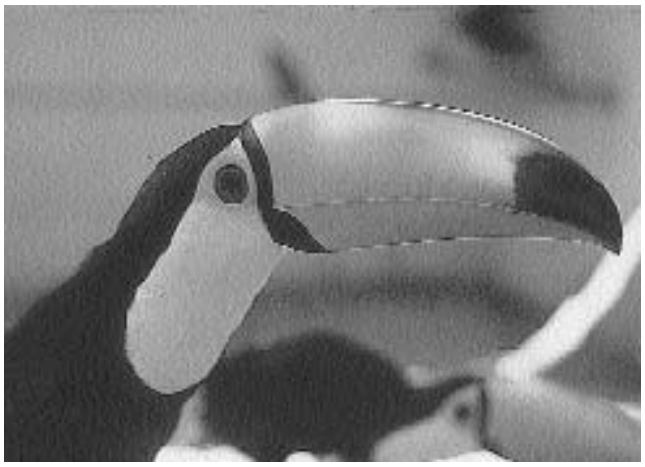

19 Order Piciformes (Toucans, Woodpeckers)

Sandra Bos Mikich
Jerry Jennings
Zalmir S. Cubas

BIOLOGY

Sandra Bos Mikich

CHARACTERISTICS OF PICIFORM BIRDS

Piciforms are characterized by zygodactyl toes, that is, toes 2 and 3 pointing forward and toes 1 and 4 pointing backward. They also have a special arrangement of the toe tendons and leg muscles, a lack of basipterygoid processes in the skull, a syrinx with one pair of tracheobronchial muscles, the presence of 14 cervical vertebrae, a lack of down feathers in adults, hole-nesting habits, and they lay white eggs.[62]

TAXONOMY AND DISTRIBUTION OF SOUTH AMERICAN PICIFORMES

The order Piciformes is usually divided into five families: Galbulidae, Bucconidae, Capitonidae, Ramphastidae, and Picidae. According to Stotz et al.[78] there are 172 piciform species (17 Galbulidae, 32 Bucconidae, 12 Capitonidae, 34 Ramphastidae, and 77 Picidae) in South American countries.

BIOLOGY OF PICIFORMES

Galbulidae

GENERAL CHARACTERISTICS Jacamars have glittering metallic plumage coloration, long bills, small feet, and long, graduated tails. The sexes are usually separated by the color of the throat. The voice is composed of melodious whistles.[23,64]

HABITAT AND DISTRIBUTION Jacamars are sedentary birds restricted to the Neotropical region, ranging from northern Argentina to southern Mexico. They depend on wooded lands, and several species are found along rivers or streams in forests.[23,64]

DIET AND FORAGING BEHAVIOR The diet of Galbulidae is basically composed of insects captured in flight. They make aerial sallies from a perch to catch passing insects and return to the same perch. The diet is usually composed of large prey, including mainly Lepidoptera (butterflies) and Hymenoptera (wasps), but they also eat Coleoptera, Hemiptera, Diptera, and

Homoptera.[45,58] Before consumption, large prey is pounded on the perch several times to break its wings and other hard chitinous body parts. They regurgitate pellets containing chitinous waste.[11,64]

Where several species coexist, they avoid competition by occupying different ecological niches: larger species hunt in the canopy, whereas smaller species feed on the lower and middle levels; some are restricted to the forest interior whereas others prefer to hunt along the forest edges; and some prey mainly from foliage.[23]

NESTING AND BREEDING BEHAVIOR Using their bills, jacamars excavate nest burrows in earth banks or termite mounds. They remove loose particles of earth with their feet. The nest is usually located in the forest or along river courses. Nest construction is performed by a pair or a group of up to five birds (probably a family). They lay two to four white eggs. The incubation period is 20–23 days, and both sexes incubate. The young are hatched covered with dense down, unlike other Piciformes that are born naked. They leave the nest within 21–26 days and can be recognized by their shorter bills.[11,23,64]

Bucconidae

GENERAL CHARACTERISTICS Bucconidae species are generally called puffbirds because of their fluffy but dull plumage. The head is large, with prominent eyebrows; the iris and the eyelids may be colorful in adult birds; the bill is strong and colorful, and there are whiskers around it; the legs and wings are short; the feet are small; and the tail is narrow. The sexes are alike, but the female may be slightly larger than the male and has duller plumage. Immature birds have shorter bills. The voice is similar to that of Galbulidae, and they can perform duets or choruses.[64]

They may sit motionless for long periods while watching the surroundings. They live in families and sleep among the foliage. Some species may make seasonal migrations. [64]

HABITAT AND DISTRIBUTION Puffbirds are forest birds that inhabit an area from Mexico to southern Brazil. [64]

DIET AND FORAGING BEHAVIOR Bucconidae species are fly-catching insectivorous birds. Like Galbulidae, some species capture flying insects, whereas others capture insects from foliage, tree trunks, and branches. The size of prey varies, and they eat several other arthropods as well as small lizards and vegetable food. Chitinous material is regurgitated in pellets.[11,45,58,64,75]

NESTING AND BREEDING BEHAVIOR Puffbirds nest in burrows excavated in earth, arboreal termite mounds, or rotten wood. The incubation chamber may be bare or lined with dry leaves. They lay two to three shiny white eggs that are incubated by both sexes for approximately 15 days. The young are altricial, with small heel pads. There is no nest sanitation. The pair may receive help in feeding the young, which leave the nest within 20 days.[11,64,75]

Capitonidae

GENERAL CHARACTERISTICS Usually, barbets are brightly patterned, heavy-bodied birds with a deep, broad, pointed bill. The head is large; the bill is surrounded by whiskers; the tongue is relatively long and brush tipped (like toucans) in the most frugivorous species; and the legs are short, but the feet are large. Most Neotropical barbets are sexually dichromatic in contrast with Afrotropical species. The voice is low and harsh, and the pairs perform duets.[62-64]

HABITAT AND DISTRIBUTION Barbets occupy the tropical regions of Asia, Africa, and South America. Neotropical barbets are largely frugivorous forest-dwelling birds, concentrated in the Amazon region. Their distribution reflects a series of forest refuges proposed for this region, because unlike their Afrotropical counterparts, Neotropical barbets are not prone to traverse woodland or open grassland, being true forest species.[62-64] According to Short,[63] "the knowledge of the biology of Neotropical capitonids is poor compared with that of Afrotropical and Asian species."

DIET AND FORAGING BEHAVIOR Barbets forage in the canopy, sometimes in mixed species flocks. They are largely frugivorous, but include arthropods and even small vertebrates in their diet, especially during the breeding season.[58,62-64] There are also records of flower eating,[51,54] which is consistent with a frugivorous diet.

According to Burton,[11] Capitonidae "are the least specialized family of the Piciformes, yet they show some interesting modifications of feeding apparatus structure that suggest possible ways in which the more extreme specializations of other families originated." Remsen et al.[50] analyzed the diet of Neotropical barbets based on museum specimens and concluded that *Eubucco* and *Capito* are less frugivorous than *Semnornis,* which resemble toucans more than New World barbets.

NESTING AND BREEDING BEHAVIOR They may excavate their own nests in rotten wood or occupy woodpecker cavities. Most barbets use their bills for nest excavation, but unlike Picidae, they carry the

debris away (like toucans do). The eggs are white and shiny. The young are altricial, hatching after a 13-day incubation.[11,64]

The heel pads are large, and the development of the young is slow. Both characteristics are shared by Ramphastidae and are related to cavity nesting and/or the frugivorous diet, as discussed by Riley.[53] Heel pads occur in most cavity-nesting birds, but are most developed in Capitonidae, Indicatoridae, Ramphastidae, and Picidae.[22] They disappear by the time of the first postjuvenile molt.[3]

Ramphastidae

GENERAL CHARACTERISTICS Toucans are colorful, with a long beak and brush-tipped tongue. The functions of the bill and tongue are unknown, although several hypothesis have been formulated.[3,13,14,16,23,66,77,83,87]

The periophthalmic region is nude and brightly colored; the legs and feet are strong; and the tail is long and graduated in most genera, except *Ramphastos*. Their songs consist of rather simple croaking or yelping calls. The sexes are alike, except in *Pteroglossus viridis* and *Selenidera* spp., but males usually have larger bills.[64]

Toucans live in pairs or in groups. The larger toucans sleep among the foliage, whereas toucanets sleep in holes (they may also be used as nests). They assume a peculiar position to sleep, resting the bill on the back and covering it with the tail.

