Subcutaneous (SC) fluids can also be used to rehydrate mildly dehydrated patients (<5%). In severe cases of dehydration (>8%), other routes of fluid administration, such as intracoelomic, intraosseous, and intravenous fluids, should be used. There are a number of advantages to using SC fluids, including ease of administration and an ability to deliver large volumes of fluids. The primary disadvantage of using SC fluids is that the subcutaneous space in most animals is relatively avascular, leading to variable absorption rates. The most common site to administer SC fluids in snakes and lizards is the lateral body wall. In chelonians, SC fluids are generally administered in the inguinal/femoral space. In birds, the inguinal and scapular areas are the most common sites of SC fluid administration. In mammals, the dorsal thoracic (scapular) and lateral body walls are the preferred sites for SC fluid administration.

Intraosseus (IO) fluids can be used in cases with moderate to severe dehydration. The IO route may be used when peripheral vasoconstriction limits intravenous access. Intraosseous catheters are clinically advantageous and appropriate in small and fractious patients due to ease of placement, catheter stability and clinical response. The femur, tibia, and humerus may be used for IO catheter placement in reptiles. In birds, the ulna and tibiotarsus are preferred. The femur and humerus should never be used because they may be associated with air sacs. In mammals, the proximal femur and tibia are preferred sites for IO catheters. A local anesthetic, such as lidocaine, should be used to reduce the pain associated with catheter placement. The author prefers to use spinal needles for IO catheters, as they have a stylet that prevents plugging the needle with a bone core.
Intracoelomic (ICo) fluids can be administered to reptiles and mammals with moderate to severe dehydration; however, this route should never be used in birds as it can lead to accidental drowning. The large serosal surface area of the viscera and the coelomic/peritoneal membranes of reptiles and mammals serve to resorb the fluids. Irritating compounds should not be administered ICo. Intracoelomic fluids are not recommended in reptile patients that have respiratory compromise, as they may place an additional burden on the animal. Intracoelomic fluids should be given in the caudal coelomic cavity.

Intravenous fluid administration is the preferred route of fluid administration in moderately to severely dehydrated patients. The jugular vein can be used for lizards, chelonians, and snakes. Placement of the jugular catheter in the snake and lizard requires a surgical cut-down. A local anesthetic, such as lidocaine, should be used to reduce discomfort. The cephalic vein is another site for catheterization in the lizard, whereas the heart may be directly catheterized in severely moribund snakes. In birds, the jugular, basilic or medial metatarsal veins can be used to place IV catheters. The medial metatarsal vein is generally large (and approachable) in waterfowl, raptors, and large psittacines. In smaller psittacines, the basilic vessel is preferred. In mammals, the jugular, cephalic and lateral saphenous sites can be used for IV catheters. When collecting blood samples from exotic pet patients, it is important to consider possible IV sites prior to sample collection. For example, the author never collects a blood sample from a rabbit cephalic vein, preferring to save the site for IV catheterization.
Clinicians working with exotic pets should establish consistent anesthetic and analgesic protocols to manage cases that require diagnostic or surgical procedures. Unfortunately, there are still cases where patients are being managed using “bruticaine” or analgesic limited protocols that aren’t taking into account the potential pain that develops or continues after a procedure (e.g., only using isoﬂurane anesthesia with no other long term management plan). Advances in domestic animal anesthesia have provided safer, consistent compounds that may be used to anesthetize exotic pets and provide long term analgesia.

A patient should receive a thorough examination, including auscultation of the heart and lung(s), prior to any anesthetic procedure. In those cases where auscultation is limited, such as with reptiles, an ultrasonic Doppler may be used to assess the heart. Pre-surgical blood work, which is commonly performed in domestic species, can provide insight into the physiological status of an animal. A complete blood count and plasma chemistry panel should be performed when possible. In cases where blood volume or owner finances are limited, a packed cell volume, total solids, and blood smear can be performed to provide important information regarding the animal’s status.

Ectotherms, such as reptiles and amphibians, should be provided supplemental heat during an anesthetic procedure that is consistent with their preferred environmental temperature. Endotherms, including birds and mammals, should also be provided supplemental heat during these procedures. Hypothermia in endotherms can result in the loss of essential energy to maintain an appropriate core body temperature. Animals maintained at an inappropriate temperature will experience a prolonged recovery. Water-circulating heat pads and forced air heating units provide good results and are unlikely to cause thermal burns. Radiant heat from an incandescent light can also be used to provide supplemental heat.

Variability in the physiology of exotic pets often results in variable responses between classes of animals. For example, anesthetics that provide surgical anesthesia in a mammal or bird may provide little to no anesthesia in a reptile or amphibian. Differences in anesthetic responses within animal classes have also been described. The anesthetic agents that have been found to provide the most reliable results in exotic pets include the dissociatives, benzodiazepines, alfaxalone, alpha-2 agonists, propofol, and inhalant anesthetics.

Benzodiazepines, such as midazolam, are excellent for sedating exotic pets for diagnostic procedures or as part of a pre-anesthetic protocol. The author routinely uses midazolam to sedate exotic small mammals for diagnostic imaging. Doses for rabbits range from 0.5-1 mg/kg, while for rodents may range from 0.5-2 mg/kg. Combining the midazolam with an opioid, such as buprenorphine (0.03-0.05 mg/kg), is useful if any painful procedures are expected (e.g., orthopedic manipulation for radiographs).

Dissociative agents are routinely used to anesthetize exotic pets. The most common dissociative agents used are ketamine (Ketaset, Fort Dodge Laboratories, Ft. Dodge, IA, USA) and tiletamine (Telazol, Fort Dodge Laboratories, Ft. Dodge, IA, USA). Reported dosages for ketamine are quite varied. When a short, painless procedures (e.g., examination) or pre-anesthetic is required (e.g., facilitate intubation) for reptiles, a dose between 10-30 mg/kg IM is sufficient. Ketamine provides minimal analgesia and should be combined with an analgesic when a painful procedure is performed. A dose of 55-88 mg/kg IM has been recommended for surgical anesthesia in reptiles, but ketamine is inappropriate as a sole anesthetic in a surgical procedure. Ketamine is generally used in combination with alpha-2 agonists in mammals. If used alone, a dose from 15-30 mg/kg may be used, whereas the dose can be reduced when the drug is used in combination with an alpha-2 agonist. Side effects reported with ketamine usage include respiratory arrest, bradycardia, skin depigmentation, and prolonged recoveries. These side effects are usually associated with the administration of high doses (>80 mg/kg). Tiletamine is more potent than ketamine and provides similar results at a lower dose in reptiles (3-8 mg/kg). The addition of zolazepam is of benefit because it improves muscle relaxation and is an anticonvulsant. Tiletamine has been used in snakes, lizards and crocodilians with some success, but recoveries are still prolonged. Tiletamine should only be used for short, painless procedures or as a pre-anesthetic as it provides limited analgesia. The dissociatives have been used in birds, but generally result in violent recoveries.

The alpha-2 agonists, including xylazine and dexmedetomidine, have been used with good success in exotic pets. In general, they are used in combination with other drugs. Of the two drugs, dexmedetomidine is used more frequently because of its greater effect and potency. Dexmedetomidine provides muscle relaxation, analgesia and is reversible with atipamezole. The primary side effect associated with this drug is cardiopulmonary depression.

Propofol is a non-barbiturate anesthetic agent that can be used to provide general anesthesia. Propofol is readily metabolized, has no cumulative effect, and provides approximately 10-45 minutes of anesthesia. To be effective, propofol must be administered intravenously (IV) or intraosseously (IO). The author has been able to anesthetize amphibians using the intracoelomic route, but the
dose is much higher (35 mg/kg) than the IV dose. A dose of 10-15 mg/kg IV will provide general anesthesia in birds, mammals, and reptiles. Additional boluses of propofol may be necessary during a procedure. Because propofol is a respiratory depressant, the patient should be intubated and ventilated.

Inhalant anesthetics are still considered the gold standard for anesthesia. The primary advantage of the inhalant anesthetics is that delivery is controlled via a precision vaporizer. The most common inhalant anesthetics used in veterinary practice are sevoflurane and isoflurane. Exotic pets, like domestic species, should be intubated to ensure consistent delivery of the anesthetic. Birds, chelonians, and crocodilians have closed tracheal rings and should be intubated with a non-cuffed endotracheal tube. Intubating a reptile or bird is a simple procedure because the glottis is located on the floor of the mouth. Intubating lagomorphs can be very difficult because of their long, narrow oral cavity. Birds and reptiles under general anesthesia may become apneic during the procedure and should be ventilated using intermittent positive pressure. Typically, 4-6 breaths per minute at a pressure less than 12 cm of water is satisfactory. Non-rebreathing systems are appropriate for animals under 5 kg.

