are commonly detected in captive bearded dragons and are host specific with a direct life cycle. These parasites are spread via an oro-feacal route (Mader 2005). In the wild, it is believed that coccidia are transmitted by the female dragon as the egg passes through the cloaca. The egg surface is contaminated with large numbers of the highly resistant and virulent oocysts which infect the hatchling dragon as it emerges from the egg (Stöcker, 2019).

Adenovirus is a commonly reported disease of captive bearded dragons world-wide. 29 of the captured dragons were tested for adenovirus via PCR of oro-cloacal swabs. 8 of the dragons tested positive for agamid adenovirus-1 and 1 dragon tested positive for *Lizard atadenovirus A*. All positive testing dragons appeared healthy on physical examination as well as on haematology and plasma biochemistry, concluding that bearded dragons are the natural host for these viruses (Hyndman et al., 2019).

Evidence of intraerythrocytic iridovirus has been detected on blood smears in 16 of the 129 dragons sampled. All the samples detected have been male animals and appeared healthy on physical examination as well as haematology and plasma biochemistry. Its spread is suspected to be a haematophagous vector such as ticks in the wild (Grosset et al., 2014). In the author's experience with this virus in captive *Pogona barbata*, it is suspected to spread via oro-faecal transmission as well. The significance of only the males showing the disease in the wild population of this study is unknown but it could be speculated that haematogenous spread during combat may be a factor.

## References

1. Australian Museum (2019). Central Bearded Dragon. [online] [australianmuseum.net.au](https://australianmuseum.net.au). Available at: <https://australianmuseum.net.au/learn/animals/reptiles/central-bearded-dragon/> [Accessed 8 Aug. 2019].
2. Badham JA (1971). A comparison of two variants of the bearded dragon, *Amphibolurus barbatus* (Cuvier). PhD Thesis. School of Biological Sciences, University of Sydney.
3. Baines F, Chattell J, Dale J, Garrick D, Gill I, Goetz M, Skelton T and Swatman M (2016). How much UV-B does my reptile need? The UV-Tool, a guide to the selection of UV lighting for reptiles and amphibians in captivity. *Journal of Zoo and Aquarium Research* 4(1): 42 - 63. <http://www.jzar.org/jzar/article/view/150>. *Journal of Zoo and Aquarium Research*. 4. 42 - 63.
4. Brown D (2014). A guide to Australian lizards in captivity. Burleigh BC, Queensland: ABK Publications.

5. Bureau of Meteorology (2010). Average rainfall map of Australia 1961-1990. Australian Government.  
[http://www.bom.gov.au/jsp/ncc/climate\\_averages/rainfall/index.jsp?period=an&area=oz#maps](http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp?period=an&area=oz#maps)
6. Bureau of Meteorology (2008). Average UV Index Map Summer 1979-2007. Australian Government.  
[http://www.bom.gov.au/jsp/ncc/climate\\_averages/uv-index/index.jsp?period=sum#maps](http://www.bom.gov.au/jsp/ncc/climate_averages/uv-index/index.jsp?period=sum#maps)
7. Davies RR (2008). Common parasites of pet reptiles. UK Vet Companion Animal, Vol. 13. No. 4.
8. Grosset C, Wellehan JFX, Owens SD, McGraw S, Gaffney PM, Foley J, Childress AL, Yun S, Malm K, Groff JM, Paul-Murphy J and Weber III, E (2014). Intraerythrocytic iridovirus in central bearded dragons (*Pogona vitticeps*). Journal of veterinary diagnostic investigation: official publication of the American Association of Veterinary Laboratory Diagnosticians, Inc. 26. 354-364.
9. Hyndman TH, Howard JG and Doneley RJT (2019). Adenoviruses in free-ranging Australian bearded dragons (*Pogona* spp.). Veterinary Microbiology. 234.
10. Körtner G, Pavey CR and Geiser F (2008). Thermal Biology, Torpor, and Activity in Free-Living Mulgaras in Arid Zone Australia during the Winter Reproductive Season. Physiological and biochemical zoology: PBZ. 81. 442-51.
11. Mader D (2005). Reptile Medicine and Surgery. 2nd ed. Philadelphia, Pennsylvania: Saunders.
12. Oonincx DGAB, Stevens Y, Van den Borne JJGC, Van Leeuwen JPTM and Hendriks WH (2010). Effects of vitamin D3 supplementation and UVb exposure on the growth and plasma concentration of vitamin D3 metabolites in juvenile bearded dragons (*Pogona vitticeps*). Comparative biochemistry and physiology. Part B, Biochemistry & molecular biology. 156. 122-8.
13. Oonincx DGAB, Van Leeuwen JJGC, Hendriks WH and Van der Poel AFB (2015). The Diet of Free-Roaming Australian Central Bearded Dragons (*Pogona vitticeps*). Zoobiology. 34. 10.
14. Stöcker B (2019). Parasiten bei Reptilien. [online] Reptira.com. Available at: [http://www.reptira.com/PDF\\_Dateien/parasiten\\_bei\\_reptilien.pdf](http://www.reptira.com/PDF_Dateien/parasiten_bei_reptilien.pdf) [Accessed 8 Aug. 2019].
15. Wilson S and Swan G (2017). A Complete Guide to Reptiles of Australia. Chatswood, New South Wales: Reed New Holland Publishers

## **Applications for thermoplastic film in avian and exotic patients**

Dr Glynn Lam BVSc  
Bird and Exotic Animal Clinic  
19 Ponting St, Williamstown  
Melbourne VIC 3016

### **Introduction**

A “thermoplastic” refers to any plastic polymer that becomes soft and malleable when heated, and when cooled reverts to its original chemical and mechanical properties. There exists a huge variety of types, each with different properties when heated and cooled, the properties at each temperature, and temperatures required to alter the structure. In human medicine and surgery, thermoplastics are largely used as splinting material for the digits.

In the author’s practice in Melbourne, Victoria, where we only see avian and exotic patients, we have been experimenting with a cheaply available thermoplastic marketed as “cap material” or “hobby thermoplastic,” which is actually intended for use in crafting. It comes in large rolls of flattened sheets. This type of thermoplastic is readily and cheaply available from online art and craft stores, and in certain privately owned craft stores. The most commonly used brands are Worbla’s Finest Art® (Switzerland) and Lumiflex® (Australia), well known in the costuming community for making lightweight jewelry, props and armour. From here onward, the author will refer to these crafting thermoplastic films collectively as TPF.

Fresh from the package, TPF is an inert, brown-coloured plastic sheet, usually in a roll. It can be cut with regular scissors. A heat gun can be applied to the film to reach its malleable state at 90 degrees Celsius and above. Once the surface cools enough to touch, there are approximately three minutes where it can be moulded to whatever shape is desired. In its malleable state it is so pliable that it can be used to make a moderately fine detail cast of what is directly underneath. Once cooled (setting within 5 minutes and solid by 15 minutes) it is lightweight, durable, waterproof and non-toxic, and can be cut, sanded or drilled. Both brands mentioned above come imbued with non-toxic surface glue, allowing it to stick to itself and various materials including foam and plastic. If two glue surfaces come into contact, it is essentially impossible to part (but can be cut when cooled). It can also mould nearly seamlessly into itself, leaving no tab for patients to pick at. When TPF has cooled, it can be flattened back into sheets and re-used.

The exact polymers contained in the above brands are difficult to ascertain and are most likely closely guarded due to copyright law. The MSDS sheets refer to the complete product as non-toxic to ingest, touch or inhale. When heated, it does not produce any smell. In our practice we have not experienced any adverse effects in small patients while the material is being heated nearby, and in cases of birds that have ingested the material there do not appear to be any effects for as long as we have been using it (approximately three years). We do not have any biochemical information about these patients, but as far as we are aware, there have been no effects of vomiting, inappetence or faecal changes in the following three months when following up those particular patients. The most significant known hazard for this material is minor burns to the staff and patients if it is contacted immediately after heat application, and severe burns if the heat gun is contacted or pointed at the operator. Insulation (such as foam or soft bandaging materials) is strongly recommended if the material is applied quite close to the skin of the patient, particularly in patients with thin skin.



## **Applications**

The most useful applications for TPF in the author's practice have been to create temporary and permanent splints for fractures, hobbles or casts to manage developmental joint deformities, and struts in external fixation devices.

For braces and splints, TPF can very quickly applied and customised for the individual patient, who sometimes require short anaesthesia times. As it is moulded to the individual, careful planning can quickly lead to a strong splint that is difficult to remove if the joint above and below the area of stabilisation is encompassed. It can also be customised so that some areas are free to move in certain directions, but not others (for example, allowing a patient with a tibial/tibiotarsal fracture to still move the hock joint without rotating the tibia/tibiotarsus). The rough surface of reptile scales are an excellent surface to mould to, and greatly restrict unwanted movement of the material. We have also successfully used TPF as part of a quick, first aid stabilisation of a fractured bone in the conscious patient as part of a Robert-Jones bandage system.

The author has also trialed TPF in young birds with joint deformities, as an alternative to tape based constructions. Splay leg in juvenile chickens, and hock walking in budgies, have been improved to varying degrees by altering the shape of the hobbles or casts as the patient grows.

As a strut material in external fixation, TPF has some advantages over traditional material such as epoxy putty (Selleys Knead-IT®), which acts more like clay and does not adhere well to smooth metallic surfaces. Although TPF also does not adhere to metallic surfaces, it adheres so well to itself when folded that it forms an immediate, strong bond that is simple and neat to apply.

In theory, this lightweight and waterproof material could be considered in repair of fractured chelonian shells. It can be easily adapted to hold clasps, wire and nails. Currently, we have not yet had the opportunity to trial it for this purpose.

## **Limitations**

There are certain limitations we have encountered when using this material. It is relatively thin (3mm), and if over-stretched it will weaken in the centre, collapsing on itself or becoming too brittle for its assigned task. It requires the user to utilise complex spatial thinking, converting a flat piece of material into a 3d material. It is quite flexible over large areas and can collapse on itself without appropriate support; therefore it is best suited to small areas (a limit of 10x10cm is suggested). There are no biochemical studies following the ingestion of the material to support its safety, so restraint from ingestion of the material is strongly recommended. The material would not withstand a large parrot's beak or herbivore teeth, so we recommend that certain large or destructive patients be fitted with kind an Elizabethan collar.

## **Future**

As hobby thermoplastic becomes more popular in crafting communities, there are more brands and subtypes being developed that have different properties that are yet to be explored. There are some that form at lower heat or are more rigid than the most commonly available options. Clear materials are also available which may be useful in monitoring a wound or perhaps covering a catheter on a small limb or ear.

In our practice which only sees avian and exotic patients, hobby based thermoplastic film has certainly been a useful addition to our kit, having many advantages over traditional bandaging, splinting and ex-fix materials. As a novel, inexpensive material with low start-up costs, it is hoped that the exotic animal clinician will consider adding it to their practice, and to explore further possibilities in its use to further improve the management of small patients.

## **Unveiling the mysteries of the reptile cloaca and navigating it for diagnostic purposes**

Helen McCracken  
Melbourne Zoo  
P.O. Box 74, Parkville VIC 3052

The cloaca of reptiles is an important anatomical region for clinicians to understand as it contains the outflow openings of the gastrointestinal, reproductive and urinary tracts. In other species, we routinely identify these openings for examination, diagnostic sampling and cannulation, however, with the exception of chelonians, the anatomy of the reptile cloaca is scantily described in clinical texts in common use by veterinarians.

The reptile cloaca is described as having three sequential compartments arranged cranially to caudally in the following order: coprodeum, urodeum and proctodeum. The distal colon opens into the coprodeum; the ureters, urinary bladder and reproductive tracts open into the urodeum; and the proctodeum is the most caudal chamber through which the products of these tracts exit the body. The external opening of the cloaca is termed the vent (McArthur and Machin, 2019).

The anatomy of the chelonian cloaca is well described and illustrated in several clinical texts. The coprodeum is the most cranial region, receiving the opening of the colon dorsally. The urodeum is a complex region: the urinary bladder opens into its most ventral aspect via a short urethra; the oviducts and vas deferentia open bilaterally, a very short distance dorsolateral to the urethral opening; the ureters enter bilaterally on its dorsal aspect; and some semi-aquatic species have two small accessory bladders that open into the dorsal aspect. The ventral aspects of the coprodeum and urodeum also house the phallus, the male copulatory organ, or a smaller clitoral organ in the female (McArthur et al., 2004; McArthur and Machin, 2019).

In the chelonian urodeum, kidney outflow passed through the ureters moves either into the proctodeum for immediate voiding via the vent, or into the coprodeum and colon by antiperistalsis, or into the urinary bladder via the urethra. Significant physiological modification of the urine, most notably water resorption, occurs while it is stored in the bladder, colon or coprodeum, prior to being voided by the animal (McArthur et al., 2004).

In chelonians, there are no dividing tissues separating the three cloacal compartments from each other.

When examining the chelonian cloaca via the vent, one first enters the proctodeum, then moves cranially into the urodeum. Once in the urodeum, one can locate and cannulate the ventrally located openings of the bladder and oviducts and the more dorso-cranially located opening of the rectum in the coprodeum. Given this anatomical understanding, several authors have described diagnostic and surgical procedures achievable by endoscopy of the bladder, oviducts and colon via the cloaca (Di Girolamo and Selleri, 2015; Mans and Foster, 2014; Spadola et al., 2016).

Descriptions of the cloaca of squamates (snakes and lizards) in clinical texts lack details regarding how the three compartments and their internal openings may be identified via the vent. This has been a source of frustration and confusion for the author and other clinicians for many years. Without this knowledge, one cannot confidently perform a range of standard clinical procedures including placement of enema tubes, collection of rectal swabs, lubrication of the oviduct for the management

of dystocias and identification of the tissues involved in cloacal prolapses. Recently, a snake presented to the author that required contrast salpingography, necessitating an investigation to solve this conundrum.

This investigation involved review of historic squamate anatomical literature (Beuchat, 1986; Rheubert et al., 2015; Siegel et al., 2011; Siegel et al., 2015; Trauth and Sever, 2011) and dissections of numerous species of Australian and exotic snakes and lizards.

This work found that the three cloacal compartments are not arranged sequentially in squamates. With the animal in dorsal recumbency, on passing through the vent, one enters the short proctodeum. One can then find a horizontal tissue septum that divides the more cranial part of the cloaca into a ventral region (the coprodeum) and a dorsal region (the urodeum). This septum is generally not immediately obvious because it is often reflected dorsally, covering the opening into the urodeum; sometimes it is reflected ventrally, covering the opening into the coprodeum. It may be found by gently probing for its margin with a speculum or blunt forceps. Once the septum is lifted, one may distinguish and enter each of the two chambers.

The urodeum is located dorsal to the horizontal tissue septum. It is shorter than the coprodeum and is “blind ended”. The openings of the ureters, termed urinary papillae, are situated on its dorsal aspect at the level of the caudal margin of the septum, representing the junction between proctodeum and urodeum. There are two closely positioned ureteral openings in most species, but some have only one opening because the ureters converge before opening into the cloaca. In most species, these openings are detectable as small holes or slits on the dorsal wall of the urodeum, but in some species the openings are located within one or two fleshy papillae (Rheubert et al., 2015; Siegel et al., 2011; Siegel et al., 2015; Trauth and Sever, 2011).

In females, the bilateral openings of the oviducts, termed genital papillae, are found at the cranial termination (blind end) of the urodeum. The appearance of these openings varies between species from simple apertures to complex fleshy structures. In some species, the most cranial part of the urodeum is bilobed with the oviducal openings positioned at the termination of each short lobe (Siegel et al., 2011; Siegel et al., 2015).

