CHAPTER 4

Chelonians (Turtles, Tortoises)

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BIOLOGY

Currently, 322 living species of tortoises and freshwater and marine turtles are in existence (Table 4-1). They are found in diverse habitats on all continents except Antarctica and in all oceans except the Arctic. The largest concentrations of turtle species occur in North America, more than in any other temperate region of the world. Ninety-eight species of chelonians are endangered or critically endangered because of habitat degradation, human encroachment, and harvesting for food, medicines, and the pet trade. Of the chelonians with known threat status in 2010, 53% of the species are considered threatened, making chelonians the most highly endangered of any of the major vertebrate groups.[8]

Unique Anatomy

Chelonians range in size from the 100-gram (g) speckled tortoise (*Homopus signatus*) to the leatherback turtles (*Dermochelys coriacae*) weighing more than 800 kilograms (kg). Turtles and tortoises may be instantly recognized by the presence of a shell comprising the carapace (dorsal) and the plastron (ventral), which are joined laterally at the bridge. In most species, keratinized epithelium overlies a rigid bony structure that provides protection. The extent of shell coverage, flexibility, degree of mineralization, fenestration, hinging, and epithelial coverage vary. Most species have keratinized epithelium covering a thin dermis layer consisting of collagen fibers, melanophores, vessels, and nerves, beneath which is dermal bone.[4] Most terrestrial species have firm, dense shells such as those of gopher tortoises (*Gopherus polyphemus*). Loss of bone in the central portions of the carapace and plastron of the pancake tortoise (*Malacochersus tornieri*) is normal and allows the species to wedge itself into rock crevices, where it may inflate itself to escape predation. Shells may be flexible at the bridges, which allows the hinged plastron of some species (*Terrepene* spp., *Cuora* spp., *Kinosternon* spp.) to seal tight against the carapace, whereas tortoises in the genus *Kinyxs* have hinged carapaces for protection. Certain aquatic species such as snapping turtles and certain species of the genus *Kinosternon* have reduced plastrons providing minimal rigid protection of the limbs. Vertebrae are incorporated into the carapace from the first thoracic vertebra caudally to the coccygeal vertebra. Sea turtles are unable to retract their heads and necks fully under their shells. Retraction of the head and neck may be in a horizontal plane as in the Pleurodiran species (side-necked and snake-necked turtles), or in a vertical plane by direct caudal retraction as is done in Cryptodiran species (typical of all land tortoises and most freshwater species of the northern hemisphere).

Chelonian limbs are highly variable between species groups. Sea turtles and the freshwater pig-nosed turtle (*Carettochelys*) have flattened limbs that are highly adapted to an aquatic existence but that serve very poorly for walking on land. Most freshwater turtle species have varying degrees of interdigital webbing to facilitate swimming but retain the ability to walk on land. Some aquatic species such as snapping turtles are not good swimmers but "walk" on the bottom substrate during normal locomotion. Fully terrestrial species (Testudinadae) may have flattened forelimbs for burrowing and tend to have elephantine hindlimbs adapted for walking on land.

The renal-portal system directs blood from the caudal region of the body through the kidneys or may divert it into the central circulation. Blood is shunted through the kidneys in times of water deprivation; however, pharmacokinetic studies have shown no significant difference in drug metabolism if injections are given in the caudal region versus the cranial limbs.[3]

Special Physiology

All chelonians are considered ectothermic, although leatherback sea turtles are somewhat homeothermic. Preferred optimal temperatures differ according to species and should be considered in housing chelonians. Temperatures in the natural environment change according to diurnal and seasonal cycles. Captive animals should not be subjected to constant temperatures but should be provided with a diurnal fluctuation and a thermal gradient. Most turtles and tortoises depend on behavioral adaptations such as basking in the sun, seeking shade, or entering water or burrows to elevate, maintain, or decrease body temperatures. Immune function is enhanced when animals may achieve their preferred optimal temperature. For highly aquatic species, maintaining appropriate water temperature ranges is critical for behavioral reasons and for physiologic functions such as digestion.

Chelonians may demonstrate episodic breathing and may shunt blood to or away from the lungs via vascular and intracardiac shunting mechanisms. Additionally, species adept at breath-holding demonstrate adaptations such as tolerance of hypoxia, large lung volume, rapid and extensive air exchange during ventilation, and physiologic buffering by bone, blood, and pericardial fluid of lactic acid and hydrogen ions built up during anaerobic metabolism. In aquatic species, gas exchange may also occur through the integument, pharynx, or cloacal tissues. Soft-shelled turtles may obtain up to 70% of their oxygen during submergence through their leathery shell.[9]

The kidneys of turtles have fewer nephrons than those of mammals and no loop of Henle, which creates an inability to concentrate urine. Nitrogenous waste is excreted as ammonia, urea, or uric acid. Proportions vary according to the biology of the species. Marine turtles and highly aquatic freshwater turtles may excrete up to 25% of their nitrogenous waste as ammonia. Other aquatic turtles may excrete primarily urea. Tortoises excrete most nitrogenous waste as relatively insoluble uric acid to prevent water loss. Water may be held in the urinary bladder and resorbed into general circulation. The ability of tortoises to store water in this manner enhances survival in xeric habitats and during times of drought. When handling tortoises in the wild, care must be taken to prevent the animals from urinating because this could result in significant losses of fluids that the animal might not be able to replace.

FEEDING

The diverse species of chelonians demonstrate great diversity in diet and feeding habits. They may be omnivores, eating a broad spectrum of foods to constitute a complete diet, or they may be specialist feeders and have a strict, narrow spectrum of food items that they will accept. They may be herbivores, omnivores, or carnivores. Many have feeding strategies that change during different life stages.

TABLE 4-1

Biologic Information for Families of Chelonia

Family (Number of Species)	Common Name	Weight (Adult)	Habitat	Geographic Distribution
Carettochelyidae (1)	Fly river (pig-nosed) turtle	15 kg	Rivers	Australia and New Guinea
Chelidae (54)	Snake-necked turtles	0.25 to 20 kg	Rivers and lakes	Australia, New Guinea, Eastern South America
Cheloniidae (6)	Sea turtles	80 to 500 kg	Oceans	Worldwide
Chelydridae (4)	Snapping turtles	90 kg	Lakes, slow moving streams	Central, Eastern North America, Eastern Mexico, Western Columbia
Dermatemydidae (1)	Central American river turtle	30 kg	Rivers	Central America
Dermochelyidae (1)	Leatherback turtle	350 to 800 kg	Oceans	Worldwide
Emydidae (51)	Emydid turtles: terrapins, box turtles, sliders, and cooters	0.25 to 50 kg	Lakes, rivers, streams, and brackish water	Americas, Europe, North Africa, Middle East
Geoemydidae (69)	Asian box and freshwater turtles, and neotropical wood turtles	0.1 kg to 50 kg	Freshwater and terrestrial habitats	Asia, Mexico to northern South America
Kinosternidae (25)	Mud and musk turtles	0.15 to 2 kg	Freshwater; mud banks	Americas
Pelomedusidae (19)	Afro-American sidenecks	Up to 90 kg	Freshwater lakes, streams	South America and Africa
Platysternidae (1)	Bigheaded turtles	Up to 0.5 kg	Mountain streams	Asia
Podocnemididae (8)	South American and Malagasy sidenecks	Up to 75 kg	Rivers	South America and Madagascar
Testudinidae (59)	Tortoises	0.1 to 250 kg	Semi-arid, arid, mountain, and forest	Americas, Europe, Africa, and Asia
Trionychidae (31)	Softshell turtles	0.25 to 300 kg	Rivers and lakes	North America, Africa, and Asia