Exotic pets should be monitored during an anesthetic procedure using standard procedures. Breathing can be monitored by observing contraction of the body wall, or with the assistance of an audible respiratory monitor. Auscultation of the heart is difficult, if not impossible, in reptiles. Esophageal stethoscopes may be used to monitor the heart rate in larger species, but are impractical in smaller animals. An ultrasonic Doppler produces an audible sound that insures cardiac function. An electrocardiogram (ECG) can also be used to monitor heart rate and rhythm. The pulse oximeter is a monitoring device that continues to gain popularity in veterinary medicine because it enables the anesthetist to monitor both heart rate and oxygen saturation. There are a number of different monitoring probes that can be purchased with these systems. Although these devices simplify anesthetic monitoring, placement and re-positioning may be required during the procedure. Mucous membrane color and hydration status of the patient should also be monitored during the surgical procedure. Any animal that experiences significant blood loss during a procedure should be given fluids (e.g. intravenous or intraosseous). Recovery from an anesthetic procedure should take place in a warm, dark, quiet area.
In the past two decades, there has been a rise in the number of emerging and re-emerging infectious diseases reported in reptiles. Emerging infectious diseases include newly identified pathogens, while those characterized as re-emerging include those that may have been previously characterized but are being reported with increased frequency. Veterinarians play an important role in the diagnosis of infectious diseases in herpetological collections and should closely monitor the literature to keep abreast of new findings and current research.

The rise in emerging infectious diseases in reptiles may be attributed to several factors, including the increased number of reptiles being imported into the United States and Europe, poor quarantine and sanitation programs, and improved diagnostic assays. The popularity of reptiles in the United States remains high, with millions of reptiles being imported annually. The popularity of reptiles has led to the growth of reptile swap meets, where herpetoculturists have the opportunity to select from a large number of different reptile species. At these swap meets large numbers of reptiles are maintained in relatively small areas with minimal/no biosecurity. Herpetoculturists routinely handle different specimens without washing their hands, possibly introducing and disseminating pathogens through the reptiles. The sanitation methods used to control or eliminate pathogens in reptile collections may also be suspect. Inappropriate use of disinfectants may lead to the development of resistant strains of microbes.

The number of diagnostic tests available to the clinician treating reptiles has increased dramatically over the past ten years. Historically, clinicians treated all “infections” in reptiles as bacterial diseases. However, over the past ten years, there have been an increased number of reports of viruses and fungi being isolated from diseased reptiles. The advent of molecular diagnostic testing has led to the development of highly sensitive and specific enzyme-linked immunosorbent assays, polymerase chain reaction (PCR), and reverse-transcriptase PCR.

The incidence of herpesvirus infections in chelonians has been on the rise since originally being isolated from sea turtles in 1975. Herpesvirus infections have been identified in freshwater, marine, and terrestrial species of chelonians. Transmission of the herpesvirus is believed to be via the horizontal route, although it has been suggested that a vertical route of transmission is also possible. Affected animals may present with rhinitis, conjunctivitis, necrotizing stomatitis, enteritis, pneumonia, and neurological disease. Molecular diagnostics, electron microscopy, and viral isolation have been used to diagnose herpes infections in chelonians. Affected animals should be provided appropriate supportive care (e.g., fluids, enterals, and antibiotics) to control clinical signs. Acyclovir has been used with some success by reducing viral replication. However, there is no effective treatment for this virus. Affected animals should not be released into the wild to prevent translocation of the virus to naïve chelonians.

Mycoplasmosis is a bacterial infection that has been associated with severe disease in chelonians. Affected animals may present with nasal and ocular discharge, conjunctivitis, palpebral edema and pneumonia. Mycoplasmosis has also been identified in squamates and crocodilians. There are several diagnostic tests available to confirm mycoplasmosis in reptiles, including culture, an ELISA and a PCR assay. Microbiologic culture can be used to confirm an infection, but it is difficult to isolate this bacteria and time consuming. Currently, parallel testing using both the ELISA and PCR assays provides the highest degree of sensitivity. Treatment may be attempted using tetracyclines and fluoroquinolones. Mycoplasmosis has been associated with declines in native tortoise populations in the United States and treatment of wild specimens is not recommended.

Cryptosporidium serpentis is a considered a “plague” of captive snake collections. This apicomplexan parasite has been associated with both high morbidity and mortality in captive collections. Affected snakes commonly regurgitate their meals, have a mid-body swelling, and are dehydrated. A variety of methods may be used to diagnose cryptosporidiosis in snakes. Acid-fast cytology of a regurgitated meal or fecal sample is often diagnostic. Because there is currently no effective treatment, affected animals should be culled. Cryptosporidium saurophilum is a more recently diagnosed species associated with lizards. Whereas C. serpentis is associated with the stomach, C. saurophilum is associated with the intestine. Currently, no consistent treatment is available for C. saurophilum or C. serpentis.

Bearded dragon adenovirus was first reported in Australia in the early 1980’s. The virus was not characterized in the United States until more than a decade later. Since that time, the virus has spread through the bearded dragon population in the USA and should be considered endemic. Transmission of the virus is primarily by the direct route (fecal-oral), although vertical transmission may also be possible. Affected animals may present with anorexia, weight loss, limb paresis, diarrhea and opisthotonous. Concurrent dependovirus and coccidial infections have also been observed in neonatal bearded dragons. Biopsies of the liver, stomach, esophagus, and kidney may be collected to confirm diagnosis (ante-mortem). On histopathology, basophilic intranuclear inclusion bodies are strongly suggestive of adenoviral infection. Currently, there is no non-invasive ante mortem diagnostic test to confirm adenovirus in the reptile;
however, the author is currently working on a polymerase chain reaction (PCR) assay to detect adenovirus in the feces of affected animals. There is no effective treatment for adenoviral infections, although supportive care (e.g., fluids, enterals, antibiotics) may be useful in stemming the secondary effects of the disease. Again, very little is known regarding the epidemiology of this virus; therefore, special precautions should be taken when working with affected animals. Because there is no effective treatment, affected bearded dragons should be culled from breeding populations.

Coccidiosis is a major cause of morbidity and mortality in reptiles. A species of special concern, Isospora amphiboluri, is found in bearded dragons. These endoparasites are especially problematic in neonatal dragons, often resulting in stunting, diarrhea, and death. Whereas most coccidial infections in higher vertebrates are self-limiting, these infections often persist in bearded dragon colonies. Historically, eliminating coccidia from bearded dragons was difficult because most of the therapeutics used to eliminate the parasites were coccidiostatic. Penazoril (30 mg/kg per os once with a second treatment 48 hours later) is coccidiocidal and has excellent therapeutic value against *I. amphiboluri*. Quarantine and environmental disinfection/sanitation should also be done to eliminate coccidia from dragon colonies.

Microsporidians are obligate intracellular parasites. The life cycle of these parasites includes both merogenic and sporogenic phases. These parasites are common in lower vertebrates (e.g., fish), but have also been implicated as a concern in humans with acquired immunodeficiency virus. Bearded dragons infected with these parasites can present with a similar clinical picture as adenovirus or coccidiosis. Affected dragons are anorectic, unthrifty, cachectic, and may die acutely. Diagnosis is generally made at post-mortem. Hepatic and renal necrosis is common, although other organ systems (e.g., intestine and gonads) may also be affected. There is no effective treatment. To limit the likelihood of introducing this parasite into a collection, herpetoculturists should only acquire animals from reputable breeders and quarantine any new arrivals for a minimum of 60-90 days.

Ranavirus is an emerging disease of chelonians. This virus has a high morbidity and mortality. It has been isolated from both captive and wild chelonians. Affected animals typically develop upper respiratory signs (e.g., palpebral edema, conjunctivitis), lower respiratory signs, oral ulcers, cervical edema, and gastrointestinal signs. Diagnosis can be done using PCR. There is currently no effective treatment for affected animals.
Chelonians are commonly presented to veterinarians for a variety of health concerns. The purpose of this presentation is to provide a review of important biologic, husbandry, and disease information as it relates to these animals.

Chelonians are long-lived reptiles that have always been of interest to humans, originally as a source of food, and more recently as pets. Chelonians are found on all of the inhabited continents. Since the 1980’s the popularity of chelonians has increased dramatically. The primary reason for this has been the successful reproduction of these animals in captivity. As the popularity of these reptiles continues to rise, veterinarians can expect to encounter them more frequently in their practices.

