Chapter 12
Health and Welfare of Howler Monkeys in Captivity

Rosalía Pastor-Nieto

Abstract Among platyrrhines, howler monkeys are commonly traded illegally as pets in Central and South America, resulting in the high mortality of specimens. Many of these animals end up in long-term captive situations in zoos and rehabilitation centers, where adaptation may be difficult. Careful husbandry planning, taking into account the animals' behavioral, anatomical, and evolutionary characteristics, can greatly improve survivability. This chapter aims to provide information on howler monkey welfare in captivity, including enclosure design, environmental enrichment, feeding and nutrition, and diseases, based upon the biology and ecology of the species. Digestive physiology, behavioral ecology, and the social system of howler monkeys are major factors to take into account to provide adequate captive conditions. Aspects such as social integration, controlled temperature, indoor and outdoor enclosures, and hiding places should be met. The provision of foraging plants within the enclosure is ideal to stimulate natural feeding behavior. Behavioral enrichment measures need to be devised to prevent behavioral disorders. For successfully maintaining howler monkeys in captivity, animals should be trained to consume a wide variety of natural fiber sources. Special attention should be placed on quantities of food sources rich in gluten and other allergenic proteins. Acute and chronic syndromes such as gastric dilatation, howler monkey wasting disease, and metabolic bone disease can be prevented when provided adequate diets. Many diseases may be acquired in the wild. However, other infectious diseases (viral, bacterial, and parasitic) are concomitant to stress and improper management. Very few studies have been carried out in captive howler populations to fully understand the husbandry and care requirements. Although howlers are very adaptive in nature and although it is a genus widely distributed throughout Central and South America, they are susceptible to many diseases that might threaten their population in the wild. Achieving a better knowledge of these factors in captivity may contribute to the development of healthy captive populations for future reintroductions to the wild.

R. Pastor-Nieto (✉)
School of Veterinary Medicine, Universidad del Valle de México,
Campus Coyoacán, Mexico D.F., Mexico
e-mail: rosalia.pastor@gmail.com

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Resumen Entre los platirrhinos, los monos aulladores son comúnmente comercializados ilegalmente en Centro y Sudamérica, dando como resultado una alta mortalidad de ejemplares. Muchos de estos monos terminan en confinamiento por largos períodos de tiempo en zoológicos y centros de rehabilitación, donde su adaptación suele ser complicada. Para proveer de condiciones de vida adecuadas que permitan mayor sobrevivencia de individuos en cautiverio, se requiere de una planeación en el manejo que considere las características evolutivas, anatómicas y conductuales de la especie. El objetivo de este capítulo es proporcionar información para promover el bienestar a los monos aulladores en cautiverio, incluyendo el diseño de recintos, enriquecimiento ambiental, nutrición y sistema alimenticio, necesidades sociales y enfermedades reportadas en el género *Alouatta.* Aspectos tales como la integración social, locomoción elevada en tres dimensiones, el control de temperatura, instalaciones internas y al aire libre, así como sitios de resguardo, son aspectos importantes que se deben tomar en cuenta para el diseño de recintos. Se debe promover consumo de fuentes de fibra natural o forrajes naturales no tóxicos, los cuales favorecen una correcta digestión, salud de la microbiota y tránsito intestinal. Al igual que para otras especies de primates cautivos, se debe proveer de elementos de enriquecimiento ambiental para prevenir desórdenes conductuales. Es necesario evitar el consumo de proteínas alergénicas y azúcares simples para evitar trastornos gastroentéricos agudos y crónicos como la dilatación gástrica y el síndrome desgastante del mono aullador; así como dietas balanceadas en calcio, fósforo y suplementadas con vitamina D_3 para prevenir la enfermedad metabólica de los huesos. Muchas enfermedades de los monos aulladores pueden ser adquiridas en vida libre. Sin embargo, otras enfermedades infecciosas (virales, bacterianas y parasitarias) son concomitantes al estrés y a malas condiciones de cautiverio. Muy pocos estudios se han llevado a cabo en poblaciones cautivas de monos aulladores para comprender de manera completa sus necesidades de manejo y cuidado. Aunque los monos aulladores se adaptan fácilmente a distintas condiciones ambientales y constituyen un género ampliamente distribuido en Centro y Sudamérica, son susceptibles a muchos factores que pueden deteriorar su salud y amenazar a sus poblaciones silvestres. A través de un mejor entendimiento sobre los factores que afectan a los monos aulladores y a su manejo, salud y bienestar en cautiverio, se puede contribuir al desarrollo de poblaciones cautivas sanas que constituyan una opción para futuras reintroducciones y/o reforzamientos de poblaciones en vida libre.

Keywords *Alouatta* • Captive management • Health • Welfare

12.1 Introduction

There are numerous factors involved in the decline of wild populations of primates in Central and South America, two of the most important being habitat destruction and illegal pet trade. Forest clearing is still a serious threat because tropical forests are being fragmented and destroyed, due to agricultural encroachment, cattle

ranching, road building, and installation of electric power lines (Mittermeier 1991; Vickers 1991; Pastor-Nieto 2007). All these activities allow poachers easy access into primate habitats.

Illegal trade of live monkeys continues to be a great threat to primates because it generally goes on undetected. Poachers chase and harass small groups of monkeys in forest fragments until the animals are forced to descend from trees. Then, the females carrying babies are killed, and surviving infants are sold to tourists at the edge of roads, or to animal dealers who will deliver the infants to specific customers (Cuaron 1991). For example, in Mexico, the trade of live monkeys is a very profitable activity for intermediate and final dealers, because a baby howler or spider monkey may sell for more than the national monthly minimum wage. In addition, local poachers may consume the meat of adult animals or use the carcasses for other purposes, such as fishing bait (Mittermeier 1991; Vickers 1991; Pastor-Nieto 2007).

Hunting and trade not only reduces the size of wild populations, it also modifies the demographic structure (age/sex structure) of the population, which is highly detrimental to large-bodied primates such as spider monkeys or howler monkeys, due to their low fecundity rates. By targeting females, the most sensitive reproductive unit, natural populations are placed in a risky situation (Cuaron 1991).

Unfortunately, information on the impact of illegal trade of primates in Central and South America is very scarce, and there are very few quantitative field studies that evaluate the effect of hunting of primates in rural communities. For example, in Mexico between 1995 and 2011, a total of 1,063 live, wild-caught spider monkey and howler monkey specimens were confiscated by the Procuraduría Federal de Protección al Ambiente (PROFEPA). Most of these specimens were transferred to zoological collections.

Within the ISIS-ZIMS databases, 70 zoological institutions worldwide hold howler specimens in their animal collections. Most of these specimens have been captive-bred. The geographic origin of breeding specimens is not always certain. Most of these zoological institutions are located in Europe and North America, where *Alouatta caraya* (black howler monkey) is overrepresented with a total of 58 institutions, followed by *A. arctoidea* (Venezuelan red howler monkey) with 9 institutions. The least represented species in captivity are the Guatemalan Black Howler monkeys (*A. pigra*) with two institutions and the Mantled Howler monkey (*A. palliata*) in only one registered zoological institution (ISIS 2012). There is a lack of information on captive numbers of howler monkeys in zoos of Central and South America.

To be able to provide improved management of captive howler monkeys, there are a number of fundamental considerations to take into account. These include nutritional needs healthy microbiota and digestion, prevention of behavioral pathologies such as infanticide and aggressive encounters, achievement of adequate social structures and group sizes, enriched environments and disease prevention. Other factors to consider, when first receiving wild howlers into captivity, include age and the psychological and health status of the particular individuals.

The purpose of this chapter is to summarize the factors related to adequate captive management of *Alouatta.* Proper management designed to promote welfare is essential for ex situ conservation of howlers in zoos and rehabilitation centers.

By meeting the most important welfare needs, these institutions may contribute to perform quality research and broaden our knowledge of this species.

To obtain adequate management, enclosure design, captive enrichment, nutrition, and major health concerns of these primates in captivity, it is essential to understand the link with their ecological adaptations. Howler monkeys are known to be a difficult species to maintain in captivity due to their specialized nutritional and social requirements (Lindbergh 1976; Edwards et al. 1989; Edwards and Ullrey 1999). Very few studies have been conducted in captivity due to the difficulty of keeping these primates outside of their natural environment.

12.2 Behavior in Captivity

Captivity may force primate species to behave in a totally different manner than their conspecifics in the wild. There are various reasons for this. On one hand, food is provisioned in abundance and therefore animals do not compete for resources, predation pressure is nonexistent and, in most cases, monkeys live in environments with controlled conditions. On the other hand, captivity prevents animals from dispersing to avoid conflict; therefore, they need to find alternative mechanisms to cope with group living (Cubas 1996; Mallapur and Choudhury 2003).

The genus *Alouatta* is one of the most extensively studied primates in the wild. The main reason for this is their wide distribution range in the Americas, and their lethargic nature (almost 70–80 % of time is spent resting). This allows observers to keep track of the behaviors of individuals, collect detailed data related to use of habitat resources, and monitor changes in population densities. Captive studies of howler monkeys are extremely scarce, although they could provide further information on specific behaviors, physiology and medical aspects.

Concerning captive behavior, the few studies conducted in captivity suggest that males are dominant over females. In many instances males act as control animals, by settling fights between females (Benton 1976). On the other hand, females tend to be more sociable and less competitive. Interestingly, females are observed to be more frequently involved in grooming bouts than males (Shoemaker 1978). Adults tend to spend a great proportion of their time resting; however, they have been observed playing early in the morning or late in the afternoon (Benton 1976). Food competition has been observed between females, especially over novel or scarce food items. Juveniles are commonly devoted to play (Benton 1976). A recent captive study was performed to evaluate the association of social behaviors and reproductive success of female *Alouatta caraya* in European Zoos. This study revealed that more offspring were born and survived from females held in family groups than from those in pairs. Moreover, regular hearing of howls of familiar conspecifics also increased reproductive success of females. Therefore, maintaining familiar groups seems to favor successful breeding in captivity (Farmer et al. 2011).

As many howler monkeys come into zoos and sanctuaries as confiscations and as ex-pets one sees a number of behavioral problems related to their unnatural

upbringing and deficient health and psychological care. It is very well known that social interactions with conspecifics during infancy have been shown to affect the formation of affiliative and sexual preferences (Watts and Meder 1996). When animals have been hand-raised imprinting to the caretaker might seriously interfere with integration to a conspecific group. Planning for social integration is critical in these cases. Orphan infants should have visual, auditory, and/or olfactory contact with conspecifics as soon as possible. Integration process should be planned into different stages, and security for the introduced individual should be always a priority (Watts and Meder 1996). In such cases, nutritional transition has to be considered from the inappropriate foods provided as a pet to suitable foods for howler monkeys.