Wild-caught animals may be very difficult to acclimate to novel food items, and some may never willingly transition to captive foods. It is important to be familiar with the natural history of certain "specialized feeders" to provide familiar and acceptable food items while transferring animals to a balanced captive diet. Tortoises are herbivores that tend to graze on grasses and annual forbs but have very little natural exposure to fruits. Freshwater turtles are primarily omnivorous, consuming fish, crustaceans, snails, aquatic grasses, fallen fruits, and many other food items. Some are more carnivorous as juveniles but become more herbivorous with age. Complete rations have been formulated specifically for different groups of animals, and some may be used successfully for all life stages. Like other aquatic turtles, sea turtles may be omnivorous, carnivorous, or herbivorous. Green sea turtles feed on sea grasses and algae. Loggerhead and Ridley sea turtles prefer a diet of molluscs and crustaceans, whereas hawksbills specialize on sponges and leatherback sea turtles consume primarily jellyfish. Captive sea turtles will eat fish, crustaceans, and molluscs and may be acclimated to balanced diets in pellet or gelatin form. Obesity is not uncommon in captive turtles. One should remember that in nature, chelonians may spend a considerable amount of time foraging as a daily activity and such activity may provide benefits for well-being beyond simple nutrition. In general, hatchling chelonians of all species should be fed daily. Frequency of feeding may be reduced with age, but most species should be fed at least twice per week as adults.

RESTRAINT AND HANDLING

Most chelonia are relatively easily restrained. A potential risk exists for handlers from bites, scratches from claws, or cuts from projections of scales or points on the shell. Green sea turtles may flap their front flippers forcefully enough to fracture their humerus and may easily injure handlers while struggling. It is generally most safe to lift larger animals, placing one hand on the anterior carapace over the neck and the other hand on the caudal carapace over the tail. This minimizes the potential for bites or scratches. For species that may be lifted easily, care must be taken not to flip them upside down rapidly. This may cause immediate changes in hemodynamics that may cause distress to the animal, may impair ventilation because of compression of the lungs under the weight of coelomic viscera, or result in intestinal or uterine torsion. Aggressive animals may require diversion, immobilization, or blocking of the head to safely examine them. Materials such as rolls of tape or padded sticks or polyvinyl chloride pipes serve well as bite blocks placed in the mouth and secured with tape around the head. For small species, pushing the head under the carapace in a natural position and maintaining it there manually or with padding covered and taped to the shell allows nonpainful procedures on other portions of the body to proceed in safety. Many tortoises will not struggle if their eyes are covered or the heads are in the confines of their shells. Conversely, when chelonians are regressed completely into their shells, extricating limbs or the head without harming the animal is challenging. Some animals will extend their limbs when securely balanced on a pedestal, allowing for visual examination of the appendages and potentially permitting restraint of a limb or the head and neck. Using a small metal spatula, usually, even the tightest hinged plastron of a box turtle or the armored front leg of a tortoise may be breeched. Gentle, steady traction on the closed plastron or leg is usually rewarded by relaxation of the defense mechanisms. In extreme cases, chemical immobilization must be used to examine or treat the animal.

SURGERY AND ANESTHESIA

General anesthesia may be induced and maintained with parenteral agents given through intravenous or intramuscular routes (Table 4-2). Gas anesthetics may be used to induce and maintain anesthesia, but induction under voluntary respiration may be prolonged when animals hold their breath. Direct intubation of the glottis may be accomplished in the awake chelonian through use of an oral speculum. The glottis is located at the base of the tongue and is closed

TABLE 4-2

Sedative, Anesthetic, Analgesic, and Restraint Agents Used in Chelonians

Generic (Trade) Name	Dose and Route	Comment
Atipamezole (Antisedan)	5× dose of medetomidine, 10× dose of dexmedetomidine	α-adrenergic reversal for medetomidine and dexmedetomidine
Bupivacaine	1 to 2 mg/kg local infiltration 4 mg/kg maximum dose	Local anesthetic
Buprenorphine	0.075 mg/kg SC	Effect lasts 24 or more hours
Butorphanol (Torbugesic)	0.2 mg/kg IM	Tranquilizer
Dexmedetomidine (Dexdomitor)	0.03 to 0.075 mg/kg	Anesthesia Use in combination with ketamine Reverse with atipamezole
Diazepam (Valium)	0.2 to 1.0 mg/kg IM	Use with ketamine for relaxation
Isoflurane (IsoFlo)	3% to 5%	Use face mask, chamber, or endotracheal tube Long induction time
Ketamine HCl (Multiple)	5 to 25 mg/kg IV or 20 to 60 mg/kg IM	Highly variable response to IM dosing Use lower doses IV or in combination with α-adrenergic and higher dose IM or when given alone
Lidocaine (0.05-2%) (Multiple)	Up to 2 mg/kg total dose, 1 mL 2%/20 kg for epithecal	Local infiltration or epithecal
Medetomidine (Dormitor; Zaloprim)	0.1 to 0.15 mg/kg IV or IM	Use with ketamine, 5 mg/kg Reverse with atipamezole
Meloxicam	0.1 to 0.5 mg/kg PO, IM, or 0.22 mg/kg IV	Analgesia Study in red-eared sliders Better absorption IM versus PO Rapid elimination after IV administration
Morphine	1.5 to 6.5 mg/kg SC	Analgesia Higher dose has more rapid onset (2 hours versus 4), both last over 8 hours
Propofol (Deprivan)	5 to 10 mg/kg IV	Restraint for 30 to 60 minutes May cause respiratory depression requiring intubation and positive-pressure ventilation
Tiletamine/zolazapam (Telazol)	5 to 10 mg/kg IV or IM	Prolonged recovery, generally insufficient as sole anesthetic Reverse with flumazenil 1 mg/20 mg zolezepam IM or IV
Tramadol	10 mg/kg PO 10 mg/kg SC	Analgesia Lasts 9 to 96 hours Analgesia Lasts 12 to 48 hours
Xylazine (Rompun)	0.1 to 1.25 mg/kg IV or IM	Variable results, not recommended Reverse with yohimbine 0.125 mg/kg IM

IM, Intramuscularly; *IV*, intravenously, *PO*, per os.