Chelonians represent a diverse group of animals that can be found in different ecological niches, including aquatic, temperate, semi-arid and desert habitats. Characterizing the specific habitat required by a chelonian can be useful when designing a vivarium. These diurnal species prefer to bask in the morning and late afternoon hours in to avoid the excessive heat of the day. Because chelonians are ectotherms, it is important to provide them an appropriate environmental temperature range. In general, a diurnal range from 80-90°F is appropriate; while a nighttime drop to 70-80°F will suffice. Chelonians not provided an appropriate environmental temperature may have a decreased metabolic rate and immune response, resulting in limited growth and chronic infections.

For years there has been very little research focused at identifying the specific nutritional requirements of chelonians. Chelonians are generally classified as herbivorous, omnivorous or carnivorous. Herbivorous tortoises generally feed on a high degree of succulents and grasses within their native environments. The grasses are important sources of fiber, and provide essential cellulose for microbes in the colon of these reptiles. These microbes utilize these plant sources to generate volatile fatty acids (e.g., energy) for the tortoise. Captive tortoises should be provided a diverse diet comprised of vegetables, fruits, and grasses. The author prefers to use timothy or Bermuda grass hay, mustard and collard greens, and romaine lettuce as the basis for the diet. Fruits generally comprise 10-15% of the diet. Other green leafy vegetables, beans, and squash can be used to round out the diet. When offered a diverse diet, nutritional supplements are not generally required.

Omnivorous chelonians should be provided a diet comprised of both animal and plant materials. As juveniles, omnivorous chelonians tend to prefer animal proteins, while adult animals tend to consume more plant protein in their diet. Omnivorous chelonians should be provided the same plant based diet as described previously for herbivorous reptiles. In the United States, there are six invertebrates sold commercially, including the commercial cricket (Acheta domesticus), mealworm (Tenebrio molitor), superworm (Zoophobias morio), waxworm larva (Galleria mellonella), fruit fly (Drosophila spp.), and earthworm (Lumbricus terrestris). The primary advantage to using these invertebrates is that they are readily available through most pet distributors year round. Unfortunately, these prey items do not provide a complete and balanced diet for an omnivorous chelonian. Most of these invertebrates are deficient in calcium, the exception being earthworms maintained in high calcium soils. Feeding or “gut-loading” commercial invertebrates prior to offering them to a chelonian can help to increase the mineral content of the prey items. Dusting the prey item with a calcium carbonate powder may also help to increase the calcium content of the prey items.

Some pet owners elect to capture wild invertebrates to feed their chelonians. It is important to only collect invertebrates from areas that are free of insecticides. There are a number of invertebrates that produce toxins that can prove fatal to a reptile. The same considerations should be followed when allowing tortoises to free-graze in a yard. Pesticides or insecticides used to treat grass can also be toxic to tortoises.

Chelonians not provided a balanced diet might develop hypovitaminosis A. Hypovitaminosis A is a common finding in tortoises that are offered a vitamin A deficient diet. Affected tortoises may present with blepharoedema, nasal and ocular discharge, dermatitis, diarrhea, and pneumonia. In severe cases, affected animals can die from hypovitaminosis A. Fast-growing juveniles and reproductively active females are most commonly affected. Affected chelonians develop squamous metaplasia, which results in the loss of tight cell junctions and increases the risk of opportunistic infections. Diagnosis is generally made based on history, physical examination, and measuring vitamin A levels. Hematologic samples and radiographs should also be performed to determine the extent of the disease. Treatment should include correcting dietary and environmental deficiencies. Parenteral vitamin A (1,500-2,500 IU/kg) can be used to initiate treatment. Over dosing an affected chelonian with vitamin A can cause an iatrogenic hypervitaminosis A, which can lead to the sloughing of the integument. Special care should be taken to only use the parenteral vitamin A in cases where the veterinarian is confident in their diagnosis.

Obesity is a common problem identified in captive chelonians that are offered ad lib food and not provided any exercise. Obesity can lead to other health issues, including dystocia and hepatic disease, and clients should be provided dietary recommendations to reduce the weight of their chelonians.
In the past decade, there has been a rise in the number of “new” or emerging infectious diseases reported in reptiles. Emerging infectious diseases include both newly identified pathogens and those pathogens that may have been previously characterized and are being reported with increased frequency. Veterinarians play an important role in the diagnosis of infectious diseases in herpetological collections and should closely monitor the literature to keep abreast of new findings and current research.

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Chelonians are routinely presented to veterinarians for traumatic injuries. The majority of these injuries generally result in the fracture of the shell. Shell fractures should be managed as an emergency. Fractures to the shell can result in the loss of body heat, fluids, and the natural barrier against pathogens. A thorough examination is performed to assess the extent of the animal’s injuries, with shell fragments stabilized to minimize pain. Analgesics should be given prior to reducing the shell fractures. To determine the chelonian’s general health condition, diagnostic tests including a packed cell volume, complete blood count, and plasma biochemistries analysis are needed. Survey radiographs should be taken to assess the extent of skeletal and soft tissue injuries. Shell fractures greater than six hours old are managed as a contaminated injury, and samples from within the wound collected for microbial culture. The author has isolated both Gram-positive and Gram-negative bacteria from these injuries and broad-spectrum systemic antimicrobials are warranted in these cases depending on the antimicrobial sensitivity pattern.

The first step is to managing a shell fracture is to remove any debris by liberally flushing the injury with sterile warm physiologic saline. Care should be taken not to introduce excessive amounts of saline into the coelomic cavity. Wet-to-dry bandages can be applied to the shell surface to facilitate removal of debris. I generally use physiologic saline or dilute chlorhexidine for the wet bandage. Wet-to-dry bandages should only be used until the exudate associated with the wound is under control, as long-term use of these bandages can result in the desiccation of the viable tissues.

There are a number of opinions on the best method to correct a shell fracture. The author generally uses surgical hardware to reduce the fractures or manage the injury as an open wound and allow it to heal completely by second intention. Surgical correction is necessary for shell fractures that are not stable or involve greater than 20% of the shell surface area. Cerclage wire, plates or metal braces have all been used to reduce shell fractures. These devices are generally not removed from the shell fracture unless the animal remains in captivity until the shell fracture is completely healed. Once the fractures are reduced, the injury can be allowed to heal by secondary intention healing or covered with an acrylic polymer. Wounds that are not covered should be irrigated daily and kept free of debris until a protective epithelial barrier is observed. Commercial epoxy resins are also routinely used to repair shell injuries.
However, these compounds are exothermic, and leakage into an injury could cause osteomyelitis or coelomitis. If the acrylic polymer is used to protect the fracture site, than the epoxy can be used to cover the acrylic and form a watertight seal for aquatic chelonians. The convalescence period for a chelonian shell fracture can range from 6-30 months, depending on environmental and physical variables (e.g., environmental temperature and age).
The gastrointestinal tract of rabbits and rodents is unique in comparison to other domestic mammals. Veterinarians should become familiar with the anatomic and physiologic differences of the gastrointestinal tract of these animals in order to improve their management of diseases associated with this organ system. Diseases of the gastrointestinal system are a common finding in captive rodents and lagomorphs and have been associated with infectious diseases, parasites, toxins, and neoplasia. The purpose of this presentation is to provide attendees with a review of important anatomical features of the gastrointestinal system of rabbits and rodents and to discuss common diseases associated with the gastrointestinal system.

History and physical examination
A thorough history is essential to identifying any potential etiology(ies) responsible for gastrointestinal disease in rabbits and rodents. In many cases, there will be deficiencies in the animal’s husbandry. Inappropriate diet is a common problem encountered in the author’s practice. The physical examination should be thorough and complete. The ears, nares and eyes should be clear and free of discharge. The oral cavity should be examined closely. Because incisor and molar malocclusions are common in these animals, it is imperative that the teeth be closely inspected. The incisors can be evaluated by lifting the upper and lower lips, while examining the molars may require a more invasive approach, such as an oral speculum. The integument and fur should be evaluated for the presence of ectoparasites and injuries. The lungs and heart should be ausculted to determine in there are any problems with the cardiorespiratory systems. The extremities should be palpated. The plantar surfaces of rabbits should be closely inspected. Pododermatitis is a common problem in rabbits housed on wire bottom cages. The abdomen should be palpated. The kidneys, urinary bladder, stomach, and large intestine can generally be palpated during a routine examination. The anus and urogenital area should be examined, and these areas free of discharge. A rectal temperature should be taken. Rabbit body temperature is generally between 99-102°F. The appearance of the droppings produced during the examination should be evaluated. Rabbit and rodent pellets should be well formed and moist. If the fecal component of the dropping is loose or watery, it is suggestive of a diarrhea. Changes in fecal color can also suggest a gastrointestinal abnormality.