In captive howler monkeys, female rank is linked to reproductive condition, just as in the wild. High-ranking females reach sexual maturity and breed earlier than low ranking females. Passive infanticide appears to be a common feature of captive *Alouatta*, sometimes observed when females allow infants to fall from perches (Shoemaker 1982). Therefore during social integration juveniles should be closely monitored. In addition, males may benefit from infanticide by killing infants likely to be sired by a non-kin male, and hence shortening female's interbirth interval through the cessation of lactation and subsequent return to ovarian cycling. Infanticidal males are thought to gain reproductive advantage by impregnating the dead infant's mother (Sugiyama 1967; Hausfater and Hydy 1984; Crockett and Janson 2000).

Studies of *A. caraya* suggest the absence of reproductive seasonality in captivity (Shoemaker 1982; 1978), although controversial results have been obtained in the wild (Calegaro-Marques and Bicca-Marques 1993; Zunino 1996).

12.3 Management of Baby Orphans

When considering hand-rearing baby howler monkeys, there are several life stage factors to consider; these are age, weight, and dentition. Other features include anatomical differences among species, for example, descent of testes in scrotum. Newborns and infants of *Alouatta palliata*, have undescended testicles, compared to *A. pigra* and other howler species, in which, testicles are present in the scrotum from birth (Kinzey 1997). Infants are considered at 0–14 months of age, juveniles at 14–29 months of age, subadults at 28–35 months of age, and adults at 40–48 months of age. These age categories take into account dependence to mother, as well as size and type of diet (Balcells and Veá- Baró 2009).

Routine health examinations are essential. Basic criteria for hand rearing infant primates can also apply to baby howlers. Hypoglycemia is common in undernourished orphans. Hypoglycemia is treated by administering a 5 % glucose solution for the first 24 h (Summers et al. 2002). If the animal is alert and responding to external stimuli, it is ideal to administer this solution orally. Commercial brands of puppy bottle feeders are appropriate to provide oral fluids and milk formula. If the infant is

lethargic or unwilling to eat, a size 8–12 French polyethylene nasogastric feeding tube can be used. The feeding tube can be maintained for several days if properly secured in place with tape (Moreland 1970; Bohm et al. 2012). Before fully introducing infant milk formula, a transitional option is mixing the formula with electrolytes, starting with 25 % formula-75 % electrolytes, then later providing 50 % to 100 % infant milk formula (Fig. 12.1). This process may take a few days, depending on how infants tolerate each stage (Barnes and Cronin 2010). Primilac (Bioserve Laboratories) infant primate formula is readily available. However, commercial infant human formulas have been used successfully in many primate species: an abandoned baby muriqui (*Brachyteles arachnoides*) was successfully bottle fed with human baby formula such as NAN (Nestlé Company) or SMA (SMA Nutrition) and returned to his mother in the wild (Nogeira et al. 1994). The opening of the nipple should allow an easy flow of the formula; excessive flow may choke the baby. Initially, one ounce may be offered every 2–3 h. Volume requirements and frequency of feeding are adapted according to demand. After the first week of bottle feeding it is advisable to verify an intake of 100–120 kcal/day (Swenson 1999; Summers et al. 2002).

Body weights of infants should be recorded on a daily basis. No weight gain or weight loss is an unequivocal sign of inadequate nutrition or early illness. The amount of weight gain is less important than a steady increase in weight.

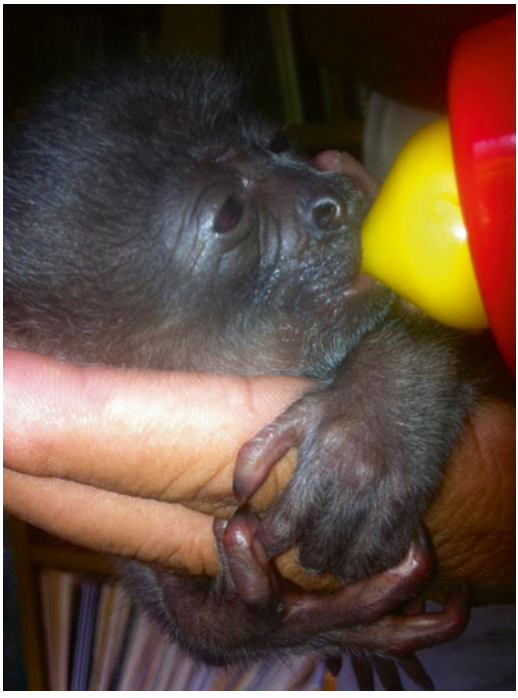

Fig. 12.1 Bottle-feeding a male newborn howler monkey (photo courtesy of Antonio Pastrana Martino)

The proper ambient temperature should be ranging from 27 to 32 ° C. Considering the high cost of an incubator, an infrared light situated at an adequate distance can provide a proper source of heat. Handling practices during the neonatal and infancy periods are essential for later development, as primates are characterized by an extended infancy period. During development, mother–infant contact is crucial to learn social skills (Harlow and Suomi 1971; Mason 1991; Joffe 1997; Pavé et al. 2010). Considering this, it is important to provide the infant with a "surrogate mother" to avoid imprinting with humans and promote gripping reflex. In this case, a cloth toy (i.e., a teddy bear) may be useful. For sanitation purposes, it is advisable to cover the cloth toy with an extra washable layer or have many available so they can be rotated and washed.

As soon as the babies feed by themselves, social integration with other conspecifics is important. Adoption of orphaned infants has been reported among howler monkeys in the wild. These adoptions have been observed in adult females. Therefore, adoptions would be a recommended husbandry alternative to promote social integration whenever possible, always taking into consideration the risk of infanticide (Agoramoorthy and Rudran 1992).

In natural conditions, baby howler monkeys suckle for 6 months to 1 year of age on average. If baby howlers are hand-raised, in addition to a baby formula, small amounts of solid foods can be offered, such as vegetables and greens (i.e., celery, spinach, watercress, zucchini, and green beans) (Fig. 12.2). A wide variety of leafy vegetables and mixed greens are vital for promoting natural foraging behavior.

Fig. 12.2 Female infant howler monkey *Alouatta pigra* feeding from elevated feeding tray (photo by Rosalia Pastor-Nieto)

If rearing facilities are located in or near natural habitats of wild troops of *Alouatta*, it is important to include the consumption of young shoots, buds and fruits of typical browse plant species. Inclusion of these natural foods is usually overlooked, even if they are readily available.

Orphan neonates or infants usually suffer from hypothermia. Predisposing factors include sudden temperature changes, wet and windy weather, improper housing conditions, low social rank and maternal neglect, disease (diarrhea), trauma, and stress. Animals suffering from hypothermia often appear cold, weak, and unresponsive, and may have stiff muscles, bradycardia, weak pulses, cardiac arrhythmias, and pale or cyanotic membranes. The most effective treatment consists of placing them in a shallow warm water bath (30 °C). Other effective measures include the use of hair dryers or a massage. As mentioned in other sections, the use of heat-lamps is also effective, but should be used with extreme caution to prevent thermal wounds. Hypothermia in infant primates is usually associated with hypoglycemia, therefore it is essential to initially provide a 25 % warm dextrose solution intravenously at 2–2.5 g/kg/day or 6–8 mg/kg/min. Care must be taken to not let this solution become extravasated, as it is hypertonic and may cause severe tissue damage. Oral administration of a 50 % dextrose solution may also be effective.

Finally, the social environment in captivity surrounding natural mother rearing should be closely monitored to prevent infanticide. In zoological collections, the risk of infanticide may be increased due to the presence of more than one male in a social group (Crockett and Janson 2000; van Belle et al. 2010).

12.4 Management of Subadults and Adults

Despite the difficulties in keeping infant and juvenile howlers in captivity, the proper captive management of adults also requires the consideration of specific important factors. Species-specific nutritional, behavioral, and housing requirements should be considered for successful captive management. Early detection of potential competitive behaviors and aggression of adults towards juveniles is also very important for establishing viable captive populations.

12.4.1 Nutrition

Proper nutrition of howler monkeys in captivity requires feeding formulation criteria that should be based on the behavioral and ecological demands of the genus. Howler monkeys are mainly folivorous, but supplement their diet with ripe and unripe fruits in the wild. Several studies on optimal foraging of howler monkeys reveal that their natural diets are high in fiber, derived from leaves, buds and shoots (20–80 % fiber), as well as fibrous fruits (20–70 % fiber). Wild howler monkeys are considered folivores-frugivores, based on selection of different plant parts, such as leaf shoots

and buds, stems, flowers and fruits of a great variety of plant species, including epiphytic, and in different phenological stages (Coelho et al. 1976; Estrada 1984; Silva-López 1993; de Thoisy and Richard-Hansen 1997; Estrada et al. 1999; Silver et al. 2000; Serio-Silva and Rico-Gray 2002; Fuentes et al. 2003; Pavelka and Knopff 2004; Estrada et al. 2005; Pozo-Montuy and Serio-Silva 2006). To digest highly fibrous foods items, howler monkeys possess an elongated caecum for fiber fermentation, complex gut microbiota, and have a very slow gut transit time (Chivers 1994; Anapol and Lee 1994). The health of the intestinal microbiota of howler monkeys is essential to maintain adequate digestion. Only a few studies have examined the impact of captivity on the primate intestinal microbiota (Benno et al. 1987; Uenishi et al. 2007; Fujita and Kageyama 2007), all of which showed clear differences between wild and captive populations. Recent research has also shown that there is an impact of captivity on the hydrogenotrophic microbiota of howler monkeys, which has important implications for howler monkey health (Nakamura et al. 2010).

Because of these anatomical and physiological adaptations, it is assumed that howlers require a low protein intake. However, various studies suggest that they obtain great amounts of protein from young leaves, shoots and buds (Milton 1980; Silver et al. 2000; Serio-Silva and Rico-Gray 2002). Moreover, various authors have demonstrated that howler monkeys are very selective about the kinds of leaf buds they consume, favoring those that are rich in digestible proteins, amino acids, minerals, and different types of fiber (Milton 1980; Milton 1982; Silver et al. 2000). Many browse plant species provided in zoos are usually protein rich (Clauss and Dierenfeld 2008).