unless the animal is taking a breath. An appropriate sized endotracheal tube may be gently forced into the glottis and the animal induced using positive pressure ventilation until an acceptable level of anesthesia is achieved. The trachea bifurcates into paired bronchi in the cranial one third of the cervical area and has complete cartilagenous rings. Care should be taken to prevent unilateral bronchial intubation. Anesthetic agents are metabolized more slowly under low body temperatures, so special attention should be given to maintaining the anesthetized chelonian at or near its preferred optimal temperature range. The turtle's ability to withstand prolonged anoxia may cause reduced ventilation, resulting in reduced exchange of anesthetic gases. Whenever possible, animals under anesthesia should be intubated and provided with assisted ventilation. Recovery after gas anesthesia may be prolonged because ventilation is not induced by hypercapnea and decreases during hyperoxia. The use of room air rather than oxygen will speed anesthetic recovery.[7] The use of local anesthetic (lidocaine 2% or bupivacaine 0.5%) may be used as adjunct to general anesthesia. Epithecal anesthesia (2% lidocaine at 1 mL/20 kg) may be used alone or in conjunction with general anesthesia for surgeries of the cloaca and tail (Figures 4-1 and 4-2).[6]

Surgical procedures should be performed under appropriate anesthesia and aseptic conditions. Intracoelomic surgery such as ovariectomy, salpingotomy for removing retained eggs, or enterotomy for removing a foreign body may be achieved by accessing the coelom through the prefemoral fossa. Incision size may be kept to a minimum by using rigid endoscopy to retract the ovarian tissue, oviduct, or intestine and bring it to the skin incision. Intracoelomic access may be limited via this route, however, and surgical objectives may require cutting through the plastron. In brief, the shell is cut to make a beveled edge by using a drill or a saw while attempting to keep a portion of the cut shell attached by preserving the periosteum. Care is taken to identify the coelomic blood vessels before incising them. With the shell out of the way, surgery may proceed as for any routine abdominal procedure. After the primary surgical objectives are met, closure of the coelom is accomplished by replacing the shell

FIGURE 4-1 Needle insertion for epithecal injection in a giant tortoise.

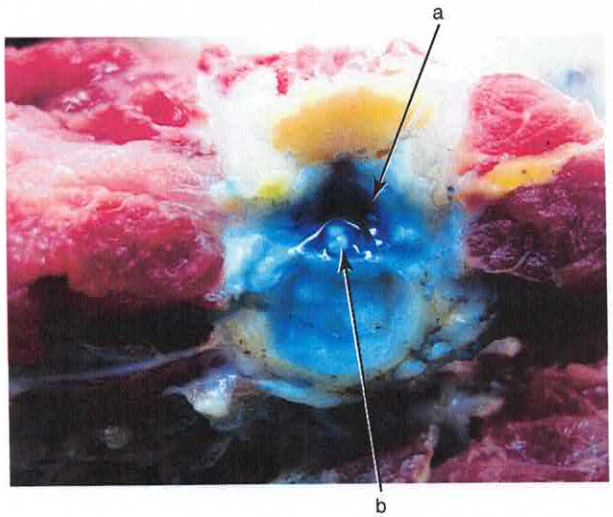

FIGURE 4-2 Cross-section of caudal vertebra showing epithecal space *(a)* and spinal cord *(b)*. (Photo courtesy of Steve Divers.)

with the use of the beveled edge to help position and stabilize the flap during closure. The flap is affixed to the plastron using materials such as bone cement, acrylic, screws, and cerclage wire, in combination or alone. As with any orthopedic manipulation, complete healing of the shell may take months. Plastrotomy is not advised in species having dynamic movement of the plastron during normal respiration or diving (e.g., sea turtles), as the surgery site will be in constant motion, impeding or preventing the healing process. Fish hooks are commonly ingested by sea turtles and frequently lodge in the lower esophagus near the base of the heart. These may generally be accessed through a ventral cervical incision, retracting the esophagus cranially to access the site where the hook has lodged (Figure 4-3).

Orthopedic procedures are similar to those for other animals. The density of long bones is generally greater than for mammals, and external splints may be challenging to maintain. Limbs may be taped inside shell openings for crude but effective means of immobilizing fractures of extremities. Shell fracture is a common presentation of animals hit by automobiles or speedboats. The fracture site is frequently grossly contaminated with dirt or water, with contamination of the lungs or coelomic cavity being a potential risk. The wound

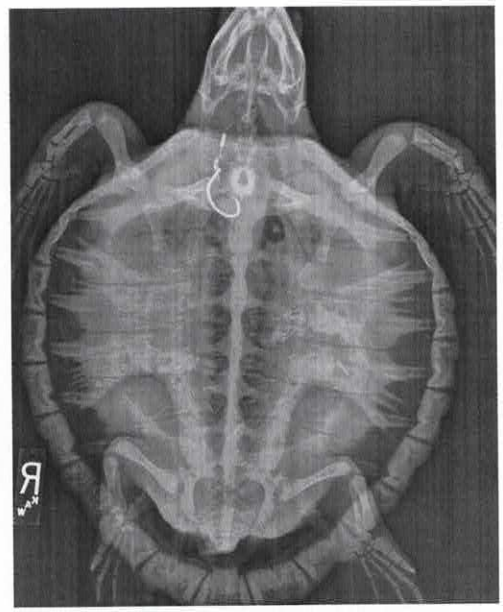

FIGURE 4-3 Radiograph of a Kemp's ridley sea turtle with esophageal foreign body. The hook was removed via caudal cervical esophagotomy.

should be cleaned and the fragments stabilized by using support bars or cerclage wire, which will allow treatment of the fracture site as an open wound. Large defects with loss of shell fragments may be treated with vacuum-assisted closure. Healing time may take up to a year for bony bridging and reepithelialization.

CLINICAL PROCEDURES

Physical Examination

It may be daunting to try to perform a physical examination on a chelonian that is completely and firmly withdrawn into its shell, but the foundation of diagnosis lies with a good physical examination in combination with the history and signalment of the patient. Ideally, the patient should be examined in its primary enclosure, where it may be observed swimming or ambulating. In aquatic species, buoyancy, limb use, respiratory pattern, and environmental awareness have to be assessed. Once "in hand," the animal should be weighed. Healthy chelonians often seem slightly heavier than expected when picked up. If an animal feels light, it may be malnourished or dehydrated. It is possible to overpower most smaller individuals, but patience and gentle, firm handling will often yield excellent results. Visual examination of the head, neck, limbs, and tail should help assess symmetry, skin condition, presence or absence of scars, ectoparasites, excess skin, overgrown nails, and presence and density of epibionts (algae and other commensal organisms) on the carapace. Presence of an abundance of epibionts may indicate chronicity of a problem. Thick algae on the carapace of a basking species may indicate that it has not hauled out to thermoregulate, and high numbers of barnacles on sea turtles may indicate prolonged lethargy or reduced activity, as healthy turtles tend to have cleaner shells. Evaluation of the gastrointestinal (GI) system starts with the oral cavity (often easily done with more aggressive species!) for abnormal mucosa or foreign bodies (fish hooks are common in some species). The cloaca is examined for swelling, foreign bodies, or trauma. Evaluation of the respiratory system is done through examination of the nares, choana, and glottis. This is followed by listening to respiration and auscultating the lung over the dorsum of the carapace. Percussion of both right and left lungs should sound the same. Neurologic evaluation includes observation of posture, carriage of

head, symmetry of muscle mass, tone, and strength. Reflexes may be evaluated using tactile stimuli such as a toe pinch. Eyes should be clear and symmetrical, with no discharge or swelling of adnexa. The tympanum, located just caudal and ventral to the eye should be flat and bilaterally symmetrical. Abdominal palpation performed in the prefemoral fossae may reveal the presence of coelomic masses, ova, bladder stones, and ascites.