Diagnostic testing
A complete blood count and plasma chemistry analysis should be done to assess the physiologic status of the rabbit or rodent patient. Inflammatory leukograms are frequent findings in animals with gastrointestinal disease, and are characterized by a heterophilia/neutrophilia and monocytosis. Anemia is also a frequent finding in chronic cases of gastrointestinal disease. Alterations in the enzymes, electrolytes, and proteins may be observed in animals with gastrointestinal disease. Survey radiographs can be used to assess the gastrointestinal tract. When the gastrointestinal tract of these animals becomes static, ileus will become evident. Microbiological culture should be done to isolate a specific pathogen, and an antimicrobial sensitivity assay performed to determine the most appropriate antibiotic for the case. A fecal examination should be done to rule-out parasitism and bacterial infections. Endoscopy can also be used to evaluate the gastrointestinal tract.

Bacterial diseases
Bacterial diseases are one of the most common causes of gastrointestinal disease in rabbits and rodents. The majority of the isolates recovered from animals with diarrhea are opportunistic Gram-negative bacteria, although certain Gram positive bacteria (Clostridium spp.) can also cause issues. Many of these isolates are typically found in the animal’s environment. An antimicrobial sensitivity assay should be performed on the isolate to determine the most appropriate antibiotic. A fluoroquinolone or potentiated sulfa may be used as a first order antibiotic while the sensitivity assay is pending. Penicillins and cephalosporins should never be given orally to rodents and rabbits.

Gastric stasis
Gastric stasis is a common finding in captive rodents and rabbits. Animals that develop gastric stasis may do so as a result of ingesting fur or another obstructive material (e.g., carpet) or as a result of some other medical gastrointestinal slow down. Fur ingestion may be accidental, which is thought to occur as a method to increase dietary fiber, or purposeful, as a result of nest building or barbering. Rabbits and rodents that present with trichobezoars may be anorectic, depressed and lethargic. Often these animals have a “doughy” abdomen. A firm mass can often be palpated in the stomach. Survey radiographs can be used to confirm the presence of hair in the stomach. In most cases the history will be that the animal has been anorectic, but their will be apparent ingesta (the fur) in the stomach. In many cases, ileus occurs secondarily to the trichobezoar. These cases can be treated medically or surgically. Medical management should consist of re-hydrating the animal and re-stimulating the gastrointestinal tract. Any fluid imbalances should be corrected first. Motility enhancers should not be used if an obstructive trichobezoar is suspected. Antimicrobials should be used if
enteritis develops. Mineral oil can also be used to assist in the passage of the trichobezoar. Surgical removal of a trichobezoar should be attempted if medical management is unsuccessful.

Parasites
Protozoal parasites (e.g., coccidian) are the most common endoparasites encountered in rodents and rabbits in the author’s practice. Although coccidians are generally considered self-limiting in mammals, they do not appear to be in rabbits. *Eimeria* is the most common genera encountered. Diagnosis can be made from direct saline smears. Treatment can generally be accomplished using appropriate anti-coccidiocides such as ponazuril. The most common nematodes encountered in captive rabbits and rodents are pinworms. These parasites are considered by many to be commensals. The author generally recommends treating animals with pinworms when burdens appear heavy or it is a breeding operation.

Neoplastic diseases
Gastrointestinal neoplasia is an infrequent finding in rabbits and rodents. Neoplasia should always be considered in a differential diagnosis when an undetermined mass is associated with the gastrointestinal tract. Diagnosis is generally made using hematology, radiography, and biopsy/histopathology. Management of neoplasia in rabbits and rodents is dependent on the type of neoplasia.
There are two ways to approach a disease issue in fish: 1) ante-mortem tests and 2) post-mortem tests. Ante-mortem tests, or those done on live fish, are done when the aquarist is interested in saving a particular fish. The aquarist may pursue this route because of either personal (yes, the human-animal bond does occur with non-furry animals!) or financial (e.g., valuable breeding animal) reasons. Post-mortem tests, or those done on dead animals, are pursued when the aquarist is interested in saving a group of fish. A necropsy (animal form of an autopsy) can provide a great deal of insight into the disease condition of a particular fish, and therefore the population of animals that it originates from. The purpose of this presentation is to review the common diagnostic tests used to assess the disease status of a fish.

There are a number of different reasons that fish develop disease, including poor water quality, inappropriate husbandry, nutritional deficiencies, infectious disease (e.g., bacteria, viral, fungal), and parasitic disease. To determine which of these etiologies is responsible for disease in a particular fish (or fishes), diagnostic testing is required. Although the concept of performing these tests may appear overwhelming, with practice, diagnosing disease can become second nature.

The most common ante-mortem tests performed on fish are gill biopsies, skin scrapes, fin biopsies, complete blood counts, cultures, and fecal direct smears. Selecting which test to perform should be based on the clinical signs of the fish. Dyspnea (rapid breathing) in fish is suggestive of gill disease, and a gill biopsy would be appropriate. Lesions found on the skin (e.g., excessive mucous production) or fins (e.g., erosions) may be suggestive of infectious or parasitic disease, and a skin scrape or fin biopsy would be appropriate. Fish that are depressed, anorectic (not eating), or thin (muscle wasting) may have an internal disease (e.g., infectious or parasitic disease). A bacterial culture can be done to identify a specific bacterial pathogen. An antibiotic sensitivity profile can also be done to determine which antibiotic is best suited for eliminating the infection. A complete blood count can be used to interpret the animal’s overall well-being or a fecal exam can be used to assess the potential for internal parasites. All of these tests can be done on alert or anesthetized animals, although the author prefers to anesthetize animals for the procedures. Tricaine methane sulfonate (MS-222; Argent Laboratories, Redmond, WA 98052)(100-200 mg/L) is the preferred anesthetic for anesthetizing fish.

Gill biopsies (clips) are an excellent method for assessing the quality of the gills. Teleosts, or bony fish, have 4 pairs of gills. The gills reside in the protective buccopharyngeal chamber under the operculum (gill cover). At the microscopic level, the gills can be divided into the primary and secondary lamellae. The primary lamellae represent the individual gill filaments that can be observed with the naked eye, while the secondary lamellae are comprised of a single layer of epithelial and endothelial cells and line the primary lamellae. The secondary lamellae are the site for gas exchange (e.g., oxygen absorption and carbon dioxide off-loading) and the excretion of wastes (e.g., ammonia). The surface area of the gills is vast, and allows for the rapid movement of water across the gill surface. Any damage to the gills can decrease the surface area associated with the secondary lamellae, and lead to dyspnea and death. Elevated levels of chlorine, ammonia, and nitrite, along with infectious and parasitic diseases, are the most common causes of gill disease in ornamental fish. To confirm which of these problems is associated with a specific case, diagnostic tests, such as a gill biopsy, should be done. If ammonia, nitrite or chlorine toxicity is suspected, than a water test should be done too. Elevated levels of any of these toxins, in combination with microscopic changes in the gills (e.g., excessive mucous production and a loss of respiratory surface area), are diagnostic. The presence of infectious (e.g., bacterial or fungal) or parasitic diseases with abnormal gills is also diagnostic. Once a diagnosis is made, an appropriate treatment plan can be devised. For example, water changes can be made to reduce the toxicity associated with ammonia or nitrite, sodium thiosulfate used to dechlorinate water, or an appropriate antibiotic or anti-parasitic given to treat infectious or parasitic agents.