A basic aspect of diet formulation to meet the needs of captive New World monkeys includes proper protein-fiber ratio (da Rocha e Silva 2001). Properly formulated captive diets frequently consist of both a variety of leafy greens and vegetables, fresh browse, as well as a properly formulated commercial diet for folivorous primates, and an alternative protein source. Commercially available primate diets are highly recommended because they are balanced and contain adequate amounts of fiber (14 %) and crude protein (23 %) (Allen 1990). There are many commercial brands of primate diets available including Mazuri Leaf-Eater Primate diet (PMI Nutrition International), ZuPreem diet with 20 % protein, canned or dry (Premium Nutritional Products, Inc.), and Animal Spectrum Primate Diet's dry biscuits (18 % protein) (Animal Spectrum Laboratories). Additionally, when supplementation is necessary, Complan (H. J. Heinz Company) can be included in the diet (strawberry or vanilla flavors are very well accepted), especially if animals are undernourished. Special attention is focused on types of diets provided. Howler monkeys fed with legumes and cereals may suffer from changes in blood counts and chemistry profiles, such as an increase in alanine transaminase (ALT) and lymphocytosis. On the other hand, higher levels of albumin and bilirubin have been observed in captive howlers fed with diary products (Johnson et al. 2001).

When the leafy vegetable portion of the diet is provided at midday, it can increase activity and encourage natural foraging behaviors. As mentioned above, the inclusion of natural browse plant species is very important for the species' proper feeding ecology. Examples of nontoxic plant species cultivated in zoos and included

as foraging source for herbivore primates are: *Bischofia javanica, Coprosma repens, Catalpa speciosa, Eugenia cumini, Eugenia jambos, Eugenia paniculata, Ficus benjamina, Ficus macrophylla, Ficus microcarpa nítida, Ficus microcarpa retusa, Ficus religiosa, Ficus thonningii, Hibiscus, Morus alba, Tecomaria capensis,* and *Tipuana tipu.* Some of these plant species have been successfully fed to primates in North American zoo collections. A more extensive list of nontoxic browse fed to primates in zoos is also provided by Tresz (2003) (Table 12.1, Fig. 12.3).

Table 12.1 List of browse species generally considered safe for primates (adapted from Tresz 2003)

Common name (English)	Scientific name
Acacia	*Acacia* spp.
Queen Palm	*Arecastrum romanzoffianum*
Desert Broom	*Baccharis sarothroides*
Bamboo	*Bambusa* spp.
Carob Tree	*Ceratonia siliqua*
Palo Verde	*Cercidium* spp.
Lemon Grass	*Cymbopogon citrates*
Umbrella Grass	*Cyperus alternifolius*
Ficus	*Ficus* spp.
Hibiscus	*Hibiscus* spp.
Desert Fern	*Lysiloma microphylla*
Mint	*Mentha* spp.
Banana	*Musa* spp.
Cat Nip	*Nepeta cataria*
Cat Mint	*Nepeta faassenii*
Basil	*Ocimum basilicum*
Oregano	*Origanum vulgare*
Jerusalem Thorn	*Parkinsonia* spp.
Fountain Grass	*Pennisetum setaceum*
Date Palm	*Phoenix dactylifera*
Pine	*Pinus* spp.
Cottonwood	*Populas fremontii*
Mesquite	*Prosopis* spp.
Pumpkin	*Pumpkin*
Pomegranate	*Punica granatum*
Rose	*Rosa* spp.
Palmetto	*Sabal* spp.
Sugar Cane	*Saccharum* spp.
Gooding's Willow	*Salix goodingii*
Bulrush	*Scirpus* spp.
Tamarisk	*Tamarix* spp.
Yellow Bells	*Tecoma stans* (*flowers*)
Cape Honeysuckle	*Tecomaria capensis* (*flowers*)
Tipu Tree	*Tipuana tipu*
Cat-tails	*Typha* spp.
California Fan Palm	*Washingtonia filifera*
Mexican Fan Palm	*Washingtonia robusta*

Fig. 12.3 Female infant howler monkey *Alouatta pigra* feeding freshly cut *Ficus* sp. (photo by Rosalia Pastor-Nieto)

In general terms, the total daily amount of food is divided into two or more portions. This is to keep the animals busy by prolonging feeding times and simulating wild conditions. Although each portion may be balanced to meet the nutritional needs of all animals in a group, high-ranking individuals tend to achieve preferential access to high quality foods (Wolfensohn and Honess 2005). Hierarchy sometimes deters subordinates from climbing to feeding platforms (pers obs); therefore, it is crucial to verify that low-ranking individuals are also provided with a balanced portion of the diet. Mixed exhibits with two or more species of howler monkeys are not recommended. Size differences, such as those seen between *Alouatta pigra* and *A. palliata* may result in intimidation of the smaller *A. palliata,* forcing them to climb to less optimal feeding stations (pers obs).

12.4.2 Housing and Behavioral Enrichment

Captivity provides a very static environment compared to wild habitats, often resulting in reduction in animal attention, propensity to seek, problem solving, and reduced interests in novel items. *Environmental poverty*, defined as *"inappropriate social and physical environments in relation to the basic needs of primates"* (Hosey et al. 2009), may trigger a series of nonadaptive responses, such as increased aggressiveness, abnormal behaviors (such as coprophagy, lethargy, auto-mutilation), stereotypic

behaviors, inappropriate sexual behaviors (inappropriate mounts, hyper-sexuality or abnormal postures), inadequate immune response, disease, parasitism, and poor reproductive performance (Meyer-Holtzapfel 1968; Harlow and Suomi 1971; Mason 1991; Sapolsky 1993; Boere 2001; Hosey et al. 2009; Behie et al. 2010). Insufficient space and isolation are the most important characteristics of an impoverished environment (Hosey et al. 2009).

Conversely, *environmental enrichment* consists of a series of measures to modify these impoverished environments, with the goal of improving the physical and social potential of the animals, and therefore improving their quality of life by meeting their ethological needs (Hosey et al. 2009). Basic aspects of behavioral enrichment include minimal clinical interventions, minimizing and/or eradicating animal suffering, providing proper nutrition, adequate enclosure design and dimensions, promoting proper social conditions, and shaping novel and interesting environments by creating occupational therapies. Some examples of occupational therapies are food seeking on substrate, foraging plant species within the enclosure, nest-boxes, perches and refuges, promoting three-dimensional locomotion with ropes, tree trunks and/or branches, elevated feeding trays, and group housing (Novak and Suomi 1988; Woolverton et al. 1989; Boere 2001).

Moreover, enclosure design is not only linked to psychological well being but also to health. Considering that howler monkeys are tropical primates, housing has to take into account ambient temperature (optimal room temperature should be between 20 and 26 ° C), or an additional heat source should be provided. Another relevant, yet commonly overlooked, enclosure design is the position and location of feeding trays. Howler monkeys are arboreal primates adapted to feed and move on trees, and for this reason it is highly likely that they lack natural immunity to many terrestrial pathogens. Placing feeding trays on elevated platforms can aid in preventing further stress and disease. Enclosures for captive howlers should be designed to meet the needs of arboreal primates. Most zoos that hold howler monkeys include perches, nests, hammocks, and natural foraging vegetation within their facilities. Howler monkeys should be able to move in an elevated, three-dimensional environment (Hosey et al. 2009) (Fig. 12.4). In captivity, there is a tendency towards inactivity and a lack of use of the prehensile tail. Promoting natural feeding behaviors through enrichment activities, by varying the presentation of the diet encourages activity and use of the tail. Finally, enclosures should be designed with external and indoor sections and a heat source when low temperatures are expected to occur.

Aberrant behaviors are sometimes observed, like in *Alouatta clamitans* as described by Dada (2009). Among the most common pathologic behaviors are circle locomotion, head and body swinging, back hitting with tail, tongue flicking to observers, self-mutilation, flexing and stretching limbs, sexually directed behaviors, and aberrant eating. In this study, singled housed animals showed higher rates of stereotypic behaviors, among which locomotion in circles was observed in highest frequencies, especially before feeding hours, suggesting increased anxiety levels before feeding. Dividing the diet into a number of smaller portions and hiding them in different parts of the enclosure are good strategies to reduce levels of anxiety.

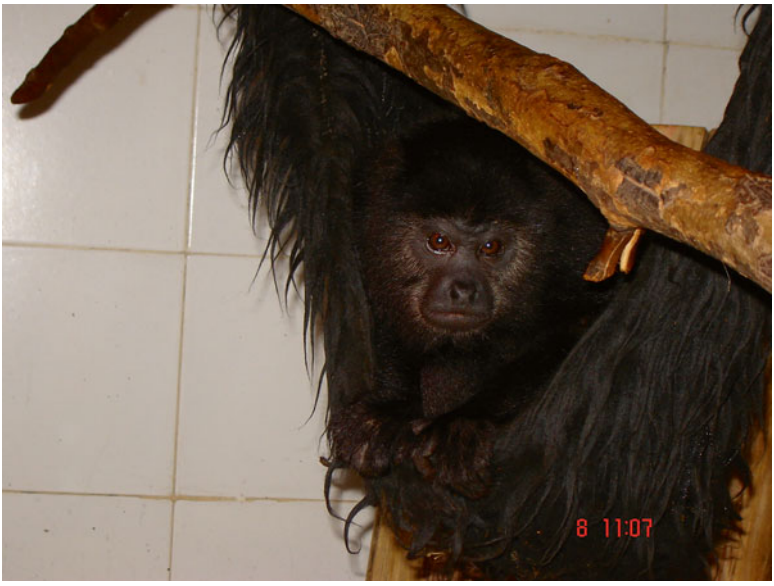

Fig. 12.4 Infant male *Alouatta pigra* resting on a hammock (photo by Rosalia Pastor-Nieto)

Social interactions with familiar conspecifics are essential for howler monkeys in captivity (Farmer et al. 2011). Other social events such as separation from the mother, a sibling or nursery peer, a cage partner, or a roommate are detrimental for howlers and may result in chronic stress and illness (pers obs). Another factor, possibly associated with captivity stress in some primate species is the visitor effect (Hosey et al. 2009), but its responses have not been yet evaluated in howler monkeys in captivity.

12.4.3 Injuries Associated with Improper Management

Conditions associated with overcrowding, lack of behavioral enrichment, and improper enclosure design may lead to otherwise avoidable animal injuries. In many cases, an increase in aggression is observed in overcrowded conditions, when a male sex-biased group is housed together, and when animals are maintained in improper facilities. The most common injuries include lacerations of ears, face, and fingers as a consequence of fighting. It is worthwhile mentioning that good knowledge of the behavioral characteristics of howler monkeys is essential to prevent injuries caused by fights, aggression, and infanticide (Crockett and Janson 2000). Captive howler managers should consider specific behavioral traits, such as signs of psychological well being. Factors such as group structure, hierarchy, and age are important factors to take into account to prevent aggressive behavior (Hosey et al. 2009).