HABITAT AND DISTRIBUTION Toucans inhabit tropical South and Middle America from southern Mexico to northern Argentina. Haffer[23] studied the speciation of Ramphastidae and verified that the center of abundance of this family is located in the western Amazonian forests, where seven species coexist. These sympatric species, however, differ significantly in body size and bill length. Geographic exclusion of closely related species resulted in a high number of subspecies.

Toucans are typical forest birds, although some species may live in dry woodland or even in nonforest regions, inhabiting gallery forests or savannas. Most toucans occupy the lowlands, but some genera (*Aulacorhynchus* and *Andigena*) are restricted to higher elevations.[23]

DIET AND FORAGING BEHAVIOR Toucans are primarily frugivorous, but also consume arthropods and small vertebrates. They may also consume leaves[58] and flowers.[54] Small fruits are plucked with the mandible tips, then tossed back with an upward jerk of the head. Large insects are rubbed on the perch and held under the feet to remove the wings and legs before consumption. Small seeds are eliminated in the feces and large seeds are regurgitated.

Insects and other animal matter are consumed mainly during the breeding season. Species of toucans are among the most important seed dispersers in the tropical region.[27-29,42,52,55]

NESTING AND BREEDING BEHAVIOR Toucans nest in natural cavities in tree trunks or in woodpeckers' nests, which they may occupy even before the owners abandon it.[34,70] In seriously disturbed forests, where large trees are not available, they nest in fence poles or even in earth banks (P. Scherer-Neto, personal communication; author's personal observation). They may enlarge the nest door or chamber by hammering the wood and carrying the debris away.

The clutch consists of two to four dull white eggs. Both sexes incubate for approximately 16-18 days. The young are altricial with large heel pads and leave the nest in 42-47 days. At fledging they are smaller (especially the bill) than adult birds and the coloration is dull.[59,60]

CAPTIVE BREEDING AND MANAGEMENT Toucans are popular as aviary birds, not only because of their exotic appearance, but also because they are restless and playful. Captive breeding is possible, but has not been highly successful. Regardless of the physical environment, the most important factor to obtain a successful breeding seems to be pair formation and bonding, because captive toucans are aggressive.

A common event in captive breeding of toucans is the killing or mutilation of the young by the parents.[39] Although captive breeding occurs under artificial conditions, some details of pair formation and bonding, egg laying and incubation, and the development of the young were much better understood after captive studies and are important in the conservation of toucans.[37,38,40] Captivity did not change toco toucans' behavioral patterns (55 identified and described) qualitatively, but the frequency and duration of several activities was clearly altered.

Picidae

GENERAL CHARACTERISTICS Woodpeckers are characterized by a rather straight, often chisel-shaped bill and a long, hard-tipped and extensible tongue. In addition to the unique bill, they have adaptations in the skull and neck to permit hammering in wood. The tongue is used to catch insects inside wood or termite mounds, facilitated by a mucous coating. Woodpeckers have diverse combinations of color and sexual dichromatism, mainly on the head. The legs are short and the hard tail helps to support the bird when climbing trees in the upright position. They range in weight from about 7–700 g.[62,64]

Generally, woodpeckers are resident, permanently territorial birds. They sleep in holes and may live in groups (*Melanerpes* spp.). To communicate, a number of vocalizations are used in varying circumstances, as well as a typical instrumental sound (drumming) and diverse visual signals, including displays.

HABITAT AND DISTRIBUTION Woodpeckers are distributed almost worldwide, and the Neotropical region is particularly rich in species. They are forest species, with the exception of *Colaptes* spp., which live in more open areas.[62,64]

DIET AND FORAGING BEHAVIOR Their salivary glands and tongue barbs form an efficient insect-catching device for woodpeckers, but their diet is diverse, including insects (adults, larvae, and eggs), arthropods, fruits, seeds, nuts, honey, and sap.[62,64] Some species of the genus *Melanerpes* may store acorns and other food items, even in tropical regions.[76,93] Where several species coexist, they occupy different strata or employ different techniques to obtain food.[64]

NESTING AND BREEDING BEHAVIOR Woodpeckers nest in tree cavities (one or more cavities), which the pair build each breeding season. They lay two to four shiny white eggs that are incubated by both sexes. The incubation period is short (11–14 days). Hatchlings are altricial. The nest is kept clean except in fruit-eating species (whose feces are usually less firm). The nestling period is 18–35 days or longer, depending on the size of the species. Ant-foraging species feed their young by regurgitation and at long intervals, whereas more frugivorous species feed the young almost constantly.[62] The latter have helpers that, similar to toucans, are the young produced in the previous year. The presence of helpers in one cooperatively breeding species (*Picoides borealis*) was associated with improved nestling survival.[47]

CONSERVATION AND MANAGEMENT OF PICIFORMES

Because all Neotropical piciforms are hole-nesting forest birds, the conservation of mature forest ecosystems is essential for their survival. Eventually some forest-dwelling species are able to find food in secondary habitats, but only large tracts of mature forest have old trees large enough to provide nesting cavities. Even in undisturbed habitats there is keen competition (both intra- and interspecific) for nesting sites, and it is largely increased in disturbed areas. A safe and sound nest site reduces nest predation significantly. Predation may disturb bird populations dramatically (personal observation).

The Neotropical region is particularly rich in frugivorous birds and the order Piciformes includes two families (Capitonidae and Ramphastidae) that are specialized in frugivory and a third (Picidae) that includes fruit in its diet. Frugivory and seed dispersal are essential for the maintenance of the spatial heterogeneity of plant species and ecosystem integrity.[30,31] Large frugivorous forest birds, including toucans, are among the most endangered avian groups in the neotropics.[79] In forest remnants of southeastern Brazil several species of large-canopy frugivorous birds disappeared long ago.[90]

Toucans are endangered in most areas because of habitat destruction, hunting, and illegal trade. They have traditionally been maintained as pets by native peoples,[14,20] who also hunted them for their meat and feathers.[8,57,64,80,85] The beak is used in popular medicine[64] and as a trophy.[84]

Some woodpeckers are also endangered, primarily because of habitat destruction. They are key species in forest ecosystems because they provide nests for other birds, mammals, reptiles, amphibians, and arthropods. They also consume large amounts of insects and their larvae that attack forests and citrus plantations.[64] But such benefits are promptly forgotten when some species (regarded as pests) arrive in orchards to eat fruit.[2,58]

Because of their ecological and economic importance, the conservation and monitoring of piciforms is an essential part of the management of Neotropical protected areas. In the forest remnants of southern Brazil, the author has been monitoring populations of toucans and some species of woodpeckers (along with other large frugivorous bird species) for almost 10 years. Small isolated fragments show dramatic declines in their populations, and some management guidelines are being proposed to protect and eventually restore them.

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CAPTIVE MANAGEMENT: FAMILY RAMPHASTIDAE (TOUCANS)

Jerry Jennings

Toucans are among the more spectacular of the Neotropical avifauna, noted for their disproportionately large beaks, flamboyant colors, and extroverted behavior. First noticed by Europeans at the time of the conquest, toucans have been perennial favorites of zoo visitors, ecotourists, biologists, and people of all ages and backgrounds all over the world. They are represented in art, both ancient and modern, and have even found their way onto breakfast cereal boxes. Although toucans have been known to Western civilization for nearly 500 years, they have received scant attention from biologists, and subsequently there is a scarcity of published information on their natural history. Furthermore, they have been successfully managed in captivity only during the past 50 years and have been successfully propagated only since the mid-1960s. Of the existing 41 species (and numerous subspecies), fewer than half have reproduced in captivity, and many of the those only to the F_1 generation.

The first successful captive breeding of a toucan species occurred at the Los Angeles Zoo in 1966, when the crimson-rumped toucanet (*Aulachorynchus haematopygus*) fledged two young. Several other first breedings occurred at the Los Angeles Zoo, including the pale-mandible aracari (*Pteroglossus erythropygius*) and the plate-billed mountain toucan (*Andigena laminostris*). In the mid-1970s and early 1980s, a number of other first breedings occurred in various locations around the United States, and today approximately 17 species have bred on numerous occasions around the United States and in Europe. Four criteria play important roles in successful reproduction: mate compatibility, housing, diet, and general health.

