

Angiostrongylus and Australian wildlife

Fact sheet

Introductory statement

Angiostrongylus cantonensis, the rat lungworm, occurs naturally in introduced black and Norway rats but can cause neural angiostrongyliasis in accidental mammalian and bird hosts. It is the primary cause of eosinophilic meningitis in humans in Australia and an expanding area of the world, including within south eastern Australia (see Prociv et al. (2000) for comprehensive review). Native species are susceptible to neural angiostrongyliasis, with marsupials and flying-foxes appearing to be highly susceptible.

Aetiology

Angiostrongylus cantonensis is a parasitic lungworm belonging to the nematode superfamily Metastrongyloidea. It is believed to have arrived in Australia with introduced rat species.

Natural hosts

The rat lungworm occurs naturally in the introduced Norway rat (*Rattus norvegicus*), and the black rat (*R. rattus*). These are the most important hosts in Australia, but it may also be present in a number of other host species (Vogelnest 2019). Infection occurs accidentally in a wide range of native and non-native eutherian and marsupial mammals and some native birds. It causes zoonotic infection in humans.

World distribution

The parasite has a wide geographical distribution encompassing much of south-east Asia, Melanesia, Polynesia and eastern Australia. It has established a foothold in Africa, India, parts of central and southern America and in south-eastern USA (Kliks and Palumbo 1992; Prociv et al. 2000; Vogelnest 2019).

Occurrences in Australia

The parasite occurs in eastern coastal Queensland and New South Wales as far south as Jervis Bay (Stokes et al. 2007). Naturally occurring, non-human infections were first recognised in dogs in Brisbane in 1972 (Mason et al. 1976) and in Sydney in 1989 and 1991 (Collins et al. 1992).

The first natural infection in a marsupial was reported in 1978, from a captive Bennett's wallaby in Brisbane, with morphological confirmation of *A. cantonensis* worms recovered from the central nervous system [CNS] (McKenzie et al. 1978).

Subsequently, natural infections have been confirmed by necropsy in horses (Wright et al. 1991), a range of potoroid and macropodid marsupials (Higgins et al. 1997) (Rose and Spratt pers. comm.), ringtail and brushtail possums (Ma et al. 2013b) (Prociv pers. comm., Rose and Spratt pers. comm.), a captive native water rat (*Hydromys chrysogaster*) (Shamsi et al. 2019), captive tamarins (Carlisle et al. 1998) and squirrel monkeys (Rose and Spratt pers. comm.), free-living flying-foxes (Reddacliff et al. 1999; Barrett et al. 2002), tawny frogmouths, gang gang and a yellow-tailed black cockatoo (Montali et al. 2004; Monks et al. 2005; Ma et al. 2013a; Reece et al. 2013).

Epidemiology

When the life cycle of the rat lungworm was investigated in Brisbane more than 50 years ago (Mackerras and Sandars 1955), it was not then generally known to be a human pathogen. Nor was it realised at the time that the parasite under investigation was actually *A. mackerrasae*, almost identical to *A. cantonensis*; *A. mackerrasae* was not recognised as a distinct and indigenous species found in native rats until 14 years later (Bhaibulaya 1968).

Eggs released by female worms in the pulmonary arteries are carried in the circulation to the lungs where they embryonate. First-stage larvae penetrate alveoli, carried up the respiratory escalator, swallowed and passed in the faeces. They are ingested by intermediate hosts, which include a wide range of native and introduced slugs and snails. They develop to the third larval stage in molluscan tissues and are directly infective to rats, although a variety of paratenic or transport hosts (which eat molluscs) may be interspersed in transmission, including terrestrial planarians and crabs, fresh-water shrimp and fish, frogs and toads. Third-stage larvae ingested by rats penetrate the stomach, enter the hepatic portal and the mesenteric lymphatic systems, are subsequently carried around the body by the arterial circulation and enter the CNS 2-3 days post-infection. They undergo an obligatory migration to the brain, moulting twice on route to the subarachnoid space 12-14 days post-infection. At 28-33 days, worms enter the cerebral vein and travel to the heart and pulmonary arteries, where they mature (Mackerras and Sandars 1955; Bhaibulaya 1975). This parasite is not highly specific for its definitive or intermediate hosts.

In Australia, marsupials and flying-foxes appear to be highly susceptible to neural angiostrongyliasis, perhaps because of a lack of evolutionary exposure to this parasite. Australian wildlife may be important sentinels for the emergence and spread of *A. cantonensis* (Vogelneust 2019).