12.5 Physical Examination and Restraint

General physical examination in howler monkeys includes dental examination, weighing, blood and stool samples, and rectal swabs for bacteriological cultures. It is also important to evaluate systolic arterial pressure and cardiac frequency, and to check for their coordination (Chagas et al. 2010). The pulse can be monitored at the lateral metatarsal area or at the femoral-inguinal region. The recorded clinical parameters are heart rate at 151–194 (bounce/min.), respiratory frequency of 19–25 breaths/min, systolic blood pressure at 154–163 mmHg, and rectal temperature ranging between 37.5 and 39 ° C. Oral and dental examinations are essential to discover oral lesions and dentition problems. The fur and skin of newly acquired howler monkeys should be checked for external parasites, miasis and bacterial infections, especially if suspected to be wild caught. Abdominal palpation is important for checking liver and kidney size, as well as the consistency of intestines and bladder palpation. Flexion and extension of the limbs to check for range of motion and articular flexibility can be crucial in cases of contracture and arthritis due to captive conditions. Venipuncture for blood samples is in the femoral vein, located in the femoral triangle. The use of a vacutainer is usually recommended to avoid excessive handling of primate blood. Reference hematological values for *Alouatta* are reported elsewhere (Canales et al. this volume).

To perform a thorough medical examination, improved immobilization techniques have made the restraint of monkeys much safer. Before manually restraining a howler monkey, there are several factors to consider, such as the animals' physical and health condition, temperament, duration of restraint, and the handler's experience (Ølberg 2007). Other important factors involved in successful animal handling are enclosure design and careful planning. It is very important that captive howler monkeys are housed under conditions that allow for safe handling without anesthesia. This may be accomplished by a combination of properly designed facilities and management practices allowing selective movement of animals (Bush 1996). The common capture and restraint techniques for howler monkeys are netting and holding the arms and neck while wearing leather gloves.

If chemical restraint is used, ketamine hydrochloride is generally a safe drug that has been widely used with excellent results (Ølberg 2007; Sainsbury et al. 1989). It can be used alone or in combination with other agents. Ketamine can be administrated within a wide range of doses, depending on the effect and duration desired. Ketamine is not recommended for painful or surgical procedures. Occasionally, hyperthermia might be observed in howler monkeys recovering from ketamine anesthesia. This condition is associated with increase of muscular activity, resistance to handling and abnormal respiratory function, which in turn promotes lactic acid accumulation. Therefore it is always important to monitor body temperature during anesthesia (Mosley and Gunkel 2007).

Other dissociative combinations such as tiletamine and zolazepam may be used for anesthesia induction and are highly recommended because of their short induction period and good muscle relaxation (Glander et al. 1991; Agoramoorthy and Rudran 1994; Karesh et al. 1998). Other induction and immobilization

combinations used in primates are ketamine and midazolam, and ketamine and medetomidine (medetomidine reversed with atipamezole) (Vie et al. 1998; Ølberg 2007; Chagas et al. 2010). Inhalational general anesthetics such as isoflurane, halothane, or sevoflurane are ideal for long and painful procedures such as surgery.

12.6 Infectious Diseases

Captive howler monkeys are exposed to two main sources of disease: those that are naturally acquired while they are in the wild, and those that are related to captivity (Woodruffe 1999; Karesh et al. 2005). A broad summary of diseases acquired both in the wild and/or in captivity is provided in Table 12.2. Of particular concern are monkeys going through a captive rehabilitation process being potential carriers

Table 12.2 Reported infectious diseases of howler monkeys acquired in the wild and in captivity (viral, bacterial, and parasitic)

Disease	Etiological agent	References
Viral		
Dengue	Flavivirus	de Thoisy et al. (2000)
Yellow fever	Flavivirus	de Thoisy et al. (2000), De Rodaniche and Galindo (1957), Collias and Southwick (1952)
St. Louis Encephalitis	Flavivirus	de Thoisy et al. (2000), Holzmann et al. (2010)
Mayaro	Alphavirus	de Thoisy et al. (2000), Talarmin et al. (1998)
Papiloma	Papillomavirus	Sá et al. (2000)
Bacterial		
Ricketsiosis	*Haemobartonella*	de Thoisy et al. (2000)
Oportunistic/septicemia	*Chromobacterium violaceum*	Baldi et al. (2010)
Shigellosis	*Shigella flexeneri, S. sonnei*	Catao-Dias (2001)
Campylobacteriosis, Salmonellosis, Yersiniosis, Colibacilosis	*Campylobacter* sp.	de Souza Júnior et al. (2008)
	Salmonella sp., *Escherichia coli*	Banish et al. (1990), Juan-Sallés and Valls (1999), Joslin (2003), Oftedal (1991),
	Yersinia sp.	Kourany and Rossan (1971)
Mycosis	*Paracoccocidioides brasilensis*	Corte et al. (2007)
	Candida sp.	Gross et al. (2009)
Parasitic		
Protozoan parasites		
Babesiosis	*Babesia* sp.	de Thoisy et al. (2000)
Malaria	*Plasmodium* (*P. brasilianum, P. vivax, P. falciparum, malarie*)	Fandeur et al. (2000), de Thoisy et al. (2000), Duarte et al. (2006)

(continued)

Table 12.2 (continued)

Disease	Etiological agent	References
Chagas	*Trypanosoma*	de Thoisy et al. (2000)
Amibiasis	*Entamoeba* (*E. hystolytica, E. coli, E. polecki*)	de Thoisy et al. (2000), Stoner (1996), Stuart et al. (1990), Cristóbal-Azkarate et al. (2010), Stoner and González-Di Pierro (2006)
Toxoplasmosis	*Toxoplasma*	Bouer et al. (1999), Pena et al. (2011)
Enteromoniasis	*Enteromonas*	de Thoisy et al. (2000)
Tricomoniasis	*Trichomonas*	Carmona et al. (2005)
Parasitic enteritis	*Chilomastix*	Stoner (1996)
	Giardia	Stoner (1996)
	Isospora	Stoner (1996)
	Retortomonas	Stoner (1996)
	Balantidium	Stoner (1996)
	Giardia	Kowalewski et al. (2011)
	Criptosporidium	Kowalewski et al. (2011)
	Entamoeba coli	Eckert et al. (2006)
	Iodamoeba butschlii.	Eckert et al. (2006)
Pleuricellular parasites		
Gastrointestinal Nematodes	*Trypanoxyuris*	Pastor-Nieto (1991), Stoner (1996), Stuart et al. (1990), Cristóbal-Azkarate et al. (2010)
	Ascaris	Stoner (1996), Stuart et al. (1990), Cristóbal-Azkarate et al. (2010)
	Tricostrongylus	
	Ancylostoma	Stoner (1996)
	Parabronema	Pastor-Nieto (1991), Cristóbal-Azkarate et al. (2010)
	Enterobius	Stoner and González-Di Pierro (2006)
	Controrchis	Pastor-Nieto (1991), Stuart et al. (1990), Cristóbal-Azkarate et al. (2010), Kowalzik et al. (2010)
Cestodes	*Railletina*	Stoner (1996)
Filaria	*Dipetalonema*	de Thoisy et al. (2000), Notarnicola et al. (2007)

of diseases acquired in the wild. In the following sections, reported and potential diseases of howler monkeys are summarized. This information is very useful for captive managers in order to prevent disease transmission from newly acquired monkeys, especially in zoos and institutions located in endemic areas of disease to which howler monkeys are susceptible.

12.6.1 Viral Diseases

Recent studies have demonstrated that *Alouatta* are wild hosts/carriers of a variety of arboviruses. Howler monkeys appear to be particularly susceptible to yellow fever (YF) (Holzmann et al. 2010; Monath 1988; Galindo 1973), with extensive populations suspected to having been decimated in the 50s (Collias and Southwick 1952; Koontz et al. 1994; Pope 1966). Field research has shown that howler monkeys may be hosts to vector-borne infections, such as dengue, yellow fever, St. Louis encephalitis, and Mayaro fever (Talarmin et al. 1998; Fandeur et al. 2000; de Thoisy et al. 2000; Duarte et al. 2006). All of these diseases have been reported in wild specimens, and there are no reports for captive populations. Although it has been established that *Alouatta* is highly susceptible to arbovirus infections, such as yellow fever (de Rodaniche and Galindo 1957), this disease as a population regulating factor of howler monkeys is subject to controversy (Milton 1996). Recent field studies show a high seroprevalence of yellow fever titers in howler monkeys in South America, demonstrating that the virus is still circulating among wild primate hosts in endemic regions (de Thoisy et al. 2000; Holzmann et al. 2010). Recently, an outbreak of sylvatic yellow fever in Rio Grande do Sul, Brazil, caused the death of 2,013 howler monkeys (de Almeida et al. 2012). Yellow fever is a vector-borne disease, transmitted by various genera of mosquitoes. However, the main vectors, in Central and South America, are *Haemagogus* and *Sabethes*. Yellow fever is considered a re-emergent hemorrhagic fever. The lesions produced include icterus, renal and hepatic necrosis, and hepatic fatty change. The pathognomonic lesion is a peculiar hyaline change in necrotic hepatocytes or Councilman bodies (King 1976). It is important to consider that the re-emergence of yellow fever in wild howler monkeys is a stochastic epidemic that may pose a threat to their conservation.

Other serologic surveys have recently revealed that arboviral diseases such as dengue and St. Louis encephalitis are also present in wild individuals of *Alouatta* in South America (de Thoisy et al. 2000). The information generated by this recent research is most useful for captive howler monkey managers in endemic areas of these diseases of Central and South America, to prevent transmission and infections in zoos. Other viruses include one case of papillomavirus (confirmed by immunohistochemistry), which produced papular stomatitis (Sá et al. 2000), and seroprevalence of cytomegalovirus in free-ranging *Alouatta caraya* (Ferreyra et al. 2012).

12.6.2 Enterobacterial Diseases

Gastrointestinal bacterial infections are among the most common causes of death in confined *Alouatta*. However, most bacterial infections are difficult to assess mainly because they are caused by opportunistic normal flora, and are concomitant to captivity stress (King 1976). There are five enterobacteria of major concern in captive primates. These are *Shigella* (*S. flexeneri* and *S. sonnei*), *Salmonella* (*S. typhimurium*),

Campylobacter jejunii, *Yersinia*, and *Escherichia coli.* All are causal agents of enteritis of varying degrees of severity, and all are considered zoonoses and anthropozoonoses. In all of them, transmission occurs by indirect routes, by contact with carriers and contaminated objects and foods (de Souza Júnior et al. 2008; Catao-Dias 2001). Clinical signs include blood and mucus in feces. Fecal cultures and antibiograms are essential for effective treatment, although a negative fecal culture may not exclude infection. Examination of Giemsa-stained smears for the presence of leucocytes, and general coprologic exams with Gram stained smears, have proven to be reliable methods to detect invasive bacterial or enteric infections (Benjamin 1988). During antibiotherapy, diarrhea, and probiotic ministration, the hydrogenotrophic microbiota is dramatically affected (Nakamura et al. 2011), and should consider this side-effect. These infections should be treated swiftly, as they can potentially derivate into septicemia (Zanotti-Cavazzoni and Goldfarb 2009). Bacteriological cultures and antibiograms are essential for adequate antibiotherapy to treat these infections.

