Special challenges of maintaining wild animals in captivity in South America

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Summary: The author summarises the occurrence of major diseases in wild animals maintained in captivity in South America. The epidemiology, impact and significance of the diseases are discussed, together with appropriate husbandry practices to control and prevent transmissible diseases. The following animal groups and pathologies are considered in this review:

- poxvirus dermatitis
- gastroenteritis, pneumonia, amoebosis and coccidiosis in reptiles
- management practices and diseases (including botulism, bacterial enteritis, psittacosis, aspergillosis and parasitic diseases in birds)
- enterocolitis, pneumonias and internal parasites in non-human primates
- canine distemper, parvoviruses, babesiosis, internal and external parasites in carnivores
- tuberculosis and enteritis in tapirs
- haemorrhagic disease in cervids.


INTRODUCTION

South America boasts a tremendous diversity of wildlife, and a considerable amount of research on the biology of the various species present on this continent remains to be done. The study of wildlife in captivity has contributed greatly to current biological knowledge. Zoos, wildlife breeding centres and research institutions are playing a vital role in this respect.

Projects relating to wildlife conservation and research have limited budgets in South America. Nevertheless, institutions have made considerable advances over the last decade. Most of the zoos in South America are maintained by municipalities, or state or provincial governments, but the number of private ventures is gradually increasing.

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This is proving beneficial for conservation strategies, and there is no doubt that the private sector and non-government incentives have an important part to play in nature conservation.

Husbandry practices are an essential aspect of the preservation of endangered species, preventing disease and encouraging animal reproduction. The challenges of maintaining wild animals in captivity are many and varied, and the objective of this brief review is to discuss management practices in relation to the occurrence and prevention of infectious and parasitic diseases in some animal groups.

REPTILES

Reptiles are ectothermic, which means that these species need an external source of warmth to maintain the correct internal body temperature. This direct dependence on environmental conditions makes reptiles highly susceptible to inappropriate husbandry practices. Metabolic processes, such as digestion of food and antibody production, are dependent on adequate temperature. Sub-optimal ambient and body temperatures impede the synthesis of antibodies. As a consequence, opportunistic pathogens may invade tissues and cause disease.

Particular attention must be paid to basic housing conditions. Temperature is obviously an important factor. Required humidity levels vary depending on the species. Inadequate humidity can lead to impaired shedding of the old skin. Potentially hazardous pathogens can be disseminated through contaminated water. The optimal photoperiod (‘day’ to ‘night’ ratio) varies, depending on the biology of the species involved. Exposing captive reptiles to constant light results in severe stress. Reptiles which have recently been introduced from the wild are particularly susceptible to diverse stress factors, and may need a period of adaptation to the captive environment. Ideally, cage substrate should not cause skin abrasion, nor be ingested (as this may cause obstruction and impaction). Substrate material should preferably have good absorbancy, and should not be a medium for the growth of bacteria. Cages should permit easy cleaning and disinfection.

Health status is also directly dependent on nutrition. Snakes, lizards, chelonians and crocodilians feed on specific items. Scientific information on the nutritional requirements of reptiles should replace the empirical feeding practices currently in use. Nutritional and metabolic diseases cause a high percentage of the losses in captivity. Commonly-observed nutritional disorders include anorexia, inanition and dehydration (associated with stress and maladaptation), metabolic bone disease, hypovitaminosis A in turtles, hypovitaminosis E/steatitis in crocodilians, and gout.

Poxvirus dermatitis

An outbreak of poxvirus dermatitis was reported in a commercial caiman (Caiman crocodilus yacare) farm in Brazil. The outbreak involved 15% of 20,000 caimans, and animals aged between five and nine months were affected (M.C.C. Ramos and E.R. Matushima, personal communication, 1995). The virus causes grey-white superficial skin lesions on the paws, palpebrae, maxillae and mandible. The disease is characterised by high morbidity and low mortality.
Bacterial diseases

A number of bacterial diseases have been reported in this class of animals. Gram-negative bacteria are prevalent in the normal microflora of the digestive tract of reptiles, including *Pseudomonas*, *Aeromonas*, *Klebsiella* and *Proteus*. One serious disease of captive snakes is infectious stomatitis, which is associated – in most cases – with unsuitable husbandry practices, malnutrition and decreased immune resistance.

In the Instituto Butantan (Brazil), necropsies conducted on 805 snakes of the genus *Crotalus* and 301 *Bothrops* over a period of thirty months indicated that gastroenteritis and pneumonia were the most frequent causes of mortality. Regular restraint (for venom extraction) and maladaptation to captivity are considered to be predisposing factors for the high mortality (13).

Omphalitis after birth, and wounds caused by antagonistic interactions, are reported as serious problems on caiman farms in Brazil (15). Husbandry practices which can help to prevent bacterial diseases include paying strict attention to the hygiene of the terraria and bedding material, providing good-quality water, ensuring adequate food consumption and removing all possible stress factors.

Parasitic diseases

The protozoan *Entamoeba invadens*, considered the most clinically significant parasite of snakes, has produced epizootics with high mortality in several zoo collections in South America. The boa (*Boa constrictor*) and the anaconda (*Eunectes murinus*) are species which are commonly infected.

Transmission of this highly infectious amoeba to snakes and lizards is effected mainly by chelonians and crocodilians, which are considered resistant carriers for *E. invadens*. Amoebosis causes a severe necrotic enterohepatitis. Ante-mortem diagnosis is made by observation of trophozoites or cysts in the stools of the affected snakes, or of amoebae in washings from the colon.