Blood samples should be drawn into tubes or syringes containing the anticoagulants sodium or lithium heparin. Ethylenediaminetetraacetic acid (EDTA) should not be used because it causes hemolysis, which precludes obtaining accurate hematocrits and electrolyte determination. In addition, blood smears do not stain optimally with EDTA compared with heparin. Several sites are easily accessible for blood collection. Venipuncture of the jugular is the most reliable site for uncontaminated peripheral blood samples. The jugular vein is easily visualized in most species when the head and neck are held in extension. Extending the head and neck may be challenging in strong or aggressive species and may require tranquilization to prevent injury. Sample contamination with lymph is common to most venipuncture sites other than the jugular vein. The dorsal coccygeal vein requires the least overall restraint and is located just dorsal to the dorsal aspect of the vertebral body on the tail. The needle is introduced into the dorsal skin at a 45- to 90-degree angle to the vertebra. Vascular access to the axillary branch of the brachial vein in the forelimb may be achieved by extending the animal's front leg and inserting a needle through the skin distal to the carpus and between the carpal flexor tendons aiming toward the posterior side of the carpal joint. The subcarapacal sinus is located just under the carapace immediately caudal to the last cervical and cranial to the first thoracic vertebrae. The venipuncture site may be accessed by pushing the head down and into the shell then palpating the bony prominence of the vertebra where it meets the carapace. The needle is inserted on the midline just caudal to the juncture of the skin with the carapace, aiming toward the carapace just cranial to the vertebral prominence. In sea turtles, the dorsal cervical sinus (supravertebral), located one third the distance from the carapace to the base of the skull, affords a reliable site for uncontaminated blood collection with minimal restraint. The head is directed forward and down, and an appropriate length needle (up to 3½ inches in large animals) is introduced lateral to midline on either side. Raising the turtle's body relative to the head enhances filling of the sinus. Ultrasonography may be used to locate the vein if difficulty is encountered.

The occipital sinus may also be used for blood collection, but this requires that the head be restrained firmly in an extended position and tilted down at a 45-degree angle to the spine. A needle is introduced just caudal to the occipitus, perpendicular to the spine. Lymphatic contamination sometimes is encountered at this site.

Diagnostics

Hematology

Complete blood cell counts generally are performed using manual cell-counting techniques, although automated methods have been used for red blood cell (RBC) counts. Hemoglobin determination is accomplished by serometer, hemoglobinometer, or automated methods. Microhematocrit centrifugation is the standard for packed cell volume (PCV) determination. RBCs are nucleated and range in number from 0.154 to 0.980 × 10^6/μL, depending on species and time of year. RBCs have long life spans, with the mean in box turtles being 600 to 800 days. Peak reticulocyte response to blood loss takes up to 5 weeks to achieve. Because turtles have a total blood volume of 5% to 8% of total body weight and the standard procedure is to limit blood collection to 10% of the total, restricting sample size to 0.5% to 0.8% of the body weight (0.5 to 0.8 mL for a 100-g animal) is appropriate. Drawing blood frequently over a short period or in excess of recommended volumes may cause iatrogenic anemia, which corrects slowly.

White blood cell (WBC) differentiation is best performed on smears that have been made immediately after collection. Heparin is the preferred anticoagulant because of less distortion of WBC morphology. Blood smears made in the field do not stain well if staining is delayed more than a few days, even when they are fixed soon after being made. For best results, smears should be stained within a few hours of being made. Total WBC counts may be determined by the direct method (Natt-Herricks) or indirectly (phloxin B solution or estimation from smear). The most reliable results are obtained by consistent processing and analysis. All methods require some level of technical skill to achieve accuracy, and methods may not be comparable directly one with another within or between laboratories. It is ideal to use one laboratory and one or two technicians with similar training and skills, as significant variation may occur between laboratories because of the interpretations of the technicians handling the samples.

The chelonian leukocyte response is less predictable than in mammals or birds. Normal (reference) values are hard to establish because of variations by species, season, nutritional status, type of stain, venipuncture site, handling of sample, age, sex, and anticoagulant used. Twofold changes in a parameter constitute a significant change. The best use of hematologic values is to monitor a patient's response to therapy. Blood values change seasonally, especially with species that undergo brumation (hibernation). For example, total RBC counts are highest before brumation and lowest immediately thereafter. Other parameters change as well and should be considered relative to the environmental conditions and sample handling and processing. Heterophil counts increase during summer and decrease during brumation. Increased counts may indicate inflammation or bacterial disease. "Toxic" heterophils display cytoplasmic basophilia, abnormal granulation, and a lobed nucleus and are present in cases of inflammation. Eosinophilia may be seen in parasitic disease. Basophilia may be present in parasitic infection as well as in viral disease processes. Lymphocyte counts are low to absent in the winter and are low in cases of malnutrition and in diseases secondary to stress and immunosuppression. Lymphocytosis is seen in wound healing, parasitic disease, and viral infections. Monocyte numbers increase in granulomatous inflammation. Reference ranges for selected chelonian species are available elsewhere.[1]

Biochemistry

Biochemistries may be determined on plasma or serum. Whole blood should be cooled or centrifuged within 15 minutes of collection to prevent changes from RBC metabolism such as loss of potassium into the plasma. The anticoagulant EDTA causes changes in potassium and calcium directly and in other parameters through the effects of hemolysis.

Serum biochemical parameters are similarly affected by the factors that affect hematology values. Blood samples yield a higher volume of plasma compared with serum, so biochemical assays are routinely run on plasma. Often, blood samples are obtained with a varying degree of lymph contamination. Values of glucose, calcium, phosphorous, sodium, urea, and enzymes in lymph are comparable with those in plasma. Lymph is lower in total protein and potassium compared with plasma. Assessment of renal function in chelonians is more difficult because of the physiologic differences between freshwater, saltwater, and terrestrial species. Blood urea nitrogen (BUN) and creatinine are generally poor indicators of renal disease. Values are generally low (<40 milligrams per deciliter [mg/dL]) in terrestrial and freshwater species and higher in marine species (~100 mg/dL) and terrestrial species during dry season when they are conserving water. A low value in marine species may be an indicator of prolonged anorexia. Plasma uric acid levels in chelonians are generally lower than 5 mg/dL. Elevations may be seen in cases of bacteremia, septicemia, nephrocalcinosis, and nephrotoxicity but may also represent gout or the recent ingestion of a high-protein diet. Sodium levels range from 120 to 150 milliequivalents per liter (mEq/L) in tortoises and freshwater turtles and from 150 to 170 mEq/L in sea turtles. Hyponatremia may result from GI or renal disease, oversupplementation of fluids low in sodium, disease of the salt gland, or maintenance of saltwater species in fresh water. Hypernatremia may occur in dehydration or excessive dietary intake. Potassium

levels normally range from 2 to 6 mEq/L. They are elevated because of hemolysis and reduced renal secretion and are low because of reduced intake or excess GI loss. Normal blood pH ranges from 7.5 to 7.7 at temperatures of 23° C to 25° C. Increasing temperature will reduce blood pH, and prolonged anesthesia will increase it. Blood calcium levels range from 8 to 11 mg/dL. Levels may increase two to four times because of follicular development. Levels less than 8 may be caused by anorexia, dietary deficiencies of calcium or vitamin D3, hypoalbuminemia, alkalosis, or hypoparathyroidism. Normal phosphorous levels range from 1 to 5 mg/dL. Low levels are caused by starvation or nutritional deficiency. Hyperphosphatemia results from excessive dietary phosphorous, hypervitaminosis D, renal disease, or severe tissue trauma or may be falsely elevated because of leakage from RBCs when not separated quickly enough from serum or plasma.