Captive howler monkeys can be potentially infected with *Salmonella* and *Shigella* (de Souza Júnior et al. 2008), and there was one case report of a subcutaneous abscess associated with *Salmonella typhimurium* in *Alouatta* (Kourany and Rossan 1971). Reports also indicate that *Shigella* continues to be a significant and frequent cause of diarrhea (McClure 1980; Paul-Murphy and Wolff 1993; Banish et al. 1990). Interestingly, *Shigella* has been identified in normal and dysenteric stools of *Ateles* shortly after capture (García 1976). Monkeys infected with *Shigella* might remain as chronic asymptomatic carriers. It is also suspected that acute clinical disease may be precipitated in *Shigella* carriers by a variety of stressful situations. Gastroenteritis outbreaks in captive primates are commonly associated with substandard housing conditions and inadequate food management. Shigellosis has been characterized clinically and pathologically, and the main lesions observed include enteritis, gastritis, and colitis (Banish et al. 1990; Oftedal 1991; Juan-Sallés and Valls 1999; Duarte and Estrada 2003; Joslin 2003).

Salmonella is also known to produce subclinical to acute enteritis in New World primates (Brack 1987; Joslin 2003). *Salmonella* is a classical zoonosis, with food contamination being the main transmission route, and is commonly associated with enterocolitis under stressful situations (McClure 1980; Scott 1992; Ketz-Riley 2003).

Bacteriological diagnosis through routine techniques is very important to provide adequate treatment (Joslin 2003), although modern molecular techniques are currently used (Muldrew 2009).

12.6.2.1 Management of Diarrhea

Water is the single most important nutrient necessary for the proper functioning of cells. Electrolytes present in bodily water are essential for organic function, and vary in concentration depending on age and physiological state. Fluid therapy, in conjunction with antimicrobial agents, is imperative for the treatment of severe diarrhea in nonhuman primates. Infants and young howler monkeys are prone to

developing dehydration and may become comatose within a few hours of the start of severe diarrhea, making fluid therapy critical. Lactated Ringers and 5 % dextrose solutions are isotonic and may be used for intravenous or subcutaneous fluid replacement. Accessible sites for venoclysis include the saphenous, antecubital, femoral, and jugular veins. Subcutaneous and intravenous rehydration is also possible. In severely dehydrated animals, a cut down procedure to access the femoral vein may be necessary. Standard fluid therapy in primates consists in administrating intravenous solutions at a rate of 100 mL/kg/24 h.

Oral or subcutaneous fluids are recommended in mild or moderate cases. After initial parenteral rehydration, oral electrolytes (oral electrolyte rehydration solution recommended by World Health Organization) should be provided for 2 or 3 days, followed by glucose containing preparations such as apple or grape juice. In very young animals the provision of a highly caloric diet is also important. Complete dietary preparations such as Ensure or PediaSure (Abbot Laboratories) or Complan (Complan Nutritional Products) are indicated when animals are undernourished or in critical health. Prevention incorporates hygienic measures in diet preparation.

12.6.3 Bacterial Diseases of the Respiratory Tract

Chronic and untreated respiratory diseases, in howler monkeys and other primates, may derivate as airsacculitis when mucus and inflammatory debris are accumulated in the guttural sac (Fig. 12.5). Cough, halitosis, and nasal discharge are the most frequently observed clinical signs of airsacculitis. Approaches to the management of airsacculitis include combinations of medical and surgical therapies (Jones 1997; Hill et al. 2001; Lowenstine 2003; Lawson· et al. 2006). These therapies often require the drainage of exudate from the air sac, antibiotherapy, mucolytics, and nebulization (with mucolytics and antibiotics). It is important to perform bacterial cultures for proper diagnosis.

Respiratory diseases of bacterial origin are extremely common in newly acquired animals, especially when they are debilitated and/or parasitized. Most acute outbreaks of respiratory disease are multifactorial, produced by the combined action of two or more bacterial agents, and/or bacteria-virus associations (McClure 1980; Wallach and Boever 1983; Butler et al. 1996; Osborn and Lowenstine 1998; Petit and Gosi 2002; Joslin 2003). The most common agents of respiratory disease identified in New World monkeys are *Staphylococcus* (*S. aureus, S xylosus*)*, Streptococcus zooepidemicus, Klebsiella pneumoniae, Pasteurella haemolyitica, Haemophilus* sp.*, Pneumococus* sp.*, Proteus mirabilis,* and *Citrobacter freundii* (Osborn and Lowenstine 1998). However, most of these bacteria may also affect other organ systems, as well as generating systemic illness. For instance, *Staphylococcus* and *Streptococcus* infections tend to be localized in the upper respiratory tract, and are a major cause of pyogenic otitis, tonsillitis, and airsaculitis. Pneumonia produced by *Streptococcus* is characterized by the observation of polymorphs, fibrin-purulent exudates in alveoli, pleura, and pericardium (Catao-Dias 2001).

Fig. 12.5 Airsaculitis in a male howler monkey *Alouatta pigra*. Note the accumulation of purulent exudate in guttural sac (photo by Rosalia Pastor-Nieto)

Other lesions produced by *Streptococcus* are concomitant to septicemia and the most serious presentation involves suppurative meningitis and hydrocephalus (Scott 1992). *Staphylococcus* infections rarely turn systemic; however, when they do, they may cause acute myocarditis, characterized by multiple micro abscesses with hemorrhagic borders. Basic preventive measures include proper housing and management conditions. Preventive measures for respiratory disease include adequate nutrition, meeting caloric and protein, and vitamin requirements, and control of ambient temperature.

There is a recent report of a case of opportunistic bacterial infection by *Chromobacterium violaceum* in a wild howler monkey (*Alouatta palliata*) in Costa Rica (Baldi et al. 2010). Although *C. violaceum* has been characterized as a saprobe, it is also well known for its ability to act as an infectious agent in humans. The disease is systemic with the development of septicemia, skin ulcers, pulmonary and liver abscesses. Septic shock and multiple organ failure commonly result in the death of infected individuals.

There are no reports of tuberculosis in captive *Alouatta*. However, Scott (1992) describes a few cases of tuberculosis in captive *Ateles*. Tuberculosis screening is not recommended in captive howler monkeys unless a colony is suspected of having a possible outbreak or has been in contact with an infected person or animal. Apparently, the route of extension of the bacilli varies among primate species. It is suspected that the main spread route is the lymphatic system, and New World primates possess no thoracic duct. Therefore, the spread of infection and distribution of lesions are different between Catharrhines and Platyrrhines (Fiennes 1967).

Signs of tuberculosis include rough coat, weight loss, weakness, cough, enlarged lymph nodes and diarrhea, and animals may remain asymptomatic until late in the course of the disease. Because of the zoonotic risk of this disease, treatment is not recommended in primates and euthanasia of infected animals is considered.

12.6.4 Parasitic Diseases

A wide variety of parasitic infestations have been reported in Neotropical primates. Intensity of social interactions and high population density facilitates parasitic infections (Stoner and González-Di Pierro 2006). Therefore, overcrowding in captivity might be a predisposing factor associated with parasite infections. For captive howlers, provision on elevated feeding trays, perches, and locomotion in a three-dimensional environment may serve as essential preventative measures for parasitic infections, as, in the wild, they tend to move down the trees to defecate in specific sites, presumably as a parasite avoidance strategy (Gilbert 1997; Kowalewski and Zunino 2005).

12.6.4.1 Endoparasites

There are reports on amoebiasis and giardiasis in captive *Alouatta* indicating that *Alouatta* could be an asymptomatic carrier (Stoner and González-Di Pierro 2006; de Thoisy et al. 2000; King 1976). In many cases, the development of heavy parasitic loads is concomitant to captivity stress, chronic illnesses, undernutrition, and lack of hygiene. Signs of amoebiasis may range from mild or intermittent diarrhea, to acute dysentery with blood and mucus. *E. histolytica* cysts can be found in wet smears from colonic contents, but may also be identified in histologic examinations. Shedding is intermittent so repeated examinations are necessary. Fluid therapy is an essential part of treatment in acute cases (see Sect. 12.6.2.1). It is also important to treat both cyst and trophozoite presentations. Prevention incorporates hygienic measures in diet preparation to cut fecal-oral infection (Fig. 12.6).

Cases of intestinal *Tricomonas* infection have been reported in captive howler monkeys and other primate species (Brady et al. 1988; Brack et al. 1995; Carmona et al. 2005). In many cases, animals are asymptomatic. Enteritis caused by trichomonads is usually an opportunistic infection. The trichomonads inhabit the cecum, and have a tendency to penetrate the mucosal epithelial layer, causing desquamation of entire crypts.

Giardiasis is an enteric infection very commonly observed in captive primates with close contact to humans (Volotão et al. 2008; Kowalewski et al. 2011). Ingestion of contaminated food and/or water is the most common transmission route. *Giardia* thrives in the upper gastrointestinal tract (duodenum and jejunum), where it attaches to the intestinal mucosa. As a consequence, it damages microvilli, producing malabsorption of fats and carbohydrates. Clinical signs include diarrhea with

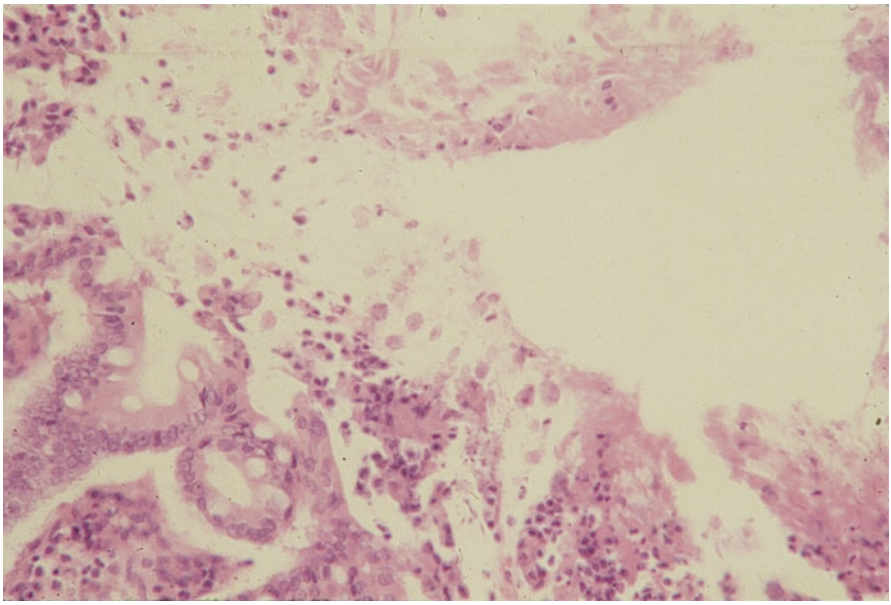

Fig. 12.6 Photomicrograph of a colon section of a howler monkey *Alouatta palliata,* with caliciform hyperplasia, inflammatory infiltration, and necrosis. Note some parasitic structures at lumen, which are compatible with *Entamoeba* (Hematoxylin-Eosin stain) (photo by Rosalia Pastor-Nieto)

mucus, cramps, gas, anorexia, vomiting, and fever. Cases of *Balantidium coli* have also been reported in captive *Alouatta* (Scott 1992). Monkeys infected with *Balantidium* may suffer from acute diarrhea or remain asymptomatic for years (King 1976; Catao-Dias 2001).