Recommended prophylatic measures to control and prevent the disease include strict quarantine for new arrivals, followed by three negative results in direct faecal examination. Other reptiles, especially turtles and crocodilians, should never be kept with snakes, and the water supplies of these distinct groups of reptiles should also be kept separate. Affected animals must be immediately isolated and treated; contaminated cages must be disinfected. Preventive treatment with metronidazole before leaving quarantine has been suggested. Effective prophylaxis depends on strict hygiene and water quality control.

Systemic coccidiosis was reported in caimans (*Caiman latirostris*) maintained in concrete tanks in Brazil. Eight adult caimans died over a twenty-day period. Post-mortem lesions were congestion of lungs, liver, spleen and kidneys, and haemorrhagic enteritis (3). Oocysts of *Isospora* spp. can be found in caimans, but pathogenicity is considered low. Only stressed animals develop the disease.

Several internal and external parasites are found in reptiles. Periodic physical examinations must be conducted to prevent diseases.

**BIRDS**

As the various groups of birds evolved, they each developed particular physiological and biological features. Providing general guidelines applicable to every group of birds is a challenging assignment, as peculiarities occur in every bird family. The primary
focus of this review is to report some of the most important parasitic and infectious diseases of captive birds in South America, and to provide guidelines for health management.

A considerable number of avian deaths in captivity could be prevented simply by implementing basic good husbandry practices. In general, diseases cannot be viewed as chance occurrences, but as pathological processes initiated by environmental, physiological or genetic factors detrimental to health. The more that is understood about the physiological necessities of animals in the captive environment, the better are the chances of achieving successful long-term maintenance and reproduction. Good husbandry and disease prevention practices must be enforced.

Management practices

Enclosures

Inappropriate aviary design favours the occurrence of accidents and diseases. It has been seen that many enclosures do not fulfil the basic needs of adequate space, shelter, privacy, security and hygiene. An aviary should provide protection against predators and adverse climatic conditions. Food and water containers should be located so that excrement contamination is reduced to a minimum. Perches should be secure and of adequate diameter for the size of the species exhibited. Nest boxes should be protected from rain and direct sunlight. Care must be taken that nesting material does not become a substrate for fungus growth. Aviary floors should always be designed with hygiene requirements in mind; a slight slope and a drainage system in the floor favour the removal of organic debris. Clean, fresh, uncontaminated water is a basic necessity for keeping birds healthy. Overcrowding may lead to antagonistic interactions and deaths.

Preventive medicine programme

Veterinarians should establish preventive medicine programmes, which may vary in accordance with a number of factors, including aviary design, the bird group involved, incidence of disease in the collection and geographical area. Quarantine procedures are mandatory to prevent the introduction of new pathogens into the collection. Preventive practices include periodic physical examinations, standard faecal examinations, periodic de-worming, prophylaxis of chlamydiosis, vaccination of populations at risk, and control of rats and other vermin. All birds which die must be submitted for necropsy.

Hygiene and sanitation

Good hygiene is critical to the prevention and control of diseases. In the captive environment, there is inevitably a concentration of organic debris and pathogenic organisms. Constant exposure of the birds to potentially pathogenic microorganisms increases the chance of infection and disease. Daily cleaning of aviaries is ideal; in breeding colonies, however, the constant human interference may reduce reproduction rates. Organic debris must be removed physically before using water hoses and
disinfectants. When disinfection is necessary, sodium hypochlorite, quaternary ammonium and phenol are commonly used. Food and water bowls should be made of stainless steel, hard plastic or ceramics to facilitate daily cleaning and disinfection.

**Nutrition**

An imbalanced diet represents a limiting factor in the reproduction of several species of birds in captivity. In the long term, incorrect diet results in weaker birds, which are more susceptible to disease and less able to reproduce. Scientific information on the nutritional needs of every bird species is essential to ensuring the health of birds and maintaining sustainable, genetically-viable populations in captivity. Formulated commercial diets for birds are not generally available in South America. Waterfowl and ground-dwelling birds are usually given commercial poultry food. Formulated diets for toucans, psittacines and other groups of neotropical birds seem not to be available and, as a consequence, empirical feeding practices are employed. Clinical conditions associated with malnutrition may be perceived only after a prolonged period of deficiency. Disorders consequent to malnutrition can affect virtually every organ or system. Birds should be provided with good-quality food items, which should be stored in a dry and well-ventilated area, thus preventing mould. Access by rodents and insects must be prevented.

**Diseases**

**Botulism**

Avian botulism results from ingestion of a neurotoxin produced by *Clostridium botulinum*. Outbreaks of botulism can be disastrous in a collection of aquatic birds. Favourable environmental conditions are necessary for the occurrence of the disease.

Outbreaks have been reported in zoos in South America. Botulism occurrence with high mortality was reported between 1980 and 1986 in the Buenos Aires Zoo (Argentina). Larvae of flies were involved in the cycle of the disease (1). In a park in Curitiba (Brazil), 27 ducks died in 1981 due to botulism. Beetles were found in the crop and ventriculus of the affected birds, and in the mud of the ponds (24). The author studied cases of botulism type C in South American terns (*Sterna hirundinacea*) in the summer of 1992, and in waterfowl in 1993. Both outbreaks occurred at the Curitiba Zoo (Brazil). Maggots were found in the ventriculus and intestines of the dead birds. Botulism in waterfowl with a high associated mortality also occurred in 1993 and 1994 in the Sorocaba Zoo (Brazil) (A.L.V. Nunes, personal communication, 1995), and recently in the São Paulo Zoological Park (Brazil) (J.D.L. Fedullo, personal communication, 1995).

