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Clinical Disorders in Armadillos (Dasypodidae, Edentata) in Captivity

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With 3 tables

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Summary

The major health problems found in 113 armadillos are presented and correlated with management in captivity. The most common of 217 recorded clinical disorders involved injury (28.5%), digestive system (17.9%), respiratory system (15.2%), nutritional deficiency (13.3%), skin problems (3.6%), septicaemia (1.8%), nervous system (1.3%), urinary system (0.9%) and effects of environmental (0.9%), with 14.7% of the cases inconclusive. Internal parasites were identified in 42.0% of faeces samples, mainly eggs of helminths (66.6%), of which the commonest were *Ancylostoma* sp. (33.3%), *Strongyloides* sp. (30.5%), *Ascaris* sp. (25.0%), *Trichuris* sp. (11.1%), and also protozoa (13.0%). Enterobacteriaceae were the bacteria most frequently isolated, with *Escherichia coli* the most prevalent, followed by *Salmonella* sp. and *Enterobacter aerogenes.* The most successful treatments are listed. The influence of some captive factors on the onset of the diseases was also analysed: donated animals 91.1% and zoo born 8.8%; quarantine enclosure 84.0% and exhibition 15.0%; and related to time in captivity, 92.2% occurred with animals in the first 6 months in the zoo and 7.8% with animals more than 6 months.

Introduction

The armadillos, family Dasypodidae, of the order Edentata (Xenarthra), 'without teeth', lack incisors and canine teeth. Their cheek teeth grow continuously through life (MERRIT, 1983; DIVERS, 1986). Edentates are ancient members of the South American fauna. They arose and spread there, and only the species *Dasypus novemcinctus,* has strayed into North America (KENT, 1994). The armadillos are distributed from the southern United States to the south of Latin America (WETZEL, 1985).

One of the many interesting characteristics of this group is heterothermia (body temperature 32–33°C which fluctuates according to that of the environment). They have only a narrow range of thermal neutral temperature and humidity, and suffer stress when the environmental temperature goes below 12°C (MERRIT, 1983).

Armadillos usually live and travel singly, but occasionally are seen in small bands. They possess scimitar shaped claws, making them powerful diggers. If unable to escape from predators by running, they burrow digging in 45 s, as does the genus Cabassous, or roll into a ball covering all vital areas with armour, like the southern three-banded armadillo (*Tolypeutes* sp.) (SANTOS et al., 1994).

Most armadillos are basically insectivorous, preferring ants and termites, although some species, like the genus Dasypus, consume fruit, carrion and small vertebrates (KENT, 1994).

It is very important to obtain better knowledge of this family, since some species are

already listed as vulnerable or endangered (WORLD WILDLIFE FUND, 1982). In this regard special consideration must be given to the maintenance of *Dasypus novemcinctus* in captivity due to its importance in biomedical research. This animal is susceptible to Chagas' disease, leprosy, nocardiosis, leishmaniasis, etc. and therefore is widely employed as a model for human diseases (KIRCHHEIMER and STORRS, 1971; MONTGOMERY, 1985).

Although some species have been studied and important medical and biological information collected, there are only a few papers on pathological conditions and management of armadillos in zoos (DIVERS, 1986; GRINER, 1983; WALLACH and BOEVER, 1983). Accordingly, it was felt desirable to review the clinical conditions and the respective treatment in armadillos in order to establish the major clinical problems and some factors affecting their maintenance in captivity.

Materials and Methods

Clinical information was collected over 28 years from 113 armadillos in the family Dasypodidae, kept at the São Paulo Zoo, Brazil. The following animals were studied: 55 nine-banded armadillos (*Dasypus novemcinctus)*, 48 yellow armadillos (*Euphractus sexcinctus*), five greater naked-tailed armadillos (*Cabassous* sp.), four three-banded armadillos (*Tolypeutis* sp.) and one giant armadillo (*Priodontes maximus*). Nineteen animals were born in captivity and 94 were received as donations. The group was comprised of 59 female and 54 male, being 90% adults and 10% young animals. The origin of animals (zoo born or donation), climatic conditions, enclosure facilities and time in captivity were considered to establish the influence of these factors on the onset of the diseases.

Newly arrived animals were kept in quarantine in sheltered quarters of about 15 m^2, cement floors and area of ground, surrounded by 60 cm wall with a screen fence 2 m high. The public exhibition enclosures in the park were about 30 m^2 covered with grass, and surrounded by a cement wall.