Aspartate aminotransferase (AST) and lactate dehydrogenase (LDH) activities are high in chelonian liver tissue but are not specific for this organ. AST is found in many tissues. Levels above 250 international units per liter (IU/L) suggest liver or muscle damage, septicemia, or toxicity. LDH levels above 1000 IU/L may be associated with hemolysis or with damage to the liver, heart, and skeletal muscle. Elevation of LDH and AST in the absence of elevation of creatinine kinase (CK) is indicative of liver disease. Plasma protein levels range from 3 to 7 g/dL. Low levels are seen in chronic malnutrition, protein-losing enteropathies, and maldigestion and in chronic liver and kidney disease. Elevated levels are most commonly seen during folliculogenesis but may also be seen in dehydration or may be caused by hyperglobulinemia associated with infectious disease. Plasma glucose normally ranges from 60 to 100 mg/dL. Low levels may be caused by starvation, malnutrition, hepatobiliary disease and septicemia. Elevated levels are most likely iatrogenic and caused by excess glucose administration or the administration of glucocorticoids. CK is a muscle-specific enzyme. Elevations occur with muscle injury from trauma, struggling, systemic infection, or administration of intramuscular injection of fluids or irritating drugs such as enrofloxacin. Reference ranges for selected chelonian species are available elsewhere.[1]

Other Tests

Serologic testing (enzyme-linked immunosorbent assay [ELISA]) for *Mycoplasma* spp. is performed readily on small quantities of plasma or serum. At the time of sampling, nasal flushes should be performed and frozen for polymerase chain reaction (PCR) testing or culture, to be run if the titer is positive.

Fresh or formalin-fixed feces may be used for fecal centrifugation or flotation and for direct examination for detection of enteric parasites and ova. Immunofluorescent antibody testing also may be performed for detection of *Cryptosporidium* spp. Fresh feces, feces in neutral media, and feces frozen in tryptose soy broth or neutral media are appropriate for enteric culture. Fresh or frozen feces also may be examined routinely under transmission electron microscopy for viral particles. If enteric clostridial infections are suspected, frozen feces may be used for assaying for clostridial toxins. Urinalysis may be performed on voided urine. The kidney cannot concentrate, and urine passes from the kidney, through the urodeum, into the bladder, so it cannot be considered sterile. Standard urine dipsticks appear to be useful but have not been validated on reptile urine. Urine pH tends to be alkaline in herbivorous species and acidic in carnivorous species. Urine protein levels should be zero to trace. Glucose should be negative. Hemoglobin, myoglobin, or RBCs may produce a positive reaction on the blood test of the strip. Any positive reading should be followed up with a urine sediment evaluation. Ketones may be detected from animals coming out of brumation or hibernation, but abnormal urine color may result in a false-positive test. Urine sediment evaluation may reveal crystals, casts, bacteria, fungi, protozoans, and helminth eggs. Interpretation of findings should be made relative to the animal's clinical presentation, keeping in mind that urine passes through the common urodeum and is likely contaminated with products from the genital and GI systems.

Gross postmortem evaluation with histopathologic examination should be done on any animal that has died.

Imaging

The old adage "A picture is worth a thousand words" holds true with respect to recording visual observations. Digital photographs are useful in recording the appearance of animals at presentation and for tracking change over time. Radiography is useful for diagnosing a variety of conditions. Three whole-body views commonly are obtained for general surveys: anteroposterior, dorsoventral, and lateral (Figures 4-4, 4-5, and 4-6). The anteroposterior and lateral

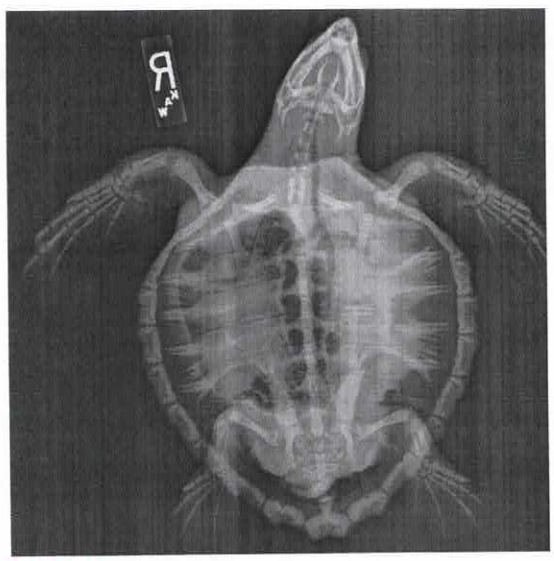

FIGURE 4-4 Dorsoventral radiograph of a Kemp's ridley sea turtle showing opacity in the left lung field.

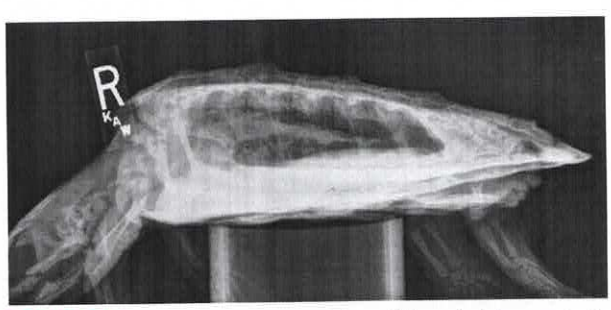

FIGURE 4-5 Horizontal beam lateral view of Kemp's ridley sea turtle.

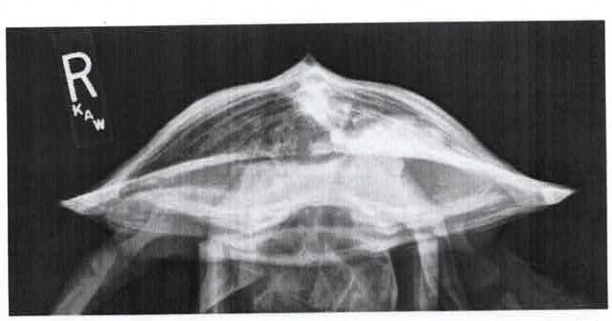

FIGURE 4-6 Horizontal beam anteroposterior view of Kemp's ridley sea turtle showing opacity in left lung field.

views are best obtained by maintaining the animal in a normal posture (rather than turning the animal on its side or upending it) with the x-ray tube being moved relative to the animal to obtain the desired view. The anteroposterior view is best for screening for potential pneumonia and the dorsoventral view for surveying the GI and reproductive systems. Contrast radiography is performed by administration of the appropriate media via gavage or intravenously. In leopard tortoises, transit time for barium sulfate from the stomach to the large intestine is 5 to 8 hours, with emptying of the large intestine occurring in 144 to 166 hours, whereas transit time in Galapagos giant tortoises may be 2 to 4 weeks.