Procedures to control the disease involve management of the environment (e.g. control of water quality and level of ponds), prompt removal and disposal of carcasses, removal of healthy birds from problem areas during an outbreak, and vaccination. A commercially-available mink botulism vaccine was used at the Denver Zoological Gardens (United States of America), after seven consecutive summer outbreaks; results suggest that the vaccine was highly efficacious (7). Mink botulism vaccines are not commercially available in South American countries, but a bovine botulism type C vaccine could serve as a substitute. An experimental trial using this vaccine might be indicated in collections where avian botulism is a problem.
Bacterial enteritis

Salmonella organisms may be pathogenic to birds, causing septicaemia and death. Subclinical carriers serve as a reservoir of these bacteria in the aviary. Free-living birds, rodents, insects and other vermin are considered vectors. Insanitary conditions favour the propagation of the bacteria. Salmonella Typhimurium caused the death of a hyacinth macaw (Anodorhynchus hyacinthinus) in a flock of smuggled birds confiscated at an airport in Brazil. Treatment with danofloxacin has proved to be effective (5). Practices to prevent the disease include quarantine (accompanied by culture of faeces from suspected birds), hygiene and disinfection of aviaries, and rodent and insect control. Other bacteria of clinical importance are Klebsiella, Escherichia coli, Pseudomonas, Staphylococcus and Streptococcus.

Respiratory diseases

Several aetiological agents are associated with respiratory diseases in birds. The number of clinical cases and deaths from respiratory diseases in captivity is high, especially in regions with a cold climate. A higher incidence of clinical cases occurs during the coldest months of the year. Enclosures which do not provide adequate protection against winds may favour the onset of an infectious process in the respiratory tract. Special attention should be paid to tropical birds which have been moved to subtropical areas; a period of acclimatisation is necessary, prior to release. The aetiology of avian respiratory disease can be nutritional (e.g. hypovitaminosis A), toxic (e.g. cigarette smoke and airborne pollution) or infectious (e.g. viruses, bacteria, fungi or parasites).

Chlamydia psittaci is an organism which may be the causative agent of respiratory diseases in psittacines. As few laboratories are equipped to isolate C. psittaci, the diagnosis is not usually confirmed. Preliminary results from a serological survey in seven clinically-healthy red-tailed parrots (Amazona [brasiliensis] brasiliensis) in a zoo in Brazil, revealed antibody titres in all birds tested (J.H. Fontenelle, personal communication, 1995). This suggests that incidence of psittacosis may be higher in South American zoos than is generally assumed. The zoonotic potential of this disease must be taken into consideration when handling psittacines and pigeons. Government regulations in some South American countries instigate preventive treatment prior to importation of exotic psittacines.

Aspergillus spp. are widespread mycotic agents which frequently cause granuloma or plaques in the lower respiratory tract. All bird species can be affected, but waterfowl, penguins and psittacines are especially susceptible. Conditions conducive to stress – such as transportation, malnutrition, oil contamination, insanitary conditions and overcrowding – contribute to the occurrence of this agent. Preventive treatment has been advocated after circumstances of continued stress (e.g. long-distance transportation). Itraconazole seems to be a safe and very effective treatment, depending on the extent of the lesion. Ketoconazole, amphotericin-B and flucytosine can also be used to treat aspergillosis. Proper husbandry, nutrition and hygiene are essential to prevent the disease. Early diagnosis improves the chances of cure, and X-rays are helpful in this respect.

Parasitic diseases

Capillaria spp. are the most common cause of toucan mortality in many zoo collections in South America. Long-term maintenance and reproduction of toucans has been hindered due to Capillaria infection, among other factors. Psittacines may
also be infected. The author reported *Capillaria columbae* as the cause of death of toco-toucans (*Ramphastos toco*) in Curitiba Zoo (Brazil) (8). Diagnosis is confirmed by detection of bipolar eggs in faecal flotation. Treatment with the usual anthelmintics has proven to be ineffective in some instances. Anthelmintics used to control capillariosis include pyrantel pamoate, mebendazole, febendazole and ivermectin. Birds in collections where *Capillaria* spp. are a problem should have a minimum of one faecal flotation per month. Birds which have access to the ground, and to food and water contaminated by faeces, tend to be subject to reinfection. Efforts should be made to destroy *Capillaria* eggs on the ground.

Ascarids are frequent internal parasites in psittacines and gallinaceous birds. Pathogenicity may vary between species. Mortality due to heavy ascarid infection has been observed in the purple-bellied parrot (*Trichlaria malachitacea*), pileated parrot (*Pionopsita pileata*) and conures (*Aratinga* spp.). Regular faecal flotation and de-worming are effective methods of controlling roundworms.

A fluke (*Ribeiroia insignis*) was described in a colony of five magellanic penguins (*Spheniscus magellanicus*), with 100% mortality (Fig. 1). Flukes had burrowed into the wall of the ventriculus, causing ulcers and haemorrhagic gastritis (Fig. 2). Treatment with triclabendazole is effective in the early stages of the parasitism (9).