The urodeum of male squamates is less deep than that of conspecific females. Genital papillae are absent in males as each vas deferens converges with its ipsilateral ureter immediately cranial to the cloaca (Rheubert et al., 2015; Trauth and Sever, 2011). These differences between genders may be used for sex determination.

The coprodeum is located ventral to the horizontal tissue septum. It is a relatively long structure contiguous with the distal colon. A distinct anal sphincter separating coprodeum from colon is not apparent in all species. Frequently urates are found in the coprodeum, immediately caudal to faeces in the distal colon. The outflow from the ureters is retro-pulsed into this position after passing through the urinary papillae. As in chelonians, significant modification of the renal output, most notably water resorption, occurs in the coprodeum and colon (Kuchel and Franklin, 2000), producing concentrated white pasty urates. The juxtaposition of faeces and urates at this site explains why squamates generally void urates together with faeces as the active process of defaecation pushes out the urates ahead of the faeces.

Urinary bladders are present in some lizard species, but absent in all snake species (Beuchat, 1986). The opening of the bladder into the cloaca is positioned immediately ventral to the coprodeum – it is the most ventral opening in the cloaca. The role of the bladder in lizards is not well understood, but it is assumed to have a urine modification

role similar to that of chelonians. Of the lizard species commonly kept as pets in Australia, Blue-tongued and Shingleback Lizards have well developed bladders, whereas Bearded and Water Dragons have only rudimentary bladders that are not readily detectable on dissection (Beuchat, 1986).

The openings of the ureters, oviducts, colon and bladder may be readily cannulated in most snake and lizard species dissected by the author (more challenging in small specimens).

In conclusion, it is interesting to note that in squamates, the coprodeum is ventral to the urodeum, whereas the reverse is the case in chelonians. In both chelonians and lizards with bladders, the urethral opening is the most ventrally positioned opening in the cloaca.

Since establishing this understanding of the cloacal anatomy of squamates, the author has applied this knowledge to many species in numerous clinical situations. These include the correct placement of rectal temperature probes, performing rectal swabs and flushes, urine collection, gender determination, positive contrast cloacography for better definition of spinal lesions, salpingography, identification of the system origin of cloacal discharges and the organs involved in cloacal prolapses, and enabling the correct identification of structures during cloacoscopy.

## References

1. Beuchat CA (1986). Phylogenetic distribution of the urinary bladder in lizards. *Copeia* 1986(2), 512-517.
2. Di Girolamo N and Selleri P (2015). Clinical applications of cystoscopy in chelonians. *Vet Clin Exot Anim* 18, 507-526.
3. Kuchel LJ and Franklin CE (2000). Morphology of the cloaca in the Estuarine Crocodile, *Crocodylus porosus*, and its plastic response to salinity. *Journal of Morphology* 245, 168-176.
4. Mans C and Foster D (2014). Endoscopy-guided ectopic egg removal from the urinary bladder in a leopard tortoise (*Stigmochelys pardalis*). *Canadian Veterinary Journal* 55, 569-572.
5. McArthur S, Meyer J and Innis C (2004). Anatomy and physiology. Pp. 35-72 in McArthur S, Wilkinson R and Meyer J (eds.) *Medicine and Surgery of Tortoises and Turtles*. Blackwell Publishing, Oxford, UK.
6. McArthur S and Machin RA (2019). Gastroenterology – cloaca. Pp. 775-785 in Divers SJ and Stahl S (eds.) *Mader's Reptile and Amphibian Medicine and Surgery*. Elsevier, St. Louis, Missouri, USA.
7. Rheubert JL, Sever DM, Siegel DS and Trauth SE (2015). Male reproductive anatomy: the gonadoducts, sexual segment of the kidney and cloaca. Pp. 253-301 in Rheubert JL, Siegel DS and Trauth SE (eds.) *Reproductive Biology and Phylogeny of Lizards and Tuatara*. Science Publishers, Enfield, New Hampshire, USA.
8. Siegel DS, Miralles A, Chabarria RE and Aldridge RD (2011). Female reproductive anatomy: cloaca, oviduct, and sperm storage. Pp. 347-409 in Aldridge RD and Sever DM (eds.) *Reproductive Biology and Phylogeny of Snakes*. Science Publishers, Enfield, New Hampshire, USA.

9. Siegel DS, Miralles A, Rheubert JL and Sever DM (2015). Female reproductive anatomy: cloaca, oviduct, and sperm storage. Pp. 144-195 in Rheubert JL, Siegel DS and Trauth SE (eds.) *Reproductive Biology and Phylogeny of Lizards and Tuatara*. Science Publishers, Enfield, New Hampshire, USA.
10. Spadola F, Morici M, Oliveri M and Knotek Z (2016). Description of cloacoscopy in the loggerhead sea turtle (*Caretta caretta*). *Acta Veterinaria Brno* 85, 367-370.
11. Trauth SE and Sever D (2011). Male urogenital ducts and cloacal anatomy. Pp. 411-475 in Aldridge RD and Sever DM (eds.) *Reproductive Biology and Phylogeny of Snakes*. Science Publishers, Enfield, New Hampshire, USA.

## The challenge of diagnosing renal disease in rabbits

Dr Lizzie Selby BVSc BSc MANZCVS(Unusual Pets)  
The Rabbit Doctors @ CARE (Centre for Animal Referral and Emergency)  
5 Hood Street Collingwood Vic Australia

Chronic renal disease is a common and under diagnosed problem in rabbits. Unlike dogs and cats diagnosis cannot be made based on bloods alone even in combination with urine specific gravity. Renal disease is common in rabbits with comorbidities (i.e. arthritis, dental disease, aural disease) some of which require surgery, making renal status particularly relevant. Clinical signs can be vague and similar to other common health problems including dental disease and gut stasis. This talk reviews the diagnosis of renal disease using urine protein creatinine ratio as seen in 102 cases presented at The Rabbit Doctors @ CARE. Further work up and management options are briefly discussed.

### Summary of cases

Retrospective records from The Rabbit Doctors @ CARE from 2018 to April 2019 showed 102 cases where the urine protein creatinine ratio had been measured. Urine results with an active sediment were discarded from the study. Reason for testing varied, including screening tests for well rabbits or work up of an unwell rabbit or prior to surgery. The cases ranged in age from 13 weeks to 11 years and were quite evenly divided for sex (52 female 50 male). The UPC result ranged from 0.15-3.8. Renal disease was detected in 53 of 102 cases (52%) with a UPC >0.4. Urea and creatinine results were available for 58 of 102 cases. Of these, 28 had a UPC >0.4 and 30 had normal renal function with UPC <0.4.

Reference ranges for UPC in rabbits is 0.11-0.4(Harcourt-Brown and Chitty, 2013). Reference ranges for urea and creatinine are taken from ASAP normal ranges where all blood and urine testing was undertaken (ASAP 53 Glenvale Crescent Mulgrave Victoria Australia 3170, Urea 3.8-7.3mmol/L and Creatinine 70-200umol/L).

*Table 1 – Percentage of results with high, normal or low urea and creatinine split into those with proteinuria (UPC>0.4) and those without.*

UPC <0.4		UPC >0.4	
UREA		UREA	
High	23%	High	60%
Normal	26%	Normal	40%
Low	16%	Low	0%
CREATININE		CREATININE	
High	0%	High	10%
Normal	70%	Normal	57%
Low	30%	Low	32%

### Discussion

A large proportion of the cases tested had renal disease based on proteinuria with an inactive sediment (52% had a UPC>0.4). While rabbits tested will be skewed for those rabbits which are older, have comorbidities or are generally unwell, 52% is a large number of rabbits with renal disease. This is extremely relevant for practitioners performing surgery on rabbits and prescribing potentially nephrotoxic drugs such as meloxicam commonly.

While a greater proportion of rabbits with renal disease also had elevated urea and creatinine, of these rabbits 40% had a normal urea and 90% had a normal creatinine.

Rabbits can show massive increases in urea due to pre renal azotaemia (i.e rabbits presenting with small intestinal obstruction), levels can also change over the day and due to diet (Meredith and Lord, 2013) This makes urea and creatinine extremely poor indicators of renal disease in rabbits. Many of these elevations in urea and creatinine were only mild or only one of these values was elevated.

Clinical signs of renal disease seen in cats and dogs such as polyuria and polydipsia may be harder to spot in rabbits and most rabbits with renal disease exhibit polyphagia rather than nausea and inappetence as seen in other species. Commonly rabbits in renal failure eat well but lose weight (Harcourt-Brown, 2013). Clinical signs may also be confused with comorbidities such as dental disease which can also cause weight loss and polydipsia.

These results indicate that routine blood work alone is grossly insufficient to rule out renal disease in rabbits. While there is work being done on the normal ranges for SDMA in rabbits, at present urine protein creatinine ratio appears to be required. It is essential to assess the urine for an active sediment as this can increase urine protein.

Further work up for renal disease in rabbits should include imaging. Ultrasound or radiographs can be used to assess kidney size or calcification. Nephroliths and ureteroliths are common in rabbits and can cause post renal obstruction and severe renal disease (Harcourt-Brown, 2007). Urine culture is helpful to rule out underlying infection. Blood pressure is ideally used as part of monitoring but can be difficult to get accurate and comparable results.

Management is similar to cats and dogs. Stop any nephrotoxic drugs (such as meloxicam), increase water intake (wet greens before feeding, provide multiple water bowls, offer rabbit teas such as Baraka station), subcutaneous fluids can be used if indicated in later stages of the disease process, reduce work load on kidneys by reducing any high calcium foods.

ACEi's such as benazepril appear to be useful however there are no studies to date. The author has seen reductions in UPC in rabbits on benazepril, however, while it does anecdotally seem to improve quality of life, it may not improve longevity.

## **Conclusion**

Renal disease is very common in rabbits. Basic blood work is insufficient to rule out renal disease. Urine protein creatinine ratio is recommended as part of a basic work up for a rabbit.

## **References**

1. Harcourt-Brown, F and Chitty, J (2013). BSAVA Manual of rabbit surgery, dentistry and imaging.
2. Meredith, A and Lord, B (2013). BSAVA Manual of Rabbit Medicine.
3. Harcourt-Brown, F (2013). Diagnosis of renal disease in rabbits. Vet Clin North Am Exot Anim Pract 16(1), 145-174.
4. Harcourt-Brown, F (2007). Radiographic signs of renal disease in rabbits. Vet Rec 160, 787-794.

## Anterior eye chamber abscess and *E.cuniculi* infection in a guinea pig

Monika Sidorowicz DVM MRCVS  
Freelance Veterinarian  
Rozana 13/24, 15669 Bialystok, Poland

### History and clinical examination

A 2-month-old intact female guinea pig was presented to the clinic because of the lesions in both eyes. The owner didn't report any abnormalities in eating, drinking, urinating, defecating or behaviour. Diet consisted of *ad libitum* hay provided daily and fresh vegetables, occasionally pellets. The patient was kept in a cage with two other female guinea pigs from the same litter and has a special enclosure provided for daily exercise. Clinical examination didn't reveal any pathologic findings- pink mucosal membranes, CRT <1 sec, no abnormalities detected during auscultation, abdominal and lymph node palpation, temperature was 39.2 degrees Celsius, patient was bright, alert and responsive. Oral cavity examination was performed routinely under anaesthesia using isoflurane- no dental disease was detected at this stage.

### Ophthalmologic examination

Both eyes were examined using an ophthalmoscope, Schirmer tear test (STT), applanation tonometry, and fluorescein test. During ophthalmologic examination whitish, dense, most probably purulent material was visible in both anterior eye chambers. STT values were 2 mm/min in both eyes, intraocular pressure (IOP) 15 and 17 mmHg in right and left eye, respectively, and fluorescein test was negative on both corneas. There were no signs of other eye structure diseases (no keratitis, blepharospasm, conjunctivitis, exophthalmos or dacryocystitis). There were no lens capsule rupture, hyphema, hypopyon or cataract which may suggest phacoclastic uveitis linked with *Encephalitozoon cuniculi* infection (in rabbits).

### Diagnosis and treatment

The patient was sent home with a diagnosis of possible anterior eye chamber abscess and topical anti-inflammatory (indomethacine-1 drop per eye q8h; Indocollyre, Laboratoire Chauvin, France) and antibiotic (ofloxacin- 1 drop per eye q12h; Floxal, Chem.- Pharm. Fabrik GmbH, Germany) medications as well as systemic antibiotic (sulfamethoxazole- trimethoprim 30mg/kg PO q12h; Bactrim, Roche, Switzerland) and non-steroidal anti-inflammatory drugs treatment (meloxicam- 0.5 mg/kg PO q12h; Metacam, Boehringer Ingelheim GmbH, Germany).

### Follow up

The patient came for the check up 10 days later and ophthalmologic examination parameters remained the same. During the control examination blood was collected for serologic testing for *E. cuniculi* which came back positive- both IgG and IgM titers were elevated (IgG= 1:80; IgM > 1:64) which, according to the laboratory interpretation (Laboklin GmbH), indicated active infection. The patient received fenbendazole treatment (20 mg/kg PO q24h; Fenbendazol, aniMedica GmbH, Germany) and the owner was informed to schedule the next ophthalmologic examination in 3 weeks. Unfortunately, follow up was lost as the owner didn't come for the visit and it was not possible to reach the owner over the phone for an update.

### Discussion

*Encephalitozoon cuniculi* can be found in clinically healthy seropositive rabbits and guinea pigs. The *ante mortem* diagnosis (serology via ELISA, Indirect Fluorescent Antibody Technique (IFAT), Carbon Immunoassay (CIA) or direct agglutination methods; microscopic detection of spores excreted in urine; gamma globulin elevation,



lower A/G ratio and lower total protein on protein electrophoresis (PE)- dubious as clinically non-healthy rabbits not suspected of having encephalitozoonosis can also exhibit such PE changes) is challenging both in guinea pigs and rabbits. Definitive diagnosis is made by histologic evaluation of brain or kidney tissue; alternatively PCR of ocular content can be tested in patients with phacoclastic uveitis. PCR of cerebrospinal fluid, urine and tissues remains an unreliable diagnostic tool as it's heavily dependent on the stage of infection (acute, chronic, latent, reinfection) (Cray et al., 2009, La'toya et al., 2014).

In rabbits, phacoclastic uveitis is a pathognomonic symptom. It is defined as spontaneous lens capsule rupture and subsequent hyphema (presence of blood in the anterior eye chamber), hypopyon (presence of pus in the anterior eye chamber) and possible cataract. Rabbits with ocular signs that are seropositive are infected, whereas seronegative rabbits with ocular signs are not affected. Removing the lens and iridal granuloma/abscess by phacoemulsification is indicated as a treatment of choice, then lens material can be tested via PCR to detect the presence of *E.cuniculi* DNA in spores (Holmberg et al., 2013). In the author's opinion, an identical treatment plan can be adjusted to guinea pigs.

The patient's condition wasn't called phacoclastic uveitis and was simply defined as anterior eye chamber abscess (or equally likely iridal abscess) because of several reasons: there was no hypopyon present (defined as ventral deposition of purulent material in the anterior eye chamber; no horizontal line present inside anterior eye chamber indicating the presence of hypopyon), no uveitis (no diffuse corneal oedema, bulbar conjunctival hyperaemia or excessive vascularisation were present as signs of uveitis) and no hyphema or cataract present.