There is reasonable knowledge of some of the infection pathways from snails and slugs (indigenous and introduced) ingested by Australian hosts, including humans (Mackerras and Sandars 1955; Bhaibulaya 1975; Yong et al. 1981; Collins et al. 1992; Higgins et al. 1997; Carlisle et al. 1998). However, the infection pathway responsible for the high prevalence of infection in tawny frogmouths (*Podargus strigoides*), in the northern

suburbs of Sydney has not been clearly elucidated (Spratt 2005). The relevance of snails and slugs in the diet of these birds has not been clarified. Free-living tawny frogmouths would seem to be at high risk of exposure to this infection as their natural diet comprises mainly invertebrates, including the intermediate or paratenic host species of *A. cantonensis*. Snails and slugs are not part of the natural diet of cockatoos, but infection in these species may have occurred through accidental ingestion of an infected snail or slug, or contamination of food (Monks et al. 2005).

Human angiostrongyliasis was first reported in Australia from Brisbane in 1971, although case records indicated infections might have occurred as early as 1959 (Heaton and Gutteridge 1980). Human infection has resulted from ingestion of small intermediate or paratenic hosts, either deliberately or accidentally (for example on poorly or unwashed salad greens) (Gutteridge 1971; Gutteridge et al. 1972; Saltos et al. 1975; Tiernan and Prociv 1987). There have been three reported Australian fatalities in infants, probably through direct ingestion of snails or a planarian (Tiernan and Prociv 1987; Cooke-Yarborough et al. 1999; Prociv 1999). A human case in Sydney resulted from deliberate ingestion of a large slug on a bet (Senanayake et al. 2003). Infective lungworm larvae escaping from molluscan tissues in the mucous deposited on salad vegetables may be another source of infection although current evidence for this probably derives from *A. malaysiensis* rather than *A. cantonensis* (Heyneman and Lim 1967).

Evidence of a long association of *A. cantonensis* with its “domiciliated” rat hosts, *R. norvegicus* and *R. rattus*, stems from the fact that they can survive relatively large infective doses (150 parasites developing in the brain at 28 days), often without significant disturbances to the CNS (Prociv et al. 2000). Surveys of rats in the environs of Brisbane confirmed that *A. cantonensis* occurred only in these two exotic rat species, that its distribution was focal and concentrated near the river, and that virtually all slugs and snails tested experimentally were suitable intermediate hosts, including *Helix aspersa*, the exotic European garden snail (Yong et al. 1981). The presence of the indigenous species of *Angiostrongylus*, *A. mackerrasae*, only in indigenous rats *R. fuscipes* and *R. lutreolus* in Australia, including Tasmania, indicates a long co-evolution of this association (Prociv et al. 2000). Like *A. malaysiensis* in Malaysia, *A. mackerrasae* has not been associated with infections of humans or other accidental hosts.

Clinical signs

In animals, the predominant clinical features of angiostrongyliasis are neurological and include depression, ataxia, muscle wasting, ascending paresis, lumbar hyperalgesia and paralysis of the limbs, which in severe forms may involve the muscles of the head and neck (Mason et al. 1976; Mason 1987; Wright et al. 1991; Monks et al. 2005). The most common, and often only, symptom of neural angiostrongyliasis in adult humans is severe, prolonged headache (Punyagupta et al. 1970).

Diagnosis

Histological examination of the brain and spinal cord and dissection and recovery of worms is essential for definitive diagnosis. Because cerebrospinal fluid (CSF) collection is rarely performed in birds, antemortem diagnosis in birds can only be presumptive, relying on history and clinical signs in endemic areas (Monks et al. 2005). It is noteworthy that several flying-foxes in Brisbane with neurological disease tentatively attributed to lyssavirus infection, were, on retrospective examination of preserved brain tissue, shown to have variable numbers of *A. cantonensis* (Reddacliff et al. 1999).

Identification can be achieved by morphological examination of whole worms. The size of the spicules of males in particular is highly diagnostic, with spicule length in *A. cantonensis* being approximately 1.0 mm and about twice the length of that in *A. mackerrasae* (Bhaibulaya 1968).

First-stage larvae passed in the faeces of infected rat hosts cannot be satisfactorily differentiated from other lungworm species. Infection in accidental vertebrate hosts generally does not develop to the stage of production of first-stage larvae or their subsequent occurrence in faeces.

Clinical pathology and pathology

Along with the clinical signs of ascending paresis and lumbar hyperalgesia, CSF analysis is a valuable aid in the diagnosis of neural angiostrongyliasis (Mason 1987). Peripheral eosinophilia is commonly present.

