Wildlife Health AUSTRALIA

Salmonella in Australian macropods

Fact Sheet

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Introductory statement

Macropods are susceptible to infection with *Salmonella* bacteria, which may result in disease. Macropods may also harbour *Salmonella* without displaying clinical signs of disease [1]. Much of the concern around *Salmonella* infection in macropods is linked to the possibility of zoonotic transmission to humans. Human salmonellosis is one of the most common and economically important zoonotic diseases in the world [2]. People may come into direct contact with macropods or their faeces in the urban environment, since kangaroos are commonly found grazing at local parks and golf courses, and wildlife carers often hand-rear orphaned joeys. There is a potential risk of *Salmonella* infection in both people and pets through handling and/or consuming kangaroo meat, as carcasses may become contaminated during harvesting and processing. Improved carcass handling procedures have significantly reduced the prevalence of *Salmonella* in harvested kangaroo meat [3, 4]. There are currently no reports in Australia of humans acquiring *Salmonella* infection through the handling or consumption of macropod carcasses or meat products. There have been no confirmed reports of primary clinical disease in macropods in their natural habitat.

Aetiology

Salmonella are gram-negative, rod-shaped bacilli belonging to the family *Enterobacteriaceae*, genus *Salmonella* [5]. *Salmonella* nomenclature is complex and evolving. Currently, the genus *Salmonella* consists of two species, *Salmonella enterica* and *S. bongori*. *Salmonella enterica* is further divided into six subspecies, which are referred to by a Roman numeral and a name [2, 6]. The individual names of each serotype may be used for identification; antigenic formulae are used for unnamed serotypes[1].

Salmonellosis refers to clinical disease associated with *Salmonella* infection (in either humans or animals).

Natural hosts

Salmonella have been identified in species from all classes of vertebrates (fish, amphibians, reptiles, birds and mammals) and in invertebrates. Serotypes may have predilection for certain species (e.g.

[1] At the first citation of a named serotype, the genus name is followed by the word “serotype” or the abbreviation “ser.”, then the serotype name. Subsequently, the name may be written with the genus followed directly by the serotype name. The serotype name is capitalised and not italicised.

Salmonella ser. Choleraesuis usually infects pigs) or groups of organisms (e.g. *S. enterica* subsp. *arizonae* is usually found in cold blooded vertebrates). However, most *Salmonella* serotypes can infect a broad range of hosts [5].

World distribution

Salmonella have a world-wide distribution, but appear to be most prevalent in areas of intensive animal husbandry, particularly where pigs, calves and poultry are housed in confinement [2]. *Salmonella* have been detected in opossums (marsupials; family *Didelphidae*) throughout the Americas [7-10].

Occurrences in Australia

Within Australian macropods, *Salmonella* has been isolated most commonly from hand-reared joeys, pet kangaroos, kangaroos held in captivity and quokkas (*Setonix brachyurus*) [11-14]. *Salmonella* has been detected at low prevalence in wild western grey kangaroos (*Macropus fuliginosus*) populations [15].

Salmonella spp. in macropods reported to the National Enteric Pathogens Surveillance Scheme (NEPSS) have also been most frequently isolated from quokkas, kangaroos and wallabies. The majority of reports in kangaroos and wallabies have been of subspecies I serovars, with *S.* Muenchen and *S.* Typhimurium reported most frequently in kangaroos, and *S.* Typhimurium reported most frequently in wallabies. The majority of isolations from quokkas have also been of subspecies I serovars, with *S.* Muenchen and *S.* Adelaide the most frequently reported, although *Salmonella* subspecies II serovar Wandsbek has also been reported frequently [16].

Epidemiology

Salmonella spp. are gut-associated bacteria that can be shed in the faeces either continuously or intermittently [5]. Studies on free ranging quokka and western grey kangaroos and on contamination of harvested kangaroo meat show that wild macropods are capable of harbouring the organism. Although theoretically possible under conditions of environmental stress, there have been no confirmed reports of primary clinical disease in macropods in their natural habitat and the morbidity and mortality rates of *Salmonella* infection in wild macropods is believed to be negligible [4, 15, 17, 18].