SELECTING A MATE Toucans in their natural state have a wide choice for mate selection, which is denied them in captivity. Consequently, it is unlikely that a particular bird will find a suitable mate unless the aviculturist has a variety of birds with which to work. Random pairing of toucans occasionally results in aggression between birds, but more often results in indifference, with the male and female birds ignoring each other. Time will often overcome indifference, and eventually the birds may decide to breed. When this occurs, and it may require several months to several years, the pair will engage in certain behaviors that demonstrate their mutual interest. Sitting close together, touching beaks, and offering food items to each other are the most obvious signs. These behaviors are usually followed by joint nest inspections, excavation of the nest cavity, copulation, and egg laying. Occasionally, pairs will not properly incubate their eggs or rear newly hatched young. Rather than a sign of incompatibility, such failures are probably a result of outside disturbance, insufficient choice of dietary items, or one or both birds may be imprinted on humans. If a particular pair of toucans has failed to reproduce after several years, they should be separated and re-paired with different mates. These two "new" pairs should not be housed near each other.

HOUSING Proper housing of toucans is technically easy. Cage enclosures need not be fancy, but the more the following conditions are met, the more likely reproduction will occur. First, the cage should be large.

Although cages as small as 3 × 4 meters have produced results, larger cages (4 × 8 × 3 m high) produce higher numbers of young.

Second, flight cages should be screened visually from any other toucan species. Toucans establish territories around their nests, which they aggressively defend. If they can see neighboring toucans, they are less likely to reproduce, and if they share a common wall with other toucans through which they can see, they will spend too much time interacting with the neighbors to hatch and raise young.

Third, toucan pairs should be housed alone for best results. Although there are a number of reports of toucans reproducing in mixed-species enclosures, these successes have usually been in exceptionally large, planted, walk-through flight cages in zoological parks and have come at the expense of other birds that became toucan prey.

Fourth, flight cages must be secure from outside disturbances, including rodents and nocturnal predators. Predators such as raccoons or coatis may frighten toucans at night or catch them on the wire and pull their toes and legs through the wire. Rats and mice scurrying around in the dark disturb toucans and may contaminate their feed and water receptacles with feces and urine. Rats also may scare toucans off the nest at night and eat the eggs or small nestlings.

Fifth, toucan flight cages should be lightly planted to provide security and perching opportunities. Plants should not be so close to the nest that they provide an avenue of approach for predators. Wild toucan nests are usually located in free-standing trees, some distance from any other tree, and free of climbing vines. Toucans prefer a clear view of the surrounding area so they may see danger approaching in time to escape.

DIET Toucans enjoy a wide variety of fruits in the wild and are known for their contributions to forest ecology as seed dispersers. To reproduce this wide selection of items in captivity is difficult, if not impossible, because most of the natural dietary items are not available as cultivated crops. However, there is sufficient variety in cultivated fruits to satisfy toucans, and variety is a stimulus to breeding activity. Toucans, because of the relatively weak muscles of the beak, have specialized in taking advantage of plant species that supply fruits that can be easily picked and swallowed. They are able to "tear apart" soft fruit, but they prefer species that are already bite size, such as the many varieties of ficus. It is important, therefore, to chop fruits that are offered to captive toucans. The ideal size appears to be 1–2 cm in diameter.

Most fruits are recommended for toucans. They especially enjoy colorful fruits, such as papaya, grapes, cherries, and blueberries. They will also readily consume a variety of melons and bananas and any other berry variety. High-acid fruits, such as oranges, tangerines, grapefruit, pineapple, and tomatoes, should be avoided, because these encourage the uptake of excessive iron.

Toucans also require a source of high protein not available in fruit. Proprietary pellets low in iron are recommended, because they offer all that is needed in proteins, vitamins, and minerals. Supplemental feeding of vitamins and minerals when a quality pellet is provided may lead to gout and other metabolic disorders.

The key consideration in selection of dietary items is concern for the iron content. Toucans are vulnerable to a metabolic disease known as hemochromatosis, or the super absorption of dietary iron that is stored in the liver and pancreas. As iron accumulates over the life of the bird, these organs break down, leading to premature death. High-acid fruits contribute to the superabsorption of iron as they weaken the barrier between the intestinal wall and the blood supply, which encourages the absorption of iron. This has been debated in animal medicine, but it is well recognized in human medicine. Prevention of hemochromatosis requires a low-iron diet.

It should be noted that toucans require *both* fruit and pellets. Although it may seem simpler to offer only pellets, toucans require fruit to properly digest their food. Fruit is also the main source of hydration, because toucans drink little water. Water receptacles in the flight cage are used primarily for bathing. Fruit items must be prepared and served fresh on a daily basis. If the birds are housed in a hot climate, it is wise to change the fruit twice daily to prevent spoilage and the buildup of fungi.

Finally, when toucans do reproduce, the adults will be stimulated to care for their young if live food is offered, and frequently will not feed their young if it is unavailable. In the wild, flying insects such as crickets and grasshoppers, are the primary sources of live food. This need is easily satisfied in a captive situation by supplying crickets, which are cultivated and commercially available in the United States. Other insects, such as mealworms, are less interesting to toucans. If toucans are not offered insects during the breeding cycle, they will hunt their own and may take undesirable species, such as pill bugs, earwigs, and other ground-dwelling arthropods that serve as intermediate hosts for several intestinal parasites that affect toucans.

GENERAL HEALTH A reproductive toucan must be in good health. A particular bird may superficially appear to be healthy, but it is not always the case. Birds selected for a breeding program not only must appear to be healthy and have good body weight, but must be free

from infectious disease and have a history of proper nutrition. To ensure that this condition prevails, birds should be carefully examined before placement in an enclosure. Such examinations should include a fecal exam for intestinal parasites and cultures for bacterial problems. Blood panels should be performed if an apparent problem exists.

MEDICINE: FAMILY RAMPHASTIDAE (TOUCANS)

Zalmir S. Cubas

RESTRAINT, ANESTHESIA, AND SURGERY

Restraint and Anesthesia

Ramphastids may inflict painful injuries to handlers. Birds may be restrained by holding the bill, taking care not to obstruct the nostrils located at the base of the beak. Isoflurane is the most reliable volatile anesthetic agent for restraint and anesthesia of birds. A modified face mask that fits the long beak may be constructed from a cylindrical plastic bottle (saline solution plastic bottle), which is taped to a dog or cat mask. A rubber glove is stretched over the other side of the mask and taped into place. The beak and nostril are inserted into the mask through a slit in the glove. To reduce mechanical dead space the mask should be the exact size of the beak.

Induction and maintenance gas flow rates for isoflurane are similar to those recommended for psittacines; induction should not exceed 3% and maintenance should be 1.5–2%. Despite the advantages of isoflurane, halothane has been used with a good margin of safety in birds when administered through precision vaporizers. Halothane is less expensive, but has the disadvantage of potentially causing liver disease in exposed hospital personnel (rooms without adequate ventilation) and respiratory and cardiac depression in avian patients.

Endotracheal Cole tubes or tubes constructed from urinary catheters are recommended for surgeries on the head or beak repair procedures. Intubation in ramphastids is a simple procedure; the tongue is small and filamentous and the glottis may easily be seen by pulling out the tongue. The endotracheal tube should adapt perfectly to the trachea without offering resistance, and precaution should be taken not to traumatize the glottis and trachea. The usual anesthesia monitoring procedures, such as respiratory, cardiovascular, body temperature, and glucose monitoring should be followed during surgeries.

The author has used injectable anesthetics in combination with tranquilizers in painful short procedures (duration 15–20 min.). An intravenous (IV) combination of ketamine (20 mg/kg) and xylazine (1–2 mg/kg) administered slowly makes possible the surgical sexing of birds. Xylazine increases muscle relaxation, analgesia, and recovery times. Intravenous injections should be given at a slow rate to prevent arrhythmia and cardiac arrest. Another possible combination of drugs is ketamine (20 mg/kg) and diazepam (1 mg/kg) given intravenously.

Surgery

Beak Repair

Toucans are territorial birds, preferably maintained in pairs. Mate aggression, fights between males, and interspecies aggression are common. During the breeding season, males caged next to each other without the presence of a visual barrier may engage in beak jousting. In an attempt to reach an opponent through the wire, self-inflicted beak fractures may occur, usually in the upper bill. Wild-caught birds and young ramphastids that have recently been introduced into aviaries may fracture the bill by repeated strokes against wire netting. To prevent injuries, a period of adaptation in an aviary sheltered with plastic or nylon cloth on the inner wall is recommended. Mate-related injuries may occur.