Ultrasonography of the coelom commonly is performed to assess the cardiac, hepatic, renal, and reproductive systems. The prefemoral fossae provide a window to the coelom and are adequate for most studies. With animals that are too small for the ultrasound probe to fit into this space, the body of the animal may be placed into water, and scanning may be done with water providing conductivity so that the probe may be offset with resulting magnification of the images.

Magnetic resonance imaging (MRI) and computed tomography (CT) are modalities that are useful for imaging internal lesions after initial screening with radiography and ultrasonography.

Rigid endoscopy may be used for directly visualizing the viscera and taking biopsies and may be used for sex determination of young animals. Flexible endoscopy also provides nonsurgical access to the GI and respiratory tracts for evaluation and biopsy.

TREATMENT MODALITIES

Parenteral treatments may be administered intramuscularly, subcutaneously, intracoelomically, or intravenously. The pectoral muscle mass is the preferred site of intramuscular (IM) injection in most species. It may be accessed from the cranial direction and is ventral to the thoracic limb. Intracoelomic injections may be given from the cranial aspect between the bridge and the thoracic limb, directing the needle parallel to the bridge, and caudally toward the coelomic cavity. Injections may also be given into the prefemoral fossa, but it is easy to inject into the urinary bladder at this site. Intraosseous catheterization may be performed using the bones of the bridges of the shell.

Many treatments may be administered per os, on food, or with a ball-ended feeding tube. To avoid excessive restraint on the head and neck, many chelonians may be encouraged to open their mouths in a defensive posture. The lubricated feeding tube may be placed in the mouth quickly, and usually the animal, in an attempt to reject the metal object, will advance its head, and the feeding tube may be advanced gently down the esophagus without the head being tightly restrained.

For repeated gavage treatments or for enteral nutrition, use of an indwelling pharyngostomy tube is indicated. The animal is anesthetized, and the left side of the neck is prepared surgically. A closed hemostat is placed into the mouth and past the pharynx into the esophagus. An incision is made over the point of the hemostat, through the skin, and into the esophagus. A rubber feeding tube of appropriate size for the animal is grasped by the hemostats and pulled into the esophagus. The tube then is advanced to the level of the stomach, is secured with sutures at the neck, and then is taped to the carapace, leaving enough length for extension of the neck. Taping of the left leg into the shell to prevent it from dislodging the tube may be necessary. Pharyngostomy tubes may be left in place for months. Aquatic turtles may have access to water with the tube in place. In the case of anorexic animals, the tube should be left in place until the animal is eating consistently.[5]

Treatment of pneumonia may be enhanced by using pulmonic catheters for direct administration of antimicrobials or removal of mucous or purulent material. To place the catheter, a small hole is made in the carapace, and a catheter with stylet is introduced into the lung. Samples for culture may be obtained through the catheter before introducing medication. The catheter is capped with an injection port and taped to the carapace. In the case of aquatic animals, silicon or cyanoacrylic may be used to seal the hole to prevent entry of water.[5]

DISEASES

The relative prevalence of disease in captive chelonia is related to husbandry, housing, and movements of animals among collections (Tables 4-3 to 4-5). Environments that are stable, with the provision of adequate nutrition and few or no additions of new animals, afford little opportunity for infectious disease to gain a foothold. At the other end of the spectrum are some animal dealers and collections with numerous additions of animals from diverse sources, fluctuations in environmental conditions, and marginal nutrition. Under those extremes, without proper quarantine programs, infectious diseases are not uncommon. Additionally, individual animals are more likely to be affected by potential pathogens when good husbandry practices are not followed. In free-ranging animals, change in habitat, vegetative cover, water clarity, temperature, food resources or predators from change associated with invasive species, and the introduction of novel potential pathogens are important determinants of disease status. The presence of a potential pathogen is not synonymous with disease and should be evaluated relative to the condition of the animal and the potential impact on a group of animals, captive or free-ranging.

Diseases of concern in captive collections include infectious, parasitic, nutritional, metabolic, and traumatic. Infectious diseases may be controlled or prevented by screening animals before adding them to a collection, by quarantining all incoming animals, and by maintaining good environmental conditions and hygiene. During quarantine routine physical examination, fecal centrifugation or flotation, and direct examination, screening for pertinent infectious diseases, survey radiography, complete blood cell count and chemistries, and banking of plasma for further testing, if necessary, should all be performed. Treatment for parasites should be provided, as indicated (Tables 4-6 and 4-7). Animals showing signs of illness, in quarantine and in the collection, should be isolated until resolution of the problem. Because some diseases may be spread via fomites or other secondary methods, all quarantined or ill animals should be serviced after healthy ones or preferably by separate staff.

Routine screening tests may sometimes yield positive results for potential pathogens. Decisions regarding the significance of the finding should not depend solely on the test results but should take into consideration such factors as the test status of potential contact animals, predictive value of the test for the species in question, value of the animal (genetic, conservation), morbidity or mortality potential of the disease being tested, and treatment possibilities. As chelonian-specific testing modalities are developed, more diseases will be elucidated. Pathogens may be encountered in species or individuals where they were not previously recognized or encountered. A condition of "zero risk" is unlikely to be achieved with respect to disease transmission. Relative risks and potentially mitigating actions need to be evaluated and weighed against the conservation, education, or display potential of the action considered. This holds true for translocations of free-ranging animals as well.

REPRODUCTION

All chelonia lay shelled eggs on land, usually in a nest cavity dug with the hindlimbs. The texture of the eggs ranges from leathery to hard. Clutch size may range from one in small tortoises and turtles, to greater than 100 in sea turtles and some freshwater turtles. Clutch size and potentially the number of clutches per season are influenced by nutritional status. In desert tortoises, the number of eggs laid is reduced rather than a size reduction of the eggs laid during a poor nutritional state.[2] Incubation time may vary from 45 to 360 days, depending on the species. A few species have been shown to undergo diapause prior to embryonic development, potentially extending incubation time by months, even within the same species. Most species of turtles have temperature-dependent sex