**FIG. 1**

A fluke (*Ribeiroia insignis*) of approximately 2 mm in length, which caused mortality in a colony of magellanic penguins (*Spheniscus magellanicus*)
Gastrointestinal protozoans of clinical significance in captive birds in South America are *Coccidia* and *Histomona*. Coccidiosis has clinical importance in toucans and passerines. Asymptomatic birds which shed oocysts in faeces may develop severe clinical disease when the symbiotic parasite/host relationship is disrupted. Histomonosis is caused by the flagellated protozoan *Histomona meleagridis*, which causes ulceration and necrosis in the caecum and liver of gallinaceous birds.

**PRIMATES**

The extensive use of non-human primates in biomedical research has contributed to the evolution of medical primatology, and has yielded a number of publications dealing with the husbandry and diseases of these species. In recent years, emerging viral diseases of non-human primates – either in the wild or in captivity – have assumed increasing importance in biomedical investigation. Due to the zoonotic significance of these diseases, they have become an important subject of research. Literature is relatively scarce, however, on the prevalence of diseases in captive primates in South America. The pet trade in New World monkeys has regularly introduced an increasing number of animals into South American zoos which cannot be properly housed. The process of transition from the wild to the captive environment exposes animals to a variety of stresses. Repeated stress and an imbalanced diet may render an animal more susceptible to infectious agents than would normally be the case.
Diseases which most frequently cause mortality in captive New World primates are usually associated with inadequate nutrition and errors in management. Undernourished animals will usually offer little immunological resistance to opportunistic pathogens. Infectious diseases which frequently result in significant losses are bacterial enterocolitis, pneumonia and parasitism. This review is concerned primarily with spontaneous infectious diseases which have high incidence and mortality in New World monkeys.

**Enterocolitis**

Incidence and mortality due to enteritis in captive primates in South America are relatively high. Bacteria are the most frequent cause of diarrhoea. Protozoans, helminths and viruses may also be causative agents of gastrointestinal disorders.

Pathogenesis of infectious diarrhoea may be associated with improper diet, poor sanitation, mismanagement, and other physical and psychological stressors which would be conducive to immune suppression. The incidence of diarrhoea is higher in younger monkeys. Bacteria commonly associated with enteritis are *Campylobacter*, *Shigella* and *Salmonella*. Other enteric pathogens identified with less frequency in New World primates are *Klebsiella*, *Proteus*, *Pseudomonas*, *E. coli* and *Yersinia*. Detailed information concerning the epidemiology, pathology and pathogenesis, diagnosis and treatment of bacterial enterocolitis can be found in specialised literature (18).

An outbreak of diarrhoea due to *Campylobacter jejuni* in a breeding colony of tamarins (*Leontopithecus chrysomelas* and *L. chrysopygus*) was reported in the São Paulo Zoological Park (Brazil). Several individuals were identified as asymptomatic carriers (19). *C. jejuni* was also isolated from ten of fifteen *Saguinus mystax* with diarrhoea in a Peruvian colony (21). *Shigella* infection has been reported in laboratory marmosets and tamarins. This bacterium is frequently isolated in primates taken from the forest and exposed to factors conducive to stress.

Bacterial infections usually result from contact with humans, or with similar or different animal species. Newly-acquired animals should be quarantined for at least thirty days. Faecal cultures for *Campylobacter*, *Shigella* and *Salmonella* are advisable for primates in quarantine. Cleaning and disinfection of cages, and of feed and water containers, is highly recommended in preventing epizootics of bacterial enterocolitis. Chronic carriers should be identified and treated or eliminated from the colony. Sources of infection must be determined for outbreaks to be controlled.

Although lesions and clinical signs can vary slightly depending on the organism involved, a common clinical manifestation is mild to severe diarrhoea, which may appear haemorrhagic or catarrhal. Non-specific signs include depression, fever and dehydration. In the advanced stages, cure is difficult and mortality can be high.

Diagnosis is based on clinical signs and laboratory findings. As viruses and parasites are not the causative agents of the enterocolitis, bacteria need to be identified by microbiological culture. Antimicrobial susceptibility tests indicate the most effective antibiotics for treatment.

*Entamoeba histolytica*, a protozoan, can cause necro-ulcerative colitis. Diagnosis depends on the recognition of the causative agent in faeces or in the intestinal mucosa. *Giardia* and *Trichomonas* can be found in cebids and callitrichids, but pathogenicity is considered low.
Pneumonia

Bacterial pneumonia is a significant cause of mortality in captive primates. Incidence of this disease is higher during winter. Organisms which have frequently been identified as the causative agents are *Streptococcus*, *Staphylococcus*, *E. coli*, *Pasteurella* and *Klebsiella*. Inadequate husbandry contributes to an increase in the incidence of the pathology. High humidity in the shelter and enclosure, poor sanitation and ventilation, and improper cage design are factors which favour the emergence of the disease. Enclosure design must take into consideration the environmental and sanitation aspects necessary to prevent pneumonias and other diseases in primates.

Internal parasites

Internal parasites are common in New World primates. A summary of internal and external parasites is found in specialised publications (21, 26). Many helminths occur sporadically and appear to exist in balance with the host. When this equilibrium is disrupted by various stress factors, clinical disease and mortality ensue.