The animals were fed twice a day and each animal received 50 g of a mixture per kg body weight. The mixture was composed of 400 g of chopped raw meat (chicken neck), 200 g of dog ration, 100 g of fruits (banana, orange, papaya), 100 g of boiled tubercle (carrot and sweet potato), 100 g of peanut and 100 g of cooked corn meal, besides one egg per animal per day. The diet was complemented with termites or chick plus vitamin and mineral supplements (Vionate P, Ciba-Geigy Química S.A., São Paulo, Brasil).

Mechanical and/or chemical immobilization with ketamine (Parke Davis, Rio de Janeiro, Brasil), 10–20 mg per kg body weight was employed to facilitate clinical examinations and to collect materials for laboratory procedures.

Bacterial culture was performed on samples of faeces, urine and secretions from the skin and nose. The study of the enteroparasites was done by the identification of eggs, larvae, cysts or worms in the faeces, and the identification of ectoparasites was carried out on skin scrapings. Blood and urine analysis were also undertaken with the aim of aiding diagnosis and guiding proper treatment.

Results

The total number of clinical disorders found was 217, and sometimes two or more conditions were concurrent. They are detailed in Tables 1 and 2. Some captivity factors affecting the onset of the diseases are listed in Table 3. None of the diseases showed any sex-related differences in prevalence.

Major aetiological agents identified were as follow: Protozoa (13.0%), represented by Coccidia sp. and Entamoeba; helminths (66.6%), represented by *Ancylostoma sp.* (33.3%), *Strongyloides sp.* (30.5%), *Ascaris sp.* (25.0%), *Trichuris* sp. (11.1%); cestodes (1.8%), and bacteria (18.5%) represented by *Escherichia coli, Salmonella sp., Enterobacter aerogenes, Acinetobacter hinshawii* and *Streptococcus sp.*

Injury was the major problem (28.5%) in this study. Injuries usually occurred in the wires of enclosures, or during mechanical immobilization for clinical examination or transportation. The main injured body sites were mouth, nostrils, nails, digits and interdigital membranes.

Digestive processes were the second most commonly disorders observed and intestinal problem represented 74.3%, comprising enteroparasites and diarrhoea (Table 1).

Apathy, breathlessness, loss of appetite and weight loss were associated with pneumonia, the third most important disorder found in this study. Nasal and/or ocular discharges were present in some cases. The animals with nutritional disorders had poor physical development.

Table 1. Major organic disorders in armadillos in captivity

Clinical problems-*n* (%)	Associated factors
Injuries 62 (28.5)	wounds 59, fractures 3
Digestive 39 (17.9)	enteroparasites 12, diarrhoea 17, hepatic processes 4, tongue inflammation 2, vomit 1, intestinal impactation 1, rectal prolapse 1, foreign body 1
Respiratory 33 (15.2)	pneumonias 32, nose bleeding 1
Nutritional deficiency 29 (13.3)	nutritional deficiency 25, anaemia 4
Skin problems 8 (3.6)	ectoparasites 7, dermatitis 1
Septicaemia 4 (1.8)	infectious sign 4
Nervous 3 (1.3)	convulsions 3
Urinary 2 (0.9)	blood in urine
Climatic temperature problem[1] 2 (0.9)	winter 1, summer 1
Circulatory 1 (0.4)	heart insufficiency
Ophthalmic problem 1 (0.4)	conjunctivitis
Behaviour problem 1 (0.4)	cannibalism
Inconclusives 32 (14.7)	

n = 217 (total number of clinical disorders); 1, death due to environmental temperature.

Table 2. Ethiological agents found in captive armadillos and the most commonly employed treatments

Enteric pathogens and treatment	
Protozoa 7 (13.0%)	*Entamoeba* sp, Coccidia: Metronidazole, 50 mg/kg/2 × /5–7 days; Tinidazole, 50 mg/kg/2 × /5 days
Helminths 36 (66.6%)	*Ancylostoma* sp, *Strongyloides* sp, *Trichuris* sp: Thiabendazole, 50–100 mg/kg/4 days; Mebendazole, 15 mg/kg/5 days. *Ascaris* sp: Levamizole, 10 mg/kg/ repeated after 7 days; Piperazine, 80–100 mg/kg
Cestodes 1 (1.8%)	(not identified)
Bacteria* 10 (18.5%)	*Acinetobacter hinshawii* sp, *Escherichia coli*, *Enterobacter aerogenes, Salmonella* sp: Chloramphenicol, 25–75 mg/kg/2 × /10 days; Ampicillin, 50 mg/kg/2 × /5–10 days; Trimethoprin+sulphamethoxazole 0.5 ml/kg 2 × /5–7 days
Respiratory pathogens and treatment	
Bacteria* (90%)	*Staphylococcus* sp, *Streptococcu* sp: Chloramfenicol, 50–100 mg/kg/2 × /10 days; Ampicillin, 50 mg/kg/3 × /5–10 days; Tetracycline, 10–20 mg/kg/2 × /5–10 days; Kanamycin, 10–20 mg/kg/2 × /5–10 days; Trimethoprin+ sulphametoxazole 0.5 ml/kg/2 × /7–10 days

*Most commonly employed therapy after the antibiogram procedure.