TABLE 4-3

Selected Infectious Diseases of Chelonians

Disease (Agent)	Epizootiology and Affected Species	Signs	Diagnosis	Management
Adenovirus (Siadenovirus)	Sulawesi tortoise (*Indotestudo forsteni*)	Anorexia, lethargy, mucosal ulcerations and palatine erosions of the oral cavity, nasal and ocular discharge, and diarrhea	Consensus PCR and sequencing	Quarantine, isolation, potential treatment with cidofovir
Herpesviral infection of tortoises, freshwater turtles, and sea turtles (gray-patch disease; lung, eye, and trachea disease; fibropapillomatosis) (Herpesvirus)	Animal-to-animal and contaminated environment Documented in freshwater turtles, tortoises, and sea turtles	Nasal discharge, weight loss, necrotizing bronchitis, hepatitis, conjunctivitis, stomatitis, tracheitis, pneumonia, dermatitis, fibropapillomatous tumors, and death	Histopathology: intranuclear inclusions in a variety of tissues; plasma neutralization and plasma ELISA; isolation of virus in viral culture	Isolate infected animals Supportive care is required Excise tumors
Iridovirus, Ranavirus (Iridovirus)	Tortoises (*Testudo and Gopherus*), Eastern box turtles (*Terrapene carolina*)	Necrotic stomatitis, esophagitis, rhinitis, pneumonia, abscess, splenitis, vasculitis, and death	Hepatic foci and basophilic intracytoplasmic inclusions Consensus PCR and sequencing	Isolate affected animals Supportive care No specific treatment is available
Salmonellosis (*Salmonella* spp.)	All species are susceptible Found commonly in asymptomatic animals May cause disease when new serotypes are encountered or with concomitant stressors	Enteritis and sepsis	Blood culture and cloacal culture	Appropriate systemic antibiotic and supportive treatment are required
Septicemic cutaneous ulcerative disease (Bacteria, including *Citrobacter freundii* and *Pseudomonas* spp.)	Animals in contaminated environment or with chronic environmental stressors Aquatic turtles and many species are susceptible	Cutaneous ulceration, sloughing skin, septicemia, dehydration, and death	Clinical signs; blood culture; and cutaneous culture	Provide antibiotic therapy; increase environmental temperature; increase salinity of the water temporarily; use medicated baths; and give supportive care
Upper respiratory disease (*Mycoplasma* spp.)	Animal to animal contact, possibly fomites Tortoises (*Gopherus and Testudo*) Serosurveys indicate exposure in other groups of chelonia	Nasal and ocular discharge, pneumonia, weight loss, unthriftiness, and death	PCR of nasal flush, rising serological titers, and culture	Isolate seropositive animals May attempt treatment with systemic antibiotics Supportive care is required

ELISA, Enzyme-linked immunosorbent assay; *PCR*, polymerase chain reaction.

determination, that is, the sex of the embryo is determined by the temperatures to which the eggs are exposed during certain stages of incubation. With exception, females are produced at higher temperatures and males at lower temperatures. Age at reproduction varies by species. Large, slow-growing tortoises may require 15 to 20 years to reach sexual maturity. Faster growth may result in breeding at an earlier age, and slow growth may delay reproduction for years. Research has shown that in desert tortoises (*Gopherus agassizii*), reaching adult size and weight is not a predictor of successful reproduction in females.

During folliculogenesis, plasma calcium levels exceeding 25 mg/dL, globulin levels greater than 8.0, and cholesterol levels greater than 200 are not uncommon. Folliculogenesis may be diagnosed directly by ultrasonography or indirectly via plasma biochemicals. If oviductal eggs are detected by palpation or appear to be calcified via ultrasonography, radiography may be used to count the number of eggs present. If females do not have a secure place to deposit their eggs, they may retain them for an extended period. One method for recovering eggs to lower the likelihood of damage is to place the animal in a shallow pool of water after administering oxytocin (10 IU/kg intramuscularly or intracoelomically, or 7.5 IU oxytocin/kg mixed with 1.5 mg/kg prostaglandin F2α [Feldmans M, personal communication]). The eggs will be deposited in the water and then float so that the animal is less likely to crush them than if they were deposited on land in a less than optimal site. Also, when there are multiple animals in an exhibit, exhibit mates are less likely to damage the eggs. Several species have been observed not to deposit all the eggs present in the oviduct in one clutch. Retention of shelled eggs in an otherwise healthy animal is not cause for concern. If the animal becomes anorexic or lethargic or otherwise seems systemically affected, more aggressive intervention consisting of subcutaneous or intracoelomic administration of fluids, calcium gluconate (100 mg/kg), and repeated oxytocin or oxytocin with prostaglandin is indicated. Surgical extraction of the eggs occasionally is required. Rarely,

TABLE 4-4

Selected Noninfectious and Nutritional Diseases of Chelonians

Disorder	Cause	Signs	Treatment
Drowning	Fishing nets; getting caught in drains or on obstacles in enclosures	Dyspnea or apnea, raspy respirations, coma, and death	Treat for shock; keep on a head-down incline; intubate and apply PPV; oxygenate; and give antibiotics.
Foreign body ingestion	Unusual items in environment mistaken for food items and ingested (plastic bags, coins, or fish hooks)	Weight loss and lethargy; diagnosis with radiography and endoscopy	Remove foreign body via endoscopy, laparoscopy, stomach flushing, or surgery
Hyperthermia	Not able to thermoregulate downward	Hyperactivity, then depression and subsequent organ failure	Cool animal to ambient temperature with water baths, provide intracoelomic fluids, treat for shock, and administer antibiotics
Hypervitaminosis A	Iatrogenic, administration of too high a dose of vitamin A parenterally, or chronic dietary oversupplementation	Flaking and sloughing skin	Treat sloughed skin locally and prevent infection until skin is healed
Hypothermia; cold stunned	Sea turtles (rapid change in water temperatures); captive or terrestrial (sudden suboptimal temperatures with no basking areas available)	Coma, flaccidity, depressed respirations, and bradycardia	Warm animal to optimal temperatures slowly over days to weeks Give supportive treatment with fluids, steroids, antibiotics, antifungals, and parenteral nutrition
Hypovitaminosis A	Deficiency of vitamin A in diet	Squamous metaplasia blepharoedema, nasal discharge, and pneumonia	Give vitamin A parenterally once or twice, followed by addition of vitamin A to diet
Metabolic bone disease	Low calcium diet, inadequate exposure to ultraviolet radiation, chronic low environmental temperatures, and renal failure	Soft shells, abnormal shell formation, inability to raise body off of ground, and hypocalcemic tetany	Increase dietary calcium without increasing phosphorus; provide a source of ultraviolet radiation; administer calcium gluconate parenterally; increase environmental temperatures; address cause of renal failure; and treat symptomatically
Pneumonia	Bacteria, fungus, or protozoa; chronically low environmental temperatures Fungal pneumonia may be seen subsequent to prolonged antibiotic use	Mucopurulent tracheal discharge, radiographic lesions in lungs, and floating asymmetrically in water	Parenteral antimicrobial therapy, intrapulmonic therapy, and supportive care are required Prolonged treatment usually is required
Scute abnormalities	Genetic and incubation factors	Asymmetry of scutes sometimes results in significant deformities during growth	Supportive and palliative care are required
Shell rot	Bacteria, possible emboli, or fungus; environmental contamination; suboptimal environmental and nutritional conditions; and sequelae to sepsis, inability to bask at preferred temperature	Soft spots in shell, hyperemia, fibrinonecrotic debris	Provide systemic antimicrobial therapy and antimicrobial baths Do not debride over-vigorously too often Prolonged treatment usually is required.
Shell trauma	External force	Shell broken or displaced	Surgically debride and cleanse; repair with external fixation (acrylics, wires, and tape)

PPV, Positive pressure ventilation.

an egg may be too large to pass. However, some softening of the posterior portions of the shell may occur, allowing an apparently oversized egg to pass. In most cases, failure to lay eggs is attributable to concurrent nutritional, infectious, or husbandry problems.