At the Rio de Janeiro Primate Centre (Brazil), Callitrichidae of several genera are commonly infected by an acanthocephalid, *Prosthennorchis elegans* (A. Pissinat, personal communication, 1995). Parasites attach their proboscis to the walls of the ileum, caecum and colon with consequent inflammation, necrosis and fibrosis. Perforation of the intestine wall and peritonitis may result. Clinical signs include anorexia, depression and emaciation. Acanthocephalids have indirect life cycles, and intermediate hosts are cockroaches and certain beetles. Control of the intermediate host is necessary to prevent infections in New World primate colonies. *Prosthennorchis* eggs are shed intermittently in small numbers. Therefore, negative results in faecal examinations do not rule out the possibility of acanthocephalid infection. Treatments currently employed have not proved completely effective.

Strongylids, whipworms (*Trichuris* spp.), hookworms (*Ancylostoma* spp.) and roundworms (ascarids) are treated with the usual anthelmints, such as thiabendazole, mebendazole, fenbendazole, pyrantel pamoate and ivermectin. When handling primates, one should keep in mind the zoonotic risk to humans, and protective clothing should be worn.

*Strongyloides* spp. were diagnosed in cebids and callitrichids with intestinal perforation, peritonitis and necrotising colitis. The route of infection is oral or skin penetration by larvae. There is evidence of intra-uterine or transcolostral transmission. Infection causes a catarrhal or haemorrhagic enterocolitis. Diagnosis is by identification of larvae in the stools. Pinworm genera described in New World primates are *Primasubulura* spp., *Subulura* spp., *Trypanoxyurus* spp. and *Enterobius* spp. These parasites inhabit the colon and caecum. Trichostrongylids in the genus *Molineus* are known to cause haemorrhagic or ulcerative enteritis. The presence of a spirurid, *Trichospirura leptostoma*, was reported in the pancreas of three adult tamarins (*Leontopithecus chrysopygus*) in the Rio de Janeiro Primate Centre (20). Cebids are reported to be affected by *Trichuris* spp. Many genera of trematodes and cestodes are occasionally found in New World primates. Specific anthelmintics are used, such as praziquantel and niclosamide.

Controlling internal parasites requires prophylactic measures, including strict quarantine ranging from thirty to ninety days. Primates should yield three consecutive negative results in faecal examinations before release. Faecal samples should be examined by sedimentation to detect *Prosthennorchis* ova.
CARNIVORES

Canine distemper

Canine distemper is an infectious disease with a world-wide distribution, and is of considerable importance in the Canidae, Procyonidae and Mustelidae families. In South America, canine distemper has been recognised in some zoo collections; diagnosis has been based on clinical signs and histopathological identification of virus inclusion bodies.

In Brazil, the higher incidence and mortality of non-domestic canids due to canine distemper over the last six years has been viewed with deep concern by members of the zoological association. Previously, zoos did not employ vaccination programmes. This was possibly due to the absence of outbreaks in zoo collections and ignorance of the risks of, and immune responses to, available vaccines when used in non-domestic species.

A survey to identify causes of mortality in the maned wolf (*Chrysocyon brachyurus*) in twenty Brazilian zoos within a five-year period (1989 to 1993) showed that 18.5% of 108 deaths were caused by canine distemper and 1.8% by encephalitis suggestive of the disease. Six zoos reported cases of canine distemper in maned wolves (C. Pessuti and M.E.S. Bodini, personal communication, 1995). In 1990, an outbreak in Sorocaba Zoo (Brazil) caused mortality in four crab-eating foxes (*Cerdocyon thous*), three coatis (*Nasua nasua*) and three maned wolves. A crab-eating fox which had been introduced to the collection was considered to be the source of infection (14). Another outbreak occurred in the Brasilia Zoo (Brazil) in November and December 1993, causing mortality in five non-vaccinated maned wolves. Clinical signs included a hoarse howl, diarrhoea, purulent ocular discharge, ataxia, clonic convulsions and spasm of the hind limbs. Post-mortem findings were pneumonia, petechias and ulcers of 5-7 mm in diameter along the intestinal mucosa. Acidophilic intracytoplasmatic inclusion bodies in leukocytes confirmed the diagnosis. Vaccinated maned wolves housed in an exhibition area of the zoo, at a distance of approximately 3 km, did not present any sign of the disease (C.L. Magalhães, personal communication, 1995).

These outbreaks in various zoo collections made the Zoological Society of Brazil (ZSB) establish a committee of veterinarians to discuss and propose a vaccination programme for South American canids. The coordinators of the ZSB Maned Wolf and Bush Dog Species Survival Plan had the responsibility for including the vaccination programme in the master plans. The ZSB subsequently obtained a monovalent modified live virus (MLV) vaccine of avian origin, which has been distributed to the participating institutions. To date, commercial multivalent MLV vaccines (canine distemper MLV of avian cell origin; adenovirus type 2; parainfluenza virus; *Leptospira*) produced in Brazil have been shown to be safe in South American canids. The regimen recommended for the domestic dog can be appropriate for non-domestic canids. Vaccination should be performed at six to eight weeks of age and repeated twice at two- to three-week intervals (a total of three inoculations). In special cases, the vaccination series can be extended to four or five injections to ensure protection; annual re-vaccination is recommended. MLV vaccines of avian cell origin have proved to be safe and to provide protection. The immunogenic response and safety of multivalent commercial vaccines need to be further investigated in South American species of the Mustelidae and Procyonidae families. Nevertheless, systematic vaccination is recommended. Care should be taken to avoid the use of canine origin vaccines in members of these families. In addition to a vaccination programme, strict quarantine and sanitation procedures should always be employed.
Enteroviruses

Non-domestic carnivores are susceptible to enteric viruses which cause disease in dogs and cats. Canine parvovirus (CPV) has been reported in South American canids, e.g. the bush dog (*Spheos venaticus*), maned wolf and crab-eating fox. Feline panleukopenia (FPL) has been confirmed in the jaguar (*Panthera onca*), ocelot (*Felis pardalis*) and margay (*Felis wiedii*). Members of the Mustelidae and Procyonidae families are considered susceptible to CPV infection and FPL.