In animals, the classic presentation is eosinophilic meningoencephalitis throughout the brain and spinal cord, presumptive diagnosis being strongly supported by the finding of marked eosinophilic pleocytosis and sometimes even larval *A. cantonensis* in the CSF (Mason et al. 1976; Wright et al. 1991; Collins et al. 1992). Inflammatory foci may contain dying or degenerating nematodes. Monks et al. (2005) reported Wallerian degeneration of white matter and variable chronic inflammation in infected birds.

Laboratory diagnostic specimens and procedures

Fresh brain and CNS in saline - frozen or fixed - are useful for dissection and recovery of larval and adult worms, subsequent to microscopic identification to species level.

Assessment of human patient sera, in an enzyme-linked immunosorbent assay (ELISA) based upon purified extracts from adult female worms, and using a wide range of controls, showed a sensitivity of 100% in clinically affected patients, but a very low specificity and positive predictive value of the test (Nuamtanong 1996). A major drawback in diagnosing subclinical infection is that small numbers of worms might not elicit detectable serological responses. This could also apply to monoclonal antibody (mAb)-based tests, aimed at detecting *Angiostrongylus* antigens in sera and CSF, which have shown promise in patients with clinical eosinophilic meningoencephalitis (Chye et al. 1997). PCR-based assays for parasite DNA may prove more useful, but these have not yet been investigated in angiostrongyliasis.

Treatment

The use of anthelmintics to treat Angiostrongyliasis is generally not recommended as the death of the parasite can result in a severe inflammatory reaction in the host (Vogelnest 2019). There are reports that fenbendazole has been used to successfully treat *A. cantonensis* infection in grey-headed flying-foxes (*Pteropus poliocephalus*) and suggestions that it could be used in macropods (Reddacliff et al. 1999). In domestic species and humans, are generally based on high-dose corticosteroid treatment to reduce the inflammatory response (Vogelnest 2019). Transient but short-lived improvement was reported in a yellow-tailed black cockatoo following treatment with dexamethasone, but no improvement was evident in two tawny frogmouths 24 hours after treatment with dexamethasone (Monks et al. 2005).

Prevention and control

The only effective strategy for prevention and control is to reduce or eliminate contact between potential vertebrate hosts and the intermediate or paratenic hosts of the parasite. This is not a practical approach with free-living wildlife. In zoos and fauna parks, a broad-based rodent, snail and slug control program is recommended, with a particular focus on autumn and winter, as climatic conditions at these times seem to enhance snail and slug activity (Vogelnest 2019).

Surveillance and management

Wildlife disease surveillance in Australia is coordinated by Wildlife Health Australia. The National Wildlife Health Information System (eWHIS) captures information from a variety of sources including Australian government agencies, zoo and wildlife parks, wildlife carers, universities and members of the public. Coordinators in each of Australia's States and Territories report monthly on significant wildlife cases identified in their jurisdictions. NOTE: access to information contained within the National Wildlife Health Information System dataset is by application. See the WHA website for more information:

www.wildlifehealthaustralia.com.au/ProgramsProjects/eWHISWildlifeHealthInformationSystem.aspx#requests

There are a large number of reports of neural angiostrongyliasis in the national wildlife health information system eWHIS. Reports are primarily from flying-foxes (*Pteropus* sp.) and tawny frogmouths (*Podargus strigoides*) in north eastern NSW and coastal Qld.

Human health implications

Neural angiostrongyliasis is a significant disease in humans especially young children prone to ingesting the intermediate or paratenic hosts of the parasite: snails, slugs, planarians and crabs (Ash 1976).

Research

The precise geographical distribution of *A. cantonensis* in Australia remains unknown, even between southern Queensland and Sydney. If *A. cantonensis* entered the continent through northern ports, one would expect it to be established throughout the wet tropical regions. A systematic survey of rats on the mainland of the Northern Territory and northern Western Australia could be very informative.

The geographical distribution of *A. cantonensis* now extends to the coastal forests of Jervis Bay (Stokes et al. 2007). The occurrence of the parasite in black rats in bushland close to campgrounds and rural homes has possible human and wildlife health implications.

Further studies should be directed towards establishing the modes of dispersal of *A. cantonensis*, the potential role of humans in its spread, its geographical distribution and its impact on native fauna. Finally, a test for accurate diagnosis of *A. cantonensis* infection in vertebrates would be highly beneficial.