In any species, faecal shedding of *Salmonella* is often intermittent and may not be related to the level of stress to which the animal is exposed. For example, healthy macropods (species unspecified) housed in hygienic, large, grassed enclosures were found to have higher rates of faecal shedding than macropods (at a different captive institution), that were regularly exposed to stress associated with handling, fighting and travel. Despite the introduction of a carrier kangaroo (actively shedding) to this latter group, all animals remained negative. There were no differences in the prevalence (of either shedding or carriage) which could be attributed to the sex, age or species of macropod. Three agile wallabies (*M. agilis*) fed a dose of *S.* Infantis began shedding the organism within 24 hours, despite the absence of clinical signs [1].

The natural history of *Salmonella* in wild macropods has largely been studied in the quokka on Rottnest Island, off the coast of WA [12, 13]. Despite virtually all individuals showing evidence of faecal shedding throughout the summer months, no evidence of disease has been found in infected quokkas [12]. On Rottnest Is, quokkas in better body condition were less likely to be subclinically infected with *Salmonella* [17]. Whilst no gross or histological changes were noted at post mortem in experimentally infected agile wallabies, *Salmonella* was recovered from the walls of the ileum, caecum, stomach, stomach contents and mesenteric lymph nodes draining the intestine [19].

A study investigated prevalence of *Salmonella* in the faecal matter of western grey kangaroos harvested for consumption in WA and found only 3.6% of animals were positive. In the case of these animals, and the quokkas on Rottnest Is, no disease associated with the infection was detected [15, 17].

Studies have demonstrated the presence of *Salmonella* carriage in a large number of healthy, captive macropods. Animals in captivity may be exposed to the organism as a result of consumption of contaminated feed or water [1].

Orphaned and hand-raised macropods (joeys) are considered more likely to be infected with, and develop clinical disease from *Salmonella*, presumably as a result of poor immune status. Between 1981 and 1985, 65 live and 38 dead orphaned macropod joeys were sampled with 26.8% infected with *Salmonella* and 21.7% actively excreting the bacteria in faeces. The presence of *Salmonella* infection in orphaned joeys is considered to be significant for the individual animal (and associated carers) and a severely ill joey is likely to excrete more *Salmonella* than a healthy joey, with a likely greater zoonotic risk to the carers [11]. Orphaned macropods taken in for hand-raising (particularly those in poor health) should be considered at high risk of carrying and shedding *Salmonella*.

Clinical signs

Most wild macropods and many captive macropods that are carrying *Salmonella* exhibit no clinical signs [1, 20]. Clinical signs, when present, include loose faeces (anywhere from soft and semi-formed through to haemorrhagic diarrhoea) in association with lethargy, anorexia and dehydration. These changes are not pathognomonic and other disease processes should also be considered. Animals may also be found dead with no observed ante mortem clinical signs. Orphaned joeys often present with abdominal pain characterised by teeth grinding and abdominal guarding.

Diagnosis

Diagnosis in macropods is based on isolation of the organism from aseptically collected tissue at necropsy or from faeces or rectal swabs. As individuals may be asymptomatic carriers, other evidence of disease compatible with salmonellosis must be present. Prior or current infection of animals by some serovars may be diagnosed serologically [2], although this has not been reported in macropods. Carriers often harbour the organism in their mesenteric and ileocaecal lymph nodes. *Salmonella* has been isolated less commonly from the urine, liver, lung, kidney, heart, abdomen and spleen of macropods [21].