There are currently no reports stating that *E.cuniculi* can be linked with ocular presentation of the disease in guinea pigs. Ocular signs in rabbits (phacoclastic uveitis) are linked with transplacental transmission (La'toya et al., 2014). Due to this patient's age (2 months) this is the most likely infection route for this particular patient. Because the second follow up on the patient was lost and the last collected data stated that the patient was seropositive for *Encephalitozoon cuniculi* and observed ocular changes remained the same despite ophthalmic treatment, it was assumed and hypothesised that eye lesions and parasitic infection are most likely linked. Therefore, without further tests (aspiration of the ocular lesion via keratotomy and PCR, microbiological and cytological testing or more radically histopathology of the eye after enucleation) it cannot be fully confirmed and clearly stated that bilateral anterior eye chamber abscess was the result of *E.cuniculi* infection in this guinea pig. The author recommends to perform further testing as described above to confirm the presence of ocular lesions in guinea pigs with encephalitozoonosis. To the author's knowledge this is the first report connecting ocular lesions and *Encephalitozoon cuniculi* infection in a guinea pig.

## References

1. Cray, C., Arcia, G., Schneider, R., Kelleher, S.A. and Arheart, K.L. (2009). Evaluation of the usefulness of an elisa and protein electrophoresis in the diagnosis of encephalitozoon cuniculi infection in rabbits. *Am J Vet Res* 70(4), 478-482.
2. Holmberg, B.J., Maggs, D.J., Miller, P.E. and Ofri, R. (2013). Chapter 20 - ophthalmology of exotic pets. *Slatter's fundamentals of veterinary ophthalmology (fourth edition)*. W.B. Saunders, Saint Louis, pp 445-450.
3. La'toya, V.L., Bradley, C.W. and Wyre, N.R. (2014). Encephalitozoon cuniculi in pet rabbits: Diagnosis and optimal management. *Veterinary Medicine: Research and Reports* 5,169-180.

## **When a dental disease is not a dental disease**

Monika Sidorowicz DVM MRCVS  
Freelance Veterinarian  
Rozana 13/24, 15669 Bialystok, Poland

### **When a dental disease is not a dental disease**

Histiocytic brain granuloma associated with skull osteolysis and *E.coli* infection in a domestic rabbit (*Oryctolagus cuniculus*).

#### **Introduction and history**

A 5-year-old intact male domestic rabbit was presented to the clinic because of incisor malocclusion due to clipping the teeth with pliers by another veterinarian. The animal was inappetent and lethargic for three days. The owner was also concerned about the rabbit holding the right ear pinna down. The patient was fed with muesli mix and occasionally vegetables, the owner reported the animal never liked hay. The rabbit was kept as a single pet in the household, and the owner provided daily exercise in a special enclosure.

#### **Clinical examination**

Auscultation of the heart and lung sounds showed no abnormalities. Palpation of the abdomen revealed an empty small intestine. There were no abnormalities detected during lymph node palpation. Mucosal membranes were pink, CRT <2 sec, the patient was quiet but responsive. Body Condition Score (BCS) was lower than in most other patients- 2/5. The body temperature was 38.5 degrees Celsius. As a part of clinical examination skull palpation was performed as well- there were no deformities noted during palpation of the zygomatic arch, ventral mandibular cortex, orbital and nasal area. No epiphora, dacryocystitis, blepharospasm or exophthalmos were noted.

#### **Oral cavity examination**

As a routine part of clinical examination oral cavity examination was performed using isoflurane anaesthesia to optimise information about the dental condition. This examination revealed inability to open the mouth cavity properly to examine the cheek teeth; the oral cavity was open to only 3 cm for examination. There was also a notable pus scent from the oral cavity. There was incisor (apart from peg teeth) malocclusion and elongation of their clinical crowns as well as discolouration and enamel demineralisation of upper and lower incisors. Cheek teeth were checked using proper mouth gags and cheek dilators- some clinical crowns were elongated as well and presented with minor spurs: left mandible- P2 and M1; right mandible- P2; right maxilla- P2 and M1. Periodontal and interproximal spaces were not widened, there were no longitudinal teeth splits, intraalveolar rotations or resorptive lesions of the dentine present. No teeth were mobile, no soft tissue lesions were present in the oral cavity. Based on the oral cavity examination findings, the patient's dental disease was assessed as basic (stage 1 out of 4).

#### **Computed tomography**

The owner was informed about the findings and because of suspected iatrogenic temporomandibular joint luxation or subluxation (due to inability to open mouth cavity properly for examination) and possible beginning of apical abscess formation computed tomography was performed. CT examination revealed normal temporomandibular joint appearance as well as a lack of apical abscess formation. There was no significant apical elongation of cheek teeth reserve crowns and lamina dura was mainly intact (apart from slight medial right P1 protrusion through ventral mandibular cortex). There were no apical osteolysis, intraalveolar rotations or apical

inflammation present. According to the oral cavity exam, minor clinical crown spurs and uneven occlusal surface of the cheek teeth were noted. All teeth had proper radiodensity, no moth-eaten structures were found. Other findings included a mass on the right side of the brain and partial skull osteolysis on the same side.

### **Other diagnostic test and results**

Due to suspected granuloma formation associated with *E. cuniculi* infection, serological testing was performed and the results were negative (both IgG and IgM titers were not elevated). Routine CBC and biochemistry were also performed and no abnormalities were found. Due to the general poor condition (inability to eat properly after clipping the teeth with pliers by another veterinarian and subsequent low BCS) and revealed findings, the animal was euthanised. Fine needle aspiration of the mass was performed under CT control *post mortem*. Bacteriological examination of the mass revealed *E.coli* infection. Cytological differential diagnosis consisted of medulloblastoma, histiocytic granuloma or less likely, lymphoma. Histopathological samples were taken as well- a diagnosis of histiocytic brain granuloma of unknown origin with skull osteolysis was made.

### **Discussion**

To have an insight on the disease process it is best to study temporomandibular joint (TMJ) anatomy. The TMJ consists of a mandibular condyle (ventrally), zygomatic process of the temporal bone, more precisely articular surface of temporal bone (dorsally) and articular disc formed inside the joint. The joint is also surrounded by a zygomatic process of temporal bone (dorsally), zygomatic process of temporal bone and temporal process of the zygomatic arch (laterally) and squamous part of the temporal bone (medially) (Kyllar et al., 2018).

The inability to open the mouth cavity properly for cheek teeth examination was clearly connected with skull osteolysis. After thorough studying of the rabbit's skull, it was believed that the missing skull part was squamous part of temporal bone, to be even more precise- crest of petrous part of temporal bone. Anatomy of a rabbit's skull reveals that temporal muscle can be divided into deep and superficial parts; deep part of the temporal muscle originates from squamous part of the temporal bone which was missing in this case.

There are a couple of questions to be answered during discussion and making sufficient conclusions: if and how is missing squamous part of the temporal bone affecting TMJ function? Is inflammation of the superficial and deep temporal muscles as well as located nearby pterygoid muscle the reason for stiffening TMJ (as inflammation may have spread from muscles to the fibrous capsule of the joint)? Is the missing squamous part of the temporal bone the reason for improper muscle function and subsequently affecting the TMJ function? Was holding the right ear pinna down the reason for not enough bony support for the ear cartilages? All the answers are most likely to be positive but there are currently no literature reports concerning this matter.

Apart from CT results, serological tests for *E.cuniculi* was also performed which was negative in this case but only serology was done as this wasn't author's main interest.

At this point a hypothesis of missing squamous part of the temporal bone (and subsequently deep temporal muscle inflammation and TMJ stiffening) mimicking TMJ luxation can be made- as far as the author is concerned, this is the first report of such mimicking process and the author recommends to consider this issue in differential diagnosis when dealing with a patient with possible TMJ trauma.

## **References**

1. Kyllar, M., Putnova, B., Jekl, V., Stehlik, L., Buchtova, M. and Stembirek, J. (2018). Diagnostic imaging modalities and surgical anatomy of the temporomandibular joint in rabbits. 38-50.

**Winner - Stephen Ross Memorial Scholarship**  
**Satellite Tracking Rehabilitated Raptors to Determine Survivability and Efficacy of Rehabilitation Techniques**

UPAV Scholarship Submission – Dr Kiara Simonis

**Researchers:** Dr Kiara Simonis, Dr Charles Carter (Southern Highlands Veterinary Centre), Peggy McDonald (Founding Director and Head Raptor Carer of the Higher Ground Raptor Centre)

## **Introduction**

Rehabilitation of raptors is a very specialised field, due to the requirement of unique equipment, skills, facilities and resources (NSW Government, 2011). A study has not yet been undertaken determining the efficacy of rehabilitation techniques and post release survival rates of rehabilitated Australian raptors. This information is critical for assessing the value of rehabilitation to population conservation, particularly when dealing with threatened or endangered species. Previous overseas studies utilised radiotracking to assess the movements and survival post-release of rehabilitated red-tailed hawks (Hamilton and Olsen, 1987) (*Buteo jamaicensis*), bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*). However, similar studies have not been undertaken for rehabilitated raptors in Australia. This was previously noted by Olsen and Olsen (1980) who described in a case study that, although raptor rehabilitation techniques in Australia have been well documented, the outcome of releases have not been discussed and therefore these methods of rehabilitation cannot be accurately assessed.

Due to the prohibition of the use of falconry techniques in New South Wales (NSW) according to the New South Wales Parks and Wildlife Services' (NPWS) guidelines for the rehabilitation of raptors (NSW Government, 2011), carers in NSW rely on the use of flight aviaries to develop pre-release fitness in raptors they are rehabilitating. Raptors being rehabilitated in NSW are placed in holding aviaries with the aim of developing fitness required for survival. However, the efficacy of this rehabilitation technique for fitness development is questionable. According to the guidelines, these aviaries are a minimum of 15 x 10m for large raptors or 5 x 3m for small raptors (Office of Environment and Heritage NSW, 2011). They allow the bird to fly lengths of the aviary only, which is short and does not replicate what the bird would be required to fly upon release and for survival in the wild. Additionally, the aviary size prevents the bird from practicing basic aerial manoeuvres that are imperative for development and maintenance of fitness (Rasidi, 2016). A study by Greene, et al in 2004 found that creance flight (a falconry technique using tethered flying) was more effective at developing muscle fitness than cage flight. Cage flight, however, uses minimal handling, which is an advantage in some settings because of the drawbacks of falconry techniques which include tameness, aggression and dependence on humans (Office of Environment and Heritage NSW, 2011 and Greene, 2004). Therefore, it is clear that both standard methods of rehabilitation utilised in Australia have their downfalls.

According to the guidelines, raptor rehabilitation facilities contain a series of enclosures that a raptor graduates through as its treatment progresses. This standard aviary system includes the following; intensive care housing; an intensive care aviary for birds that still require treatment but no longer need hospital cage housing; and a holding or flight aviary for raptors that no longer have serious injuries requiring intensive care (Office of Environment and Heritage NSW, 2011). In most rehabilitation situations, a bird would be released following a period of time in these holding aviaries. On the contrary, after a period in a large flight aviary, a raptor being rehabilitated at the Higher Ground Raptor

Centre (HGRC) is placed in the specialised Peter Spitzer free flight aviary to develop fitness at its own pace prior to its release.

The Peter Spitzer free flight aviary, located at the HGRC (Fitzroy Falls, NSW), is based on an aviary design at the Abu Dhabi Falcon Hospital. Important aspects of the design of this aviary include its size and shape – circular in nature and containing a central, circular pavilion, which allows the birds to fly freely in circles without having an endpoint that forces them to land. The aviary stands at a height of 8m with an internal circumference of 100m and contains multiple roosting spots, feeding areas, baths and alcoves that allow for privacy from other birds in the aviary (Rasidi, 2016). The design of this aviary is imperative in that it addresses the problems with developing fitness associated with standard aviary system described above.

To address the gaps in current knowledge about the survival of rehabilitated Australian raptors after release, Australian Raptor Care and Conservation Inc. (ARCC Inc.) has begun an ongoing study using satellite tracking. Considering that healthy, wild raptors may only catch prey once out of seven attempts, it is imperative that rehabilitation techniques allow the development of an adequate level of fitness prior to release to ensure they will be able to find food (Blair, 2000). Therefore, the aim of this study is to investigate the efficacy of specialised rehabilitation techniques by satellite tracking wedge-tailed eagles (*Aquila audax*) and white-bellied sea eagles (*Haliaeetus leucogaster*) rehabilitated at the HGRC through the Peter Spitzer free flight aviary.

## **Materials and methods**

### **Birds tracked**

The subjects of this study (Table 1) were four wedge-tailed eagles and three white-bellied sea eagles rehabilitated by Peggy McDonald at the HGRC from 2016-2018. All raptors used in this study underwent the final stage of their rehabilitation in the Peter Spitzer free flight rehabilitation aviary according to ethics approval from NPWS. Birds were selected for release after demonstrating an ability to take off and land appropriately, perform aerial manoeuvres, and fly distances considered reasonable for the species (Rasidi, 2016). Prior to release they had to undergo a veterinary health check before being deemed adequately fit for release. They also had to be completely recovered from the condition causing them to be in rehabilitation and be within a suitable body condition score for that species (Office of Environment and Heritage NSW, 2011).

The birds tracked in this study presented for a variety of problems and underwent standard diagnostic procedures including haematology, serum chemistry, radiology and parasitology. After a primary diagnosis was made, appropriate therapy was undertaken. Treatment depended on the individual case diagnosis but in general was limited to medical therapy or supportive care. WTE 009 suffered severe feather dysplasia and emaciation, and after a period in intensive care to address the bird's body condition, it spent nine months in the Peter Spitzer free flight aviary during which time the bird went through two moults before developing normal plumage. WTE 016 presented with a laceration of the right foot and a partially healed oblique fracture of the distal left femur with callus formation. The laceration was treated with antibiotics and allowed to heal. The fracture was slightly misaligned but too close to the stifle to intervene. However, orthopaedic specialist advice found it stable and best to allow healing to continue without intervention. WTE 024 was unable to stand on arrival at the HGRC but was bright and responsive. Radiographs did not show any abnormalities, but the bird's white cell count was highly elevated. The bird was treated with Clavulox (Amoxicillin and Clavulanic acid) at 125 mg/kg PO for 10 days and was then held in intensive care for a week being hand-fed, treated with meloxicam at 0.5 mg/kg PO SID (Carpenter and Marion, 2018) and rehydrated. WBSE 001, WBSE 007 and WTE 025

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all went through a period of intensive care including hand feeding and fluid therapy before moving into a recovery aviary.

*Table 1: Capsule histories of the tracked birds*

SPECIES	ID	REASON FOR PRESENTATION
Wedge-tailed Eagle	WTE 009	Emaciated fledgling Feather Dysplasia
Wedge-tailed Eagle	WTE 016	Trapped in dog trap Fracture of the distal left femur
White Bellied Sea Eagle	WBSE 001	Trapped in chicken pen Emaciated
Wedge-tailed Eagle	WTE 024	Motor vehicle accident
Wedge-tailed Eagle	WTE 025	Malnourished nestling Fell out of the nest
White Bellied Sea Eagle	WBSE 006	Nestling that attempted to fledge too early
White Bellied Sea Eagle	WBSE 007	Caught in fishing net Soft tissue damage Dropped wing

### Tracking system

The tracking system utilised in this study was Argos, a satellite-based data and location tracking system. Birds were fitted with Kiwisat 303 Argos transmitters (model K3H 154A) and Pinpoint GPS Argos 120 (Biotrack, 2018). The Kiwisat 303 Argos transmitters are an older, non-rechargeable model. During the study, the newer Pinpoint GPS Argos was released, so the switch was made to the newer model. Both platforms integrate a transmitter certified by Argos through which data is relayed to processing centres and interpreted by members of the ARCC Inc committee. Results are stored and made available to Argos users within four hours of the data being received (Argos User Manual, 2018).