A gill biopsy can be collected from an anesthetized or alert fish; however, the author performs this procedure on anesthetized patients. When handling fish it is best to wear latex exam gloves to minimize the likelihood of traumatizing the skin of the fish. The integument of fish is an important component of their innate (natural) immune system. Any damage to the skin can lead to an increased likelihood of opportunistic pathogens invading a fish. The gloves should also be moistened with the water from the animal’s aquarium. The fish should be netted and removed from the aquarium. The thumb of your non-dominant hand should be inserted under the operculum, and the operculum raised slightly. Once elevated, a fine pair of scissors can be inserted under the operculum to collect the gill biopsy. A small cutting (4) of primary lamellae should be collected. A small amount of bleeding may occur, but generally ceases within seconds. The gill sample should be placed onto a glass microscope slide, a drop of water from the animal’s aquarium placed on the sample, and a coverslip added to protect the sample. Water from the aquarium is preferred because it is isotonic (balanced) for any pathogens found on the gill. Adding water from another source that is not balanced can lead to the death of the organism and an inability to make a diagnosis. The sample should be reviewed immediately after collection to ensure best results.
A skin scrape should be done in cases where a fish has lesions on the skin. The skin scrape can be used to identify infectious or parasitic organisms. A glass microscope slide can be used to collect the sample. The slide should be held at a 45° angle and drawn in a cranial to caudal direction (e.g., from head to tail). The sample should be placed on a second microscope slide, mixed with a drop of water from the aquarium, and covered with a coverslip. Again, the sample should be read immediately for best results. If bacteria are a concern, than a Gram stain or Diff-quik stain can be done to evaluate the types of bacteria present. To prepare these slides, the sample and drop of water are mixed, the sample heat fixed using a match or lighter, and the sample stained according to the manufacturer’s recommendation.

A fin biopsy should be considered in cases where lesions are found on the fins. Many times these lesions are associated with a bacterial, fungal or parasitic infection. A fine pair of scissors should be used to collect the sample. If the sample can be collected between fin rays, that is preferred; however, this is not always possible, and the fin will regenerate. The sample should be handled in a similar fashion to the skin scrape, and either be placed on a slide with a coverslip or stained.

Fecal exams for parasites can be done on free-catch samples (e.g., found in the tank) or via enema. The samples should be placed on a slide with a drop of water and a coverslip and reviewed.

Post-mortem examinations should always be performed immediately after the fish has expired. Autolysis, or tissue disintegration, can occur rapidly in fish, and can severely limit the value of a necropsy. Fish that have been dead in the water for even a couple hours, depending on the water conditions and temperature, may have limited value. Therefore, it is important to perform the procedure as soon as possible after death. In cases where this is not possible, the animal should be stored in a refrigerator in an air tight bag. Freezing a fish can lead to tissue crystallization and eventual autolysis with thawing and is not recommended. Storing a fish in water is not also recommended, again, because of the potential for autolysis.

A fish post-mortem can be divided into two major parts: the gross examination and the microscopic examination. The gross examination will provide a significant amount of information; however, this is not generally diagnostic. The microscopic examination requires a review of the tissues under a light microscope. This aspect of the post-mortem examination generally requires the assistance of a veterinary pathologist. Veterinarians interested in submitting samples can find individuals capable of reviewing a case by searching the internet or local/state diagnostic laboratory. The author sends his samples to Dr. Michael Garner at Northwest ZooPath (www.zoopath.com).

When performing a necropsy on a fish, it is important to protect yourself against potential zoonotic diseases (e.g., those diseases that can be transmitted from animals to humans). The author highly recommends wearing latex exam gloves (or nitrile gloves for those with allergies to latex) when performing a necropsy. There are a number of bacterial and fungal fish diseases that can cause localized or even systemic diseases in humans. The cuts and scrapes we have on our hands can serve as excellent sites of entry for these pathogens, and thus the reason gloves are important.

The gross post-mortem examination will be the primary focus of this article, as the histologic examination is beyond the scope of this article. The post-mortem examination should start with an external examination of the fish. The general appearance of the fish should be closely inspected. How is the muscling? Is the animal thin? This can usually be determined by evaluating the large (epaxial) muscles along the spine. Animals with chronic disease typically lose muscle in an attempt to generate energy to defend against an infectious disease (e.g., mycobacteriosis). Are there erosions or ulcers on the skin? How large are they? Are they full thickness (e.g., can you see the underlying muscles)? These types of lesions may be indicative of aggressive bacterial infections that may be contagious to other fishes (e.g., Aeromonas spp.). A close external examination can provide a significant amount of insight into the health status of the animal. Not fully evaluating the fish can result in misdiagnosis. Once the external examination is completed, a thorough internal examination should be done.

Prior to opening the coelomic cavity (abdomen), it is important to evaluate the oral cavity and gills. The operculum should be removed and the gross appearance of the gills recorded. If the fish is only recently expired, they should remain moist and red. If the fish has been expired for an extended period of time, then they may appear deteriorated. Excessive mucous production or a loss of color is suggestive of disease. A clip of the gills can be taken and reviewed (unstained) under a light microscope to identify potential pathogens.

The author prefers to open the fish on the left side for the internal examination, as it provides better access to the spleen. The initial incision should be made on the ventral surface of the fish, cranial (in front of) to the anus. The incision should then be extended cranially to the level of the operculum. The incision should then be extended dorsally towards the spine. At this point, the incision can be extended caudally towards the tail, parallel to the spine. Finally, the incision can be extended ventrally back to the level of the initial incision. Once the incision is completed, the entire lateral aspect of the body wall can be removed. With the body wall removed, it will be possible to visualize the internal organs. With over 20,000 different teleosts, it is impossible to describe the variation in organ position, size, color, and texture in a single article. For the most part, these things are similar, but you can expect to be stumped on occasion. A review of the general locations of these organs in two different species of cichlids. For a more complete review of fish anatomy, the readers are directed to Michael Stoskopf’s Fish Medicine (1992, W. B. Saunders Publishing). With time...
and practice, a veterinarian can become quite adept at identifying organs and knowing what looks normal and what looks abnormal. The gross examination of the organs can certainly provide some insight into the health status of the animal, but is generally limited without histopathology (microscopic review of the tissues). Again, this is when submitting samples to a pathologist can prove invaluable. For example, the gills of a fish may appear grossly abnormal, but it would require histopathology to confirm the presence of a mycobacteriosis.

To truly characterize a specific cause of disease in a fish or a group of fish, diagnostic tests must be performed. For many veterinarians, the idea of performing these tests may be daunting; however, with practice any veterinarian can become proficient at performing and interpreting these tests.
Veterinarians working with reptiles and exotic mammal patients are routinely presented with challenging cases. The purpose of this presentation is to provide attendees with a series of actual reptile and exotic mammal cases in an interactive forum and discuss different diagnostic and treatment approaches.

A thorough physical examination should be performed on every reptile and exotic mammal patient. If the animal presents in respiratory distress, the physical examination should be postponed until the animal is stabilized. Placing the animal into an oxygen chamber or delivering oxygen via a facemask or endotracheal tube should be done to reduce the likelihood of hypoxia in the animal. The physical examination can be used to develop an initial prognosis regarding the case. Veterinarians must be realistic when considering the potential outcome for a case.

Diagnostic tests can be invaluable in confirming a specific etiology associated with a case. A complete blood count (CBC) can be used to evaluate the likelihood of an inflammatory response within the animal. In general, reptile and exotic mammal cases presenting with white blood cell counts (WBC) > 15-20,000 cells/ml are the result of an inflammatory response. However, stress leukograms can occur in animals with WBC counts in this range too; therefore, it is imperative that a differential count be done to determine the most likely cause of a leukocytosis. With stress, neutrophilia (heterophilia), monocytosis, lymphopenia and eosinopenia are common. In general, inflammatory leukograms are characterized by neutrophilia (heterophilia), monocytosis, and a lymphocytosis. Inflammatory leukograms can occur as a result of an infectious disease, toxin, neoplasia, trauma, or foreign body. In many cases, veterinarians attempt to associate inflammatory leukograms with an infectious etiology, when the etiology may not be infectious. The CBC also provides information regarding the erythron. If anemia is suspected, then attempts to classify the anemia (regenerative, non-regenerative) should be made.

Reptile and exotic mammal patients are stoic animals that can mask their illness. Serum/plasma biochemistry analysis can be used to evaluate physiologic disturbances in these animals. Veterinarians may find it difficult to find reference data for many of the species being presented to their facilities. Fortunately, the values for many of the biochemistries are similar to those described for domestic species. Veterinarians should become familiar with the physiologic differences between different reptile and exotic small mammals (e.g., herbivorous rabbits versus carnivorous ferrets) to help interpret results.

Radiographs are necessary to characterize the extent of injury associated with a fracture. When evaluating a fracture, it is important to consider which bone is affected, the location of the fracture (e.g., metaphysis, epiphysis, diaphysis), type of fracture (e.g., transverse, spiral, oblique), whether the fracture is open or closed, and whether there is soft-tissue and joint involvement. Evaluating the extent of soft-tissue injury associated with a fracture is necessary to estimate the convalescence period that will be required for the patient. A minimum of two high-quality images is required to fully evaluate an injury. Radiographs can also be used to evaluate the extent of disease associated with non-traumatic injuries too. Ultrasound imaging may also be used to assess the exotic pet patient. The author finds ultrasound especially useful for characterizing the reproductive status of animals.