Gastroenteritis suggestive of enteroviruses have been reported in carnivores maintained in captivity in South America, although conclusive laboratory diagnoses are scarce. Non-specific gastroenteritis was responsible for 8.3% of all maned wolf deaths in twenty Brazilian zoos between 1989 and 1993 (C. Pessuti and M.E.S. Bodini, personal communication, 1995). Although many cases were suggestive of CPV infection, confirmation of diagnosis by laboratory examination was not conducted.

An outbreak of CPV confirmed by laboratory diagnosis was documented in the São Paulo Zoological Park in 1989, and caused the deaths of eight of seventeen adult maned wolves (10).

FPL in ocelots occurred in the Curitiba Zoo (Brazil) in 1995. A young and an adult ocelot died after showing signs of diarrhoea, dehydration and anorexia. Histopathological findings were suggestive of FPL. During the following weeks, four ocelots presented identical clinical signs and one animal died. After this outbreak of FPL, a vaccination programme was initiated, using killed and MLV vaccines (A.S.P. Fischer Da Silva, personal communication, 1995).

Prevention of FPL and CPV infection depends on a programme which includes strict quarantine, sanitation and vaccination procedures. The determination of causative agents would certainly help to resolve questions concerning the epizootiology of these enteroviruses. The domestic dog and cat can act as reservoirs of parvoviruses, coronaviruses and other viruses which cause gastroenteritis syndrome in non-domestic carnivores. Care should be taken to prevent domestic and feral animals from gaining access to the facilities. New animals entering the collection should never be mixed in the quarantine quarters. Sanitation practices include the disinfection of the facilities with sodium hypochlorite or another virucidal agent effective against *Parvovirus*.

Studies indicate that immuno-competence may vary between species of the same family. This difference between species should be taken into consideration in a vaccination programme. It is recommended that canids be vaccinated three to four times at two- to three-week intervals from eight weeks of age. Feline vaccination should begin at weaning and should be repeated at least twice at two-week intervals. Killed FPL vaccines have been used most frequently on exotic cats. In South American countries where FPL killed vaccines are not commercially available, MLV vaccines have been used. To date, no adverse symptoms have been reported.

Parasitic diseases

Babesiosis

Babesiosis has been reported in maned wolves in South America. *Babesia* spp. are intra-erythrocytic sporozoan parasites which cause haemolytic anaemia, weakness and death.
Two cases of babesiosis in maned wolves were reported in Sorocaba Zoo (Brazil) (17). In both cases, treatment was effective. Between 1991 and 1993, however, babesiosis caused the death of four maned wolves in two zoo collections in Brazil (C. Pessuti and M.E.S. Bodini, personal communication, 1995). A fatal case of simultaneous infection by *Babesia canis* and *Bartonella canis* was reported in a maned wolf. Only *Babesia* was seen in the circulating blood cells and treatment was initiated, but post-mortem examination revealed a high level of parasitism by *Bartonella canis* (25). As different drugs are used in the treatment of haemoparasites, an accurate diagnosis is essential for therapy to be effective. Haemoparasites are transmitted by ticks and fleas.

*Internal parasites*

Exotic carnivores are susceptible to a variety of internal parasites, many of which cause clinical disease and death.

Parasitic infections may be self-limiting in adult animals, whereas in young and debilitated animals they may cause considerable losses. *Ancylostoma* spp. are a frequent cause of mortality in cubs and pups. The passage of larvae in milk can result in the infection of neonates. Ascarids – namely *Toxascaris*, *Toxocara* and *Baylisascaris* – are frequently found in adult and young carnivores. Whereas *Toxocara canis* larvae may cause prenatal infection in canids, *T. catti* larvae in felines do not infect fetuses in the uterus, but they do infect neonates through the mammary glands. *T. canis* and *Diphyllobothrium trineta tum* were reported in South American raccoons (*Procyon cancrivorus*) (4).

In South America, *Dioctophyme renale* (a kidney worm) has been documented in the free-ranging maned wolf, bush dog, coati, neotropical river otter (*Lutra longicaudis*) and gryson (*Galictis vittata*). It is uncertain whether this helminth can cause the death of the host.

Wild carnivores may be infested by a number of coccidian parasites of the genera *Eimeria*, *Isospora*, *Toxoplasma*, *Sarcocystis* and *Besnoitia*. The author observed a fatal case of haemorrhagic enteritis caused by a recurring *Eimeria* infection in a wild-caught neotropical river otter.

Despite advances in veterinary practice, parasites still cause significant losses among captive animals. Veterinarians now have access to a variety of antiparasitic drugs which are effective against internal parasites. However, other procedures are needed to reduce mortality. Neonatal physical examination is recommended when possible, to determine health status. Standard faecal examinations should be carried out as a routine procedure to detect parasitic ova and protozoa. Periodic disinfection of enclosures is recommended, and one should bear in mind that some parasites are extremely resistant and that reinfection can occur.