Trackers used were battery powered as the objective of this study was to track the birds for a relatively brief period. Published data on survival time without food for various raptor species were considered and with this information, the authors estimated that tracking the movements of Australian booted eagles for a minimum of four weeks would confirm the bird was surviving with the ability to locate food (Olsen and Olsen, 2018, García-Rodríguez, et al, 1987 and Shapiro and Weathers, 1981). It was therefore determined that daily transmissions for a minimum of one month would be most suitable for answering questions posed by this study, hence, battery powered trackers were selected. Transmitters were attached under anaesthetic to the dorsocranial surface of the rachis of the two first rectrices (Figure 1).

*Figure 1: Juvenile white-bellied sea eagle with Pinpoint Argos 120 transmitter attached (Kelly, 2017)*





## Results

Tracking lasted for a range of 25-118 days and a mean of 52 days. Table 2 outlines the total number of days each bird was tracked for – it is important to note that transmissions received for each bird were from a different location, implying movement and therefore survival of the subject. For the sake of keeping the results concise, each individual transmission has not been outlined. It should also be noted that on some days, transmissions from the platforms were received but not at a frequency of high enough quality to determine the location, so a location data point might not have been received for every day the bird was tracked. Six of the seven eagles (85.7%) survived for a minimum of four weeks post release and three of these were known to survive for over six weeks (42%). No mortalities were recorded. Individual tracking results can be found in Table 2. Some notable results that outline how far these birds can travel, and therefore why pre-release fitness is imperative to their survival will be detailed.

WTE 016 was released on site at the Higher Ground Raptor Centre - transmissions were received for 59 days. WTE 016's tracker was found 36 days after transmissions ceased attached to a moulted feather beside a kangaroo carcass, 106km north-west of the release site. The antennae of this tracker had been broken off (Figure 2). WTE016 initially stayed within the radius of its release near Moss Vale, then started making longer flights over the Southern Highlands and further inland (Figure 3). WTE 025 was released on site at the Higher Ground Raptor Centre and tracked until the 18/02/2018 for a total of 37 days, however the last location fix was received on the 4/2/2018. This bird also initially stayed around the release site but soon most fixes received were in an area between the towns of Crookwell and Oberon, approximately 80km from the site of release (Figure 4). The movements of the other birds tracked in this study are represented by Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

Bird ID	Date Released	Final Tracking Date	Total Days Tracked
WTE 009	18/9/2016	18/11/2016	61 days
WTE 016	18/9/2016	16/11/2016	59 days
WTE 024	2/2/2018	6/3/2018	39 days
WTE 025	12/1/2018	18/2/2018	37 days
WBSE 001	30/3/2017	29/4/2017	30 days
WBSE 006	22/1/2018	16/2/2018	25 days
WBSE 007	6/2/2018	4/6/2018	118 days

Table 2: Tracking results

Figure 2: Recovered tracker with damaged antennae that was attached to WTE 016 (Kelly, 2017)





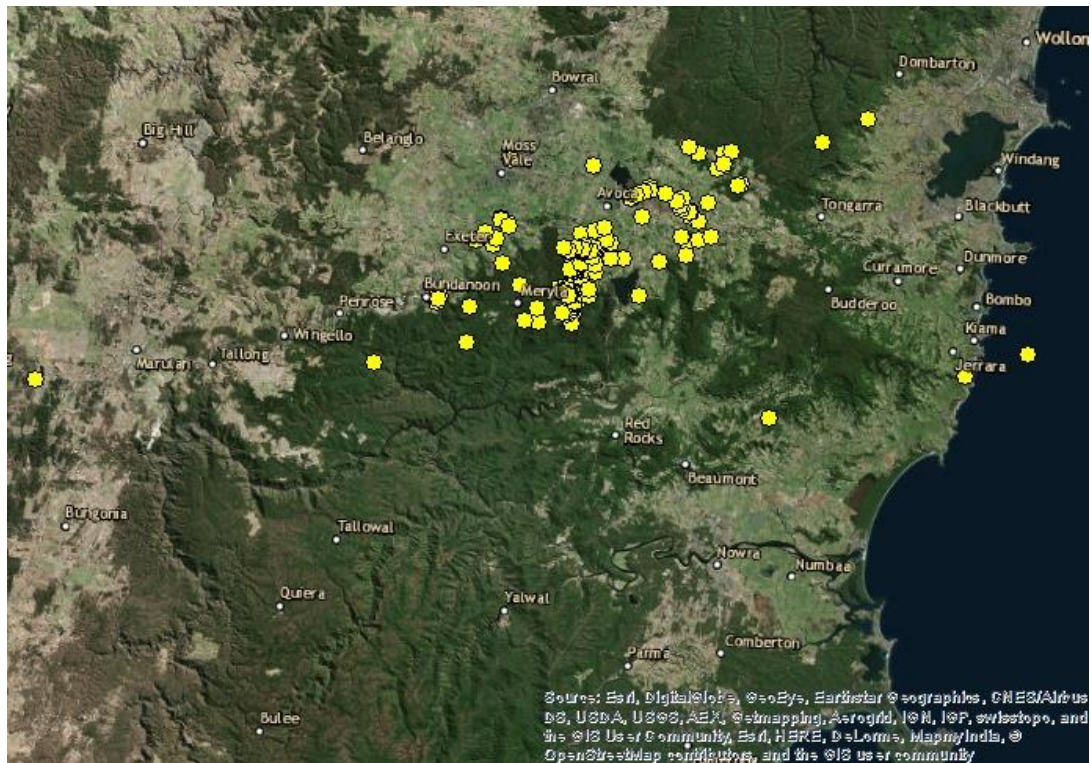


Figure 3: Satellite image of Southern Highlands (NSW) with location data points (yellow stars) transmitted by wedge-tailed eagle WTE 016 after release from the Higher Grounds Raptor Centre in Fitzroy Falls

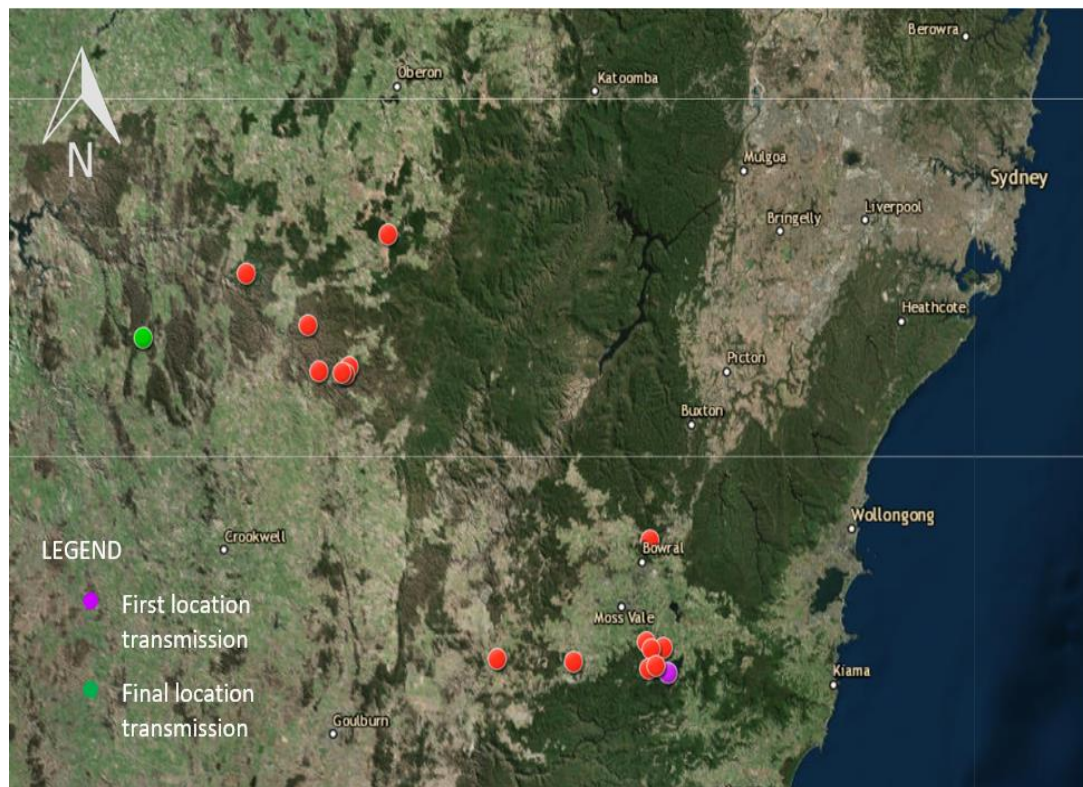


Figure 4: Satellite image of Eastern NSW with location data points transmitted by wedge-tailed eagle WTE 025 after release from the Higher Grounds Raptor Centre in Fitzroy Falls



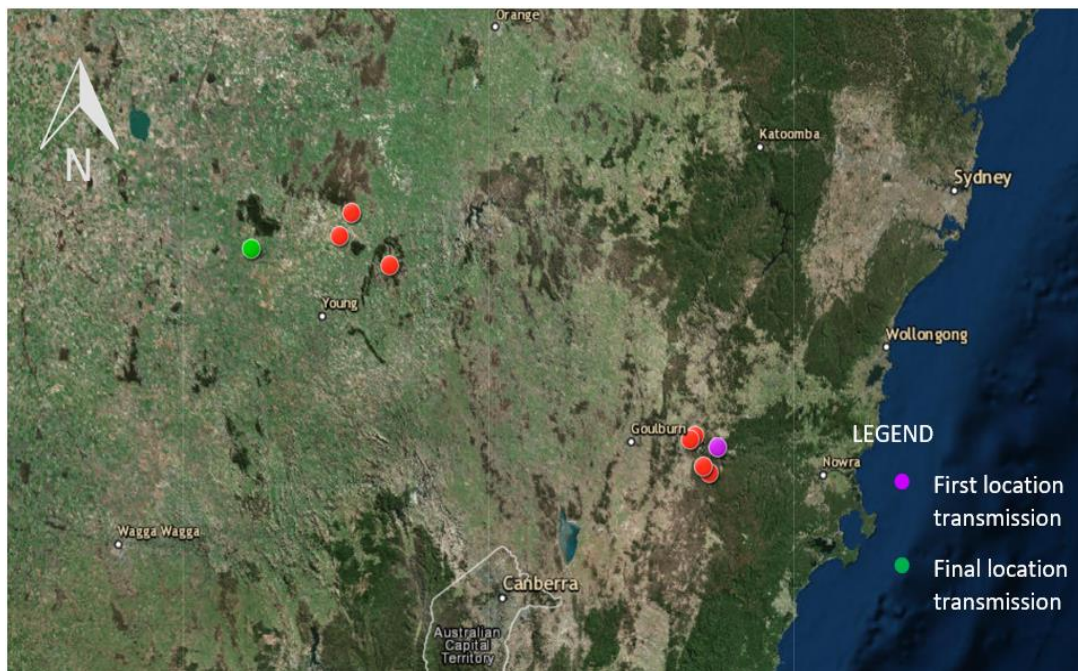


Figure 5: Satellite image of eastern NSW with location data points transmitted by wedge-tailed eagle WTE 024 after release from South Marulan

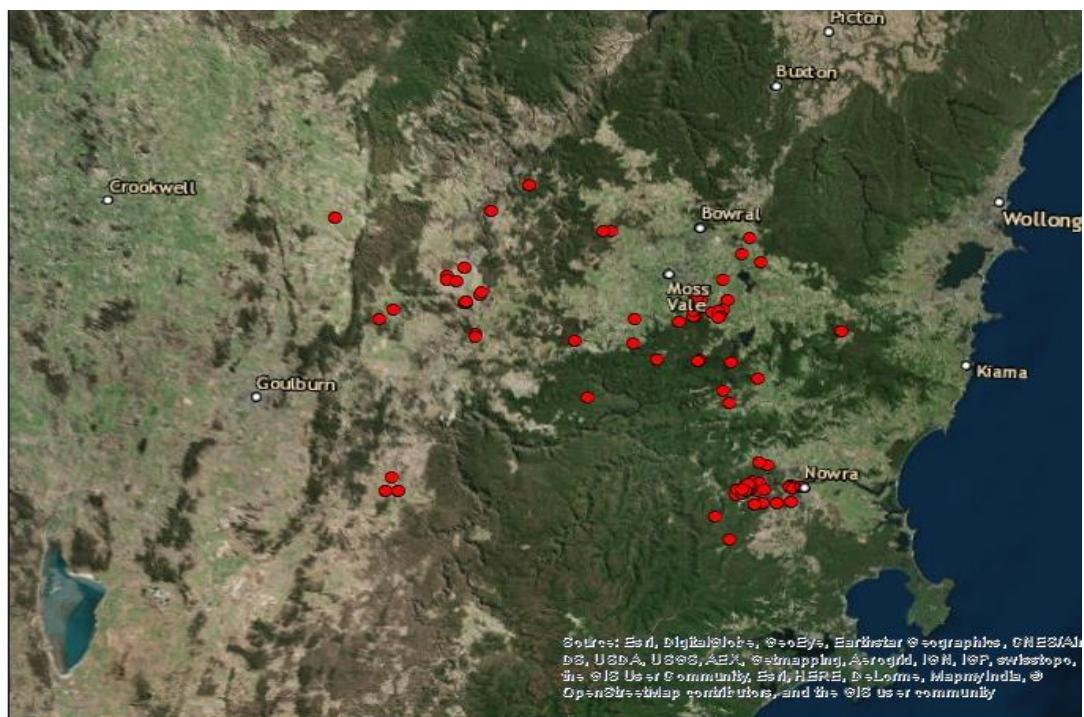


Figure 6: Satellite image of Southern Highlands (NSW) with location data points (red circles) transmitted by wedge-tailed eagle WTE 009 after release from the Higher Grounds Raptor Centre in Fitzroy Falls



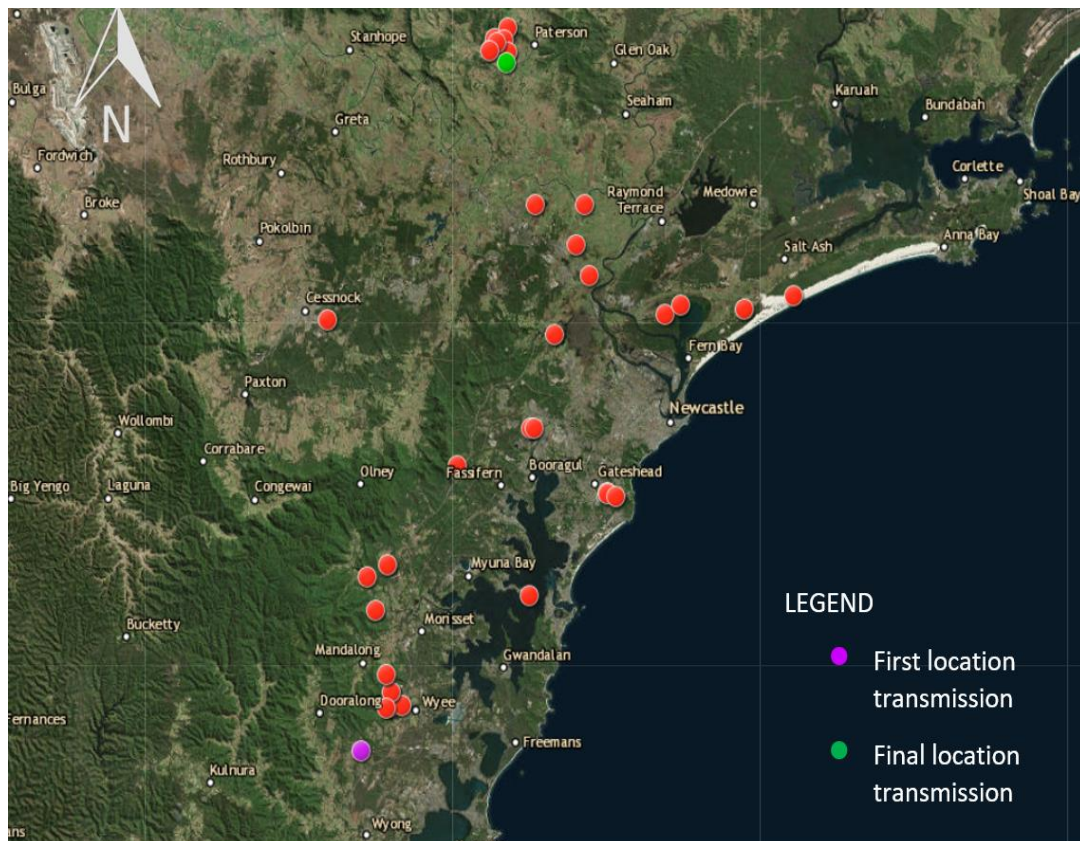


Figure 7: Satellite image of the Hunter Region (NSW) with location data points transmitted by white-bellied sea eagle WBSE 001 after release on the Central Coast of NSW