Toucans have long but light bills composed of spongy bone protected by a thin wall of keratin. The emergency procedure for fracture is control of hemorrhage. A gauze pad, moistened with povidone iodine, should be held over the wound for a few minutes. Debris should be removed and the wound cleaned and dried thoroughly. Care should be taken not to insert liquid or debris into the spongy bone, which may carry contaminants to the deeper parts of the beak and sinuses. Water-soluble antibiotic ointments may be applied to the wound and gauze dressings taped over the defect. Dressings should be replaced every 24 hours until hemorrhage and infection are controlled. Parenteral antibiotics are also recommended.

Healing of keratin is slow and requires acrylic repair in order to prevent contamination and additional trauma to the site. Abraded surfaces should be cleaned, loose particles of keratin, debris, and necrotic tissues removed, and the edges of the defect leveled. The keratin at the margin of the wound may be sanded for better adhesion of the bonding material. The beak defect (exposed spongy bone) should be covered with calcium hydroxide and sealed with a dental restorative resin

composed of bis-glycidil-methacrylate and tritilene-glycol-dimethacrylate (Composto Dental Concise; 3M do Brasil Ltda., Sumaré-SP, Brazil) or similar material that is molded and applied at a level slightly above the surface of the ramphoteca. The acrylic should fill the defect and adhere to the marginal surface of the wound. If necessary, the resin may be ground smooth with a dental or Dremel drill. The repair should be left on for a minimum period of 6 weeks, the final length of time depending on the extent of the lesion. The acrylic repair may be permanently removed only after a substantial layer of keratin has formed on the wound. For aesthetic reasons, prosthetic materials may be used to cover defects of the beak, but it should be understood that these corrective appliances are temporary and must be replaced periodically. Detailed descriptions of beak repair techniques using acrylics may be found in the literature.[2,6]

Injuries

Excessive clipping of the wing alters the bird's balance and may cause repeated falls from a perch, resulting in facial abrasion and keel laceration. Confining injured birds in a small aviary or cage with low perches during the treatment period is necessary to avoid additional trauma and allow healing. Semiocclusive bandages (Tegaderm;, 3M Company, St. Paul, Minnesota, USA) have proven to be useful in facial abrasions with loss of extensive areas of skin. Weak birds sitting on the bottom of the aviary in contact with abrasive cement surface may develop wounds and dermatitis in the metatarsus and hock joint, which may evolve to arthritis and osteomyelitis that resembles bumblefoot (Figure 19.1). The treatment protocols for pododermatitis in raptors are applicable to the metatarsal lesions of toucans. Long-term application of bandages and ointments and parenteral antibiotic therapy are required. The floor of the cage or aviary should be covered with nonabrasive material, such as a rubber mat or carpet.

Bone Fractures

Bone fractures in ramphastids are managed with same surgical techniques applicable to psittacines and other bird groups. Toucans are inquisitive, and their large beaks may trap them in holes and forklike branches, resulting in suffocation. Deep ponds inside aviaries represent a risk of drowning if toucans are unfit to fly.

DIAGNOSIS

A minimum database should be established to facilitate diagnosis, based on physical examinations, weight monitoring, fecal gram stains, fecal examinations for parasite detection, crop washes, plasma protein, hematocrit (packed cell volume, PCV), blood glucose, white blood cell count (WBC), and clinical biochemistry. Additional procedures may be necessary to make a diagnosis, including radiography, endoscopic examinations, microbiologic cultures, and biopsies.

Blood Collection

Jugular venipuncture is a common procedure for obtaining blood samples because the vessel is large and easily seen through the thin featherless skin over the neck. The right jugular vein is usually larger than the left, making it the preferred site for drawing larger volumes of blood.

FIGURE 19.1. Dermatitis in the hock joint of a toco toucan.

To collect blood, the bird should be restrained in an upright position, with the neck held in extension to facilitate location of the jugular vein, which sits in the jugular furrow next to the trachea. Wetting feathers with alcohol will aid in localization of the vessel, which may be occluded by finger pressure at the thoracic inlet to favor blood aspiration. Small-gauge needles (29 G ½) should be used to minimize hematoma formation.

The ulnar vein runs superficially along the elbow and is easily identified, because the skin over the vessel is delicate and translucent. The ulnar vein is the preferable site for fluid infusion. Drawbacks are that birds must be restrained in an unnatural position over a hard surface, and wing flapping may make the procedure impracticable, resulting in the formation of large hematomas. Pressure applied with the finger on the puncture site for a few minutes is usually sufficient to stop bleeding. A butterfly catheter aids in stabilization of the vessel and is also useful for fluid administration. The medial metatarsal vein courses superficially along the medial side of the tarsometatarsus. It is not as visible as the ulnar vein, but hematomas are less likely to occur because it is covered by thicker skin. Small volumes of blood required for hematocrit and serum protein determination mays be obtained by toenail clipping.

The reader may find in-depth reviews of avian hematology and clinical chemistry in other publications. Reference values of hematology and biochemistry for ramphastids are found in Tables 19.1 and 19.2.

TABLE 19.1. Means and ranges for hematological values in toucans

Number of birds	86	—
WBC (cells/μL)	13,500	8000–18,000
PCV (%)	49.8	42–60
Heterophil (%)	51.9	41–62
Lymphocyte (%)	50.5	35–70
Monocyte (%)	0	0–2
Eosinophil (%)	0.67	0–3
Basophil (%)	0	0–1

Source: See reference 12.
PCV, packed cell volume; WBC, white blood cell count.

TABLE 19.2. Means and ranges for biochemical values in toucans

Number of birds	86	—
AST (SGOT) (U/L)	243.3	141–340
Uric Acid (U/L)	7.93	2.4–14
LDH (U/L)	257.6	180–319
Glucose (mg/dL)	297.9	222–363
Calcium (mg/dL)	10.2	8.8–11.8
Cholesterol (mg/dL)	175.1	104–254
Albumin (g/dL)	2.1	1.4–2.4
Alkaline phosphatase (U/L)	43.3	14–88
Protein (g/dL)	3.5	2.8–4.4
Globulin (g/dL)	1.79	1.4–2.2
Albumin/globulin ratio	1.42	0.92–2.67
Bile acids (μmol/L)	54.4	16–86

Source: See reference 12.
AST, aspartate aminotransferase; LDH, lactate dehydrogenase.

Fecal Examination (Gram Stain)

Fecal examination is a useful method to assess the clinical condition of the avian patient and may indicate the presence of nematode eggs, coccidia, other pathogenic protozoans, potentially pathogenic enteric bacteria, and yeast. Healthy toucans may show various patterns of intestinal microflora, and rather than establish normal references for fecal Gram stain, the author prefers to assess a bird's overall condition, diet, and management in combination with diagnostic test results. Compared to psittacines, clinically normal toucans have lower bacterial counts and a higher percentage of gram-negative rod-shaped bacteria. However, excessive numbers of gram-negative bacteria and yeast are suggestive of poor nutrition and intestinal flora imbalance. Similar to psittacine birds, high percentages of gram-positive cocci are expected in healthy toucans. To establish normal digestive tract flora, recommendations are to feed the birds a balanced diet and improve husbandry techniques. Antibiotic therapy and acidifying agents of the intestinal tract (e.g., *Lactobacillus,* lactulose apple cider vinegar) are recommended by some practitioners for birds with a high percentage of gram-negative organisms showing clinical signs of enteritis.

DISEASES

Infectious Diseases

Bacterial Diseases

In a study of 53 asymptomatic toucans of five different species, the cloacal microflora detected was *Escherichia coli, Staphylococcus* spp., and *Streptococcus* serotype D.[8] *Klebsiella pneumoniae* has been recovered occasionally from the cloaca of healthy toucans. Low immunity may favor bacteria's penetration through the mucosal barrier, causing bacteremia.

Avian pseudotuberculosis (*Yersinia pseudotuberculosis*), a gram-negative bacteria, has been documented as the cause of peracute death in toucans kept in North America and Europe. Rats and mice are probably the reservoir, carrying *Y. pseudotuberculosis* to the aviaries. Necropsy findings included hemorrhagic to fibrinous pneumonia, hepatomegaly, splenomegaly, and cheesy masses or granulomas in many organs. Preventive measures include the implementation of a per-

manent rodent control program, isolation of suspected birds, disinfecting of cages and food dishes, and hygiene. Placing food dishes in a tray fixed on a solid wall at 1.5 m from the floor of the enclosure makes food inaccessible to rodents in the aviary and reduces spillage.