Other parasitic infections of medical importance are toxoplasmosis, malaria, and Chagas disease (Bouer et al. 1999; de Thoisy et al. 2000; Pena et al. 2011). In general, toxoplasmosis is acquired by primates in captivity mainly through contact with cat feces and uncooked red meats that are contaminated with oocysts and/or cysts. Signs of illness include decreased appetite, sluggishness, anorexia, and depression. Once animals are infected, the course of the disease tends to be acute and fatal, causing hepatomegaly, lung edema, liver multifocal necrosis, splenomegaly, and mesenteric fibrinohemorrhagic lymphadenitis (Scott 1992). Pulmonary disease ranging from congestion to pneumonia seems to be a consistent finding (Potkay 1992). Chagas disease is caused by *Trypanosoma* spp. It is a vector-borne parasitosis, in which triatomid bugs are the main vectors. The main lesions identified in trypanosomiasis are endocarditis and hyperplasia of reticulo-endothelial cells of liver and spleen. Trypanosomiasis is diagnosed in blood and/or organ smears or sections and through serological tests.

Malaria is a vector-borne re-emergent disease, transmitted by mosquitoes from the genus *Anopheles* (Deane 1976; Fandeur et al. 2000). Endemic areas in the

Americas are Panamá, Colombia, Venezuela, Peru, and Brazil. Howler monkeys infected with malaria may remain asymptomatic. Infected animals may suffer from anemia and a 72-h fever cycle (Quartan malaria). Special attention should be placed in preventing howler malaria cases in captivity in endemic regions, and vector control is the main recommended preventive measure.

In captivity, it is very common to observe positive coproparasitoscopic examinations on newly acquired howler monkeys, and treatment should always be aimed as a preventive measure. Reports on helminth parasites in *Alouatta* include *Trypanoxyuris minutus, Controrchis biliophilus, Parabronema bonnei, Mansonella* spp., and *Dipetalonema gracile* (Dunn 1968; Pastor-Nieto 1991; Castillejo-Allard 1993; Aceves Rivera 1995; Hermida-Lagunes et al. 1996; Bouer et al. 1999; de Thoisy et al. 2000; Bonilla-Boheno 2002; Abogado-Reyes 2005; Vitazkova and Wade 2006; Stoner and González-Di Pierro 2006; Trejo-Macías et al. 2007; Aguilar-Cucurachi et al. 2007; de Souza Júnior et al. 2008; Notarnicola et al. 2007; Valdespino et al. 2010; Cristóbal-Azkarate et al. 2010; Alvarado-Villalobos 2010; Pena et al. 2011).

Trypanoxyuris is located in the caecum, colon, and rectum of hosts, and, depending on the degree of infestation, may remain nonpathogenic. Typical manifestations of oxyuriasis are perianal pruritus, produced by female ovoposition in anal mucosa. Lacerations, and bacterial and mycotic infections around the anus, might be consequences of continuous scratching. However, in severe *Trypanoxyuris* infestations, colitis and/or hemorrhagic enteritis may occur (Fig. 12.7).

Fig. 12.7 Photomicrograph adult female nematode *Trypanoxyuris minutus* found in feces of a troop of wild howler monkeys at the Agaltepec Island, Catemaco, Veracruz, Mexico. Note the characteristic swollen cephalic vesicle of females (×10, photo by Rosalía Pastor-Nieto)

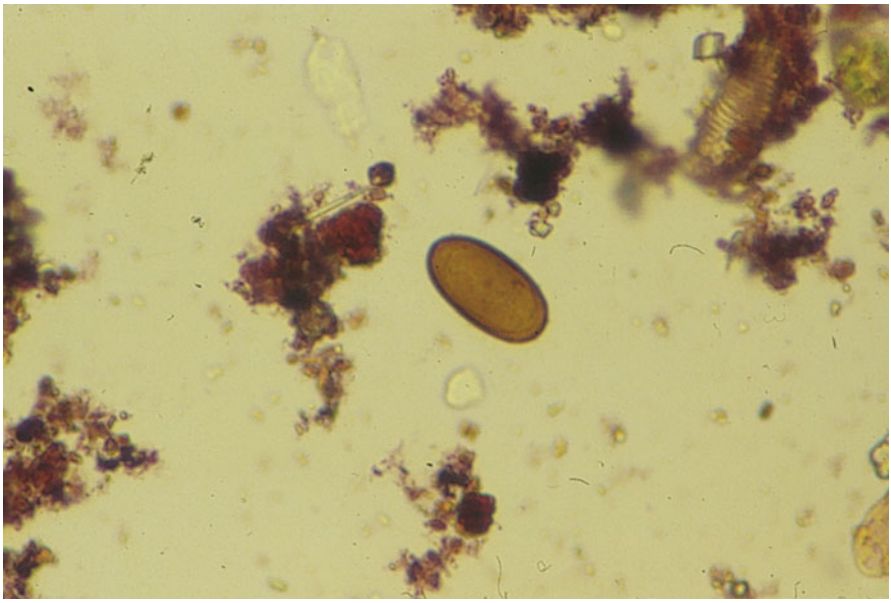

Fig. 12.8 Photomicrograph of the trematode egg of *Controrchis biliophilus*. This is an operculated egg found in a fecal sample of adult female howler monkeys at Chapultepec Zoo (×40, Photo by Rosalia Pastor-Nieto)

Although trematodiasis is only reported as incidental, it is worthwhile mentioning. *Controrchis biliophilus* inhabits the biliary passages of wild *Alouatta* and may remain for many years. The cycle of *Controrchis* requires two very different intermediate hosts: a snail and an ant (Kowalzik et al. 2010) (Fig. 12.8). Health implications are similar to other severe biliary trematodiasis: distension and irritation of biliary ducts, colecistitis, and cirrhosis in severe cases. *Parabronema bonnei* has been identified in howler monkeys (Pastor-Nieto 1991; Cristóbal-Azkarate et al. 2010). *Parabronema* is commonly located in the stomach. There are no reports on the health impact of this parasite in *Alouatta*; however it is possible that massive infestations might produce gastritis (Fig. 12.9).

12.6.4.2 Ectoparasites

Infestations with ectoparasites in howler monkeys are restricted to wild specimens and there are no reports in captivity. Myiasis or botfly infestations by *Alouattamya baeri* (King 1976: Milton 1996; de Thoisy et al. 2000; Pissinatti 2001) and *Cocliomya hominivorax* (cattle screwworm) have been reported in wild animals. Myiasis produces dermal cysts and secondary infections. Therapy consists of surgical extirpation of larvae.

Fig. 12.9 Adult male nematode *Parabronema bonnei* found in feces of a troop of wild howler monkeys at the Agaltepec Island, Catemaco, Veracruz, Mexico. Note the ventro-dorsal shields or plates (×40, photo by Rosalia Pastor-Nieto)

Pediculosis in Neotropical primates is commonly caused by lice of the order Anoplura. *Pediculus mjöbergi* is most commonly identified in wild *Alouatta* and *Ateles* (Pope 1966; King 1976; Karesh et al. 1998). Infestations by lice in captive howler monkeys have not yet been reported; however newly acquired animals need to be checked for parasite infection.

12.6.5 Mycotic Diseases

Mycotic diseases may develop in stressed and undernourished howlers. *Candida krusei* has been isolated from skin cultures of *Alouatta* (Gross et al. 2009). Mycotic cultures and identification of the agent are essential in order to provide proper anti-mycotic treatment. Other types of systemic mycosis are uncommon in captive howler monkeys. However, wild specimens are exposed to other infective fungi, such as *Paracoccidiodes* (Corte et al. 2007). In general, lesions induced by these agents are pyogranulomatous or granulomatous, and might be found in most internal organs such as lungs, brain, myocardium, mesenteric lymph nodes, liver, and spleen.

12.7 Noninfectious Diseases

Common nutritional and metabolic disorders in howler monkeys include metabolic bone disease, secondary hyperparathyroidism, howler monkey wasting disease, acute gastric dilatation, and arteriosclerosis.

12.7.1 Metabolic Bone Disease

Primates in captivity, including howler monkeys, are susceptible to and suffer from metabolic bone disease mainly deriving from secondary hyperparathyroidism. Metabolic bone disease should be considered as a consequence of husbandry mismanagement. Apparently, New World primates are more susceptible, due to a higher vitamin D requirement and/or a limited ability to use vitamin D_2, as there is evidence that vitamin D_2 is less active than vitamin D_3 in platyrrhines (Hunt et al. 1969). A possible explanation for this is the presence of a binding protein that acts as an interceptor when high levels of vitamin D are present in the blood (Meehan et al. 1996). Free-ranging howler monkeys possess higher circulating vitamin D metabolites compared to other captive New World monkeys (Crissey et al. 2003).

The main causes of metabolic bone disease are absolute calcium deficiency, calcium:phosphorus imbalance, vitamin D deficiency, and little or no exposure to UV light. In most cases, primates are provided with diets low in calcium or low in vitamin D_3, resulting in the excessive secretion of parathyroid hormone responsible of osteoclasia. A common manifestation is nutritional secondary hyperparathyroidism in howler and other New World monkeys and is characterized by chronic calcium reabsorption from bone, which may result in bowed and broken bones, lax appendicular joints, cupping of metaphyses, widening of epiphyseal plates, and thinning of the cortices, scoliosis, kyphosis, lordosis, and collapsed pelvis (Fowler 1978). Affected monkeys suffer from enlarged facial and mandibular bones (Ullrey et al. 1999). Most affected animals are unable to masticate solid foods or close their jaws. This enlargement of mandibular and maxillary bones is a compensating mechanism for osteoporosis, in which bone calcium is substituted by fibrous tissue. Dyspnea follows from occluded passageways and anorexia is common and associated with difficulties in mastication. Loss of *lamina dura dentes* causes loosening of the teeth (Swenson 1999; Paul-Murphy and Wolff 1993; Fowler 1978). Teeth may erupt in a haphazard fashion or fail to erupt. Elevated levels of serum alkaline phosphatase might also be observed due to osteoclasia (129 ± 28 UL as a range value in *Alouatta*, de Thoisy et al. 2000). Commercial diets vary widely in their vitamin D concentrations. Products balanced for New World primates provide higher levels than those designed for Old World species. However, it is necessary to verify vitamin D_3 concentrations in diets provided to captive *Alouatta*. In addition, exposure to sunlight and/or a UVB light source can be used as preventive measures. Depending on severity, oral or intramuscular cholecalciferol (D_3) together with a

balanced calcium:phosphorus diet (1.5–2:1 respectively) should be provided for affected animals. A total amount of 250 UI/day of cholecalciferol (D_3) meet the daily requirements and UVB transparent skylights in enclosures should be installed, if animals have restricted access to sunlight (Carpenter 2005.