In these cases, lethargy, scurfy skin and pallor of the mucous membranes were observed. Nutritional disorders only occurred in newly arrived animals.

The most successful treatments employed in the armadillos of this study are given in Table 2. The drugs were employed until the laboratory results were negative and/or the clinical signs disappeared. Antibiotics were administrated according to sensitivity testing.

It was observed in the present study, that some captivity factors such as poor body condition before the donation and poor adaptation to captivity may affect these animals (Table 3). The majority of health problems occurred with donated animals (91.1%) and with animals in the first six month of captivity (92.2%).

Table 3. Captive factors that may influence the onset of the clinical disorders in armadillos

Factors		Clinical disorders (total = 217) number	%	Animals (total = 113) number	% of diseases
Origin	Zoo born	19	8.8	19	16.8
	Donation	198	91.1	94	83.2
Climate	Spring	72	33.1	38	33.6
	Summer	57	26.0	30	26.5
	Winter	45	20.7	23	20.3
	Autumn	43	19.8	22	19.5
Enclosure	Quarantine	183	84.0	95	84.0
	Exhibition	34	15.0	18	15.9
Captivity period	0–6 m	200	92.2	104	92.0
	6m–2 yr	2	0.9	1	0.8
	2–5 yr	5	2.3	3	2.6
	>5 yr	10	4.6	5	4.4

m = months, yr = years.

Discussion

Natural diseases and diseases acquired by captive armadillos, mostly *Dasypus* sp., are described in the literature. Medical and surgical problems are mentioned (WAMPLER, 1969), and also the occurrence of hyperplasia, inflammation and granulomata in different organs, besides sarcosporidiosis, coccidiosis, toxoplasmosis and enteroparasites (GRINER, 1983; MACCIO et al., 1988).

Improper flooring, like wooden floors, is the main cause of skin problems because they may retain moisture, odor and are difficult to sanitize (WAMPLER, 1969). GRINER (1983), and WALLACH and BOEVER (1983) state that because of their highly specialized keratinized integument skin infections of digital cuticles (perionychitis), scales and the tail are common. Staphylococcal infection with subcutaneous abscess formation are often associated with the original lesion, and fistulous tracts may occur under the carapace. Long-standing bacterial infections in armadillos may cause severe internal sequelae such as pneumonia and septicaemia. Cellulitis was also observed in 11% of captive zoo specimens, represented by an acute inflammatory process that usually terminated in gangrene and septicaemia (GRINER, 1983). The author suspected that the origin of this infection was subcutaneous abscesses, or small yellow-tan granulomatous lesions which were found especially on the ventral surface.

Nematodes were the commonest parasites found. *Ascaris* spp., 25.0% in the present study, is considered ubiquitous in armadillos and even severe infestations may not produce clinical disease. Loss of body weight and anaemia may be noted in young or debilitated individuals (DIVERS, 1986).

Nematode larva of the genus Gnasthostoma, can be dangerous as this parasite may reach the meninges of this edentate (COCKMAN et al., 1993).

A high percentage of helminths was observed in *Dasypus* spp. in Georgia, USA, where 94.8% of the animals were infected with encysted cystacanths of *Macracanthorhynchus ingens,* pointing out that more than half of armadillos of this region were infested by this agent in association with another helminth (RADOMSKI et al., 1991).

Related to ectoparasites, Siphonaptera and Acari are described in South American dasipodides species (MAURI and NAVONE, 1993). *Tunga penetrans*, the smallest existing burrowing flea, was observed in the ventral region of three armadillos in the present study. The female flea penetrates the skin where its abdomen becomes enormously distended and filled with eggs, forming a distinct nodule. This ectoparasite occurs mainly on the feet of both, man of rural areas and Indian people, but it is rarely mentioned in domestic and wild mammals (URQUHART et al., 1987).