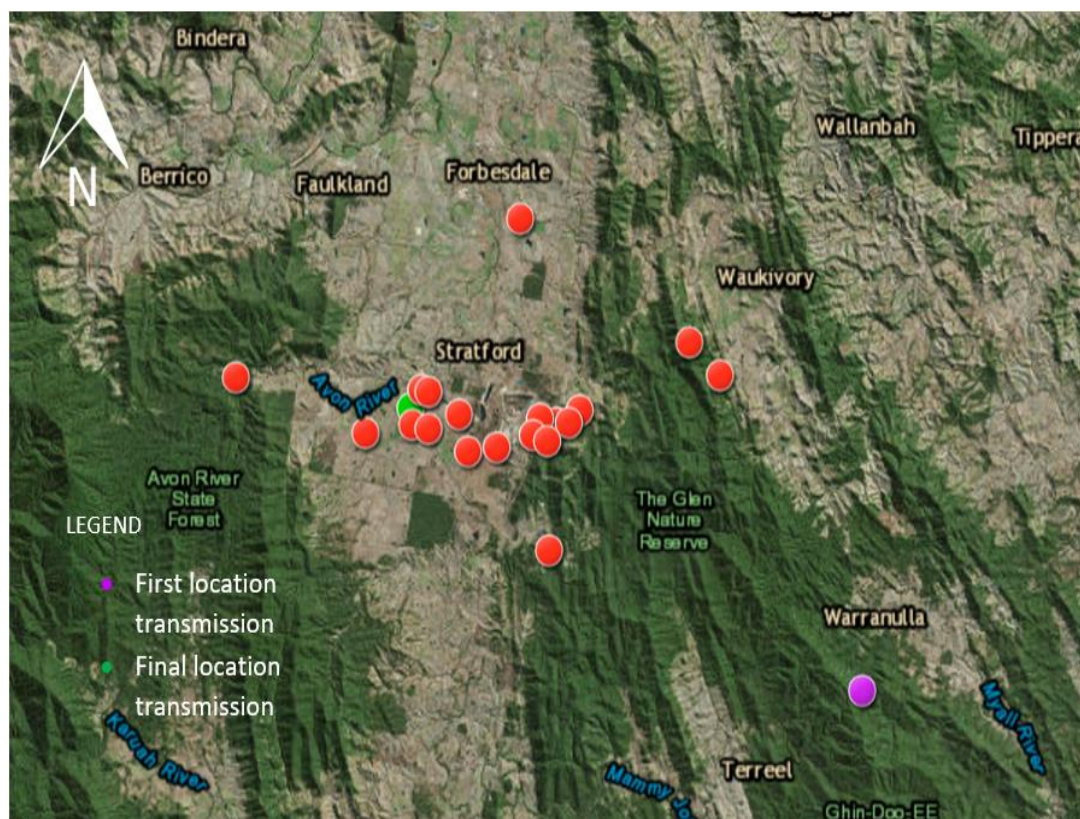


Figure 8: Satellite image of South-East NSW with location data points transmitted by white-bellied sea-eagle WBSE 006 after release from the outskirts of Moss Vale



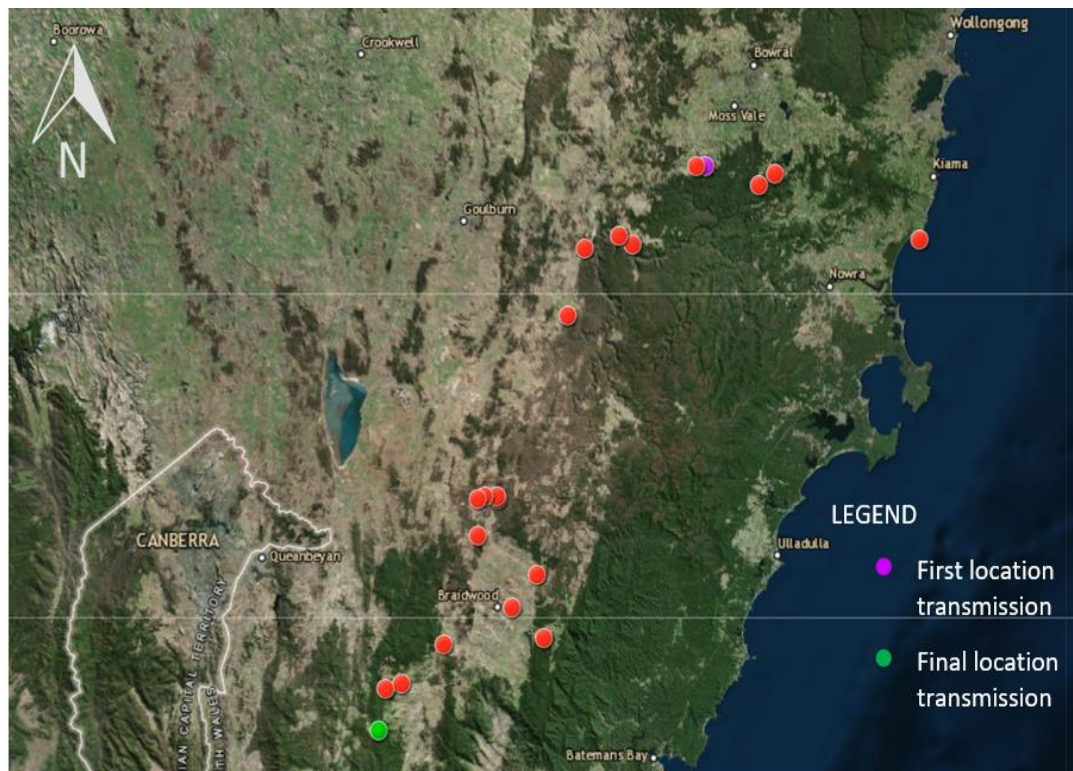


Figure 9: Satellite image of the Hunter Region of NSW with location data points transmitted by white-bellied sea-eagle WBSE 007 after release from the Central Coast of NSW

## Discussion

Six of the seven birds (85.7%) tracked in this study were known to be alive for at least four weeks after release, suggesting that the use of the Peter Spitzer free flight aviary in the rehabilitation of wedge-tailed eagles and white-bellied sea-eagles is an effective method of developing a level of fitness in raptors required for post-release survival. This study is limited in that the preliminary results are based on a small sample size and ideally, future research will add to current data. Results may be confounded by possible bias in selection of the study sample, as the individuals to be tracked were not chosen at random.

Tracking did not last for as long as expected, with the average life span of the Kiwisat 303 Argos being 124 days and the PinPoint GPS Argos 120 being approximately 360 days under ideal conditions. Considering that transmissions ceased, as opposed to receiving regular transmissions from a bird from the same location, it is likely that transmissions were stopped not because the eagle being tracked had perished, but rather because the trackers had ceased to function while the birds remain alive (Meyburg and Meyburg, 2007). It is suspected that battery failure was the cause of transmissions ceasing prematurely, as the Kiwisat 303 Argos platforms were purchased in 2016 and were a non-rechargeable model. Another possible cause for premature ceasing of transmissions is damage to the antennae, as seen in the Kiwisat 303 Argos (ID 159785) attached to WTE 016. Unfortunately, it is generally impossible to determine the exact cause, particularly if the transmitter is never recovered (Meyburg and Meyburg, 2007).

This report is preliminary in that the permit acquired to perform this study allows the tracking of ten birds in total which will be undertaken in the future, results of which will be cumulated with current data.

## References

1. Argos Users Manual. 2015. <http://www.argos-system.org/manual/>. Retrieved August 2 2018
2. Biotrack. 2018. <http://www.biotrack.co.uk>. Retrieved August 2 2018
3. Blair S. Caring for Raptors (Birds of Prey). Bird Care and Conservation Society. 2000. <http://www.birdcare.asn.au/pdf/raptors.pdf>. Retrieved August 2 2018
4. Carpenter J and Marion C. Exotic Animal Formulary. Elsevier Inc, St. Louis, Missouri. Pages 167–375. 2017
5. García-Rodríguez T, Ferrer M and Carrillo J et al (1987). Metabolic responses of *Buteo buteo* to long-term fasting and refeeding. *Comparative Biochemistry and Physiology Part A: Physiology* 87, 381-386.
6. Greene D, Engelmann M and Steck T (2004). An Assessment of Cage Flight as an Exercise Method for Raptors. *Journal of Raptor Research* 38, 125-132.
7. Hamilton L and Olsen G (1987). Movement and Survival of Released Rehabilitated Hawks. *Journal of Raptor Research* 22, 22-6.
8. Image produced by Mark Kelly Images, 2017
9. Meyburg B and Meyburg C (2007). 15 Years Satellite Tracking of Raptors. *Alauda* 75, 265-286.
10. Olsen J and Olsen P (1980). Some Considerations for Future Raptor Rehabilitation. *Journal of Raptor Research* 14, 10-12.
11. Rasidi E. Raptor Care, Rehabilitation and Medicine: Applying lessons learnt overseas to raptor care in New South Wales. 2016. [https://www.awrc.org.au/uploads/5/8/6/6/5866843/20\\_rasidi\\_raptor\\_care.pdf](https://www.awrc.org.au/uploads/5/8/6/6/5866843/20_rasidi_raptor_care.pdf). Retrieved August 2 2018
12. Shapiro C and Weathers W (1981). Metabolic and Behavioral Responses of American Kestrels to Food Deprivation. *Comparative Biochemistry and Physiology Part A: Physiology* 68, 111-114.
13. State of NSW and Department of Environment, Climate Change and Water NSW. Guidelines for the rehabilitation of birds of prey. 2011. <http://www.environment.nsw.gov.au/resources/wildlifelicences/110155RehabRaptor.pdf>. Retrieved August 2 2018
14. State of NSW and the Office of Environment and Heritage NSW. Code of Practice for Injured, Sick and Orphaned Protected Fauna. 2011. <http://www.environment.nsw.gov.au/resources/wildlifelicences/110004FaunaRehab.pdf>. Retrieved August 2 2018

## Armour-plated medicine... Tips, tricks & treatments of Shingleback Lizards

Shane Simpson  
The Unusual Pet Vets  
210 Karingal Drive, Frankton, Victoria, 3199

### Introduction

There is no denying that Australia has its fair share of weird and wonderful fauna. Whether it be mammal, or bird, or somewhere in between, we do have some pretty weird animals. Our herpetofauna is no less different and one of the more unique species is the Shingleback lizard (*Tiliqua rugosa*).

Due to Australia's strict quarantine laws it is illegal to export Australian wildlife commercially. Because of this Shingleback lizards are somewhat of a rarity outside of this country. As such they often attract hefty price tags when made available for sale. Because of this and the fact they are such a placid lizard they are also popular in the illegal wildlife trade with several people being caught attempting to smuggle animals out of Australia. A Japanese national was caught in August 2005 trying to smuggle 24 turtles and a Shingleback lizard. He was charged and fined \$24,600. The Shingleback alone was estimated to be worth \$4,000 in the Japanese black market.

### Species insights

The Shingleback is an Australian native lizard belonging to the same genus as the Blue-tongue skinks. It is known by several other names including the Stumpy-tailed lizard, Bobtail, Sleepy lizard, Pinecone lizard, Boggi, Two-headed lizard and the Aboriginal name, Yoorn. The name "Shingleback" comes from the fact that the animal's scale pattern resembles a roof clad with shingles.

First described by the British zoologist John Edward Gray in 1825 as *Trachydosaurus rugosa*, the species has undergone several name changes to arrive at its current name, *Tiliqua rugosa* which is derived from the Latin, rugam, meaning wrinkle.

There are four recognised subspecies being:

- i. *Tiliqua rugosa rugosa*: western shingleback or bobtail
- ii. *Tiliqua rugosa asper*: eastern shingleback
- iii. *Tiliqua rugosa konowi*: Rottnest Island shingleback
- iv. *Tiliqua rugosa palarra*: northern bobtail or Shark Bay shingleback

Shinglebacks are large diurnal lizards reaching up to a snout to vent length from 250 to 340mm (10-12 inches) with a total length of up to 410mm and weighing in at 550-900 grams. They may live for 30 years or more. They have a triangular head that resembles its tail, bright blue tongue and are heavily armoured with overlapping scales containing osteoderms for additional protection from predators such as dingos, snakes (e.g. Mulga snake), birds (e.g. Kookaburra), foxes and cats. Their colouration varies according to species and locality. Colours range from dark brown to cream with some specimens being well striped. Arguably the most spectacular variant originates from inland Western Australia and is commonly referred to as the "Goldfields Shingleback". Albino individuals have also been recorded.

The tail is short and stumpy to resemble the head and may confuse predators. It contains fat reserves on which the animal can draw on in times of need. Shingleback lizards do not undergo tail autonomy.

The species is widely distributed across the southern part of Australia extending from Shark Bay in Western Australia, eastwards across the southern parts of Western

Australia and South Australia, into northern Victoria, western New South Wales and south-west Queensland. They are not found along the eastern coast of the country.

Shinglebacks thrive in areas of shrubland, desert grasslands and sandy dunes. They can often be found basking in open areas and along roadsides. Depending on the time of the year Shinglebacks have a preferred body temperature of 32-33°C (89-91°F).

*Tiliqua rugosa* are omnivores that will readily eat snails, assorted insects, carrion, vegetation and flowers. They possess well developed nasal salt glands and it is not uncommon for animals to sneeze as they clear material from the nostrils.

Shingleback lizards are viviparous with litters ranging from one to four very large offspring measuring up to 220mm and weigh up to 100 grams. They have a gestation length of five to seven months. The young occupy a large portion of the coelom of the mother resulting in compression of the lungs and gastrointestinal tract resulting in a reduction in the tidal volume and food consumption as the young increase in size. Once born the young almost immediately eat the placenta and shed their skin which they also eat. The young lizards remain nearby to the parents with overlapping home ranges before moving on. Unlike most lizards this species tends to be monogamous. Each year pairs that have lived apart for most of the year have been known to return to each other every year for up to 20 years.

### **Sex identification**

Shingleback lizards are not easily sexed until they reach at least 80% of their adult snout-to-vent length.

The most common method of distinguishing males from females is visual sexing. Females are significantly longer than males. Males have a significantly longer and broader head than females.

Hemipenal probing is an unreliable method of sex identification as hemipenal pocket depth can vary considerably between individuals. In addition, probing can be difficult due to their size, strength and reluctance to be flipped on their backs.

Hemipenal popping can be difficult in this species and is generally not used by many people. In some mature males a large basal hemipenal blood vessel may be visualised when the cloacal scale is lifted.

Due to their thick scales ultrasound sex identification is inevitably useless in this species.