Laboratory diagnostic specimens and procedures

There are numerous methods for detection of *Salmonella*. In macropods, culture is the most common method of diagnosis and is used to isolate *Salmonella* from tissues collected aseptically at post mortem or from faecal and rectal swabs [15, 17]. Some studies have used PCR as the first method of detection, followed by culture to confirm and further characterise the diagnosis [4]. The relative yield of *Salmonella* isolates in faecal material is greater than from rectal swabs [22]. Lymph nodes, primarily the mesenteric, commonly harbour *Salmonella* in carrier animals, even when they are not shedding and are particularly useful tissue samples to collect at post mortem. *Salmonella* has also been isolated from ileocaecal lymph nodes, liver, lung, urine kidney, spleen and gall bladder [1, 21]. Samples should be collected as aseptically as possible during the acute phase of disease or as soon after death as possible. It is also preferable to collect samples prior to the commencement of any antibiotic treatment [2].

Isolation of *Salmonella* can be accomplished using a variety of culture techniques. Success can be increased by employing pre-enrichment to resuscitate sub-lethally damaged organisms, adding inhibitory substances to enrichment media to suppress competing organisms and using selective plating agars, which allow *Salmonella* to be differentiated from other enterobacteria. Care must be taken when selecting an enrichment media as some can be toxic to certain *Salmonella* serovars. More detailed information on the culture of *Salmonella* can be obtained from the '*Manual of diagnostic tests and vaccines for terrestrial animals'* [2].

Other forms of *Salmonella* detection include immunomagnetic separation (IMS), electrical conductance/ impedance and PCR. Serological tests to detect infected herds/flocks include the serum agglutination test (SAT) and ELISA [23], however their use has not been reported in macropods.

Clinical and other pathology

In general, haematological and serum biochemical changes in macropods are not well correlated to the severity of underlying disease and results may be unremarkable despite significant bacterial infection. Fibrinogen may be increased with salmonellosis. Neutrophilia and lymphocytosis may be present, but absence of these changes does not rule out bacterial infection [20].

There are few descriptions of pathology associated with salmonellosis in macropods. Changes include focal hepatic necrosis with and without cholangitis, inflammation in the muscularis of the intestine, intussusception of the intestine and suppurative bronchopneumonia [24].

Differential diagnoses

In captive macropods, differential diagnoses of salmonellosis include other causes of gastroenteritis and diarrhoea, including coccidiosis and campylobacteriosis [20]. Toxoplasmosis should be considered in the event of acute death. *Strongyloides* may cause diarrhoea and death [14, 25]. In hand-reared joeys, physiological stress, coccidiosis, yeast/candidiasis, roundworms, antibiotic administration and cryptosporidia are all differential diagnoses of diarrhoea [26]. Other causes of bacterial diarrhoea, including *E. coli* and *Klebsiella,* should also be considered [27].

Treatment

There are no published reports of the efficacy of antibiotics in the treatment of *Salmonella* infection in macropods. Culture and sensitivity is likely to provide a useful means of determining the most effective antibiotics. For clinically affected animals, analgesia is recommended if abdominal pain is apparent, as well as supportive care in the form of SC or IV fluids and removal of stressors [20]. There is no requirement to treat asymptomatic infection in macropods, although the potential disease risk to the host, and to humans and other animals, should be considered and managed, through appropriate hygiene practices (see below).

Prevention and control

Minimising physiological stress is key to preventing and controlling *Salmonella* spp. in macropods in captivity, especially joeys in care [20, 27]. Strict hygiene, including handwashing, hygiene of pouches, feeding equipment and the environment should be maintained whenever joeys are in care. Macropods in care or captivity should not have direct or indirect contact with domestic or feral animals. *Salmonella* are susceptible to many disinfectants and can also be killed by moist heat (121°C for a minimum of 15 min) or dry heat (160-170°C for at least 1 hour) [5].

Hygiene should be maintained during processing of kangaroo carcasses. General food safety practices should be followed when handling and storing kangaroo meat to avoid contamination of other foodstuffs. Thorough cooking of meat intended both for human and pet consumption will also reduce the risk of *Salmonella* infection [15].