*External parasites*

Infestation by fleas has been frequently observed in carnivores maintained in captivity in South America. Severe infestation may cause exsanguination, anaemia and death. Warmer environmental temperatures favour insect reproduction, to the extent that a small animal can succumb in a few days from a massive flea infestation. A survey conducted in twenty Brazilian zoos, between 1989 and 1993, indicated that
11% of maned wolf mortalities were caused by anaemia, probably due to flea infestation (C. Pessuti and M.E.S. Bodini, personal communication, 1995). Efforts should be made to control ectoparasites using suitable insecticides.

Sarcoptic mange has been reported in canids in captivity. Repeated treatment is required.

TAPIRS

Tuberculosis

Tapirs are particularly susceptible to tuberculosis in captivity. The causative agent is either *Mycobacterium bovis* or *M. tuberculosis*.

The author studied an outbreak of *Mycobacterium* infection in a group of Brazilian tapirs (*Tapirus terrestris*). Intermittent coughing and mucous nasal discharge were the only clinical signs observed over several months. Over a three-year period, three animals died in this collection as a result of tuberculosis. The comparative cervical intradermal skin test was conducted in five animals using 0.1 ml of bovine PPD (purified protein derivate) tuberculin and 0.1 ml of avian PPD tuberculin. A positive response was observed in two animals (Fig. 3). The possible sources of infection were the public (who could have had direct contact with the animals through the wire), vultures (which could have had access to contaminated carcasses and served as carriers of the bacilli to the zoo) or contaminated food and water (as a result of wastewater discharges containing the bacteria).

![Fig. 3](image)

A positive response (oedema and necrosis) to the intradermal skin test conducted in a tapir (*Tapirus terrestris*)
Tuberculosis in tapirs was also reported in Ilha Solteira Zoo (Brazil) (6) and in São Carlos Zoo (Brazil) (23).

Clinical signs observed in advanced stages of the disease are coughing, nasal discharge, dyspnoea and emaciation (which occurs despite appetite) (Fig. 4). Post-mortem lesions include abscesses, and granulomas in the lungs, thoracic lymph nodes and thoracic cavity. The ante-mortem diagnosis of mycobacterial infection requires a combination of tests, including the comparative intradermal skin test, enzyme-linked immunosorbent assay (ELISA) and culture of the respiratory tract. Although the current diagnostic tests are considered inconclusive and difficult to interpret in some instances, they are still valid and necessary. The comparative cervical test is performed by injecting *M. bovis* and *M. avium* PPD tuberculin into separate intradermal sites in the neck. A delayed hypersensitivity response to the tuberculin indicates whether or not the infection is caused by a pathogenic *Mycobacterium*. Microbiological cultures are required to confirm the diagnosis and the type of tuberculosis bacilli. The ELISA detects antibodies in the sera of animals infected or exposed to clinically-significant mycobacteria.

![Fig. 4](image)

**A tapir (Tapirus terrestris), emaciated due to tuberculosis**

As the treatment of tuberculosis in animals is controversial and of uncertain practical value, it is essential – when considering the health of the rest of the population and of other species in the zoo – to take prophylactic measures to prevent the disease. A tuberculin test should be performed on newly-introduced animals (especially hoofed livestock and primates), and they should leave quarantine only if a negative test result is achieved. The recommended minimum period of quarantine is
sixty days. Tuberculin-positive animals — on which diagnosis is confirmed by intradermal tuberculin test biopsy, microbiological cultures and ELISA — should be considered for euthanasia. Enclosures for tapirs should include barriers which maintain a distance between the animals and the public and prevent direct contact. Appropriate precautions should be taken to reduce the risk of cross-infection between animals and staff, in both directions. Food, and water for drinking and bathing, must be regularly inspected to ensure good quality and hygiene. When tuberculosis is diagnosed in a zoo collection, facilities must be decontaminated with an effective disinfectant (e.g. phenol type or cresylic compound). Sodium hypochlorite, quaternary ammonium and chlorhexidine are ineffective against the tuberculosis bacilli.

If treatment is attempted, a suggested protocol for hoofed livestock includes isoniazid in combination with rifampin or ethambutal for nine to twelve months. A female tapir which had yielded positive results in a tuberculin test was treated with streptomycin for 30 days and isoniazid for 180 days. Thirty months after the end of treatment, the female and a calf born to it both reacted negatively in a tuberculin test (23).

**Miscellaneous conditions**

*Salmonella* spp. cause enteritis and septicaemia in both adult and neonatal tapirs. Faecal cultures are recommended in animals recently introduced into the population or in individuals which present signs of gastroenteric infection. *Balantidium* infection of the gastrointestinal tract, causing enteritis and diarrhoea, was detected on post-mortem examination of a tapir. Eggs of *Fasciola hepatica* and strongylids have been identified in faeces of healthy individuals. Other bacterial and parasitic diseases have been reported in the Tapiridae family (22).

Conditions related to inadequate husbandry and management can lead to diseases and mortality. For instance, hard and rough substrates (e.g. cement) result in hoof lesions and lameness. Corneal opacity is usually seen in tapirs maintained in enclosures with insufficient shade. As tapirs inhabit thick forests, it is recommended that adequate areas of shade should be provided in captivity. The provision of bathing facilities is also important. Lack of such facilities can result in foot problems, constipation and rectal prolapse. Drowning is a frequent cause of calf mortality, however, and the female should therefore be confined in a separate nursery area with a shallow pool just prior to parturition. The ingestion of coarse food can cause oral laceration and abscess formation, intestinal obstruction, constipation and rectal prolapse. The ingestion of large quantities of sand has been reported as causing colitis and colic. All these health considerations should be taken into account when designing the captive environment.