The use of radio-opaque dye infused into the hemipenal sac has shown to be an effective method of sexing this species in the authors experience.

### **Clinical techniques**

- Radiology

The presence of osteoderms in the skin of shingleback lizards make for some very spectacular radiographic images.

- Blood collection

Because of the shape of the tail it can be near impossible to collect blood from the ventral tail vein in this species. As such it is easier to collect via a lateral approach just caudal to the rear leg.

- Sedation/Anaesthesia

Because of the difficulty accessing a vein, intravenous anaesthesia can be problematic. As such the author prefers to use an intramuscular injection of medetomidine and ketamine for the induction of anaesthesia followed by intubation and isoflurane. The induction agents allow for enough relaxation to permit an endotracheal tube to be placed.

- Surgery

Osteoderms can make surgery involving incising the skin quite difficult. Incisions need to be made between the scales. If this is not possible then a high speed dental drill can be used.

### Common conditions

- Foot abscessation

A common presentation seen in captive Shingleback lizards is that of swollen legs and feet. This is most often caused by an ascending nail bed infection that results in cellulitis of the limb. Over time small, hard deposits of purulent material form in the soft tissues of the foot and continue to cause ongoing inflammation. Surgery is required to remove this foreign material.

- Shingleback nidovirus 1

In 2016, researchers at Murdoch University identified Shingleback nidovirus as the causative agent of what was commonly referred to as “Bobtail ‘Flu’”. Animals had long presented at wildlife shelters around Perth showing varying degrees of respiratory disease and weight loss. The virus is now readily detected in captive Shingleback lizards as well as other members of the *Tiliqua* sp. in Queensland, New South Wales, Victoria and Western Australia. Affected animals show increased respiratory effort, discharge from the eyes and nose, and loss of body condition. Treatment is supportive with nebulisation, antibiotics and supplemental nutrition being the main methods used. Affected animals may recover fully but relapse later.

- Cloacal Prolapse

Like many reptile species, Shingleback lizards can suffer from cloacal prolapses. Treatment inevitably requires surgical replacement of the prolapsed tissue. In severe cases where the tissue is no longer viable amputation may be required.

### References

1. Alacs, E. and Georges, A. (2008) Wildlife across our borders: a review of the illegal trade in Australia. *Australian Journal of Forensic Sciences*. 40(2): 147-160.
2. Bull, M.C. Monogamy in lizards (2000). *Behavioural Processes*. 51: 7-20.
3. Bull, M.C. and Baghurst, B. C. (1998) Home range overlap of mothers and their offspring in the sleepy lizard, *Tiliqua rugosa*. *Behav Ecol Sociobiol*. 42: 357-362.
4. Bull, M.C. and Pamula Y. (1996) Sexually dimorphic head sizes and reproductive success in the sleepy lizard *Tiliqua rugosa*. *J. Zool., Lond*. 240: 511-521.
5. Bull, M.C., Pamula, Y and Schulze, L. (1993) Parturition in the Sleepy Lizard, *Tiliqua rugosa*. *Journal of Herpetology*. 27(4): 489-492.
6. Bradshaw, S.D., Tom, J.A. and Bunn, S. E. (1984) Corticosteroids and Control of Nasal Salt Gland Function in the Lizard *Tiliqua rugosa*. *General and Comparative Endocrinology*. 54: 308-313.



7. Firth, B. and Belan, I. (1998) Daily and Seasonal Rhythms in Selected Body Temperatures in the Australian Lizard *Tiliqua rugosa* (Scincidae): Field and Laboratory Observations. *Physiological Zoology*. 71(3): 303-311.
8. McLaughlin, A. and Strunk, A. (2017) Salpingotomy in a Shingleback Skink with Subsequent Successful Parturition. *Proceedings of the Association of Reptilian and Amphibian Veterinarians Conference*. 86.
9. Munns, S. and Daniels, C. (2007) Breathing with Big Babies: Ventilation and Oxygen Consumption during Pregnancy in the Lizard *Tiliqua rugosa*. *Physiological and Biochemical Zoology*. 80(1): 35-45.

## **Case report: Use of ear-lobe stretchers for rabbit ear surgery**

Tegan Stephens BVSc MANZCVS (Unusual Pets)  
Bird & Exotics Veterinarian Green Square, NSW 2017.

### **Abstract**

Aural abscesses are a common issue encountered in rabbit medicine and are often a frustrating condition to attempt to manage. Surgical drainage is often required in addition to long-term medical management however reoccurrence of abscesses is frequently an issue.

This case report describes the use of silicone human earlobe stretchers to provide long-term access for drainage and medication application after rabbit ear surgery. Following multiple failed attempts at resolution of the chronic infection, a silicone earlobe stretcher was placed at the surgery site and has been used to maintain an open site for drainage and application of medications over a number of months.

### **Introduction**

Lop eared rabbits are commonly affected by recurrent, medically refractory otitis media. This can be primary or concurrently associated with otitis externa or interna. Reports vary, but up to 20-35% of rabbits at necropsy have been affected, and 78-80% of those also displaying signs of upper respiratory disease had otitis media/interna at necropsy. Due to the anatomy of the rabbit ear canal and the caseous nature of rabbit pus medical resolution is difficult, and often cases will require surgical intervention. The main surgical approaches for otitis media in a rabbit include a lateral or ventral bulla osteotomy, in conjunction with a total or partial ear canal ablation. The risk of reoccurrence after these surgeries is notably high. This is particularly in cases with concurrent dental or respiratory disease, or where the entire lining of the bulla cannot be removed, which is difficult in small patients. There is also the risk of neurological complications with paralysis, head tilt or Horner's-like symptoms.

### **Case**

Hazel was a seven-year-old male desexed, dwarf lop-eared rabbit, with a three-year history of progressive acquired dental disease and recurrent episodes of medically responsive gut stasis. The first presentation of clinical ear disease occurred with accumulation of purulent material found in the right ear canal incidentally during a dental check up. The ear initially was cleaned and treated with systemic and topical antibiotic therapy (Ilium™ Benacillin, 40mg/kg SC EOD-SID, Dermcare™ Otoplush SID-BID, and Bayer™ Baytril Otic drops, BID). While the ear initially appeared to respond, over a period of four months the infection worsened and external swelling of the ventral canal was noted, so the decision was made to take Hazel to surgery.

An unusual presentation was found, with no thick capsule or remnant canal present in the most external portion of the abscess, and erosion of the canal and rupture to form multiple pockets. These appeared to be continuous with multiple small abscess pockets into the mandible associated with cheek tooth root infection. The assessment at this time was the otitis media was likely a secondary extension from the ongoing dental disease and tooth root abscessation, potentially through the auditory tubes.

The abscess chambers were opened, lining removed and the remaining tissue flushed with warmed saline. The distal canal was closed following partial ablation to form a blind-ended pocket, the bulla was opened and cleaned by curettage. The site was marsupialised to attempt to allow for further drainage. Poloxamer 407 gel (Bova Australia™) compounded with enrofloxacin at 50mg/ml was instilled in the surgical site.

The plastic hub of an intravenous (IV) cannula (size not recorded) was stitched into the site to attempt to create an open drainage hole. Six days after surgery the hub had fallen out and the surgery site had almost completely closed over, it was opened again by gentle cleaning and more gel applied. This was repeated multiple times over the following month however the wound would not remain open. During this time Hazel was on ongoing treatment with injectable long acting penicillin (Ilium™ Benacillin, 40mg/kg SC, SID). Treatment was reduced to every other day, and then twice weekly over the course of therapy.

Two months post-surgery a dental procedure was performed to remove multiple severely affected cheek teeth. The previous ear surgery site was examined but no further intervention made. It was found that a very small pin-prick hole had remained open and this allowed for some ongoing flushing using an IV cannula sheath and diluted chlorhexidine. The owners were happy to continue this plan for four months until flushing became too difficult. It was decided at this point to perform a surgery to attempt to provide a better drainage solution. The purulent material was cleaned out and the rubber end of a slippery-sam cat urinary catheter was stitched into the surgery site. This held for a week but due to the longer shaft would not sit well and was pushed out by the rabbit. At this time a 4mm silicone ear lobe stretcher was placed and stitched in with four simple interrupted sutures using 3-0 Biosyn suture (Covidien™), with the use of local anaesthetic (Ilium™ lignocaine 20mg/ml).

These stitches held for two weeks allowing ongoing flushing. The stitches were removed after this time but the stretcher left in place. The skin around the site had healed well and the owners were able to remove and replace the stretcher as required to allow cleaning. Following antibiotic culture *Pseudomonas sp* was found, and antibiotic ointment was also applied into the drainage site according to sensitivity results (Jurox™ Tricin ointment). Culture was returned negative for *Pseudomonas* following this therapy.

This method allowed management of Hazel's ear infections with daily cleaning using saline for three months. Unfortunately, fifteen months after the initial otitis diagnosis, Hazel passed away from worsening complications of his dental disease and refusal to eat.

## Results and discussion

Ear abscesses in rabbits are a common issue, and recurrence after treatment is also common. In this case, ongoing treatment was provided by allowing permanent drainage, initially with a small surgical opening, and then access was improved with a cosmetic human silicone ear stretcher. This appeared to provide the desired result of preventing further ear surgeries, however ongoing medical management was required through both antibiotic therapy and daily ear flushing.

Hazel's ear infection changed with time, and antibiotic management had to be altered in response to development of resistant infections. This is not unexpected considering the long-term antibiotic therapy he was receiving and the involvement of *Pseudomonas*, which is commonly associated with resistance.

Multiple objects were trialed to keep the ear open for ongoing drainage, including the port end of an intravenous cannula and the rubber end of a urinary catheter. The most successful option was a human silicone ear stretcher, as used for cosmetic lobe enlargement. This proved an excellent alternative, as the material was non-irritating, and the flared ends allowed it to stay in place. The ear stretcher could also be removed with gentle pressure and replaced as required. These are also readily available and if lost or fall out are quite cheap for ongoing replacement.

The author has used this same method now in three further cases, and this appears to be a useful method for maintaining a functional drainage solution post surgery. It is worth noting that some clinicians recommend against leaving these surgery sites open, due to the risk of introduction of infection into the inner ear and subsequent neurological complications. In this author's experience the difficulty in ensuring complete removal of all infectious material makes open management desirable, and the less aggressive resection required reduces the risk of post operative complications such as facial nerve damage.

It is also useful to note that these drains can be placed after an initial surgery. If the wound is allowed to close but access is then required, a second brief surgery can be performed to open the site and place a stent for ongoing management.

### **Conclusions**

In recurrent cases of otitis media in which long-term access to the bulla is desired, the placement of a silicone ear stretcher stent is an option, which allows the surgical site to remain open long term, with a low level of maintenance.

### **References**

1. Capello, V. Mancinelli, E. Lennox, A.M. ed. Kling, M. 2015. Ear Surgery of Pet Rabbits ebook. [www.ebooksdynamic.vet](http://www.ebooksdynamic.vet)
2. Chow DVM, 2011. Surgical management of rabbit ear disease. Journal of Exotic Pet Medicine. 20(3);182-187
3. Eatwell, 2012. Approach to ear and nose disease in rabbits. British veterinary zoological proceedings. April 11, 2012.
4. Powers, L. 2018. Head and Ear Surgery of Pet Rabbits. UPAV Conference proceedings, Adelaide 2018.

**Winner - Anne Martin Memorial Scholarship**  
**Serpentine dermatomycoses formerly classified as CANV complex**

Helena Tran  
Veterinary Student at University of Melbourne  
Melbourne VIC 3000

## **1. Introduction**

Emerging fungal diseases can have profound effects on biodiversity and wildlife abundance (Fisher et al., 2012). *Chrysosporium* anamorph of *Nannizziopsis vriesii* (CANV) complex has been described as an emerging fungal disease of captive and wild reptiles. Recent molecular studies have led to a reclassification of CANV into three fungal genera within the family *Onygenaceae*. The aim of this paper is to report a recent case of CANV in a captive file snake (*Acrochordus arafurae*), and to discuss the two snake-related fungal diseases previously grouped within CANV complex. Management, diagnosis, and treatment of these diseases will also be discussed.

## **2. Case report**

In April 2019, a captive file snake at a public aquarium in Australia presented with multiple well-defined white cutaneous lesions along its dorsum. Fungal culture performed by a commercial veterinary laboratory identified *Chrysosporium* spp as the causative agent. Patient was treated with itraconazole for two weeks but was later found dead in its enclosure. On post-mortem, granulomas were found throughout the liver, lungs, and renal portal system. There were also multiple enlarged lymph nodes adjacent to the renal portal system. Histopathology revealed branching fungal hyphae and eosinophilic inflammation in the lungs.

## **3. CANV overview**

CANV is an ascomycetous fungus that has been isolated from a wide range of reptiles (Johnson et al., 2011). Often described as a ubiquitous soil organism (Stchigel et al., 2013), CANV causes a progressive and often fatal skin disease in susceptible reptiles (Grillo et al., 2016). Molecular analyses of CANV isolates have prompted a taxonomic reclassification of CANV into three separate genera (Paré & Sigler, 2016):

- *Nannizziopsis*: Nine species described in iguanid lizards, chameleons, geckos, crocodiles, and humans. *N. guarroi* is the causative agent of “yellow fungus disease” in bearded dragons and iguanas. There are distinct human-associated and reptile-associated species with no cross-infection (Paré & Sigler, 2016).
- *Paranannizziopsis*: Five species. Reported in lizards, snakes, and tuataras.
- *Ophidiomyces*: an emerging infectious disease of wild and captive snakes in North America, Europe, and Australia.

Species identification was not performed on the file snake; however, given the presenting signs, history, and signalment, the fungus isolated from the patient's lesions was likely to be a member of the genus *Ophidiomyces* or *Paranannizziopsis*. Because the recent reclassification of CANV does not recognise *Nannizziopsis* as a pathogen of snakes, this genus will not be discussed.

## **4. Ophidiomycosis**

### **4.1 Causitive agent and host susceptibility**

*Ophidiomyces ophiodiicola* has been increasingly recognized as a cause of dermatomycosis in captive and free-ranging snakes (Last et al., 2016). *O. ophiodiicola* is an anamorphic fungus that appears as septate, branched hyphae on microscopic examination (Paré, 2019; Rajeev et al., 2008). To date, *O. ophiodiicola* has only been recovered from semi-aquatic or terrestrial snakes (Paré and Sigler, 2016), and is thus

colloquially referred to as “snake fungal disease.” Most existing studies characterize *O. ophiodiicola* as a primary pathogen; however, it can act as an opportunistic pathogen in the presence of skin necrosis (Lorch et al., 2016).

*O. ophiodiicola* possesses numerous enzymes which degrade keratin, proteins, chitin, urea, and lipids (Paré, 2019; Allender et al., 2015b). These exoenzymes enhance the pathogen’s survival on a wide range of substrates and allow it to persist as an environmental saprobe (Allender et al., 2015b).

Temperature is an important factor for fungal growth, and increased temperatures during hibernation season may increase *O. ophiodiicola* growth rates (Allender et al., 2015b; Lorch et al., 2016). Therefore, rising global temperatures may enhance disease transmission in wild snake populations (Allender et al., 2015b), especially in torpid states when the host’s immunity is diminished. While optimal growth occurs at 25°C and a pH of 9, *O. ophiodiicola* can tolerate temperatures between 15°C–35°C, and pH ranges of 5–11 (Paré, 2019; Allender et al., 2015b). Arthroconidia of *O. ophiodiicola* are resilient in the environment and can survive freezing (Paré & Sigler, 2016; Paré, 2019). Although reports of *O. ophiodiicola* in healthy animals are rare, recent studies with more sensitive assays recovered the pathogen on apparently healthy snakes (Paré, 2019; Bohuski et al., 2015). Thus, is it possible that asymptomatic carriers may introduce *O. ophiodiicola* into a captive population.