Microbiological culture is an important diagnostic tool for veterinarians. Historically, veterinarians managed most infectious diseases as a primary bacterial disease. We now realize that bacterial infections, at least in some cases, are secondary opportunists that occur following viral and fungal infections. When submitting microbiological samples it is important to consider not only bacterial microbes, but fungi too. Performing a cytological examination prior to submitting a sample is strongly recommended, and may be useful in guiding a diagnostic laboratory.

The advancement of serological and molecular diagnostic assays has improved the veterinarian’s chances of making an ante-mortem diagnosis for an infectious disease. Currently, hemagglutination inhibition (HI) assays are available to characterize exposure to a variety of viral pathogens. Because these assays are subject to misclassification, other more specific assays should be pursued to characterize specific viruses. Enzyme-linked immunosorbent assays and serum neutralization assays are considered more sensitive and specific than HI assays. When using serological assays, serial tests are necessary to characterize active infections. Polymerase chain reaction-based assays enable veterinarians to characterize active infections in exotic pet patients.

Necropsy, and subsequent histopathology, is often necessary to confirm a diagnosis in a case. This is especially important in the face of an epizootic. Veterinarians should take appropriate precautions when performing a necropsy on an exotic pet patient. Because many infectious diseases can be transmitted via aerosolization, necropsy should be performed under a negative pressure hood. Veterinarians should submit samples to a pathologist that is familiar with exotic pet pathology.
Success with exotic pet cases requires a thorough and well thought out diagnostic plan. Historically, exotic pet cases were approached by performing few diagnostics and administering empirical therapeutics. By practicing the same good standard-of-care expected for domestic pets, veterinarians will find improved success with their exotic pet cases.
Diagnostic Imaging in Reptiles: Am I Supposed to See That?
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Diagnostic imaging is an underutilized resource in herpetological medicine. Survey radiographs and ultrasound can be used to evaluate many different systems simultaneously, and provide insight into possible problems in a case. To be successful with diagnostic imaging, veterinarians need to acquire a basic knowledge of anatomy regarding the species of interest, methods used to restrain reptiles to collect the images, and the most appropriate techniques used to collect and interpret the results.

There are a variety of resources available to the veterinarian that is trying to learn more about reptile diagnostic imaging. Mader’s Reptile Medicine and Surgery (Elsevier/Saunders, 2006) provides an excellent review on the subject. Expert opinions can be obtained either via phone consults or via the internet (e.g., Veterinary Information Network). There are also board certified radiologists that offer consultation services. Regardless of the source, veterinarians have many options when attempting to interpret the findings of a diagnostic image.

With over 9,000 different species of reptiles, it is impossible to become comfortable with the anatomic peculiarities of all the reptiles. Fortunately, reptile anatomy is highly conserved among the orders. For simplicity, the reptiles can be categorized into one of four groups: chelonians, lizards, snakes, and crocodilians. The tuatara is not mentioned because it is not considered a common captive reptile. Reptile morphology texts are excellent resources for learning the anatomy of these animals. Short descriptions can also be found in Reptile Medicine and Surgery (Mader, Elsevier/Saunders, 2006) and Clinical Anatomy and Physiology of Exotic Species (O’Malley, Elsevier/Saunders, 2005).

The quality of the equipment used to take radiographs is an important consideration. A radiographic machine to be used for reptiles should be capable of a taking a range of images, which might include day geckos (Phelsuma spp.) to varanids (komodo dragons, Varanus komodoensis). A machine capable of such a range should have a short exposure time. 1/60th of a second or shorter is recommended. The machine should also have a high milliamperes capacity (>300). This is important because of the variability in detail that might be expected among different sized animals. The kilovolt peak range should also be large, 40-100 kilovolt peak, to accommodate the different sized patients a veterinarian may encounter. The ability to alter the kilovolt peak by small increments (e.g., 2 kilovolt peak) is important because it will enable the veterinarian to review small details between images. A machine in which the tube can be rotated to provide a horizontal beam is preferred. This will enable the veterinarian to take lateral images on animals in sternal recumbency. This is especially important with large chelonians.

For small patient, dental radiograph machines can be used. The author has used this type of equipment to take “whole body” radiographs of small lizards (e.g., juvenile bearded dragons). The detail from these images, although not always refined, does provide more detail than standard films.

Selecting the correct type of cassette or film is as important as using the correct machine. High-detail, rare earth cassettes are preferred. These cassettes should be used in combination with slow speed, single emulsion (gray) films. This combination provides the best detail for small lizards. Double emulsion (black) films can be used for larger reptiles when small detail is not required. Selecting the correct size cassette and film combination is an important consideration.

When taking radiographs it is important to always collect at least two images. The most common images are a lateral and dorsoventral or ventrodorsal image. These two, two-dimensional images will provide the most insight into interpreting the anatomy of a three-dimensional reptile. Care should be taken when positioning an animal to ensure that the area of interest can be evaluated.

A reptile must be still to collect the “perfect” image. Taking radiographs on un-anesthetized or restrained reptiles can lead to motion and a loss of detail. The author has found that reptiles can be restrained manually for images or anesthetized. Manual restraint does result in increased radiation exposure for the handlers, so it should be kept to a minimum. Placing blinders over the eyes of a lizard can also be done to minimize movement. The author has found this technique to work well with iguanas, bearded dragons, and varanids. An ophthalmic eye lube is placed in the eyes of the animal and the head is wrapped with vet-wrap (3M products, St. Paul, MN). Dimming the lights and minimizing human movement and speaking in the room will also help reduce the stimuli on the reptile.

Interpreting reptile radiographs is more challenging than in mammals or birds. Lizards do not store their fat in a mesentery like mammals. This absence of fat between the internal organs reduces the contrast between the tissues, leading the viscera to appear as a single soft tissue structure. The absence of a diaphragm also limits the radiographic interpretation of the coelomic structures. The bone of reptiles is less radio opaque than mammals, which can make the interpretation of the cortical densities more difficult. To reduce the likelihood of misclassifying a case of secondary nutritional hyperparathyroidism, the author always evaluates the cortical densities of the long bones instead of the digits. The best way to become comfortable with interpreting radiographs is to practice, practice, and practice.
As veterinarians have become more familiar with ultrasonography, its application in reptile medicine has greatly expanded. When considering an ultrasound machine for a veterinary hospital, it is important to consider the range of patients the machine will be used on. If exotic species are going to be regularly screened using ultrasound, a machine with a fine transducer is recommended. The author has found that 7.5 and 10.0 mHz transducers are generally best for evaluating reptiles; however, 3 and 5-mHz transducers have also been used in larger species. One of the problems with using these lower mHz transducers is the loss of detail associated with upper surface lesions. Because of the relative small size of many of our reptile patients, the author also prefers the transducer to have a small footprint.

Capturing a high detail ultrasound image requires intimate contact between the transducer and the animal. There are two different methods for obtaining high quality ultrasound images: direct contact via a non-irritating coupling gel or direct/non-direct contact via an aquatic medium (e.g., water). Coupling gel is the most common method used for collecting ultrasound images in mammals. In reptiles, this technique can also be used, but it is important to spread the gel between the scales to reduce the loss of detail associated with trapped air bubbles. The transducer can also be placed against a water-filled examination glove that is directed against the reptile’s body. This method is the least productive in the author’s opinion. Another technique that many reptiles are tolerant of involves placing the animal and the transducer into water. The water acts as an excellent contact medium. The author works with a number of herpetoculturists that use this method for assessing the reproductive status of their reptiles.

Ultrasound can be used to evaluate any number of systems in a reptile. This diagnostic technique is primarily used by the author to assess the reproductive status of reptiles. Follicles can be measured to predict whether an animal is likely to ovulate. For some species this information can be used to determine the best time for introducing a male and female. Images of the ovaries are best obtained by placing the transducer on the lateral body wall just caudal to the last rib. Each ovary should be evaluated individually, as one gonad may be active while the other is not.

Ultrasound can also be used to evaluate the heart of reptiles. The heart of most lizards is located in the pectoral girdle, with varanids being an exception. Their heart is located more caudally in the body cavity. The snake heart is located approximately 1/3 the distance from the head. The chelonian heart is located dorsal to the thoracic scutes of the plastron. Access to the heart with ultrasound can be obtained via the axillary region in lizards and chelonians, and direct placement over the beating heart of a snake. Lizards, snakes, and chelonians have a three-chambered heart, while crocodilians are the only reptiles with a four-chambered heart. Rotating the transducer should enable the ultrasonographer to evaluate all three (or four) chambers.