Research

Iveson et al. [17] identified a need to better understand the source of infection of *Salmonella* in free living Australian mammals. Potter et al. [15] investigated the prevalence and speciation of *Salmonella* in western grey kangaroos in WA. Similar work on other species of macropods (and other Australian native mammals) across Australia would provide a better picture of the natural levels of asymptomatic infection in these animals. The potential for these animals to act as a zoonotic source of *Salmonella* was identified by Thomas et al. [28], who saw a need for more investigations into human cases to examine contact with domestic and wild animals and animal products.

Surveillance and management

Since 1978, the National Enteric Pathogens Surveillance Scheme (NEPSS) has collected data on human and non-human isolations of enteric bacterial pathogens in Australia, including information on *Salmonella* serotypes identified in Australian animals and wildlife. Reports of isolates are voluntarily submitted by the five laboratories capable of serotyping and phage typing *Salmonella* within Australia. *Salmonella* isolates are submitted to these laboratories by primary diagnostic laboratories throughout the country.

The Australian Government Department of Health OzFoodNet network (https://www.health.gov.au/our-work/ozfoodnet-network?utm_source=health.gov.au&utm_medium=callout-auto-

custom&utm_campaign=digital_transformation) undertakes national investigations into gastroenteritis outbreaks and clusters of disease in people, if they are potentially related to food products. Results are announced quarterly, and annual reports have been published in CDI since 2002 and their "Human and Non-human Annual Reports" are available on their website or on request.

Wildlife Health Australia administers Australia's general wildlife health surveillance system, in partnership with government and non-government agencies. Wildlife health data is collected into a national database, the electronic Wildlife Health Information System (eWHIS). Information is reported by a variety of sources including government agencies, zoo based wildlife hospitals, sentinel veterinary clinics, universities, wildlife rehabilitators, and a range of other organisations and individuals. Targeted surveillance data is also collected by WHA. See the WHA website for more information https://wildlifehealthaustralia.com.au/Our-Work/Surveillance and https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/eWHIS-Wildlife-Health-Information-System.

We are interested in hearing from anyone with information on this condition in Australia, including laboratory reports, historical datasets or survey results that could be added to the National Wildlife Health Information System. Negative data are also valuable. If you can help, please contact us at admin@wildlifehealthaustralia.com.au.

Cases of *Salmonella* infection and of disease associated with the presence of *Salmonella* in macropods are reported in eWHIS, primarily in hand-raised juveniles.

Statistics

WHA provides reports on wildlife isolates to the NEPSS, which maintains a summary database of *Salmonella* isolates from wildlife in Australia. This is a valuable resource for Australia and people seeking detailed information on *Salmonella* isolates from wild animals in Australia are referred to this source.

Human health implications

Various *Salmonella* serotypes that have been isolated from macropods are also documented human pathogens [13, 21]. Three main potential routes of *Salmonella* transmission from Australian macropods to humans have been identified. On Rottnest Is, with *Salmonella* prevalence in quokkas reaching nearly 100% at certain times of year, combined with the proximity of the macropods to human visitors, there is concern of transmission via faecal contamination. Cases of human salmonellosis with the same serovars as those identified in quokkas have been traced back to the island [17]. Transmission to humans in other areas of the country where there is extensive macropod faecal contamination (e.g. some parks and public spaces) is also possible but has not been reported. An outbreak of *S.* Java in humans was linked to indirect exposure to the faeces of long-nosed bandicoots (*Perameles nasuta*) [29].

Close contact between wildlife carers, owners of pet kangaroos or zoo keepers and macropods is a potential route of zoonotic exposure to *Salmonella* in Australia. Orphaned joeys in particular are

considered a significant risk as they experience physiological stress related to sudden loss of their mother, a change in nutrition and unaccustomed exposure to humans and possibly other animals. Appropriate risk management measures should be used when caring for orphaned macropods (e.g. excellent hygiene, minimising all other stressors).