#### **4.2 Ophidiomycosis: transmission and clinical signs**

Transmission occurs through direct contact with infected skin, fomites, or soil (Paré, 2019). Although skin abrasions facilitate pathogen entry, an experimental study demonstrated that *O. ophiodiicola* is capable inducing lesions on intact skin (Lorch et al., 2015). Its ability to cause pathology on non-abraded skin may be attributed to the pathogen’s keratinases, gelatinases, lipases, and ureases, which can break down components of the skin barrier and initiate epidermal necrosis (Lorch et al., 2016). Once infected, disease severity varies substantially, ranging from mild lesions to severe disfigurement. Clinical signs include epidermal scale necrosis, ulcers, crusts, and hyperkeratosis (Guthrie et al., 2015). Once *O. ophiodiicola* colonizes skin, it can extend to underlying tissues and produce granulomas, or spread systemically. A study involving experimental inoculation of *O. ophiodiicola* in cottonmouths (*Agkistrodon piscivorus*) reported a 40% mortality rate and a median survival time of 90 days (Allender et al., 2015a).

#### **4.3 Ophidiomyces host range and distribution**

In eastern and central areas of North America, *O. ophiodiicola* poses a conservation threat, having been found in more than thirty wild snake species (Franklinos et al., 2017), including threatened species like the eastern massasauga (*Sistrurus catenatus*) [Paré & Sigler, 2016]. *O. ophiodiicola* is suspected to have contributed to a 50% decline in timber rattlesnakes (*Crotalus horridus*) in New Hampshire over a 1-year period in 2006—2007 (Clark et al., 2010). Researchers have hypothesized that factors such as habitat loss and climate change may be intensifying the emergence of this disease in wild colubrids and vipers (Thompson et al., 2018; Paré, 2019).

*O. ophiodiicola* has also been detected in wild snakes in Britain and Czech Republic; these European isolates are believed to be a distinct, slower growing strain than that of North America (Franklinos et al., 2017). In Australia, *O. ophiodiicola* has been identified sporadically in captive animals, with reports of infection in a captive file snake in 2003, and a captive broad-headed snake (*Hoplocephalus bungaroides*) in 2010 (Paré, 2019). The presence of *O. ophiodiicola* in geographically distant areas has led some to believe that the global pet trade enabled widespread movement of the pathogen (Paré, 2019).

## 5. *Paranannizziopsis*

### 5.1 *Paranannizziopsis* species and host range

*Paranannizziopsis* spp are mainly associated with aquatic snakes but have been reported in other reptiles in North America and Australasia (Masters et al, 2016; Rainwater et al., 2018). Three of the five *Paranannizziopsis* spp (*P. crustacea*, *P. californiensis*, and *P. longispora*) have been found solely in captive tentacled snakes (*Erpeton tentaculatum*) in North America (Paré & Sigler, 2016).

To date, *P. australasiensis* has only been detected in captive reptiles in Australasia and has a broader host range than the aforementioned *Paranannizziopsis* spp (Paré and Sigler, 2016). *P. australasiensis* has been isolated from two captive file snakes at the Melbourne Zoo (Sigler et al., 2013). It has also been diagnosed in five tuataras (*Sphenodon punctatus*) and a coastal bearded dragon (*Pogona barbata*) at the Auckland Zoo (Masters et al., 2016).

A novel species, *P. tardicrescens*, was recently described in captive snakes at a Texas zoo; affected animals included a Wagler's viper (*Tropidolaemus wagleri*) and a rhinoceros snake (*Rhynchophis boulengeri*) [Rainwater et al., 2018].

The prevalence of *Paranannizziopsis* spp in wild reptiles is yet to be determined, and further studies are needed to determine the effect this pathogen may have on wildlife populations.

### 5.2 *Paranannizziopsis* fungal traits

Fungal elements of *Paranannizziopsis* appear morphologically similar to *O. ophioidicola* on histopathology and culture. Therefore, DNA sequencing is required to differentiate *Paranannizziopsis* from other species formerly grouped within CANV (Rainwater et al., 2018). A distinguishing feature of *Paranannizziopsis* is the absence of fission arthroconidia, which differentiates it from *Nannizziopsis* and *Ophidiomyces* (Sigler et al., 2013).

### 5.3 *Paranannizziopsis* clinical signs

Like *O. ophioidicola*, disease severity due to *Paranannizziopsis* infection can vary greatly; however, most case reports describe multi-focal areas of yellow to brown, hyperplastic, crusting dermatitis with intralesional hyphae (Rainwater et al. 2018). Severe cases can present with regionally extensive skin necrosis and ulceration, which may then progress to systemic dissemination and death (Masters et al., 2016). Other reported findings include dysecdysis, hepatitis with hepatocyte vacuolation, and pulmonary haemorrhage (Rainwater et al., 2018). Concurrent bacterial infections with *Pseudomonas* (Masters et al., 2016) and non-tuberculous *Mycobacterium* (Rainwater et al., 2018) have been described.

## 6. Diagnosis & Treatment

Cutaneous lesions with crusts, scabs, and ulcers are suggestive of CANV-related disease. Definitive diagnosis is achieved with fungal culture, real-time or quantitative PCR, and histopathological examination of tissues (Paré & Sigler, 2016). Because an asymptomatic carrier state may exist, clinicians should pair PCR with histology when obtaining a definitive diagnosis (Bohuski et al., 2015)

Systemic and topical anti-fungal medications should be given beyond resolution of clinical signs, along with supportive thermal, nutritional, and fluid therapy. Surgical debridement or excision of lesions may be attempted, and antibiotics are indicated for secondary bacterial infections (Paré, 2019). Mild cutaneous lesions may spontaneously resolve after sequential shedding cycles (Paré, 2019); however, moderate to severe infections have a poorer prognosis and will likely require treatment.

*P. australasiensis* in tuataras has been successfully treated by surgical excision or medical treatment with oral itraconazole at 2.5-5 mg/kg, topical terbinafine, povidone-iodine, and silver sulfadiazine (Masters et al., 2016). Unfortunately, cases of

*Paranannizziopsis* in bearded dragons and snakes have responded poorly to itraconazole, and animals can rapidly succumb to disease despite treatment (Masters et al., 2016).

Likewise, treatment of *O. ophiodiicola* with antifungal therapy has mixed outcomes in the literature. In vitro studies have found that *O. ophiodiicola* is susceptible to itraconazole, voriconazole, and terbinafine (Paré et al., 2005). Treatment of individual animals is particularly sensible when dealing with threatened or critically endangered species, as each animal is important in conserving genetic diversity (Stephen et al., 2017).

## 7. Management

To prevent introduction of pathogenic fungi, all new reptiles should be held in quarantine and pass a health clearance exam before entering an existing tank. Affected snakes should be isolated and strict biosecurity measures should be implemented to prevent spread of the organism. Tankmates should be screened for skin lesions or other abnormalities associated with infection (lethargy, anorexia, dysecdysis).

Because the arthroconidia of CANV-related species are resilient in the environment, a thorough vivarium clean should be performed. For aquatic tanks, this would include full water change. All substrates and organic matter should be removed prior to disinfection to ensure adequate exposure of the disinfectant. *O. ophiodiicola* spores are sensitive to bleach 3%, ethanol 70%, and quaternary ammonium (Rzadkowska et al., 2016).

Poor diet, overcrowding, and improper environmental conditions predispose animals to fungal infections (Harkewicz, 2001); therefore, husbandry and tank maintenance protocols should be evaluated to identify health risks and ensure the animal is receiving optimal care.

## 8. Conclusion

Formerly grouped within CANV complex, *O. ophiodiicola* and *Paranannizziopsis* spp are clinically important fungal pathogens of captive and wild snakes. *O. ophiodiicola* represents a major threat to wild North American snakes, and factors such as climate change and habitat loss may be contributing to increased disease susceptibility and population decline. Further research on the disease ecology and epidemiology of these pathogens are needed to advance our understanding of fungal dermatomycoses in snakes.

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## References

1. Allender MC, Baker S, Wylie D et al. (2015a). Development of snake fungal disease after experimental challenge with *Ophidiomyces ophiodiicola* in cottonmouths (*Agkistrodon piscivorus*). *PLoS One* 10, e0140193.
2. Allender MC, Raudabaugh DB, Gleason FH, Miller AN (2015b). The natural history, ecology, and epidemiology of *Ophidiomyces ophiodiicola* and its potential impact on free-ranging snake populations. *Fungal Ecology* 17, 187-196.
3. Bohuski E, Lorch JM, Griffin KM, Blehert DS. (2015). TaqMan real-time polymerase chain reaction for detection of *Ophidiomyces ophiodiicola*, the fungus associated with snake fungal disease. *BMC Veterinary Research* 11, 95.



4. Clark RW, Marchand MN, Clifford BJ, Stechert R, Stephens S. (2011). Decline of an isolated timber rattlesnake (*Crotalus horridus*) population: interactions between climate change, disease, and loss of genetic diversity. *Biological Conservation* 144, 886-891.
5. Fisher MC, Henk DA, Briggs CJ et al. (2012). Emerging fungal threats to animal, plant and ecosystem health. *Nature* 484, 186.
6. Franklino LH, Lorch JM, Bohuski E et al. (2017). Emerging fungal pathogen *Ophidiomyces ophiodiicola* in wild European snakes. *Scientific Reports* 7:3844.
7. Grillo T, Cox-Witton K, Gilchrist S (2016). Wildlife Health Australia. *Animal Health Surveillance Quarterly*, Animal Health Australia, Issue 21(2), 6-10.
8. Guthrie AL, Knowles S, Ballmann AE, Lorch JM (2015). Detection of snake fungal disease due to *Ophidiomyces ophiodiicola* in Virginia, USA. *Journal of Wildlife Diseases* 52, 143-149.
9. Harkewicz KA (2001). Dermatology of reptiles: a clinical approach to diagnosis and treatment. *Veterinary Clinics of North America: Exotic Animal Practice* 4, 441-461.
10. Johnson R, Sangster C, Sigler L, Hambleton S, Paré J (2011). Deep fungal dermatitis caused by the *Chrysosporium* anamorph of *Nannizziopsis vriesii* in captive coastal bearded dragons (*Pogona barbata*). *Australian Veterinary Journal* 89, 515-519.
11. Last LA, Fenton H, Gonyor-McGuire J, Moore M, Yabsley MJ (2016). Snake fungal disease caused by *Ophidiomyces ophiodiicola* in a free-ranging mud snake (*Farancia abacura*). *Journal of Veterinary Diagnostic Investigation* 28, 709-713.
12. Lorch JM, Knowles S, Lankton JS et al. (2016). Snake fungal disease: an emerging threat to wild snakes. *Philosophical Transactions of the Royal Society B: Biological Sciences* 371, 20150457.
13. Masters NJ, Alexander S, Jackson B et al. (2016). Dermatomycosis caused by *Paranannizziopsis australasiensis* in five tuatara (*Sphenodon punctatus*) and a coastal bearded dragon (*Pogona barbata*) in a zoological collection in New Zealand. *New Zealand Veterinary Journal* 64, 301-307.
14. Paré JA, Andes DR, Sigler L (2005). In vitro susceptibility of fungal isolates from reptiles to antifungal drugs, *Proceedings from the AAZV, American Association of Wildlife Veterinarians, AZA/NAG* 124.
15. Paré JA. Ophidiomycosis. (2019). In: Miller RE, Calle PP, Lamberski N, *Fowler's Zoo and Wild Animal Medicine Current Therapy Volume 9*. Saunders.
16. Paré JA, Sigler L (2016). An overview of reptile fungal pathogens in the genera *Nannizziopsis*, *Paranannizziopsis*, and *Ophidiomyces*. *Journal of Herpetological Medicine and Surgery* 26, 46-53.
17. Rainwater KL, Wiederhold NP, Sutton DA et al. (2018). Novel *Paranannizziopsis* species in a Wagler's viper (*Tropidolaemus wagleri*), tentacled snakes (*Erpeton tentaculatum*), and a rhinoceros snake (*Rhynchophis boulengeri*) in a zoological collection. *Medical Mycology* 0, 1-8.

18. Rajeev S, Sutton D, Wickes BL et al. (2009). Isolation and characterization of a new fungal species, *Chrysosporium ophiodiicola*, from a mycotic granuloma of a black rat snake (*Elaphe obsoleta obsoleta*). *Journal of Clinical Microbiology* 47, 1264-1268.
19. Rzedkowska M, Allender MC, O'Dell M, Maddox C (2016). Evaluation of Common Disinfectants Effective against *Ophidiomyces ophiodiicola*, the Causative Agent of Snake Fungal Disease. *Journal of Wildlife Diseases* 52, 759-762.
20. Sigler L, Hambleton S, Paré JA (2013). Molecular characterization of reptile pathogens currently known as members of the *Chrysosporium* anamorph of *Nannizziopsis vriesii* complex and relationship with some human-associated isolates. *Journal of Clinical Microbiology* 51, 3338-3357.
21. Stchigel A, Sutton D, Cano-Lira J et al. (2013). Phylogeny of chrysosporia infecting reptiles: proposal of the new family Nannizziopsiaceae and five new species. *Persoonia: Molecular Phylogeny and Evolution of Fungi* 31, 86.
22. Stephen C, Shirose L, Snyman H (2017). Snake Fungal Disease in Canada Rapid Threat Assessment. Canadian Wildlife Health Cooperative.
23. Thompson NE, Lankau EW, Rogall GM. (2018). *Snake Fungal Disease in North America: US Geological Survey Updates*. US Department of the Interior, US Geological Survey.

## Management of a Fly River Turtle (*Carettochelys insculpta*) with ulcerative dermatitis in Wildlife Reserves Singapore

Dr. Charlene Yeong  
Wildlife Reserves Singapore  
80 Mandai Lake Road, S(729826), Singapore  
Additional authors: Dr. Guillaume Douay, Dr. Chia-Da Hsu

### Abstract

A 1.5kg female *Carettochelys insculpta* initially presented with lethargy, poor appetite, shell ulceration and buoyancy problems. The initial treatment consisted of trimethoprim sulphadiazine 25mg/kg PO x10d, 10% iodine soak TOP and tube feeding. On reassessment, the animal had deteriorated, with skin erythema and yellow plaques present in the oral cavity. Blood work revealed lymphopaenia and hyperglycaemia. The animal was not stable enough for shell debridement, culture and sensitivity and feeding tube placement under anaesthesia, but an impression smear was taken of the oral plaques, which revealed cocci and rod bacteria. It was placed under intensive care and maintained on a towel in shallow water at a temperature gradient of 26-32°C. A new course of treatment with ceftazidime 22mg/kg IM q72hr, enrofloxacin 6.6mg/kg PO SID, metoclopramide 0.1mg/kg IM SID, NaCl SC SID and 10% iodine soak TOP 30min SID was initiated. Critical Care formula was administered IG SID. Two weeks after warding, improvements were seen and feeding was switched to Oxbow Critical Care fine grind. Solid foods were introduced, with gradual response. After four weeks, it was actively swimming, eating on its own, and most shell lesions had resolved. It was discharged back to the section to continue with iodine TOP soaks for two weeks.

Seven months later, the same animal presented with generalised erythema. Treatment was started at the section with iodine soaks SID. However, the condition deteriorated and hypochlorous acid (Medilox) sprays SID, meloxicam 0.5mg/kg PO SID and enrofloxacin 10mg/kg IM SID were added to the treatment regime, to no avail. Within 2 weeks, the turtle died. On post-mortem examination, skin ulceration and hyperkeratosis on the ventrum were noted. Histopathologically, severe multifocal pseudomembranous stomatitis and diffuse hyperkeratotic, ulcerative dermatitis with abundant fungal hyphae were found. Fungal culture confirmed *Fusarium solani*. The management of this case, including husbandry considerations, is discussed.