**CERVIDS**

**Haemorrhagic disease**

The term ‘haemorrhagic disease’ has been used to describe a severe disease in cervids. The causative agent may be the bluetongue virus, epizootic haemorrhagic disease virus or a related orbivirus. To date, it has not been possible to isolate and identify the causative agent.
Serological studies in Chile, Paraguay, Guyana, Suriname, Colombia and Brazil have indicated the presence of antibodies against the bluetongue-related orbivirus in livestock. Epizootic haemorrhagic disease has not been confirmed in South America.

The first reported case of the disease in captive cervids in a Brazilian zoo was in the Rio de Janeiro Zoo in 1991. In January/February 1992, the disease was described in a herd of brown brockets (Mazama gouazoubira) on the campus of the University of Săo Paulo State (Brazil). One of the four brockets affected died. Six brown brockets died at the same institution in 1993. Serological studies by immunodiffusion in agar gel indicated antibodies against bluetongue virus or a related orbivirus (11, 12). In July 1992, the disease was documented in one specimen of marsh deer (Blastocerus dichotomus) in the Ilha Solteira Zoo (Brazil) (16). A serological study of 72 cervids from various regions of Brazil showed a prevalence rate of 20% (2). The disease is considered enzootic in a population of brown brockets maintained in a park close to Sorocaba city (Brazil), and has caused significant mortality over five years (A.L.V. Nunes, personal communication, 1995).

Incidence of haemorrhagic disease is seasonal, occurring during warm and rainy seasons when the concentration of insect vectors is relatively high. Biting flies of the genus Culicoides are considered to be vectors of the disease, but other haematophagous insects are probably involved in the epizootiology. Domestic hoofed livestock act as a reservoir of the virus. It is also likely that cervids or domestic hoofed livestock which survive the clinical disease become asymptomatic carriers.

Diagnosis has been based on the clinical signs, lesions and serological studies. Necropsy findings are of widespread haemorrhage in the digestive tract, lungs, heart, liver, spleen and subcutaneous tissue. Mortality rates vary depending on environmental conditions, pathogenicity of the viral strain, stress to which the animal is exposed, and secondary bacterial infections (e.g. bronchopneumonia).

To prevent and control haemorrhagic disease, appropriate practices must be implemented. Only seronegative animals should be acquired for the collection, to avoid introducing the virus into a population which is free of the disease. New arrivals should be placed in quarantine, and initial screening should include serological tests. Infected animals which show clinical signs should be isolated and treated, preferably in a mosquito-proof enclosure to avoid transmission to non-infected animals. Carriers should not be kept in the collection. Non-sterile syringes, needles and darts create a potential risk of spreading the virus among other individuals of the herd. Measures to control vectors can effectively reduce the chances of infection. Development of a vaccine using specific South American serotypes of orbivirus is an urgent prophylactic measure. The isolation and identification of the causative agent is therefore crucial.

Haemorrhagic disease represents a serious risk to the maintenance of cervids in captivity in South America. The disease tends to persist once it is introduced into a population, causing periodic mortality in successive years.

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LES PROBLÈMES SPÉCIFIQUES AU MAINTIEN EN CAPTIVITÉ DES ANIMAUX SAUVAGES EN AMÉRIQUE DU SUD. - Z.S. Cubas.

Résumé : L'auteur rappelle les principales maladies qui affectent les animaux sauvages maintenus en captivité en Amérique du Sud. Il analyse l'épidémiologie, l'impact et l'incidence de ces maladies, ainsi que les pratiques d'élevage adaptées au contrôle et à la prévention des maladies transmissibles. Il passe en revue les groupes suivants d'animaux et de maladies :

- dermatite à poxvirus ;
- gastro-entérite, pneumonie, amibiase et coccidiose chez les reptiles ;
- pratiques de gestion et maladies (y compris le botulisme, l'entérite, la psittacose, l'aspergillose et les maladies parasitaires aviaires) ;
- entérococite, pneumonies et parasitisme interne chez les primates non humains ;
- maladie de Carré, parvoviroses, babesioses, parasitisme interne et externe des carnivores ;
- tuberculose et entérite chez les tapirs ;
- maladie hémorragique chez les cervidés.


DIFICULTADES ESPECIALES DEL MANTENIMIENTO DE ANIMALES SALVAJES EN CAUTIVIDAD EN AMÉRICA DEL SUR. - Z.S. Cubas.

Resumen: El autor resume la incidencia de las enfermedades más importantes sobre la fauna salvaje que vive en cautividad en América del Sur. Examina también la epidemiología, impacto y significación de dichas enfermedades, así como las prácticas de cría adecuadas para el control y la prevención de enfermedades transmisibles. En este artículo se consideran las siguientes patologías y grupos de animales:

- dermatitis por poxvirus;
- gastroenteritis, neumonía, amebiasis y coccidiosis en reptiles;
- prácticas de manejo y enfermedades (includidos el botulismo, enteritis bacteriana, psitacosis, aspergilosis y enfermedades parasitarias aviares);
- enterocolitis, neumonías y parasitismo interno en primates no humanos;
- moquillo canino, afecciones por parvovirus, babesiosis, parasitismo interno y externo en carnívoros;
- tuberculosis y enteritis en tapires;
- enfermedad hemorrágica en cérvidos.

REFERENCES