Kangaroo meat intended for human and pet food consumption is the third potential route of human exposure. Whilst early studies reported contamination rates as high as 44.9% [30], enforced regulatory standards within the industry have seen this figure decrease significantly. More recent studies have reported contamination rates between 0.84% and 18% [3, 4, 31]. Post processing measures, such as thorough cooking of kangaroo meat prior to consumption, also reduces the likelihood of transmission through the oral route.

Conclusions

Salmonella infections in production animals (such as chickens and pigs) are considered to be a major source of salmonellosis in humans. Macropods have not been linked to cases of human salmonellosis, however these animals do present a potential risk of infection both to people and pets. Macropods in the wild are capable of harbouring *Salmonella* and studies have demonstrated that high rates of infection occur in orphaned joeys and some captive macropods. Although there are no reports in Australia of humans acquiring *Salmonella* infection through the handling or consumption of macropod carcasses, meat products or hand-raised macropods, it is important for all individuals coming into close contact with macropods, or kangaroo meat products to practice appropriate hygiene measures at all times.

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Wildlife Health Australia recognises the Traditional Custodians of Country throughout Australia. We respectfully acknowledge Aboriginal and Torres Strait Islander peoples' continuing connection to land, sea, wildlife and community. We pay our respects to them and their cultures, and to their Elders past and present.

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References and other information

1. Samuel JL (1982) *Salmonella* in macropods, in Wildlife diseases of the Pacific Basin and other Countries; the 4th International Conference of the Wildlife Disease Association, M.E. Fowler, Editor. WDA: Sydney. 61-63
2. OIE (2016) Salmonellosis 2.9.8. Manual of diagnostic tests and vaccines for terrestrial animals [cited 13 August 2018 2018]; Available from: http://www.oie.int/fileadmin/Home/eng/Health_standards/tahm/2.09.08_SALMONELLOSIS.pdf
3. Bensink JC, Ekaputra I et al. (1991) The isolation of *Salmonella* from kangaroos and feral pigs processed for human consumption. *Australia Veterinary Journal*, **68**(3): 106-107
4. Eglezos S, Huang B et al. (2007) A survey of the microbiological quality of kangaroo carcasses processed for human consumption in two processing plants in Queensland, Australia. *Journal of Food Protection*, **70**(5): 1249-51

6. Brenner FW, Villar RG et al. (2000) *Salmonella* nomenclature. *Journal of Clinical Microbiology*, **38**(7): 2465-2467

7. Kourany M, Bowdre L et al. (1976) Panamanian forest mammals as carriers of *Salmonella. American Journal of Tropical Medicine and Hygiene*, **25**(3): 449-455

8. Ruiz-Pina (2002) *Salmonella* in opossums from Yucatan Mexico. *Revista do Instituto de Medicina Tropical de São Paulo*: 235-237

9. Villafañe IEG, Miñarro F et al. (2004) Assessment of the risks of rats (*Rattus norvegicus*) and opossums (*Didelphis albiventris*) in different poultry-rearing areas in Argentina. *Brazilian Journal of Microbiology*, **35**(4): 359-363

10. Jijón S, Wetzel A et al. (2007) *Salmonella enterica* isolated from wildlife at two Ohio rehabilitation centers. *Journal of Zoo and Wildlife Medicine*, **38**(3): 409-413

11. Speare R and Thomas AD (1988) Orphaned kangaroo and wallaby joeys as a potential zoonotic source of *Salmonella* spp. *Medical Journal of Australia*, **148**(12): 619, 622-623

12. Hart RP, Bradshaw SD et al. (1985) *Salmonella* infections in a marsupial, the quokka (*Setonix brachyurus*), in relation to seasonal changes in condition and environmental stress. *Applied and Environmental Microbiology*, **49**(5): 1276-1281