12.7.2 Howler Monkey Wasting Disease

A retrospective report on captive howler monkey mortality revealed that 40 % of the animals died from chronic renal failure associated with wasting disease (Fontenot et al. 2004). Clinical signs of howler monkeys suffering from wasting disease include unresponsive diarrhea, hyporexia, cachexia, and rough hair coat, very similar to the ones observed in callitrichid primates suffering from wasting disease. Howler monkeys presenting these clinical signs have a very high mortality rate. At necropsy, renal and intestinal lesions include lymphoplasmocytic infiltrate, interstitial fibrosis, and kidney glomerular sclerosis, suggesting an autoimmune response.

The study of wasting syndrome in callitrichids indicates a central role of inflammatory intestinal alterations during pathogenesis (Gore et al. 2001). A multifactorial etiology in the development of enteritis is assumed, whereas immunopathological processes seem to be of major importance. Inflammatory lesions in intestines, kidney, and liver, as lymphoplasmocytic infiltrates have been described in callitrichids suffering from wasting disease (Araújo de Moraes et al. 2007). There is evidence that the inclusion of soy products, cereals, and milk products, in primate diets may trigger an immune response, which has been confirmed in intestinal biopsies (Gore et al. 2001). Dietary protein and energy concentrations are very important in preventing protein/calory malnutrition, which might also be associated with wasting syndrome in callitrichids (Crissey et al. 2003).

Wasting disease may have an important impact in captive howler monkey mortality, although detailed studies lack a retrospective analysis of postmortem findings on eleven deaths of mantled and Guatemalan black howler monkeys recorded between 2007 and 2008 at Chapultepec and San Juan de Aragón Zoo in Mexico City, revealed that in six cases there were signs of enteritis, appetite loss, diarrhea, and emaciation. Postmortem microhistology revealed inflammatory infiltrate is present in several organs, mainly in the kidney and intestines (Figs. 12.10 and 12.11). The type of inflammatory infiltrate described in all cases was confirmed as lymphoplasmocytic and was detected in intestines and/or kidneys in 50 % of all cases evaluated. The lymphoplasmocytic infiltrate described was similar to the one reported by Fontenot et al. (2004). Taking into consideration that in Chapultepec and San Juan de Aragón Zoos, ingredients included in diets incorporated baby cereals, an allergic reaction to gluten and other cereals proteins had to be ruled out as a potential cause of enteric malabsorption. These diets were also poor in alternative protein sources (Table 12.3). Therefore, antibodies for celiac disease were evaluated from deceased specimens kept in a serum bank. Initial findings revealed the presence of anti-gliadine, anti-endomisial, and anti-transglutaminase

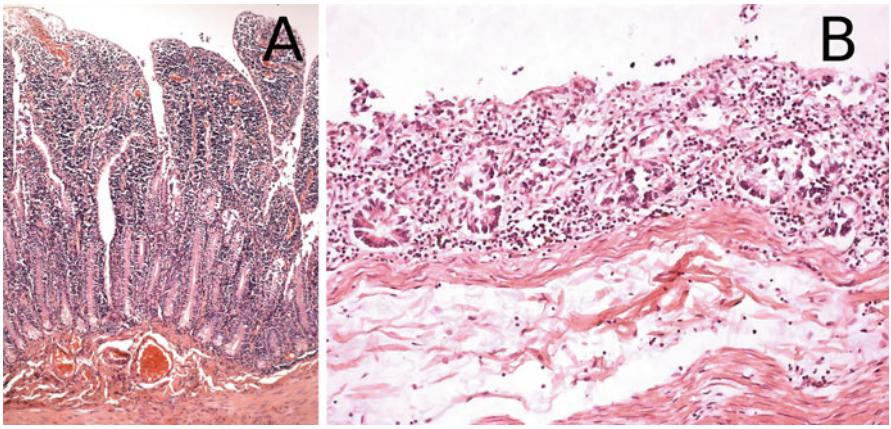

Fig. 12.10 Photomicrographs of atrophic intestinal mucosa with lymphoplasmocytic inflammatory infiltration in a howler monkey suffering from wasting disease: (**a**) widening of intestinal lamina propria caused by lymphoplasmocytic inflammatory infiltrate with moderate intestinal villi atrophy; (**b**) chronic lymphoplasmocytic enteritis with severe intestinal mucosa atrophy (photo by Rosaura Ruth Hernández Mote)

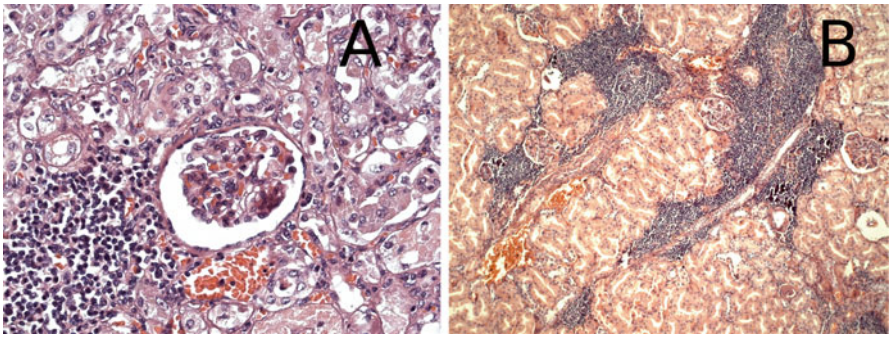

Fig. 12.11 Photomicrographs of different degrees of kidney inflammatory infiltration of lymphoplasmocytic cells in kidneys of howler monkey suffering from wasting disease: (**a**) lymphoplasmocytic nephritis with glomerular congestion; (**b**) severe lymphoplasmocytic infiltrate in kidney suggesting activation of the kidney as an immune compartment (photo by Rosaura Ruth Hernández Mote)

antibodies in 66.7 % of the cases (Table 12.4). More research on potential sensitivity to allergenic proteins and the activation of organs as immune compartments (Gluhovschi et al. 2010) is certainly warranted in *Alouatta*. Presumably, howler monkey wasting disease is a condition in which the lining of the small intestine is damaged by an allergic reaction to gluten and other allergenic proteins. By reducing ingestion of these allergenic proteins, a reduction in cases of howler monkey wasting disease is expected (Table 12.5). In similar cases, gluten-free diets in captive callithricids had positive effects by reducing cases of wasting disease in European zoos (Berndt et al. 2013).

Table 12.3 Howler monkey diet of Chapultepec Zoo rich in allergenic proteins

Ingredient (serves 1 monkey)	Description	Amount offered morning	Amount offered afternoon
Leaf eater primate biscuits[a]	Ground	150 g	150 g
Alfalfa	Fresh	1,000 g	
Romaine lettuce	Cut in 5 cm pieces	125 g	125 g
Ensure[b]	Fresh	100 g	50 g
Orange	Cut in 5 cm pieces	100 g	50 g
Papaya	Cut in 5 cm pieces	150 g	
Apple	Cut in 5 cm pieces	215 g	215 g
Banana	Cut in 5 cm pieces	100 g	100 g
Watermelon	Cut in 5 cm pieces	100 g	100 g
Sarabola[c]	Piece	100 g	100 g
Tecomaria and/or *Ficus* sp.	Freshly cut	Optional	

[a]Mazuri Primate Leaf Eater (PMI Nutrition International)
[b]Nutritional supplement (Abbot Laboratories)
[c]Baby cereals (wheat, oats, soy, barley) (Nestlé Company) mixed with sweetened yogurt, vitamins and probiotics

12.7.3 Acute Gastric Dilatation

Acute gastric dilatation occurs in many zoo primates, and howler monkeys are no exception. Gastric dilatation is caused by a variety of reasons such as chronic drug administration, food restriction, accidental overfeeding, and sugary diets. Monkeys may be found dead or may have clinical signs of colic, abdominal distention, and dyspnea. Death in untreated cases is due to impaired venous return and cardiopulmonary failure. Gastric distention with fermented gaseous ingesta and congestion of the abdominal viscera are the predominant lesions, and are related to intragastric fermentation associated with *Clostridium perfringens* and abnormal gastric function (Joslin 2003). Howler monkeys fed with excessive sugary diets, excessive amounts of fruit (such as mango), as well as prolonged antibiotherapy may cause gastric distention (Fig. 12.12a, b). For this reason, antibiotherapy should be administered with caution as it is one of the most common causes of gastric dilatation. Common antibiotics that cause this condition are penicillins (amoxicillin and ampicillin), lincosamides (lincomycin and clindamycin), aminoglycosides (gentamicin, amikacin), macrolides (erythromycin), and sometimes tetracyclines and cephalosporins (cephalexin) (Montali and Bush 1999).

Treatment consists of passing a stomach tube to relieve gastric gas and excess fluid buildup. Supportive therapy, including fluid therapy, antibiotics, analgesics, and corticosteroids for shock should also be initiated. The occurrence of bloat can be decreased by limiting food intake after fasting and anesthesia, changing diets gradually, feeding animals multiple times during the day, and the judicious use of broad-spectrum antibiotics that affect the gut flora (Montali and Bush 1999). It has been shown that antibiotic treatment can cause a pervasive disturbance in the microbial community composition, which requires more than 4 weeks to recover to the pretreatment state (Dethlefsen et al. 2008).