Ultrasound can also be used to evaluate the viscera in the caudal coelomic cavity. The author generally uses ultrasound to assist with the collection of fine-needle aspirates or biopsies of different coelomic organs. Kidney disease is a common problem in captive, adult green iguanas. Iguana kidneys are located in the intra-pelvic canal in normal animals, but enter the coelomic cavity when enlarged. Ultrasound can be used to collect a percutaneous biopsy of these organs without the need for an exploratory coeliotomy.
Burned! Ultraviolet B Radiation for Exotic Pets: The Good, the Bad, and the Photokeratitis

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Because the majority of exotic pets are being housed indoors, it is important that they are provided lighting that mimics natural light. In addition to the provision of light, the amount of light provided in captivity should also mimic natural patterns. Photoperiods in the wild are generally between 12-15 hours a day, depending on season. To have success with exotic pets in captivity, it is important that we make recommendations to our clients that can ensure their long term success with their pets/breeding animals. The purpose of this presentation is to provide attendees an overview of the different types of lighting available for exotic pets held indoors, and how we can best use these lighting systems to provide the best captive environment for our patients.

Artificial lighting is provided in two different forms: incandescent and fluorescent lighting. Many of us are familiar with the standard forms of these lighting types, although there are some exceptions we may be less familiar with. One of the confusing aspects of lighting comes when manufacturers make claims about their light bulbs that are not true. The following review is meant to help clarify any misconceptions regarding the different types of lights.

Incandescent lighting is represented by the standard screw-in light bulb. This type of light has dominated the lighting scene for the provision of light in standard lighting fixtures in human domiciles. This type of light can generate a great deal of heat, especially at higher wattages, and requires a large amount of energy to run. There is a current movement to replace these bulbs for the more energy conserving fluorescent coi bulbs. The primary benefits associated with the incandescent bulbs are that they are inexpensive, can be used to generate heat, and can be made in different colors (e.g., red, black green, clear) and lighting spectrums (e.g., black light). To the author, incandescent lighting remains the best method for providing and regulating the environmental temperature within an exotic pet’s enclosure. Incandescent lighting, with few exceptions, functions to provide visible light and infrared light (or heat). Although many manufacturers make a claim that their infrared lights are “full-spectrum” and can provide ultraviolet B radiation, it is not true. Two exceptions are the black lights and mercury vapor bulbs. Black lights do produce ultraviolet radiation, but it is not in the spectrum considered important for the photochemical stimulation of vitamin D. Some mercury vapor bulbs do produce ultraviolet B radiation within this spectrum, as well as heat. Actually, many of the mercury vapor bulbs can produce a significant amount of heat, making them only ideal for large vivariums.

Fluorescent light bulbs are sold in two forms, the original tube style and the more recent coiled screw-in type. Historically, when people discussed “full spectrum” light bulbs they were talking about the fluorescent tube light bulbs. The first to be sold as “full-spectrum”, the Vita-light, was popular among hobbyists. It wasn’t until later that research showed that this bulb did not produce an appreciable amount of ultraviolet B radiation in the appropriate range. This is an important point to consider, as there are a number of different manufacturers offering these bulbs and making claims regarding their value. It is important to research the bulbs prior to making the recommendations. The more recent coiled fluorescent bulbs appear to have the potential to produce even higher amounts of ultraviolet B radiation (in the appropriate range) than the tube bulbs. Again, the bulbs that can do this are specifically manufactured to do so. A fluorescent coi bulb from the local hardware store is not the same bulb as one produced specifically for reptile enclosures. The primary advantages associated with these bulbs is that they can provide ultraviolet B radiation in the appropriate range (290-310 nanometers) and provide high quality visible light. The primary disadvantages are that these bulbs produce little heat, requiring an additional bulb to generate infrared light heat, and can be expensive.

Ultraviolet light is produced by electromagnetic radiation. The wavelengths for ultraviolet radiation are shorter than those for visible and infrared light. Ultraviolet radiation is generally discussed in relation to those categories important to vertebrates: Ultraviolet A, B, and C. Ultraviolet C radiation represents the shortest wavelengths of the three classes (<280 nanometers). This range of ultraviolet radiation is germicidal, and is commonly used to control pathogens in aquatic systems. Ultraviolet B radiation provides the medium range ultraviolet radiation (280-315 nanometers). Ultraviolet A radiation represents the longest rays of the group and is characterized as “black light” (> 315-380 nanometers). Ultraviolet B radiation represents the range considered important in the synthesis of vitamin D3. Vitamin D3 is an essential hormone that plays many different important physiologic roles. Its role in calcium metabolism is probably its most recognized function, where it helps to ensure the development and maintenance of healthy bones. In some exotic pets, maintaining appropriate levels of vitamin D3 has also been found to be associated with increased reproductive success. Ultraviolet C is not generally discussed at any great extent, although it is considered important in regulating behavior in vertebrates.

There are two primary methods for obtaining vitamin D3: synthesizing it from exposure to ultraviolet B radiation or consuming a vertebrate that has synthesized the hormone through exposure to the sun. The production of vitamin D occurs as a result of the photosynthetic conversion of 7-dehydrocholesterol to pre-vitamin D3. Pre-vitamin D3 is converted to vitamin D3 via a temperature...
dependent process. At this stage the hormone is transported to the liver where it is hydroxylated to 25-hydroxyvitamin D3. The kidneys serve as the site for the final conversion of the hormone to 1, 25-hydroxyvitamin D3, which represents the active form.

Vitamin D is considered important in vertebrates because it plays many different roles in the body. Because captive exotic pets are generally maintained indoors and derive no unobstructed sunlight, the use of “full spectrum” lighting has become an important consideration for ensuring that captive, non-carnivorous species can obtain vitamin D3. Until recently, studies evaluating the importance of full spectrum lighting in exotic pets have been limited to species of lizards. However, recently published original research from the author’s laboratory has shown that 25-hydroxyvitamin D levels in a snake, Elaphe guttata, and chelonian, Trachemys scripta elegans, could be significantly increased after exposure to appropriate full spectrum lighting. Similarly, research evaluating these lights in rabbits and rodents has shown similar results. It has generally been accepted that these animals obtain their vitamin D through their diet; however, the results of these studies suggest that in these species, they can generate endogenous vitamin D, like humans, from direct stimulation to appropriate artificial lighting. Coiled fluorescent screw-in light bulbs were used for the study. The bulbs were placed within 6-9 inches of the study animal’s basking spot. The findings of these studies confirm the importance of using full spectrum lighting for captive exotic pets.

When making recommendations regarding lighting that provides good quality ultraviolet B radiation it is important to recognize that not all bulbs are created equal. Although “full-spectrum” lights may appear similar, they can produce vastly different quantities of ultraviolet B radiation. To confirm the quantity of ultraviolet B radiation being produced by a bulb, it is important to measure the intensity of the radiation using an appropriate radiometer/photometer. The distance the bulb is placed to a basking reptile can also have an effect on the quantity and intensity of light reaching an animal. “Full-spectrum” lights should not be shown through glass, as it can defract the ultraviolet B radiation away from the pet. Historically, only fluorescent tube light bulbs produced any significant quantity of ultraviolet B radiation; however, some coiled fluorescent bulbs and mercury vapor bulbs can also produce appropriate to high levels of ultraviolet B radiation.

Visible light
Visible light is provided in the mid-light spectrum. The quality of visible light provided by different bulbs can vary. Some light bulbs provide poor-quality visible light across the color spectrum. In these cases, the light within the enclosure may have a “yellow” quality and the vibrant colors of the pet won’t be apparent. Many exotic pets require high-quality visible light to identify the colors of foods, predators, and potential mates, among other things. Color rendering index is an important parameter to evaluate in the light bulbs. Fluorescent bulbs generally provide the best visible light. Most of the high quality “full spectrum” fluorescent tube and coil bulbs available through the pet trade provide good quality visible light.

Infrared light
Infrared radiation is in the upper end of the light spectrum, and the area in which heat is generated. Although there are a variety of different heating elements for exotic pet enclosures, the author prefers to use radiant heat sources in the form of light. This is the most natural method of providing heat to exotic pets, and mimics the primary method they absorb heat in the wild. It is possible to use variable wattage incandescent bulbs to provide a gradient of temperature for a pet’s enclosure. The wattage for the bulbs will vary depending on the size and depth of the enclosure.