Trypanosomiasis (*Trypanosoma cruzi*) is quite commonly found in armadillos, however, the disease is

asymptomatic in this species. The parasite does produce acute disease in man and dog, causing elevated temperature, oedema, anaemia and myocarditis (FUJITA et al., 1994).

Epidemiological studies on trypanosomiasis (Chaga's disease) caused by *Trypanosoma cruzi*, 'mal das cadeiras' in horses caused by *Trypanosoma evansi*, and cutaneous leishmaniasis caused by *Leishmania braziliensis*, were conducted. Armadillos were considered natural reservoir hosts of these zoonoses in South America (NUNES et al., 1994; FUJITA et al., 1994).

Infections by fungi are quite common in Dasypodidae, mainly in the respiratory system. Pulmonary adiaspiromycosis (*Emmonsia* spp.) is a very common finding, represented by a mycotic granuloma (WALLACH and BOEVER, 1983).

In the investigation of paracoccidioidomycosis (*Paracoccidioides braziliensis*), the most common deep mycosis in Brazil, NAIFF et al. (1986) inoculated hamsters with saline suspensions obtained from liver and spleen of free living armadillos (*Dasypus nevemcinctus*). Inocula from four out of 20 armadillos from the Amazon region in Brazil, induced generalized systemic infections in the hamsters after four to 13 months. No lesions were observed in armadillos, but the inoculated animals presented gross pathological changes in the viscera and abundant spherical parasitic structures were also observed in stained histological sections. Characteristic colonies of *Paracoccidioides braziliensis* were observed in the culture of the material obtained from the hamsters. A mycologic and immunochemical study of an isolate of *Paracoccidioides braziliensis* from an armadillo (*Dasypus novemcinctus*) was recently conducted in Brazil (VIDAL et al., 1995).

The soil is considered the reservoir of this fungus in nature (RESTREPO, 1985), and according to a previous study (COSTA et al., 1995) terrestrial mammals are more susceptible to paracoccidioidomycosis than arboreal species, representing 82.9% and 22. 5%, respectively.

Concerning bacteria, fatal infection by *Nocardia brasiliensis* was reported in an armadillo, presenting an ulcerated suppurating wound on the dorsal part of the carapace. Progressive respiratory disturbance was also noted. The animal died 32 days after the initial signs, and on necropsy numerous abscesses were observed in both lungs. The findings suggest the possibility of cutaneous portal of entry of bacteria through a site of injury (GEZUELLE, 1972).

The soil is the probable ecological niche of both *Paracoccidioides braziliensis* and *Nocardia* sp., and the fossorial habit of the armadillos probably makes them more susceptible to these agents.

Armadillo species are susceptible to systemic infection by the leprosy bacillus, *Mycobacterium leprae* (KIRCHHEIMER and STORRS, 1971). Although it is reported that some cases of leprosy occurred in humans who had extensive and chronic contact with armadillos, it is unlikely that a significant number of indigenous cases of leprosy in man are acquired from armadillos. The source of infection in wild armadillos remain undetermined (CLARK et al., 1987). The same authors explain that one possibility is that the infection became established in certain populations after a few armadillos initially became infected through contact with fomites derived from leprotic people. In a study of the epidemiology of *M. leprae*, in which armadillos were tested and/or histologically examined for evidence of natural acquired leprosy, 7.8% of animals were positive (STALLKNECHT et al., 1987).

According to Table 3, the incidence of the diseases of armadillos in captivity is affected by some factors and is possible to state that donated animal, quarantine enclosure and first six month are critical factors for survival in zoos. It is relevant to alert zoo technicians about these captivity conditions, encouraging them to improve better management for this animal. Concerning this fact, an adult specimen of giant armadillo (*Priodontes maximus*), an endangered species (WORLD WILDLIFE FUND, 1982), lived only 6 months in the Zoo, the victim of inability to adapt to captivity conditions and management, resulting in progressive loss of weight. Similar situations occurred with the greater naked-tailed armadillos (*Cabassous* sp.) and the three-banded armadillos (*Tolypeutis* sp.).

Armadillo species are now widely employed in biomedicine. This greatly increased use is a further problem due to the threat of depletion of wild stocks in the future. For this reason, it is important to maintain armadillos in captivity and improve knowledge especially of their biology, diseases and pathology. The setting up of breeding colonies in captivity for study would be valuable with the purpose of acquiring knowledge and strategies to avoid extinction since some species of the genus Priodontes, Tolypeutis and Cabassous are already listed as vulnerable or endangered (WORLD WILDLIFE FUND, 1982; SANTOS et al., 1994).

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