Assessing reproductive status of free-ranging females successfully is accomplished by ultrasonography. Although the numbers of eggs cannot be determined accurately, for field studies that occur other than just during egg laying (5% to 10% of the year), ultrasonography provides a way to assess ovarian activity without exposing the ovary to multiple radiographic events. The presence of mature ovarian follicles does not ensure that ovulation will occur because some females are capable of resorbing preovulatory follicles.

The primary reproductive problem in males is a prolapsed phallus. Occasionally, during attempted breeding, an injury may occur or the time of engorgement or extrusion out of the cloaca may be extended. Retraction of the phallus becomes impossible because of damage to musculature or directly to the phallus. If intervention occurs early enough, the organ may be cleansed and manually replaced into the cloaca, and a purse string suture may be placed around the cloaca for 5 to 7 days. Attempts to reduce engorgement by using hyperosmotic agents, topical steroids, and cooling may be helpful. If the phallus cannot be reduced promptly and kept in place, it will reprolapse readily and may require amputation, which may be done under general or epithecal anesthesia.

TABLE 4-5

Selected Parasitic Diseases of Chelonia

Disease	Etiologic Life Cycle	Location in Host	Diagnosis	Clinical Signs	Management
Acariasis (ticks)	Nymphs and adults on chelonians They drop off to lay eggs	Axillary, inguinal, neck, and shell	Visual	Usually minor May cause dermatitis	Use resmethrin and pyrethrins Spray is approved for use in chelonians USDA is concerned about imported tortoises because of presence of *Cowdria ruminatum* in some ticks.
Amebiasis	Direct	Colon, liver, and portal vessels	Direct fecal and histopathologic examinations	Weight loss, enteritis, and death	Keep terrestrial and aquatic separate Treat with metronidazole, paromomycin, or iodochlorhydroxyquin
Coccidiosis	Direct; may be intermediate host	Intestine, renal, and intranuclear	Fecal and histopathologic examination	Renal failure, enteritis, weight loss, and death	Treatment of renal coccidia with toltrazuril may be attempted Treat enteric coccidea with sulfonamides
Cryptosporidium spp.	Direct	Mucosa of stomach and intestine	Fecal, gastric wash IFA and direct plasma EIA	Usually none; may be associated with chronic weight loss	No treatments are proven; toltrazuril has been used.
Hexamitiasis	Direct	Kidney and gall bladder	Cloacal wash	Weight loss and depression	Isolate ill animals and treat with metronidazole, paromomycin, or iodochlorhydroxyquin
Nematodes	Direct and/or intermediate host	Gastrointestinal tract, vascular microfilaria, and lungs	Fecal flotation, direct, lung wash, and blood smear	Weight loss, enteritis, gastrointestinal blockage, pneumonia	Administer parasitacide and give supportive therapy Do not use Ivermectin!
Trematodes	Amphibians, crustaceans are intermediate hosts	Liver, gall bladder, lungs, and vascular system	Direct visualization, lung washes, and sedimentation fecal exams	Pneumonia, granulomatous inflammation, and enteritis	Treat with albendazole, Praziquantel Freeze intermediate hosts before feeding

EIA, Enzyme immunoassay; *IFA*, immunofluorescent antibody; *USDA*, U.S. Department of Agriculture.

TABLE 4-6

Antimicrobials Recommended for Chelonians

Generic Name	Dosage (mg/kg)	Route	Interval (Hours)	Duration
Amikacin	2.5–5	IM	48–72	5–10 Tx
Ampicillin	20–50	IM	12–24	7–14 days
Carbenicillin	200–400	IM	48	5–7 Tx
Ceftazidime	20–40	IM	48–72	5–14 Tx
Ceftiofur sodium	2.2–4	IM	24	7–21 days
Chloramphenicol	25–50	IM or PO	24	7–14 days
Clarithromycin	15	PO	48–72	5–7 days
Doxycycline	50 once, then 25	IM	72	5–7 Tx
Enrofloxacin	2.5–10	IM or PO	24–96	7–21 days Do not use IM in Galapagos tortoises
Fluconazole	5	PO	24	10–40 Tx
Gentamicin	5–10	IM	48–72	5 Tx
Ketoconazole	15–30	PO	24	7–21 days
Metronidazole	20–50	PO	24	5–14 days
Oxytetracycline	5–10 mg/kg	IM	24	5–10 days
Trimethoprim- sulfamethoxazole	30	PO	24	7–10 days

IM, Intramuscular; *PO*, by mouth; *Tx*, treatment(s).

TABLE 4-7

Parasiticides Recommended for Chelonians

Generic Name (Trade Name)	Dosage (mg/kg)	Route	Frequency and Duration	Comments
Albendazole (Valbazen)	50	PO	Repeat in 2 weeks	Flukes and nematodes
Fenbendazole (Panacur)	25–50	PO	1–3 days; repeat in 10–14 days	Leukopenia at higher doses
Levamisole (Levasol)	5–10	SQ or intracoelomic	Every 14 days for two treatments	Nematodes
Metronidazole (Flagyl)	100	PO	Every 14 days for three treatments	Protozoa
Paromomycin (Humatin)	35–100	PO	Every 24 hours for up to 4 weeks	Amebae and cryptosporidia
Permethrin (Provent-a-mite)	1 second/ square foot	Topical spray	Axillary and inguinal regions 1–5 seconds	Immediate kill of ticks Rinse aquatic turtles before placing in water Approved for use by USDA for imported chelonians
Praziquantel (Droncit)	8 or 25 TID for 1 day	SQ, IM, or PO	Repeat in 2 weeks	For tapeworms and flukes Sprirorchidiasis in sea turtles
Sulfadimethoxine (Sulmet)	90 once, then 45	PO	Every 24 hours for 5–7 days	Coccidia
Toltrazuril (Baycox)	15	PO	Every 3 weeks	For intranuclear coccidia; not available in the United States

IM, Intramuscular; *PO*, by mouth; *SQ*, subcutaneous; *USDA*, U.S. Department of Agriculture.

CONSIDERATIONS FOR FREE-RANGING CHELONIANS

The long-term survival of many species of turtles and tortoises is precarious. Field studies and attempts at protection and enhancement of survival have been in progress for years and are increasing in number. Well-meaning attempts to bolster populations via translocations or introductions of animals have been undertaken in the past, with little attention paid to health considerations. The International Union for the Conservation of Nature, Species Survival Commission Reintroduction Specialist Group and the Veterinary Advisory Group have specific guidelines for the quarantine and health assessment of individuals before their release into the wild. For the safety of recipient populations, any animals bred or reared in captivity and intended for release should be raised in strict quarantine away from other animals. In addition, providing health screening for free-ranging populations is recommended to establish baseline levels of individual health parameters and group exposure to diseases and chemical contaminants and to assess reproductive and nutritional status. Longitudinal studies through such efforts may provide an indication of the long-term health of a population independent of whether they are involved in reintroduction or translocation projects.

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