*Bacteroide*s spp. (nonfragilis) infection was diagnosed in a toco toucan. Lesions seen at necropsy were severe necrotising enteritis, nodules in the intestinal serosa that were replete with foul-smelling caseous material draining into the intestinal lumen (Figure 19.2). Gram-positive bacilli were the predominant bacteria present in this material. Hepatomegaly and multiple granulomatous-like lesions were seen in the liver (Z.S. Cubas,1999, unpublished data). The disease followed a chronic wasting course. Anaerobic isolation of the microorganism was achieved using an enriched media for Clostridia. *Clostridium colinum,* an anaerobic microorganism, has been reported as the causative agent of deaths in six toucans that died without premonitory signs over a period of 4 months. Necropsy findings consisted of necrotizing hepatitis and ulcerative enteritis. *C. colinum* was isolated from the liver of four of the birds. A concomitant finding was elevated iron levels, which may have contributed to the infection.[20] It is suggested that a predisposing condition allowed these bacteria to proliferate in the gastrointestinal tract. High-carbohydrate levels in the food is regarded as being a major factor. Contaminated soil, food, and water are possible sources of infection.

Avian tuberculosis was diagnosed in a black-necked aracari (*Pteroglossus aracari*).[23]

CHLAMYDIOSIS *Chlamydia* sp. was demonstrated by enzyme-linked immunosorbent assay (ELISA) in a pair of toucans housed in a zoo.[14] More research is needed to determine the clinical importance of chlamydiosis in the Ramphastidae family.

Mycotic Diseases

Candida albicans is commonly identified in the feces of healthy and ill ramphastids. White diphtheritic plaque may be seen in the oral cavity of chicks with retarded growth. Yeast organisms are easily identified by cytologic examination of oral smears and fecal samples stained with Gram stain or quick stain. The author successfully treated a saffron toucanet (*Baillonius bailloni*) nestling with nystatin at a dosage of 500,000 IU/kg 3 times a day for 5 days. Ketoconazole at a dosage of a 200 mg tablet crushed in 1 L of water and given as the sole source of drinking water for 10 days was an effective treatment of a red-billed toucan (*R. tucanus*).[13] *Penicillium griseofulvum* was reported in a group of toucanets.[1] Aspergillosis has been occasionally seen by the author in stunted chicks taken from the nest for hand-rearing. It is suspected that feces accumulating inside the nest creates an ideal environment for fungus proliferation and inhalation of spores by immunosuppressed chicks. Reproductive management includes periodic weighing of chicks and removal of feces from the nest.

Viral Diseases

A herpesvirus serologically unrelated to Pacheco's disease virus was recovered from a toucan. The toucan had been in contact with macaws that died of herpesvirus-induced

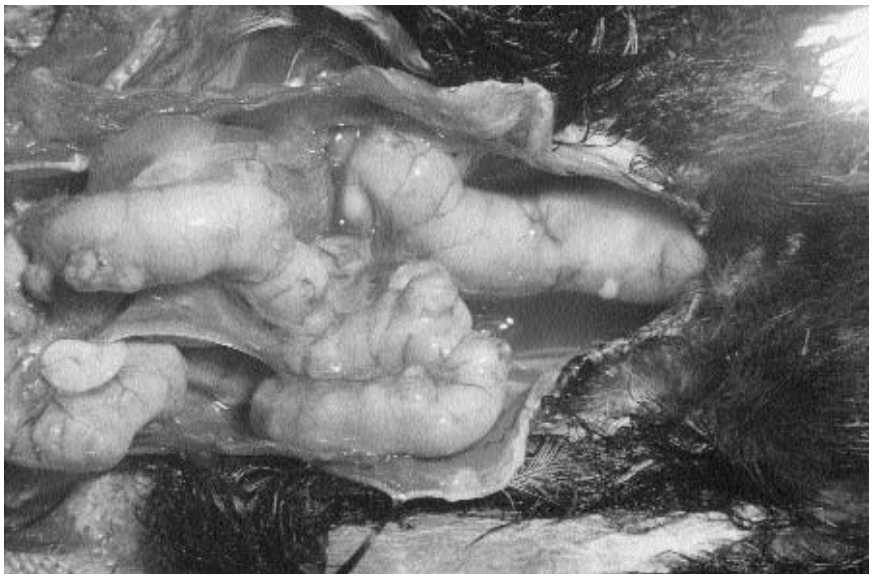

FIGURE 19.2. Nodules in the intestinal serosa with caseous material. *Bacteroides* sp. infection.

hepatitis, a diagnosis based on microscopic changes.[5] Typical lesions of herpesvirus are hepatomegaly, splenomegaly, and intranuclear inclusion bodies in the liver and spleen. Toucans may harbor Newcastle disease virus.

Parasites

CAPILLARIA *Capillaria* spp. are tiny elongated nematodes that may infect the esophagus, crop, and intestine. Ramphastids are particularly susceptible to capillaria parasitism, which may be the most common cause of mortality in captive toucans. The disease accounts in part for the low rate of maintenance and reproduction of ramphastids in captivity. Mortality occurs throughout the year; however, incidence seems to be higher in the hottest months. Parasite eggs remain infective in the environment for several months. The tenuous defense mechanism that balances the parasite-host relationship may be disrupted if the environment or management conditions deteriorate or if the host's immune system becomes impaired. Under these circumstances, mortality rates increase.

All ramphastids seem to be equally affected, nevertheless the author has observed higher mortality in some species than others, the red-breasted toucan (*Ramphastos dicolorus*) and the channel-billed toucan (*Ramphastos vitellinus*), in particular. Host susceptibility and specificity deserve more investigation.

An outbreak of *Capillaria obsignata* in toucans, with acute mortality estimated at 85%, occurred in a Brazilian zoo during the summer of 1997. Necropsy revealed hemorrhagic enteritis and a large number of nematodes in the intestinal lumen. Treatment with ivermectin, levamisole, and mebendazole at standard dosages for birds was not effective (M.S. Gomes, Personal communication, 1998). The author reported *Capillaria columbae* infection in the toco toucan (*Ramphastos toco*).[9] Pathogenicity may vary and may be associated with immune suppression. Concurrent pathologies, such as hepatitis and hemochromatosis, may undermine immune resistance, exacerbating a chronic subclinical parasitic infection. The life cycle of *Capillaria* may be either direct or indirect, depending on the species involved.

Clinical signs are nonspecific and include emaciation, apathy, lethargy, anorexia, brown to bloody diarrhea, anemia, and dehydration. Vomiting has not been observed. Adult worms burrow into the intestinal wall, causing loss of fluids and blood. Thus low PCV and plasma protein may occur in weak birds. Septicemia is a possible complication, resulting from destruction of the integrity of the intestinal mucosa. In advanced cases, ulceration and hemorrhage are seen in the intestine (Figure 19.3).

Eradication of *Capillaria* from a collection is difficult, even employing preventive medication and control of the parasite in the environment. It is suspected that free-living birds may introduce or disseminate nematodes to captive collections of toucans. Preventive and control measures that may significantly reduce infection include elevating feeders and water containers above the floor (not attached under perches); removing perches, plants, and the superficial stratum of soil from highly contaminated aviaries; destroying *Capillaria* eggs on the floor of the enclosure (flame torches are useful); removing *Capillaria*-positive birds from their original aviaries, deworming them, and keeping them in isolated cages for as long as necessary; administering anthelmintics on