Conclusions
Artificial light is an important consideration for captive exotic pets being held indoors. It is important to use high quality light bulbs that meet the animal’s needs across all three forms of the light spectrum, including ultraviolet, visible and infrared radiation. The provision of high quality light will help to ensure our client’s success with their pet.
Reptiles may be herbivorous, omnivorous, or carnivorous, depending on the species. An ideal diet for captive reptiles should mimic their natural diet as closely as possible and provide a diversified selection of food. Some herbivorous species will often readily eat an omnivorous diet, but eventually these animals will reveal signs of nutritional deficiencies. Therefore, it is important to remember that food preferences do not always correlate with appropriate nutrition.

Herbivorous reptiles
Herbivorous reptiles are primarily classified as hind-gut fermenters, with microbial fermentation occurring in the large intestine. Consequently, the bulk of the diet of herbivorous reptiles should be vegetable fiber. The vegetable fiber offered should be rich in vitamins A and D3 and should have more available calcium than phosphorous. An ideal Ca:P ratio of at least 1.5-2:1 should be present. The diet should also be low in fats, oils, proteins, thiocyanates, and oxylates. In captivity, reptiles are typically fed weeds, flowers, and grasses on a daily basis. Herbivorous reptiles housed outdoors will forage for themselves if provided with an appropriately planted enclosure, but additional food is usually required. It is important to periodically peruse the yard and rule-out the presence of any poisonous plants. A variety of foods should be offered and can be mixed with calcium, iodine, vitamin D3, and vitamin A supplementation. It is important to remember that grocery greens are generally higher in protein and lower in fiber and may have an inverse calcium: phosphorus ratio when compared to natural forage. Spinach, cabbage, and beet greens should not be fed in excess due to their high oxylate content. The majority of foods designed for dogs, cats, humans, and other mammals should not be fed to herbivorous reptiles. Debilitated herbivorous reptiles requiring force-feeding or tube-feedings should be fed a critical care diet designed for their specific needs.

Omnivorous reptiles
It has been suggested that omnivorous reptiles do best when offered plant and animal matter in proportions that range from 75:25 to 90:10. Dietary requirements in these species tend to change with age, with most juveniles requiring a diet comprised of a higher proportion of animal matter. As the juveniles mature, their dietary requirements shift to a more herbivorous diet. The primary animal proteins offered should mimic a natural diet, including earthworms, slugs, snails, millipedes, pupae, and maggots (mealworms). It is essential to monitor the diets of captive invertebrates in order to avoid nutritional deficiencies in the reptiles eating them. Offering the invertebrates a diet rich in minerals and vitamins will help to ensure that the prey is “gut-loaded”. Mammalian diets should generally be avoided as they may be too potent (e.g., excess protein and vitamins) for a reptile. Liver and yellow or dark orange colored vegetables (squash, carrots, sweet potatoes) are excellent sources of vitamin A, and Swiss chard, kale, beet greens, escarole, parsley, watercress, and green beans all have a positive Ca:P ratio.

Carnivorous reptiles
Carnivorous reptiles are generally the easiest group to provide food for in captivity, as there is a range of invertebrate and vertebrate prey species that can be offered. As was mentioned previously, however, those carnivores that specifically hunt invertebrates do need to have their prey species “gut-loaded”. Most carnivorous aquatic species are piscivorous. If frozen fish are offered, then the diet needs to be supplemented with thiamine, as frozen-thawed fish can produce thiaminases.

Nutritional diseases
Nutritional disorders in reptiles commonly present as a chronic problem, and the diet is often times centered around limited food sources or human convenience. In most cases, deficient diets are comprised of limited numbers of food items and/or are not supplemented with calcium and vitamin powders.

Hypovitaminosis A
Vitamin A is a critical component in the production and maintenance of epithelial cells, and is also intimately associated with several structures related to vision. Hypovitaminosis A is a common clinical entity in reptile medicine, especially in chelonians fed predominately vitamin A deficient foods. The most obvious clinical abnormality associated with hypovitaminosis A is squamous metaplasia, which results in the degeneration of epithelial surfaces (e.g., conjunctiva, gingiva, pancreatic ducts, renal tubules, skin, and lung faveoli). Due to the multiple epithelial surfaces of the body, squamous metaplasia can manifest itself in several different ways. Blepharospasm, conjunctivitis, blepharoedema, blindness, rhinitis, blepharitis, lower respiratory tract disease (nasal discharge, depression, dyspnea, open-mouth breathing), and/or cutaneous abnormalities may be observed. Middle ear infections and aural
abscesses have also been linked with hypovitaminosis A. The diagnosis of hypovitaminosis A can be met via dietary history, clinical signs, measuring vitamin A levels, or histopathology of tissue samples (squamous metaplasia of the epithelia surfaces). Supportive treatment should be utilized concerning the clinical manifestations of vitamin A deficiency, and appropriate husbandry and dietary changes should be instituted. Vitamin A deficiency can be corrected by oral supplementation with vitamin A products, or by offering small amounts of liver once per week. Injectable vitamin A should be used very cautiously, as hypervitaminosis A can occur with a single injection.

**Secondary nutritional hyperparathyroidism (metabolic bone disease)**
Metabolic bone disease (MBD) is defined as any metabolic defect that alters the morphology and functioning of bones. MBD is usually related to low levels of calcium or excessive levels of phosphorus, which consequently bind to calcium and render it physiologically unavailable. Decreased calcium availability results in increased parathyroid activity and mobilization of stored calcium from the shell and bone cortices. Factors predisposing reptiles to the development of MBD include: dietary deficiency of calcium and/or suitable vitamin D3, inappropriate calcium: phosphorus ratio of the diet, lack of exposure to ultraviolet light (ultraviolet B radiation increases activation of vitamin D precursors and facilitates gastrointestinal absorption of calcium), dietary excess of protein during rapid growth periods, anorexia, or abnormal vitamin D3 metabolism secondary to renal, hepatic, intestinal, or parathyroid disease. MBD is commonly observed in rapidly growing juvenile reptiles and reproductively active females. Clinical signs consistent with MBD vary depending on the age and species of the patient. The most common clinical finding in reptiles with MBD include muscle tremors/facizations, seizures, soft-shell, pathologic fractures and acute death. A thorough history is required before a diagnosis of MBD can be met. Diagnostically, radiographs and blood work can provide insight into the reptile’s disease state. Radiography may reveal fibrous osteodystrophy and pathologic fractures. Low blood calcium levels are highly suggestive of MBD, but calcium blood levels are frequently not low in cases of MBD because of hyperparathyroid activity. It must be remembered that blood levels of calcium are not reflective of physiologically available levels of calcium. Ionized levels of calcium are more indicative of the availability of calcium, but, unfortunately, published reference levels are difficult to find in the literature. Treatment of MBD is dependent upon the correction of inappropriate husbandry. An unsuitable calcium: phosphorus ratio of the diet should be corrected, the proper provision of ultraviolet light should be instituted, and oral supplementation of calcium and vitamin D3 should be initiated. Supplemental calcium during the treatment period is also strongly recommended.

**Gout**
Gout is defined as the deposition of uric acid and urate salts within visceral tissues and on articular surfaces. Gout occurs as a result of hyperuricemia, which arises secondary to increased production or decreased excretion of uric acid. Increased production of uric acid may occur secondary to the ingestion of excessive amounts of protein (e.g., an herbivorous chelonian that is regularly offered animal protein). Decreased excretion of uric acid may occur secondary to reduced perfusion of renal tissues, which may be a result of dehydration, hemoconcentration, water deprivation, or renal disease. Reduced glomerular filtration eventually leads to a decrease in the overall excretion of urate salts, which results in hyperuricemia. Hyperuricemia, in turn, leads to the precipitation of urate complex microcrystals within tissues. These deposits are known as “gout tophi”. Common sites of deposition of uric acid include articular joints and viscera. Clinical signs associated with gout include joint swelling and pain, depression, and dehydration. Affected animals are also commonly anorectic and lethargic. The diagnosis of gout may be done with blood work and radiographs/ultrasound. The mainstay of therapy is rehydration to correct the hyperuricemia, and the correction of any dietary imbalances or other predisposing causes of gout. Allopurinol, a urease inhibitor, is commonly used in hyperuricemic animals to reduce uric acid production. It must be mentioned that studies concerning the efficacy of this drug and the possible long-term effects of the drug in reptiles have not been conducted. Probenecid, which increases the renal excretion of uric acid, should be not be used until the glomerular filtration rate is considered acceptable. Any concurrent infections in affected joints or organs that occur secondary to gout deposition should be treated appropriately. Surgery is occasionally indicated when uric acid deposits are compromising joints.