Table 12.4 Cases of howler monkey wasting disease evaluated at Chapultepec and San Juan de Aragón Zoos, Mexico City (2007–2008)

ID	Sex	Age at death (years)	Clinical signs before death	Microhistological lesions	Antibodies
Sacbé	Female	6	Appetite loss, diarrhea	Interstitial nephritis	Within range
			Emaciation	Glomerulonephritis	
			Blood and mucus in stools		
Sasil-Ha	Female	4	Appetite loss, diarrhea	Interstitial nephritis	Endomysial IgA 01:40
			Emaciation	Glomerulonephritis	Transglutaminase IgG 22
					Transglutaminase IgA15
Moncho	Male	12	Appetite loss, diarrhea	Tubular nephrosis	Within range
			Emaciation	Lymphocytic interstitial nephritis	
				Lymphoplasmocytic enteritis	
Je-Lipe	Male	4	Appetite loss, diarrhea	Tubular dilatation and atrophy	Gliadin IgG 25
			Emaciation	Lymphocytic interstitial nephritis	Gliadin IgA 23
				Lymphocytic enteritis	
Gelasio	Male	5	Appetite loss, diarrhea	Tubular nephrosis	Endomisial IgA 01:40
			Emaciation	Lymphocytic interstitial nephritis	Transglutaminase IgG 22
				Lymphoplasmocytic enteritis	Transglutaminase IgA 15
Willy	Male	7	Appetite loss, diarrhea	Membranous proliferative glomerulonephritis	Endomisial IgA 01:40
			Emaciation	Interstitial nephritis	Transglutaminasa IgG 22
				Lymphoplasmocytic enteritis	Transglutaminasa IgA15

Table 12.5 Modified howler monkey diets for adults and juveniles at Chapultepec Zoo Mexico, high in fiber and low in allergenic proteins

Adult diet				
Ingredient (serves 1 monkey)	Description	Amount offered morning	Amount offered midday	Amount offered afternoon
Leaf eater primate biscuits[a] + Ensure[b]	Mini biscuit soaked in nutritional supplement	200 g + 60 mL		
Vegetable mix (zucchini, green peas, green beans and carrots)	Cut in 5 cm pieces	400 g		
Mix of leafy greens (romaine lettuce, cabbage, celery, spinach)	Cut in 5 cm pieces	500 g		
Fruit (orange, apple, papaya, banana)	Cut in 5 cm pieces, only 1 fruit in rotation			150 g
Egg	Boiled, cut in halves	1 piece	Ad libitum	
Browse *Tecomaria, Ficus* sp.	Freshly cut			
Juvenile diet				
Leaf eater primate biscuits[a]	Mini biscuit	20 g	20 g	
Vegetable mix (zucchini, green peas Green beans and carrots)	Cut in 1 cm pieces	500 g	500 g	500 g
PediaSure[b]	Reconstituted	30 mL		30 mL
Chicken breast	Cut in 1 cm pieces	20 g		10 g
Browse *Tecomaria, Ficus* sp.	Freshly cut	Ad libitum		

[a]Mazuri Primate Leaf Eater (PMI Nutrition International)
[b]Nutritional supplements (Abbot Laboratories)

Fig. 12.12 Macroscopic lesions observed in a semi-captive specimen of howler monkey found dead at Parque Zoológico La Venta, Tabasco suffering from acute gastric dilatation: (**a**) gastric distention due to gas accumulation observed at necropsy; (**b**) distended intestines due to gas accumulation; serosal congestion and multifocal equimosis (photo courtesy of Parque Museo La Venta)

12.7.4 Arteriosclerosis

Arteriosclerosis is the accumulation of lipids in large and medium-sized arteries. Spontaneous arteriosclerosis has been reported in several New World species, including *Alouatta* (Manilow and Maruffo 1968). Differences between species include the location of coronary lesions, and may present congestive heart failure secondary to aortic valve lesions. In squirrel monkeys, whole egg supplementation has been associated with this condition (Paul-Murphy and Wolff 1993), but there are no relevant data for howlers.

12.8 Vaccination

Many species of primates are vaccinated for vaccine-preventable diseases of human childhood. The most common diseases vaccinated for are poliomyelitis, measles, mumps, rubella, tetanus, diphtheria, and pertussis. However, there are no reports of howler monkeys being infected by these diseases. However, several considerations should be taken into account before developing vaccination programs for captive howler monkeys, such as risk of developing the disease, efficacy of vaccine, and adverse reactions to the vaccination. Various studies have revealed a general low susceptibility of nonhuman primates to diphtheria, pertussis, mumps, and rubella (Loomis 1990). However, as mentioned before, vaccination should be considered depending on the prevalence of disease in human populations that are in contact with monkeys. In general terms, vaccination recommendations for Neotropical primates include vaccination against tetanus and measles. Vaccine trials on a variety of nonhuman primates have shown measles vaccine to be effective in producing titers with very few vaccine reactions. Nonhuman primates are susceptible to tetanus. Due to the ubiquitous nature of *Clostridium tetanae*, risk of exposure to spores should always be considered high, especially in captivity. *Clostridium tetanae* require penetrating wounds to produce disease, and these wounds are commonly a result of fighting. Tetanus vaccine has been proven to be safe and effective in most primate species including howlers. Additionally, vaccine schedules should be adapted from human schedules (i.e., tetanus at 2, 4, and 6 months of age; measles at 15 months and revaccination at 10–12 years of age).

12.9 General Conclusions for Howler Monkey Welfare in Captivity

Howler monkey care and husbandry in captivity have to take into consideration the ecological and behavioral adaptations of the genus. To be able to provide proper management, there are basic aspects to be considered such as digestive physiology and foraging and behavioral ecology. Orphaned infants requiring hand rearing

should be provided with a surrogate mother and proper milk formulas before ablactation. Infants and juveniles should be socially integrated with other conspecifics, whenever possible. Infanticide risk should be taken into consideration in captive groups. Adequate diet is one of the key factors associated with husbandry success. Zoos should offer a wide variety of fiber sources, such as leafy greens and natural browse, to promote healthy natural gut microbiota and digestion, and to prevent nutritional and metabolic disorders. Diets should be attractive, varied, and carefully balanced in fiber, protein, and low in starch, sugars, and allergenic proteins.

Adequate captive conditions need to be provided to allow three-dimensional movement, a proper space, indoor enclosures, controlled temperature, and hiding places. Enclosure design should consider the arboreal habits and use of the prehensile tail. The provision of foraging species within the enclosure is ideal to stimulate natural feeding behavior. Food should never be provided at floor level, and this is to prevent the contamination with terrestrial pathogens to which *Alouatta* lacks natural immunity. Behavioral and environmental enrichment measures need to be devised to prevent behavioral disorders. Psychological well-being of captive howlers is of paramount importance and social deprivation should be avoided. Monkeys should be provided with the opportunity to develop natural behaviors, such as socializing with conspecifics, seeking and selecting food items, and living within a dynamic and enriched environment.

Complete physical examination is achieved by chemical immobilization. Routine medical examination includes morphometry and physical and dental examination, blood sampling and weighing. Biological sampling using fecal and rectal swabs should also be included in the medical examination. Newly acquired howler monkeys should be checked for external parasites, miasis, bacterial and viral infections. Venipuncture for blood samples can be done in the femoral vein, located in the femoral triangle.

Most infectious diseases (bacterial and parasitic) are concomitant to stress, improper management, and inadequate captive conditions. Viral diseases of howler monkeys are of serious concern as most of them are zoonotic and transmitted by vectors. Among reported viral infections of howler monkeys are dengue, yellow fever, St. Louis encephalitis, and Mayaro fever. It is very important that zoos located in endemic areas of these diseases within Central and South America take the adequate preventive measures to protect howler monkeys and personnel. Enterobacterial diseases such as salmonellosis and shigellosis are a significant health risk for captive howler monkeys. Most enteric diseases are the main cause of dehydration, and as a result, antibiotics in combination with fluid therapy are necessary. However, using antibiotics can be detrimental, because it can eliminate the normal intestinal flora and allow pathogenic bacteria to flourish in its place, resulting in gastric dilatation. During antibiotic treatment, fecal transfaunation may be advisable obtaining healthy gastrointestinal microbiota from one healthy captive howler monkey.

Good husbandry practices incorporate hygienic measures in diet preparation, hygiene and disinfection of enclosures, and rodent control. Various bacterial agents are associated to respiratory disease in New World primates. Many of these agents are cause of airsacculitis, septicemia, and meningitis. To prevent respiratory disease it is important to provide adequate nutrition, meeting caloric and protein, and

vitamin requirements, and control of ambient temperature. Amoebiasis, giardiasis, and balantidiasis are common parasitic diseases of captive colonies of primates, and *Alouatta* is highly susceptible to these diseases. Prevention of gastrointestinal parasitism includes disinfection of fruits and vegetables and controlling water quality in zoos. Other parasites of medical relevance isolated from *Alouatta* are *Trichomonas, Toxoplasma, Plasmodium*, and *Trypanosoma.* To prevent these diseases, vector control and food hygiene within zoos are essential. A wide variety of helminth parasites have been identified in *Alouatta*, many of which are acquired in the wild. Ectoparasites such as botflies and lice have also been identified and should be checked in newly arrived specimens.

Other health concerns of captive *Alouatta* are preventable nutritional and metabolic diseases, such as metabolic bone disease, howler monkey wasting disease, acute gastric dilatation, and arteriosclerosis. These pathologies are commonly associated with poor nutrition and inadequate management, and are easy to prevent. Metabolic bone disease may be easily prevented with adequate intake of calcium:phosphorus ratio and vitamin D_3, as well as regular exposure to direct sunlight. Recent data indicate that wasting disease in howlers is associated with diets containing allergenic proteins. More research on potential sensitivity to allergenic proteins and the development of howler monkey wasting disease is certainly required. Meanwhile, special attention should be placed on avoiding food sources rich in gluten and allergenic proteins. Acute gastric dilatation in howler monkeys is related to sudden changes in gut microbiota. Diets rich in simple carbohydrates and prolonged antibiotherapy are predisposing factors. It has been shown that antibiotic treatment can cause a pervasive disturbance in the microbial community composition. Therefore, whenever antibiotherapy is necessary, careful selection of antibiotics and probiotic supplementation and/or fecal transfaunation are essential to recovery healthy gut microflora after treatment.

Vaccination recommendations are based upon whether captive colonies are located in endemic areas of specific diseases. Other factors to be evaluated are severity and risk of developing the disease, efficacy of vaccines, and adverse reactions. A basic vaccination scheme for New World primates and howler monkeys should also include immunoprophylaxis against tetanus.

All these issues provide the necessary background for establishing a rich and healthy environment for captive howler monkeys and create stable populations in captivity. Although howlers are very adaptive in nature, and even though it is a genus widely distributed throughout Central and South America, they are susceptible to many diseases that can easily deteriorate their health and threaten their wild populations. Given the alarming rate of destruction and fragmentation of howler habitats, wild populations are being seriously affected. If we ever need to recuperate wild populations we need to breed and correctly manage captive populations and meta-populations of these monkeys. For this, it is necessary to maintain healthy and robust captive populations. Joint efforts and collaboration between zoological institutions are also necessary. Moreover, research performed in captivity under controlled conditions will provide relevant information for any action plans designed to protect and conserve howler monkeys in the wild.

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