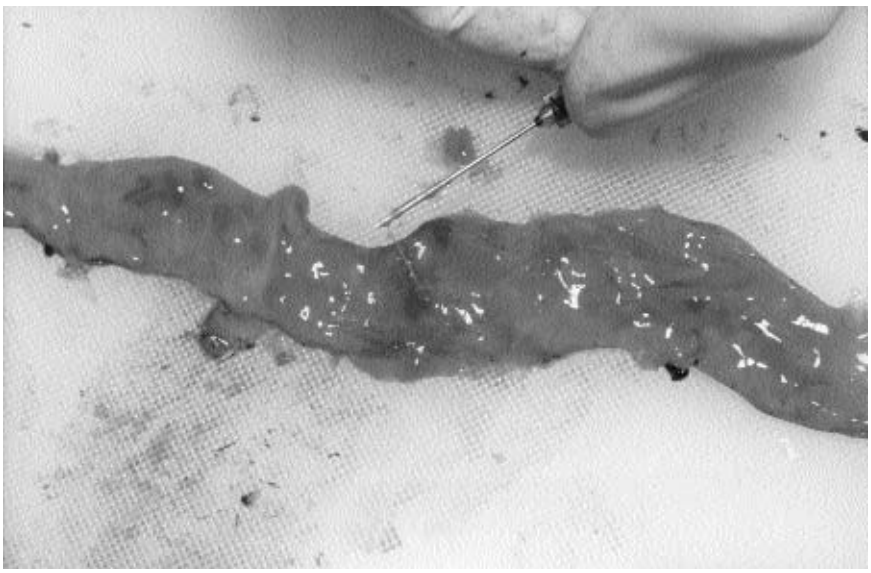

FIGURE 19.3. *Capillaria* infection. Ulcers in the intestinal mucosa and tiny worms in the intestinal lumen or mucosa can be found.

a regular basis (every 2–6 months, according to infestation severity in the collection); and performing periodic fecal examinations to assess treatment effectiveness (monthly in critical premises and periods). At least three sequential negative fecal examinations are recommended before considering a bird to be free of parasites. Some of these measures may prove to be difficult to implement in large aviaries and mixed-species exhibits.

Treatment efficacy with anthelmintic depends on *Capillaria* species sensitivity and the anthelmintic regimen instituted. Some *Capillaria* spp. have proven to be resistant to most of the available drugs, including albendazole, ivermectin, pyrantel pamoate combined with oxantel, levamisole IM, and moxidectin IM at the recommended dosages, either when given as the only drug or in combination with another. A listing of common anthelmintic dosages used by the author is found Table 19.3. Repeated administration may be necessary until fecal exams are negative. Adverse effects of the drugs should be considered when calculating dosages. For instance, benzimidazoles are known to cause bone marrow suppression and anemia. The author uses various anthelmintics in combination to obtain a synergistic effect when dealing with resistant strains of *Capillaria*. High dosages of pyrantel pamoate have been used without adverse effects. Rotation of anthelmintics to prevent development of resistance is recommended.

PROTOZOA *Eimeria* oocysts are occasionally seen in asymptomatic birds, but clinical disease may occur, especially under unsanitary conditions and improper management. Species reported are *Eimeria vitellini* in a red-billed toucan (*Ramphastos tucanus*) in a zoo in the Brazilian Amazon region[16] and *Eimeria forresteri,* reported as causing severe diarrhea in a group of toco toucans in South America.[19] Therapeutic protocols similar to those used for prevention and treatment of poultry coccidiosis are recommended: toltrazuril (7 mg/kg orally for 2 days) or sulfaquinoxaline (125–250 mg/L of drinking water 3 days on, 3 days off, and 3 on) or amprolium (50–100 mg/L of drinking water for 5 to 7 days). *Giardia* spp. is commonly seen in clinically healthy birds. Treatment with usual giardiastats, such as metronidazole, tinidazole, and secnidazole is recommended. *Sarcocystis* sp. is a protozoan that requires both an intermediate and a definitive host. In an outbreak in a zoo collection in Brazil, two toco toucans died from sarcosporidiosis. Death was rapid, although the birds were externally in good condition. A remarkable histopathological finding was lung hemorrhages and schizonts within the endothelium of pulmonary capillaries and in macrophages.[14] Opossums (*Didelphis marsupialis*) proved to be the definitive host that passes oocysts in the feces. Large numbers of oocysts were found in the intestinal submucosa of trapped opossums.

OTHER PARASITES *Plasmodium* species have been reported in toucans, but only high levels of *Plasmodium huffi* are known to cause severe anemia and death. Filarid nematodes are occasionally found in wild toucans. The species *Dessetfilaria guianensis* has been described in a free-flying channel-billed toucan (*R. vitellinus*) in French Guiana,[3] and *Dessetfilaria braziliensis* was found in the outer wall of the aorta and pulmonary trunk in two red-breasted toucans (*R. dicolorus*) and one channel-billed toucan in São Paulo State, Brazil (J. H. Fontenelle, personal communication,1999). The author encountered adult filarids in two red-breasted toucans originating in Iguassu National Park, Paraná State, Brazil. The filarids were found in a capsule in the pulmonary trunk and in the left auricle. Filarid nematodes are considered to be incidental findings.

Noninfectious Diseases

Hemochromatosis

Iron is an essential element in normal physiologic processes, and storage in the liver and other organs is a

TABLE 19.3. Anthelmintics used in ramphastids

Anthelmintic	Dosage/Route	Frequency
Albendazole + ivermectin	15–20 mg/kg PO and 0.4 mg/kg PO	Once. Repeat if necessary
Oxfendazole + ivermectin	15–25 mg/kg PO and 0.4 mg/kg PO	Once. Repeat after 15 days if necessary
Fembendazole	50 mg/kg/day PO	Over 5 days
Mebendazole	25 mg/kg bid PO	Over 5 days
Pyrantel pamoate	70 mg/kg PO	Once. Repeat if necessary
Moxidectin	0.2 mg/kg IM	Once. Repeat if necessary
Ivermectin	0.2–0.4 mg/kg SC, PO	Once. Repeat if necessary

IM, intramuscularly; PO, orally; SC, subcutaneously.

natural mechanism. However, it may become pathologic under certain circumstances. Iron accumulation in organs without deleterious effect to the cells is called *hemosiderosis,* whereas the term *hemochromatosis* describes toxic iron deposition in the tissues and compromising of the organ function.

Iron absorption requires its release from the organic compounds ingested and reduction to the ferrous state. After absorption in the gastrointestinal tract, the element is transported by proteins called transferrins and stored in combination with proteins in the forms of ferritin and hemosiderin. Whereas ferritin is not readily seen on histologic sections, hemosiderin appears as brown granules on hematoxylin and eosin stains or as a blue-green color with Prussian blue stain (Figure 19.4). Hemosiderin overload in the cells may lead to hematoma formation, focal hemorrhages, and severe vascular congestion. In advanced cases, fibrosis and cirrhosis develop, and ultimately the liver fails to function. For more detailed information on the mechanisms of iron overload in various animal classes the reader is referred to current texts.[47]

One of the most important diseases in the Rhamphastidae family, hemochromatosis has been reported in 13 species of toucans and aracaris.[22] No species seems to be more susceptible than any other. A higher prevalence has been reported in toco toucans, but because the toco toucan is the most common species in captivity, the seemingly higher incidence may be a result of its more numerous captive population. It is suspected that hemochromatosis has been accompanied by capillariosis and infectious hepatitis in South American zoo collections. Because a high incidence of *Capillaria* infection is evident at necropsy, concurrent iron storage disease may be being overlooked. Studies in poultry supplemented with excess iron have demonstrated an increase in iron absorption in chicks infected with *Eimeria* spp., probably as a result of the disruption of the integrity of the intestinal mucosa.[18] Iron overload may harm liver function and reduce the action of macrophages and