13. Iveson JB and Bradshaw SD (1973) *Salmonella javiana* infection in an infant associated with a marsupial, the quokka, *Setonix brachyurus*, in Western Australia. *Journal of Hygiene*, **71**: 423 - 432

14. Arundel JH (1981) Wildlife diseases of the Pacific Basin - Australia. In '4th International Conference of the Wildlife Disease Association'. WDA: Australia

15. Potter AS, Banazis MJ et al. (2011) Prevalence of *Coxiella burneti*i in western grey kangaroos (*Macropus fuliginosus*) in Western Australia. *Journal of Wildlife Diseases*, **47**(4): 821-828

16. NEPSS (2018) National enteric pathogen surveillance system scheme data: *Salmonella* in macropods; unpublished data

17. Iveson JB (2007) Seasonal and spatial variation in *Salmonella* infections rates. *Journal of the Royal Society of Western Australia*: 127-136

18. Speare R, Donovan JA et al. (1989) Diseases of free-ranging *Macropodoidea*. In 'Kangaroos, wallabies and rat-kangaroos.' (Eds G.C. Grigg, P. Jarman and I.D. Hume) pp. 705-734. (Surrey Beatty & Sons: Sydney)

19. Samuel JL (1983) Jaw disease in macropod marsupials: bacterial flora isolated from lesions and from the mouths of affected animals. *Veterinary Microbiology*, **8**(4): 373-387

20. Vogelnest L and Woods R (2008) 'Medicine of Australian mammals.' (CSIRO Publishing)

21. Yuill TM, Seymour C et al. (2001) Arbovirus infections. In 'Infectious Diseases of Wild Mammals.' (Eds E.S. Williams and I. Barker) pp. 98-118. (Iowa State University Press: Ames, Iowa)

22. Hart RP, Iveson JB et al. (1982) A study of isolation procedures for multiple infections of *Salmonella* and *Arizona* in a wild marsupial, the quokka (*Setonix brachurus*). *Journal of Applied Bacteriology*, **53**: 395-406

23. Wynwood SJ, Burns MA et al. (2016) Leptospirosis in Tasmanian Devils (*Sarcophilus harrisii*) in Tasmania, 2008-12. *Journal of Wildlife Diseases*, **52**(3): 636-41

24. Ladds P (2009) Bacterial diseases in terrestrial mammals. In 'Pathology of Australian Native Wildlife.' (Ed P. Ladds) pp. 65-104. (CSIRO publishing: Collingwood)

25. Winter H and O'Connor R (1957) *Salmonella* Birkenhead from a kangaroo. *Australian Veterinary Journal*, **33**(3): 67-67

26. Mason P (2007) Diarrhoea in Joeys. Available from: http://www.wildlifevictoria.org.au/cms/images/stories/docs/diarrhoea%20in%20joeys.pdf

27. Booth R (2002) Macropods. In 'Hand-rearing wild and domestic mammals.' pp. 63-74. (Wiley-Blackwell: Australia)

28. Thomas AD, Forbes-Faulkner JC et al. (2001) Salmonelliasis in wildlife from Queensland. *Journal of Wildlife Diseases*, **37**(2): 229-38

29. Staff M, Musto J et al. (2012) Salmonellosis outbreak traced to playground sand, Australia, 2007–2009. *Emerging infectious diseases*, **18**(7): 1159-1162

30. Suzuki A, Kawanishi K et al. (1967) A survey of *Salmonella* contamination of imported meats during 1965 - 1966. *Bull. Natn. Inst. Hyg. Sci.*, **85**: 188 - 195

31. Holds G, Pointon A et al. (2008) Microbial profiles of carcasses and minced meat from kangaroos processed in South Australia. *International Journal of Food Microbiology*, **123**: 88-92

Uncategorized References

5. CFSPH (2013) 'Salmonellosis: Paratyphoid, non-typhoidal salmonellosis.'. Centre for Food Security and Public Health

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