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MORBIDITY AND MORTALITY OF FREE-LIVING AND CAPTIVE ECHIDNAS, *TACHYGLOSSUS ACULEATUS* (SHAW), IN AUSTRALIA

Steven McOrist^{1,3} and Lesley Smales^{2,4}

ABSTRACT: Between 1976 and 1985 necropsies were conducted on 55 free-living and 18 captive echidnas originating from several localities in Victoria, Australia. Injuries arising from motor vehicle accidents were the most common cause of death (24 of 55; 47%). An additional nine live echidnas were presented for clinical examination for dog or fox wounds (eight), or wire snare wounds (one). Incidental infestations with ticks (*Aponomma concolor*) on the skin or in the ear canal (eight of 82; 10%), and infections with intestinal cestodes (*Linstowia echidnae*) (nine of 73; 12%) and intestinal coccidia (three of 73; 4%) were found. Intestinal trichostrongyloidosis (four of 55; 7%), purulent bronchopneumonia (three of 55; 5%) and septicemia (three of 55; 5%) were the major disease syndromes seen in free-living echidnas. Other conditions seen were a non-specific enteritis, toxoplasmosis and bacterial granulomata. The latter lesion and the bronchopneumonia may have arisen from soil bacteria entering the body during digging and feeding activities. The echidna's ability to resist these infections may be lowered due to its low normal body temperature, and periods of torpor. Several young echidnas suffered starvation or gastric dilatation soon after capture, due to the rejection or fermentation of food offered. Captive echidnas suffered from acute salmonellosis (six of 18; 33%), toxoplasmosis (two of 18; 11%) and exposure (two of 18; 11%).

INTRODUCTION

In the last 20 yr echidnas in Australia have been the subject of considerable zoological interest, particularly their anatomical, physiological and nutritional peculiarities (Griffiths et al., 1969). There are as yet no comprehensive records of the parasites of echidnas although some have been described (Mackerras, 1958; Mawson, 1973; Durette-Desset and Cassone, 1983). Also, there are remarkably few descriptions of either the pathologic effects of these parasites or of any other disease conditions.

The echidna belongs to one of the three

living genera of monotremes. It is toothless throughout its life, feeding entirely on ants and termites which it collects with a long sticky tongue. It has strong clawed feet which it uses to dig temporary nests, and to disturb termite mounds (Griffiths, 1972). It is usually solitary, with a definite but small home range (usually 800 meters in diameter) in which it is active during periods of warm to hot weather (Augee et al., 1975).

Adult echidnas are attacked occasionally and eaten by introduced carnivores, particularly dogs (*Canis familiaris*) and foxes (*Vulpes vulpes*) (Brunner et al., 1975; Triggs et al., 1984), while suckling echidnas reportedly are attacked in their nest by foxes, cats (*Felis catus*) and goannas (*Varanus* spp.).

This partly retrospective study was undertaken to establish data on diseases and causes of mortality in free-living and captive echidnas.

MATERIALS AND METHODS

Between 1976 and 1985, 82 injured, sick or dead echidnas were received at the Regional Veterinary Laboratory, Bairnsdale or the Vet-

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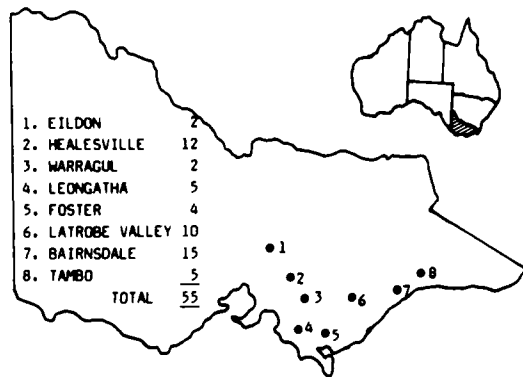


FIGURE 1. Map of the State of Victoria depicting the eight localities where echidnas were collected. The accompanying table lists the numbered localities and indicates the number of echidnas from each locality.

erinary Research Institute, Parkville, Victoria. Of these, nine live echidnas were examined, treated and had their temperatures and heart rates recorded, one was killed after being presented moribund and 72 were received dead. They were submitted by officers of the Ministry for Conservation, Forests and Lands, members of the public and some wildlife shelter operations, including the Royal Melbourne Zoological Gardens. Captive animals were considered "recent captives" if removed from the wild less than 1 wk prior to death. Captive animals held for more than 1 wk were maintained in various wildlife reserves, including the Royal Melbourne Zoological Gardens.

Fifty-five free-living echidnas originating from eight locations were examined at necropsy. The origin and numbers of animals from each locality are given in Figure 1. For 21 echidnas an estimate of age and weight was possible.