### Introduction

Ulcerative dermatitis is a common presentation of captive reptiles. In chelonians, it can present as multifocal deficits of the carapace, bridge and plastron. The condition may progress from superficial erosions to ulcerative, craterous lesions, potentially ringed with hyperpigmentation (Maas, 2013; Vogelnest, 2018; White, et al., 2010).

It is most commonly associated with improper husbandry, such as low environmental temperature, poor water quality, inappropriate water pH and inadequate nutrition. Other factors, such as overcrowding, may contribute to stress and immunosuppression (Hoppmann, 2007). Underlying aetiologies, such as trauma, burns or toxin exposure causing skin and shell weakness and deficits, then allow opportunistic pathogens to invade. Bacterial, fungal and viral causes have been implicated. Opportunistic bacteria are mostly Gram-negative, and in chelonians, *Aeromonas*, *Citrobacter* and *Beneckia* have been cultured. Although not as common as bacterial infections, fungal aetiologies have also been reported. Several pathogens have been isolated, including *Aspergillus* spp., *Mucor* spp., *Saprolegnia* spp., *Candida* spp., *Fusarium* spp., and *Trichosporon* spp. Mixed bacterial and fungal infections may occur (Vogelnest, 2018; Wellehan and Divers, 2019).

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Yeong, C - Management of a Fly River Turtle (*Carettochelys insculpta*) with ulcerative dermatitis in Wildlife Reserves Singapore

In aquatic chelonians, a more severe condition, previously termed septicaemic cutaneous ulcerative disease, may occur. This has also been termed shell rot. Systemic signs of inappetence and lethargy occur with cutaneous ulceration, petechiae and erythema. The most commonly isolated bacteria are *Citrobacter*, *Beneckea*, *Aeromonas* and *Serratia spp.*, although current thoughts are that multiple bacteria are the cause of this syndrome (Vogelnest, 2018; Meyer and Selleri, 2019).

The treatment of these dermatoses involves antibiotics, such as soaking in 2-3% chlorhexidine or 5-10% povidone iodine, twice daily, until one to two weeks after clinical signs resolve, for a minimum of three to four weeks (Vogelnest, 2018). Topical antifungals, such as miconazole, ketoconazole and nystatin, can be administered. For severe lesions and presentations, surgical debridement, systemic antibiotics, systemic antifungals and supportive care may be necessary (Vogelnest, 2018; Wellehan and Divers, 2019). The mainstay of treatment is correction of husbandry and environmental parameters – ensuring that the appropriate temperature gradient, humidity and nutrition are provided. Raising the basking temperature 1-2°C above the preferred basking temperature can be useful. For semi-aquatic species, dry docking may be helpful, but may not be suitable for obligate aquatic species (Hoppmann, 2007; Maas, 2013; Perry and Mitchell, 2019).

### Case history

A 1.5kg female, at least 3-4 years old, *Carettochelys insculpta* was initially presented on 25 September 2018 with lethargy, inappetence, ulcerative lesions on both the carapace and plastron, and buoyancy issues. It was housed off-exhibit with one other smaller conspecific in an outdoor, mosquito-proof enclosure with access to natural sunlight. The temperature gradient of the water was 24-26°C, occasionally rising higher than 26°C on hot days. The diet was a variety of fresh vegetables and fruit, as well as thawed prawns and fish.

### Clinical findings and progression

On examination, the animal was bright and responsive, but with a poor body condition score of 3/9. Multifocal ulcers with whitish granulomatous material were present on the carapace, and a large T-shaped ulcer occupying about 35% of the plastron (Figure 1). A presumptive diagnosis of bacterial ulcerative dermatitis was made, with the buoyancy issue most likely attributed to inappetence. A treatment plan of 10% povidone iodine soaks for 30 minutes SID, and trimethoprim sulpha 25mg/kg PO x10 was initiated. Assist feeding with 5ml of blended diet IG TID was also recommended.



**Figure 1 a&b.** A 1.5kg *Carettochelys insculpta* presented with multifocal, granulomatous ulcers on the carapace (a) and a large T-shaped lesion on the plastron (b).

On reassessment on 3 October 2018, the animal was more active and some improvement was observed with the skin ulcers. Iodine baths were continued and gentle brushing of the lesions was added. Food was presented and assist feeding was administered only if inappetence continued.

However, a deterioration was observed on 14 October 2018. The animal was seen to swim to the surface only to breathe, was barely eating, and had lost weight. On examination, the animal was very weak and dehydrated. An oral examination was carried out with little resistance. The oral cavity was erythematous, with yellow plaques present on the tongue and oral mucosa. No significant improvement was seen with the shell lesions. The ventral skin of the limbs was hyperaemic. Apart from a gas-filled stomach, no significant findings were observed on radiographs. No toxicity or abnormalities were seen in the erythrocytes and leukocytes. Biochemistry revealed lymphopaenia and hyperglycaemia. Reference ranges from Species 360 Zoological Information Management System (ZIMS) was used. The animal was not stable enough for ulcer debridement with swab for culture and sensitivity and feeding tube placement under anaesthesia. However, an impression smear was made of the plaques on the tongue, which revealed a large number of cocci- and rod-shaped bacteria, with proteinaceous debris (mucin). It was nursed for intensive care and maintained on a towel in shallow water, with a heating rod at one end and a temperature gradient of 26-32°C. Ceftazidime 22mg/kg IM q72hr x 4wks, enrofloxacin 6.6mg/kg PO SID x 4 weeks, metoclopramide 0.1mg/kg IM SID, 0.9% NaCl 10ml/kg SC SID and 10% iodine soaks TOP 30 minutes SID were initiated. Critical care formula IG BID was also administered. Small amounts of food, such as leafy vegetables and pieces of cut fish, was offered in the water.

After eight days, the animal was brighter and able to swim, had started to eat very small amounts voluntarily and attempted to evade restraint. Critical Care Formula was gradually switched to Critical Care Fine Grind for herbivores. Metoclopramide was stopped after 12 days and fluid therapy after 18 days. After four weeks, it was actively swimming and eating on its own, and most shell lesions had resolved. It was discharged back to section to continue with iodine soaks TOP for two weeks. It was housed alone in a tub in similar conditions as before. Improvements to shell lesions and demeanour were continued to be observed after discharge.

Seven months later, the same animal presented with generalised erythema of the plastron and limbs but was otherwise well. Iodine soaks 30 minutes SID TOP were initiated, with more frequent changes of water to improve water quality. However, deterioration was seen a week later on 3 June 2019, with sloughing of the skin and associated bleeding and pain. Yellow pseudomembranous lesions were present in the buccal cavity. Apart from a haematocrit of 45%, haematology was unremarkable. Hyperglycaemia and elevated LDH and CK were found on biochemistry. Hypochlorous acid (Medilox) sprays SID, meloxicam 0.5mg/kg PO SID, enrofloxacin 10mg/kg IM SID and 0.9% NaCl 19ml/kg PO were added to the treatment regime. The animal died overnight.

### **Post-mortem examination**

On necropsy examination, multiple skin ulceration and hyperkeratosis were present, largely on the ventrum (Figure 2). No lesions were visible on the carapace (Figure 3). The oral cavity was hyperaemic, with severe multifocal pseudomembranous stomatitis, extending to the proximal oesophagus (Figure 4). The brain surface was severely congested (Figure 5). Histopathologically, abundant fungal hyphae were found in the oral lesions. Fungal culture confirmed the presence of *Fusarium solani*. No other significant lesions were observed.



**Figure 2 a&b.** Multiple skin ulceration and hyperkeratosis was present on the ventrum of the *Carettochelys insculpta* on post mortem examination.



**Figure 3.** No significant lesions were visible on the dorsum of the *Carettochelys insculpta* on post mortem examination.



**Figure 4.** The oral cavity of the *Carettochelys insculpta* on post mortem examination. The oral cavity was hyperaemic, with severe multifocal pseudomembranous stomatitis, extending to the proximal oesophagus. Fungal hyphae were observed on histopathology of the lesions. *Fusarium solani* was cultured.





**Figure 5.** On post mortem examination, the brain surface of the *Carettochelys insculpta* was severely congested.

### Diagnosis

The initial diagnosis was severe ulcerative dermatitis, and the final diagnosis was severe mycotic stomatitis caused by *F. solani*.

### Discussion

In this case, there was progression from moderate to severe ulcerative dermatitis with septicaemia in a 1.5kg *C. insculpta* in about three weeks, despite initial topical and systemic treatment, coupled with assist feeding. The evolution from vesicular to ulcerative lesions, as described in other reptiles in Maas (2013), was not seen in this case. White et al. (2010) reported that chelonians with dermatitis most commonly had hyperglycaemia and hypercalcaemia. Hyperglycaemia was observed in this case, but not the latter. The animal responded successfully to intensive treatment with empirical systemic antibiotics and supportive care.

The re-presentation of the same individual with severe fusariomycosis seven months later, resulting in the eventual death of the animal, is concerning. Impression smears on initial warding in October 2018 revealed only cocci and rod bacteria. No fungal hyphae were seen. However, in June 2019, *F. solani* plaques were found extensively in the oral cavity, proximal oesophagus and had extended to the brain. *Fusarium* spp. are common environmental fungi and are most commonly opportunistic secondary invaders, often manifesting as dermatological and respiratory infections in reptiles (Wellehan and Divers, 2019). Infections are often affected by inappropriate husbandry and other underlying disease (Hoppmann, 2007). The *F. solani* complex is the most common *Fusarium* pathogen in reptiles and has been reported to cause deaths in loggerhead turtle eggs and juveniles and abscesses in Ridley's (Garcia-Hartmann et al., 2016; Sarmiento-Ramírez et al., 2010; Williams et al., 2012). It has not been reported to affect *Carettochelys* to date. Treatment can be difficult as resistance to therapy has been reported. Speciation and sensitivity tests are ideal. Excision of infected tissue, and empirical treatment with terbinafine and either posaconazole or voriconazole may be initiated. However, the ultimate goal of treating mycological infections in reptiles is to improve ecosystem health (Wellehan and Divers, 2019).

Various factors may have contributed to the overall decline of this individual. As an initial confiscation from the illegal pet trade in 2015, the origin of the animal is unknown. The haematology results, both complete blood count and biochemistry, did not completely correlate with the clinical presentation. No toxicity or abnormalities were seen in haematology during both presentations, despite severe cutaneous lesions and hyperaemia. Despite the availability of a reference range in ZIMS, this range is based on the data entry of participating institutions and may not be consistent. Additionally, the health, nutritional and reproductive status of the individuals, as well as restraint

method and duration can affect haematology results (Scheelings and Jessop, 2011). Normal reference ranges for *C. insculpta* should be established, particularly as this species is Endangered and is facing threats of habitat loss and harvest (Eisemberg et al., 2018). Additionally, numerous animals are surrendered or confiscated from illegal trade (Burgess and Lilley, 2014; Yeong pers obs.). Normal haematology references are crucial to assessment health status. Treatment was initiated based on clinical presentation.

On further investigation with the animal care staff, it was also determined that the concentration of povidone iodine soaks varied during treatment. The solution was not always measured to make up a 10% solution, which may have affected the efficacy of the treatment. The initial advice to provide intragastric assist feeding was also not consistently followed. Ultimately, inappropriate environmental and husbandry provisions most likely played a significant role in the initial presentation of the ulcerative dermatitis and that of the final fusariomycotic stomatitis. As ectotherms, the immune system and body functions of reptiles is closely linked to environmental conditions (Perry and Mitchell). *C. insculpta* require a water temperature gradient of 26-30°C (Doneley, 2018). When warded, the maximum temperature in the water body was raised by 1-2°C to. At the section, environmental conditions may be more difficult to control due to the nature of the outdoor set up, and the water temperature may have been inappropriate. Closer communication, monitoring and collaboration could have been achieved between the veterinary and zoology teams.

## References

1. Burgess EA and Lilley R (2014) Assessing the trade in pig-nosed turtles *Carettochelys insculpta* in Papua, Indonesia. TRAFFIC. Petaling Jaya, Malaysia.
2. Doneley B (2018) Taxonomy and introduction to common species. In Reptile Medicine and Surgery in Clinical Practice. Eds B Donely, D Monks, R Johnson, B Carmel. John Wiley & Sons, Oxford, 1-14.
3. Eisemberg C, van Dijk PP, Georges A and Amepou Y (2018) *Carettochelys insculpta*. The IUCN Red List of Threatened Species 2018: e.T3898A2884984. <http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T3898A2884984.en>. Downloaded on 07 August 2019.
4. Garcia-Hartmann M, Hennequin C, Catteau S, Béatini C and Blanc V (2017) Clusters of *Fusarium solani* infection in juvenile captive born *Caretta caretta* sea turtles. Journal de Mycologie Médicale 27, 113-118.
5. Hoppmann E (2007) Dermatology in reptiles. Journal of Exotic Pet Medicine 16(4), 210-224.
6. Mass AK (2013) Vesicular, ulcerative, and necrotic dermatitis of reptiles. Veterinary Clinics of North America Exotic Animal Practice 16, 737-755.
7. Meyer J and Selleri P (2019) Dermatology – shell. In Mader's Reptile and Amphibian Medicine and Surgery, 3<sup>rd</sup> ed. Eds SJ Divers and SJ Stahl. Elsevier, St Louis, Missouri, 712-720.
8. Perry SM and Mitchell MA (2019) Therapeutic overview and general approach. In Mader's Reptile and Amphibian Medicine and Surgery, 3<sup>rd</sup> ed. Eds SJ Divers and SJ Stahl. Elsevier, St Louis, Missouri, 1127-1129.



9. Sarmiento-Ramírez JM, Abella E, Martín MP, Tellería MT, López-Jurado LF, Marco A and Diéguez-Urbeondo J (2010) *Fusarium solani* is responsible for mass mortalities in nests of loggerhead sea turtle, *Caretta caretta*, in Boavista, Cape Verde. FEMS Microbiology Letters 312, 192-200.
10. Scheelings TF and Jessop TS (2011) Influence of capture method, habitat quality and individual traits on blood parameters of free-ranging lace monitors (*Varanus varius*). Australian Veterinary Journal 89(9), 360-365.
11. Vogelnest L (2018) Disorders of the integument. In Reptile Medicine and Surgery in Clinical Practice. Eds B Donely, D Monks, R Johnson, B Carmel. John Wiley & Sons, Oxford, 255-271.
12. Wellehan JFX and Divers SJ (2019) Bacteriology. In Mader's Reptile and Amphibian Medicine and Surgery, 3<sup>rd</sup> ed. Eds SJ Divers and SJ Stahl. Elsevier, St Louis, Missouri, 235-246.
13. Wellehan JFX and Divers SJ (2019) Mycology. In Mader's Reptile and Amphibian Medicine and Surgery, 3<sup>rd</sup> ed. Eds SJ Divers and SJ Stahl. Elsevier, St Louis, Missouri, 270-280.
14. White SD, Bourdeau P, Bruet V, Kass PH, Tell L, Hawkins MG (2010) Reptiles with dermatological lesions: a retrospective study of 301 cases at two university veterinary teaching hospitals (1992-2008). Veterinary Dermatology 22, 150-161.
15. Williams SR, Sims MA, Roth-Johnson L and Wickes B (2012) Surgical removal of an abscess associated with *Fusarium solani* from a Kemp's ridley sea turtle (*Lepidochelys kempii*). Journal of Zoo and Wildlife Medicine 43(2), 402-406.

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