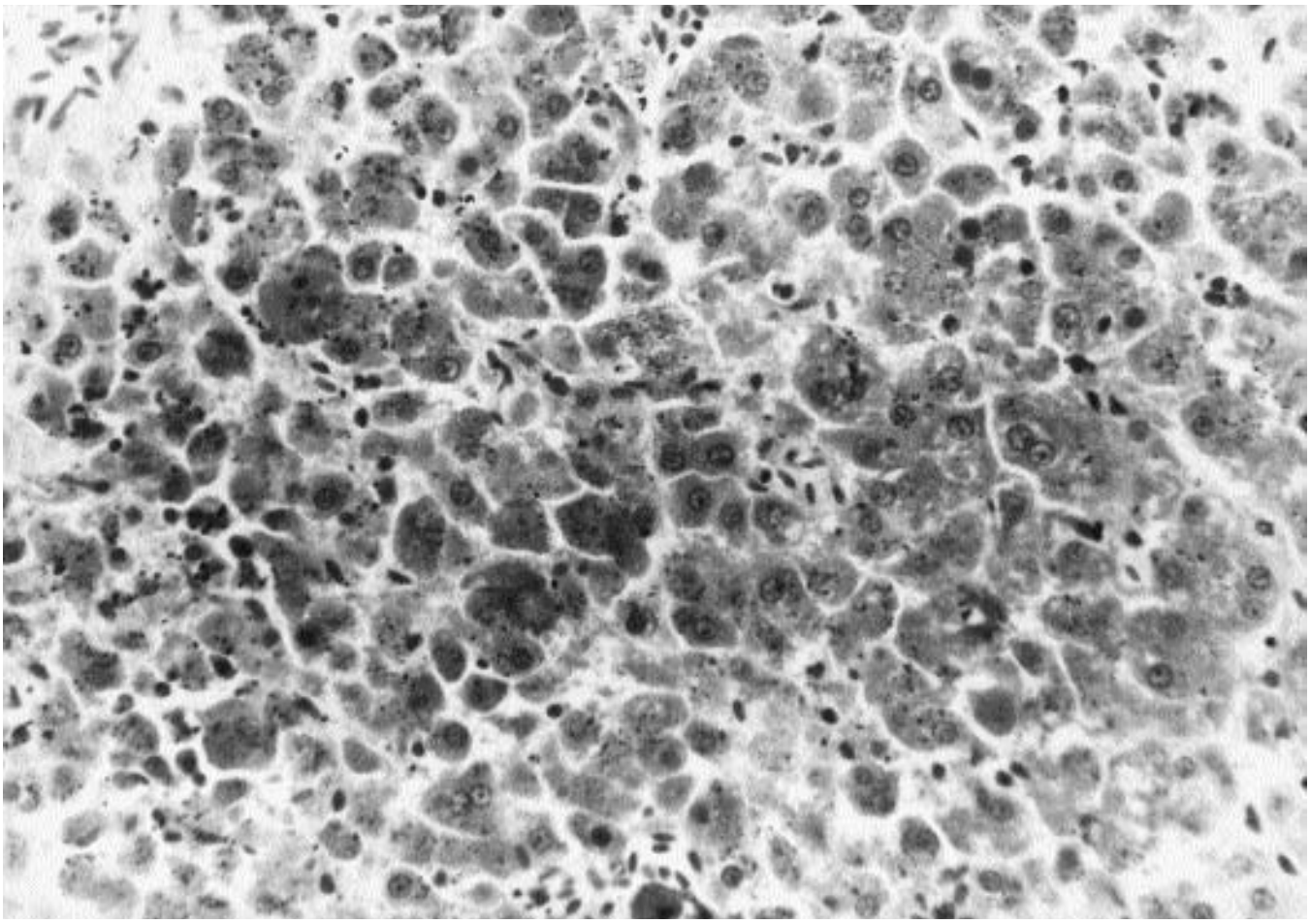

FIGURE 19.4. Liver of a toco toucan with hemochromatosis. Iron deposits appear as dark blue-green granules with Prussian blue stain.

lymphocytes, fostering general bacterial infections and possibly parasitic diseases as well. Determination of the significance of iron deposits in histological preparations must take into consideration the existence and degree of lesions.

Hemochromatosis causes an increase in free radicals. Liver glutathione, an important antioxidant in humans, is depleted in iron-overload patients. Although vitamin C has antioxidant properties, it is not recommended for toucans because it increases the bioavailability and absorption of iron from the digestive tract. For this reason, the current opinion is that fruits high in vitamin C should not be fed to toucans. Alternatively, vitamin E may be used for its antioxidative properties.

The etiology of hemochromatosis in birds is variable, and factors other than nutrition have been incriminated in the disease pathogenesis. Notwithstanding, the most convincing cause in ramphastids is excessive dietary iron intake. It is well documented that toucans receiving diets rich in iron tend to develop deposits in the hepatocytes and Kupffer's cells. Iron deposits may also be seen in the spleen, kidneys, lungs, pancreas, and intestines.[24] Studies in birds-of-paradise indicate that the intestinal absorption rate may reach 90% of the iron intake.[10] A similar efficiency of absorption could explain the high susceptibility of ramphastids to iron toxicity.

Macroscopic lesions in the liver include hepatomegaly, yellowish hepatic discoloration and multiple round foci of different sizes in the parenchyma, fibrin deposition on the surface of the organ and ascites (Figure 19.5). Concurrent hepatitis may occur, with secondary airsacculitis, pneumonia, and septicemia. Acute bacteremia caused by *Klebsiella pneumoniae* with concurrent hepatic iron overload was reported in a green aracari (*Pteroglossus viridis*).[24] Microscopic changes included granular pigments in the hepatocytes and Kupffer's cells and hepatic fibrosis or cirrhosis.

Signs of hemochromatosis may be subclinical, and the patient's general condition may be interpreted as good, because pectoral muscles are well formed and appetite is preserved until death. When clinical signs are present, they include apathy, dyspnea (ascites), and sitting on the ground. Death is usually sudden. Physical examination may reveal a distended abdomen and coelomic effusion. If hepatomegaly is present, radiographic studies may prove to be helpful. Elevated biochemical values of lactic dehydrogenase (LDH), aspartate transaminase (AST or SGOT), and bile acids are parameters indicative of hepatocellular damage or reduced hepatic function. However, serum chemistry, bile acids, and hematology values in birds with iron storage disease may fall between the normal range, which makes measurement of metabolites not fully reliable if interpreted alone.

Hypoproteinemia may also occur as a result of hepatic insufficiency. Specific tests are suggested to assess iron status, including serum iron, total iron-binding capacity (TIBC), serum transferrin levels, and saturation of transferrin. Increased levels and saturation may be indicative of iron overload.[17] Currently, liver biopsy is the most reliable method of diagnosis and monitoring of treatment for iron overload in birds. Unfortunately, this invasive method offers risk to the patient, especially debilitated birds suffering from hepatic damage or coagulopathies. More investigations are needed to develop diagnostic tests that will enable the early detection of this pathology.

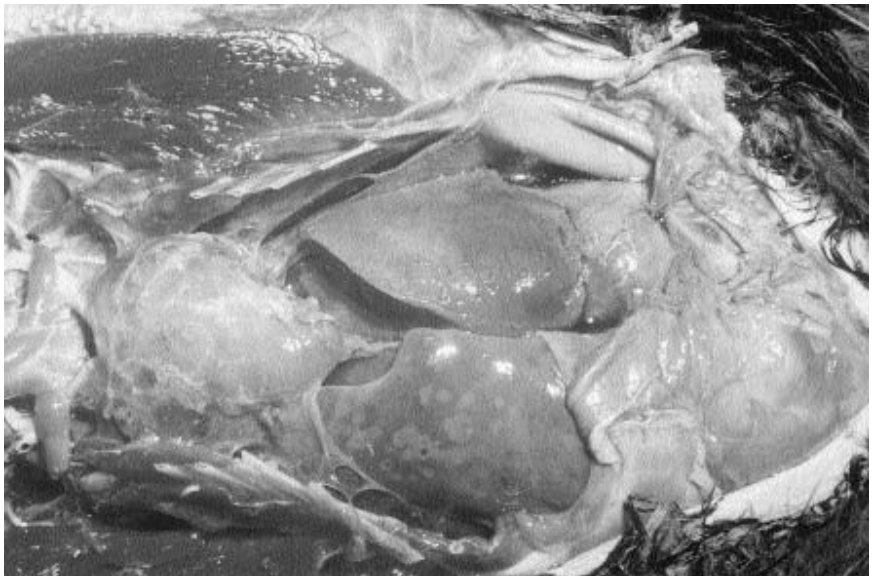

FIGURE 19.5. Macroscopic aspect of the liver with hemochromatosis in a toco toucan.

Weekly phlebotomy has been advocated as the best treatment to mobilize iron stored in the liver. Blood removal at the rate of 1–2 mL/week for 4 to 8 weeks was reported by Worell.[25] A proposed treatment protocol is phlebotomy of 1–2 mL/day until either clinical improvement is seen or borderline anemia develops. This initial treatment is followed by weekly phlebotomy until the serum iron level falls to less than 35.82 mcmol/L (200 mg/dL).[17] Hematologic monitoring is essential during treatment to prevent severe anemia. Blood removal on a weekly basis for periods longer than 1 year has been attempted.