Sera from six free-living echidnas were examined for antibodies to *Leptospira interrogans* serovars *pomona*, *hardjo*, *tarrasovi*, *icterohaemorrhagica* and *ballum* by a microagglutination technique. Appropriate controls were available for each serovar.

Tissues taken at necropsy were fixed in 10% buffered formalin for histopathological examination. Swabs of lung and liver were cultured aerobically on sheep blood agar at 37 C. A swab of intestinal content was cultured in selenite enrichment broth for *Salmonella* spp. prior to agar plating.

Abscesses or granulomata were cultured aerobically as above; in addition a smear of abscess or granulomatous material was stained with

Gram's stain and examined microscopically. No whole blood examinations were carried out.

All echidnas were examined for parasites. Ectoparasites were removed, stored in alcohol and identified. Cestodes were relaxed in distilled water, then fixed in 10% buffered formalin prior to staining. Nematodes were fixed in 10% buffered formalin, then cleared in lactophenol. Counts of nematode eggs and coccidial oocysts were performed on feces using a McMaster counting chamber on those echidnas thought to have significant infections.

Ticks were deposited in the Australian National Insect collection (ANIC), CSIRO, Indooroopilly, Queensland and helminths in the Australian Helminthological Collection (AHC) housed in the South Australian Museum, Adelaide, South Australia. Accession numbers for these specimens will be given in the Results section when each species is first mentioned.

RESULTS

Of the 10 echidnas presented alive, one was killed after clinical examination had indicated a poor prognosis for recovery. Nine were treated successfully and returned to their original habitat. The heart rates and temperatures of the live animals were 80 ± 5 per min and 32 ± 1 C respectively. Animals 3 to 10 mo old ($n = 9$) were 1 to 3 kg, whereas adults were 3 to 6 kg. Leptospiral titers were negative in all echidnas tested.

Diet in captivity: Animals kept in captivity developed diarrhea if placed onto a diet containing cow's milk. Successful diets consisted of reduced-lactose milk products, raw minced meat, and chicken eggs. The presence of dirt in the diet was thought to be beneficial by some captors. All cases of gastric dilatation and starvation occurred in young (<2 mo old) echidnas a few days after capture, when offered the milk product/egg diet mentioned. In the first syndrome, the stomach was greatly dilated with foul-smelling milky fluid and gas in affected animals. In one, gastric rupture had occurred prior to death. Echidnas with starvation showed depletion of body fat reserves and empty bowels, with no other lesions.

Pathology: A summary of the suggested

TABLE 1. Causes of death in 73 echidnas from Victoria, Australia examined at necropsy.

Cause of death	No. of echidnas		
	Free-living	Recent captive	Captive
Gastro-intestinal diseases			
Acute salmonellosis	0	1	5
Trichostrongyloidosis	4	0	0
Gastric dilatation/rupture	0	3	0
Enteritis—nonspecific	3	0	1
Respiratory system disease			
Purulent bronchopneumonia	3	0	0
Aspiration pneumonia	0	1	0
Other syndromes			
Toxoplasmosis	2	0	2
Motor vehicle injury	24	0	0
Dog, fox wounds	11	0	0
Starvation	0	2	0
Septicemia—nonspecific	3	0	0
Hepatitis—nonspecific	2	0	0
Bacterial granulomata	2	0	0
Wire snare trap wound	1	0	0
Undetermined	0	1	0
Exposure	0	0	2
Totals	55	8	10

causes of death of 73 echidnas from this study is given in Table 1 and nonfatal lesions found in 82 animals are listed in Table 2.

The lesions in six captive echidnas with salmonellosis were those of subacute enteritis and focal hepatitis. Four *Salmonella* spp. were isolated, *S. typhimurium* in three cases and *S. bovis-morbificans*, *S. dublin*, *S. saint-paul* in one case each.

Four echidnas with non-specific enteritis had marked mucosal infiltration of neutrophils, with the formation of small abscesses in the associated mesentery and acute peritonitis. A mixed bacterial growth, including *Aeromonas* sp. was isolated from these lesions, and was evident in smears.

Five echidnas showed focal granulomatous hepatitis which was of a severe nature in two. In the absence of other le-

TABLE 2. Nonfatal lesions and incidental findings in 73 echidnas examined at necropsy and nine live echidnas examined clinically in Victoria, Australia.

	No. echidnas		
	Free-living	Recent captive	Captive
Parasitic infestation			
Ixodidae			
<i>Aponomma concolor</i>	6	0	2
Sporozoa			
Coccidia	0	0	3
Cestoda			
<i>Linstowia echidnae</i>	9	0	0
Nematoda			
Rhabditoidea			
<i>Parastrongyloides</i> sp.	2	0	0
Trichostrongyloidea			
<i>Nicollina</i> spp.	6	2	1
<i>Tasmanema mundayi</i>	2	0	0
Injuries			
Dog/fox wounds	8	0	0
Wire snare trap wounds	1	0	0
Other			
Interstitial pneumonia	1	1	3
Chronic pyelonephritis	0	1	0
Focal hepatitis—nonspecific	3	0	0
Seborrhea	0	0	2
Totals	36	4	11

sions, this was considered the cause of death in these two animals. No specific bacterial agents were identified in these cases. No inclusion bodies were identified in the tissues of any echidna. The four echidnas with toxoplasmosis had non-suppurative encephalitis, interstitial pneumonia and focal hepatitis, splenitis and nephritis. Echidnas with septicemia had lesions of focal hepatitis and pulmonary edema. A mixed bacterial growth including *Streptococcus sanguis* and coliform bacteria was isolated from these cases.

Echidnas with purulent bronchopneumonia had firm, edematous lungs on gross examination, with pus evident in small airways, and excess serosanguinous fluid in the thoracic cavity. The principal histological lesion was purulent bronchiolitis,

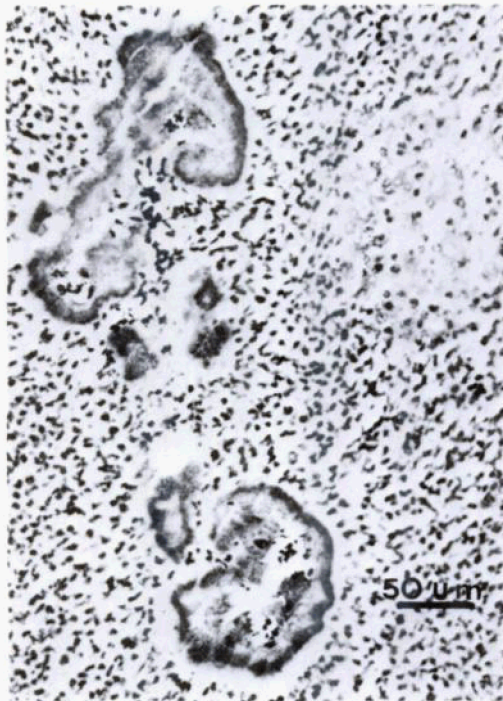


FIGURE 2. Photomicrograph of the foot lesion of an echidna from Bairnsdale. Note the bacterial club colonies with surrounding neutrophils and fibrosis. H&E.

with surrounding neutrophil infiltration into the parenchyma. A mixed bacterial growth, including *Edwardsiella* sp. was isolated from lesions and was evident in smears.

The two echidnas with bacterial granulomata were from separate locations and each had severe locally extensive swelling of one front foot. On cut section the swelling consisted of firm fibrous tissue within the subcutis, particularly around the claws. There was focal superficial ulceration and necrosis in the skin over the swellings. Histological examination of the foot lesion, local lymph nodes, and in one case the lungs, showed numerous focal bacterial club colonies, with surrounding neutrophils and fibrosis (Fig. 2). Smears of these lesions showed the bacteria in the club colonies were Gram-positive cocci. *Staphylococcus* sp. was isolated from the

lesions in one case, but full identification was not possible due to contaminating bacteria.

Parasitology: Of the 13 echidnas with trichostrongyloid infections, four with 500 to 1,000 nematodes in the small intestine, had an associated histologically evident enteritis, with a mononuclear cell infiltration of the villi. These animals were considered to have suffered fatal trichostrongyloidosis. Fecal egg counts in these cases were 5,500 to 8,000 eggs per gram. The other nine animals had intensities of adult worms ranging between 29 and 150.

Detailed examination of the species of nematodes present was only possible for five animals, including two of the four with fatal infections. Of these, two from the Latrobe Valley had mixed infections of *Nicollina cameroni* (Accession No. AHC 14756-7) and *Tasmanema mundayi* (AHC 14753-4); one from the Latrobe Valley had *T. mundayi* (AHC 14755) only; and the two animals from Healesville with fatal trichostrongyloidosis had *N. patriciae*. *Parastrongyloides* sp. (AHC 14758-9) was found in the colon of two echidnas from the Latrobe Valley and constitutes a new host record.

Histological examination of the intestines of echidnas with coccidia or cestodes present showed a mild focal superficial inflammation. Coccidia were not further identified. All cestodes were *Linstowia echidnae* and were present in intensities of 5 to 20 (AHC 13003, 14713, 14762). Infestations with ticks (*Aponomma concolor*) (eight of 82; 10%) were asymptomatic; infections were of low intensity (one to 10), on the skin, the ear canal being also infected in two cases (ANIC K.5.1.1).