Deferoxamine mesilate (DFO) is a specific iron-chelating agent, which has been shown to reverse both the biochemical indicators and clinical signs over a 2-year period of treatment in humans. Deferoxamine chelates iron stored in hepatocytes and other cells as ferritin, hemosiderin, and labile iron. Excretion may be through the feces, bile, and urine. Adverse effects and efficiency of DFO in animals needs to be investigated. Considering the secondary effects of DFO in humans, some disadvantages may be anticipated in animals, such as long-term therapy, potential toxic effects (in humans visual and auditory disturbances, neurotoxicity, allergic reactions, gastrointestinal disorders, renal impairment, and interstitial lung disease), increased susceptibility to bacterial and fungal infection, and poor iron mobilization in patients showing anemia secondary to chronic diseases, with siderosis of reticuloendothelial (RE) cells of the liver, spleen, and bone marrow.[17]

There are few reports of DFO treatment in birds. One successful treatment protocol in a channel-billed toucan (*Ramphastos vittelinus*) was subcutaneous administration of 100 mg/kg DFO daily for 110 days, followed by monthly monitoring by hemogram and liver biopsy, examined histologically by image analyses. After treatment, liver iron levels declined from 450 to 28 µmol/g dry wt. No adverse effect was reported.[7] Adjunct therapy proposed in human medicine includes vitamin E, selenium, vitamin B complex, and folic acid. Herbal remedies have been suggested, as well. Green tea has tannins and is considered to be a natural iron-chelating agent that may help to remove excess iron from the liver. If tea is added to the food, extra calcium is recommended to replace calcium lost from the phytates. Grape seed-skin extract, ginkgo biloba extract (antioxidant properties), and others are empirically used in humans with iron-overload disease.

Currently, all treatment regimens seem to be impractical, especially for large flocks, and are of uncertain effectiveness. Therefore, emphasis should be placed on prevention. Toucans should always be fed low-iron diets. The author has seen mortality in toco toucans fed on dog pellets containing iron level of 80 parts per million (ppm; 80 mg/kg of food). Studies of toucan nutrition are practically nonexistent, but it is assumed that iron levels below 65 ppm are adequate to prevent iron storage disease. Considering that recommended levels for poultry are 30–40 ppm, the author believes that a total dietary iron level within this range is safer for ramphastids. The iron content of the total diet (parts per million in dry matter) should be calculated, not only the iron content in a single food item. Kibbled or pelleted components are rich in iron and may counterbalance the lower levels in fruits and vegetables. Toucans are usually fed boiled eggs, which are, in fact, a good source of animal protein. However, the average iron content of a chicken egg is 2.3 mg, most of it (around 2.0 mg) in the yolk. For this reason, egg white alone is preferred in the diet. Interaction among nutrients is also important to iron absorption and metabolization. Certain organic acids, such as oxalic acid, phytic acid, and tannic acids form insoluble combinations with iron, thus reducing its absorption. These organic acids may be found in certain teas and foods.

Malnutrition

Nutritional disorders result from either deficiency or excess of nutrients in the diet. Young birds reared on a calcium-deficient diet based on fruit are prone to develop rickets. The bills of birds suffering from metabolic bone disease may have a soft and wrinkled appearance. In advanced cases, lameness, painful joints, reluctance to move, and spontaneous fracture of bones may occur. The author has seen bilateral cataracts in a young toco toucan suffering from metabolic bone disease.

Diabetes

Few cases of diabetes mellitus have been reported in toco toucans or keel-billed toucans.[15] Clinical signs include weight loss, decreased appetite, lethargy, ruffled feathers, polyuria, polydipsia, hyperglycemia (normal glucose range is 200–350 mg/dL) and glucosuria. It is suspected that the etiology is related to management and diet, hypothyroidism, and pancreatic islet cell tumors. Changing food to a formulated diet and instituting insulin therapy are the treatments suggested by some authors.

PEDIATRICS

Ramphastid chicks do better if parent raised. However, hand-rearing chicks is becoming a popular practice as new information about toucan pediatrics is obtained and aviculturists become more confident in hand-

rearing techniques. For breeding purposes, toucans should be housed in pairs in individual aviaries, preferably out of visual contact with adjacent cages. Nests made of palm tree logs are suitable.

Two to four chicks usually hatch, but some pairs may not be able to raise more than two nestlings. In the author's experience, ramphastid chicks should be weighed and inspected daily or every other day in the first 2 weeks of age. As they grow, the nest log should be checked every 2 to 3 days. Both male and female take care of the chicks, and handling them does not make parents abandon the offspring. Most breeding pairs will accept human presence from the first day of hatching if they are used to people in the aviary. However, care should be taken with nervous birds that are not used to people, for they may become upset and attack the chicks after manipulation. The first weeks of life are the most critical for a chick's survival. Hatchlings should be marked, and those that are not gaining weight or that show signs of disease, such as a lack of the feeding response, dehydration, pale skin, hypothermia, and empty stomach are strong candidates for removal and hand-raising. Chicks taken from the nest after 1 week of age seem to thrive better.

Eggs of pairs that have previously broken or eaten eggs should be removed for artificial incubation. Pairs that have injured their hatchlings on previous occasions will most likely do it again. It is advisable to pull the nestlings of such pairs for hand-feeding. The visual presence of other pairs of toucans nearby is a factor of stress and aggressiveness during the breeding season, which may result in destruction of the offspring by the parents.

It is recommended to increase protein in the diet during the incubation and rearing period. Laboratory-raised insects, pinkie mice, or disease-free adult mice cut into small pieces with long and sharp bones removed, are good sources of protein. The author has seen a male toco toucan kill one chick and tear the body into pieces to feed the remaining siblings. Nutritional requirements for young ramphastids are not fully known and extrapolation from diets for psittacines is suggested.

Parent-raised spot-billed toucanet (*Selenidera maculirostris*), saffron toucanet (*B. bailloni*), and chestnut-eared toucanet (*Pteroglossus castanotis*) chicks have been fed successfully with a diet that consisted of poultry pellets, low-iron dog pellets, boiled egg whites, banana, papaya, cooked carrots, and beet root. Parents have also been seen ingesting free-flying insects that entered the cages and offering them to the chicks, which may add to the captive diet. Hand-rearing formulas for psittacines may be used in association with fruits such as papaya, banana, and applesauce.

Hygiene during food preparation is essential for successful rearing. Distilled or boiled water should be used to mix food items and the use of sterile and strained fruits are a routine procedure in a breeding facility (J. Jannings, personal communication, 1991). The author has used a noncommercial hand-rearing formula made of cereals and other products for human consumption (final nutrient content similar to commercial psittacine hand-rearing formulas) to feed young aracaris and toucanets. Food is administered carefully into the proventriculus using rubber or stainless steel feeding tubes. Because the skin of a young chick is thin, the food, of a yogurtlike consistency, can be easily seen advancing down the esophagus in the right side of the neck. Food administration should cease when food starts to accumulate and flow up into the esophagus. Small pieces of fruit, cooked egg white, and moistened pellets may be given from the first week of age.

The feeding response is elicited by touching the upper beak or the corner of the beak. Food is placed in the back of the mouth and moves by peristaltic movement down the esophagus into the proventriculus. Youngsters that do not show the feeding response are in critical condition and need urgent medical assistance. Chicks in deep sleep will not respond to feeding stimulation and should not be misinterpreted as being ill. Food is better accepted if given at warm temperatures; however, older chicks will promptly take food at room temperature. Ramphastids do not have crops in which to store food as psittacines do, and small amounts of food should be given at short intervals. Ramphastids less than 1 week old may need to be fed every 1–2 hours during the daytime. A good indication of when to give the next meal is to check if the stomach is empty and if the chick displays a food-begging behavior. Well-fed chicks have a distended and round abdomen and hungry chicks will accept food until fully satisfied. The feeding interval may be extended as the chicks grow. Storage of pureed food, even in the refrigerator, is not recommended, because pathogenic bacteria may grow quickly in this nutritive media.

In the first weeks of age, chicks are best maintained in a brooder at 33°C (91.4° F). The temperature is reduced to room temperature as down feathers start to grow and chicks become physiologically able to control the core body temperature. Shivering and lethargic birds may be an indication of a low temperature in the brooder. Restless chicks and reddish skin indicate a high temperature. Thermostats are recommended to prevent overheating in the brooder.

Dehydrated birds should be treated with fluids given subcutaneously and orally (Figure 19.6). Poorly developed chicks should be removed from the nest for treatment and hydration. Candidiasis, gram-negative bacteria, and aspergillosis are common causes of stunted growth.

FIGURE 19.6. Dehydrated toucanet chick showing wrinkled skin.

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