Injuries: Twenty-four echidnas were found adjacent to roadways, with traumatic lesions evident. Eleven of these had fractured cranial bones with associated intracranial hemorrhage. The remaining 13 had thoracic trauma, with fractured ribs and hemorrhages in the heart and lungs. Twenty-one echidnas were found to have

wounds inflicted by dogs, cats or wire snares.

DISCUSSION

This survey has established that the major causes of morbidity and mortality of echidnas in Australia are gastrointestinal diseases, pneumonia and accidents caused by the machines or pets of man.

Echidnas kept in captivity on adequate diets were susceptible to toxoplasmosis, presumably from soilage of their enclosure by cats or because contaminated raw meat or dirt had been included in the diet; and exposure due to inadequate insulation of nests within their enclosure. Echidnas apparently require warm shelters to mimic their natural nests.

Salmonellosis causing acute enteritis and hepatitis in captive echidnas appeared similar to that seen in other animals, being probably associated with the stress of captivity. Gastric dilatation appeared to occur soon after captivity and was probably associated with the fermentation of a carbohydrate-rich artificial diet, compared to their protein-rich natural diet of ants and termites (Griffiths, 1978). The cause of the "non-specific" enteritis syndrome was not established, but was probably bacterial.

Purulent bronchopneumonia was a consistent syndrome in a small number of echidnas. It is possible that high numbers of soil organisms can pass into the upper respiratory tract of echidnas during their feeding and burrowing activities. Bacterial culture of these lesions did not reveal specific etiological agents, but it is likely that these lesions were associated with a mixed group of aerobic and anaerobic pyogenic bacteria.

The cause of the swollen front legs in two echidnas was not determined, but may have been an ascending infection initiated by entry of a pathogenic soil organism into the skin around the base of the front claws, during digging activity. The lesions were those of fibrous granuloma formation around bacterial club colonies. This lesion

is similar grossly to neoplasia, but the latter was not discovered in any echidna.

Of the trichostrongyloid species present, *N. patriciae* has been described previously from localities in South Australia and around Melbourne and *T. mundayi* from Central Gippsland, but *N. cameroni* is here recorded from Victoria for the first time. These additional records strengthen the suggestion that a separate south-eastern focus of speciation has existed for intestinal nematode parasites of echidnas (Durette-Desset and Cassone, 1983).

The survey presents the first records of trichostrongyloidosis in the echidna. Since neither the life-cycles nor the pathogenesis of the Nicollinidae are known, further investigation is required before the significance of these findings can be understood.

Echidnas listed in this study as having died from motor vehicle accidents included only those collected and submitted for necropsy by five or six people during the study period. No special collection effort was made, and many other dead echidnas seen on the roadside were reported to the authors. Therefore many echidnas, like other Australian wildlife (Coulson, 1982; Obendorf, 1983) are killed by motor vehicles. Preventive measures, including road warning signs, are usually of little benefit (Coulson, 1982).

The activities of foxes, dogs and cats appeared to be a major cause of injury to echidnas. This type of injury is likely to become more prevalent as man and his pets expand further into the habitat of echidnas. Two echidnas had also caught a leg in wire snare traps, causing a granulation response. One animal recovered after prolonged treatment.

The occurrence of bronchopneumonia, enteritis and bacterial granulomata as the likely cause of death of several echidnas indicated that once potential pathogens enter some echidnas they apparently meet with a weak immune response. This may be due to the reduced amount of bacterial

phagocytosis and other defense mechanisms which occur at low body temperatures (Cheville, 1983). The echidna has a low average body temperature (31.3) and a low basal metabolic rate (0.98 watts/kg) and may enter a state of torpor when environmental temperatures are less than 12 C (Dawson, 1983). Therefore any bacteria present in its body at these times may be able to multiply with little resistance.

The clinical observations on echidnas both wild and captive were similar to previous results (Griffiths, 1978). Echidnas lack intestinal lactase and therefore are unable to digest cow's milk (Griffiths, 1978). This survey of causes of mortality did not arise from a planned program, therefore some of the syndromes presented are poorly defined. In addition, the variety of syndromes seen may be only a small percentage of the number actually present. The potential impact of any disease on populations of echidnas was not determined, nor were infectious diseases capable of causing infertility rather than death detected. Echidnas examined in this study and in previous studies did not appear to have been infected with *Sarcocystis* sp. (Munday et al., 1978) or *Leptospiro* sp. (Emanuel et al., 1964).

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