Conclusions

Neural angiostrongyliasis is a life-threatening disease of wildlife, pets and humans and can occur wherever introduced black and Norway rats proliferate and where a spectrum of intermediate and paratenic hosts exist. These conditions are particularly found in cities, around fauna parks and zoos and, increasingly for the

black rat, in temperate coastal forest areas and campgrounds. Australian wildlife may be useful sentinels for emergence and spread of *A. cantonensis*.

References and other information

Ash LR (1976) Observations on the role of mollusks and planarians in the transmission of *Angiostrongylus cantonensis* infection to man in New Caledonia. *Revista de biología tropical* **24**, 163-174.

Barrett J, Carlisle M, Prociv P (2002) Neuro-angiostrongylosis in wild Black and Grey-headed flying foxes (*Pteropus* spp). *Australian Veterinary Journal* **80**, 554-558.

Bhaibulaya M (1968) A new species of *Angiostrongylus* in an Australian rat, *Rattus fuscipes*. *Parasitology* **58**, 789-799.

Bhaibulaya M (1975) Comparative studies on the life history of *Angiostrongylus mackerrasae* Bhaibulaya, 1968 and *Angiostrongylus cantonensis* (Chen, 1935). *International Journal for Parasitology* **5**, 7-20.

Carlisle M, Prociv P, Grennan J, Pass M, Campbell G, Mudie A (1998) Cerebrospinal angiostrongyliasis in five captive tamarins (*Sanguinus* spp). *Australian Veterinary Journal (Australia)* **76**, 167-170.

Chye S-M, Yen C-M, Chen E-R (1997) Detection of Circulating Antigen by Monoclonal Antibodies for Immunodiagnosis of Angiostrongyliasis. *American Journal of Tropical Medicine and Hygiene* **56**, 408-412.

Collins G, Rothwell T, Malik R, Church D, Dowden M (1992) Angiostrongylosis in dogs in Sydney. *Australian Veterinary Journal* **69**, 170-1.

Cooke-Yarborough CM, Kornberg AJ, Hogg GG, Spratt DM, Forsyth JR (1999) A fatal case of angiostrongyliasis in an 11-month-old infant. *Medical Journal of Australia* **170**, 541-543.

Gutteridge B (1971) Angiostrongylosis (Correspondence). *Medical Journal of Australia* **1**, 931-932.

Gutteridge B, Bhaibulaya M, Findlater C (1972) Human larval meningitis possibly following lettuce ingestion in Brisbane. *Pathology* **4**, 63-64.

Heaton DC, Gutteridge BH (1980) Angiostrongyliasis in Australia. *Australian and New Zealand Journal of Medicine* **10**, 255.

Heyneman D, Lim B-L (1967) *Angiostrongylus cantonensis*: proof of direct transmission with its epidemiological implications. *Science* **158**, 1057-1058.

Higgins D, Carlisle-Nowak M, Mackie J (1997) Neural angiostrongylosis in three captive rufous bettongs (*Aepyprymnus rufescens*). *Australian Veterinary Journal* **75**, 564-566.

Kliks MM, Palumbo NE (1992) Eosinophilic meningitis beyond the Pacific Basin: the global dispersal of a peridomestic zoonosis caused by *Angiostrongylus cantonensis*, the nematode lungworm of rats. *Social Science & Medicine* **34**, 199-212.

Ma G, Dennis M, Rose K, Spratt D, Spielman D (2013a) Tawny frogmouths and brushtail possums as sentinels for *Angiostrongylus cantonensis*, the rat lungworm. *Veterinary Parasitology* **192**, 158-165.

Ma G, Dennis M, Rose K, Spratt D, Spielman D (2013b) Tawny frogmouths and brushtail possums as sentinels for *Angiostrongylus cantonensis*, the rat lungworm. *Veterinary Parasitology* **192**, 158-165.

- Mackerras MJ, Sandars DF (1955) The life history of the rat lung-worm, *Angiostrongylus cantonensis* (Chen)(Nematoda: Metastrongylidae). *Australian Journal of Zoology* **3**, 1-21.
- Mason K (1987) Canine neural angiostrongylosis: the clinical and therapeutic features of 55 natural cases. *Australian Veterinary Journal* **64**, 201-203.
- Mason K, Prescott C, Kelly W, Waddell A (1976) Granulomatous encephalomyelitis of puppies due to *Angiostrongylus cantonensis*. *Australian Veterinary Journal* **52**, 295-295.
- McKenzie R, Green P, Wood A (1978) *Angiostrongylus cantonensis* infection of the brain of a captive Bennett's wallaby (*Macropus rufogriseus*). *Australian Veterinary Journal* **54**, 86-88.
- Monks DJ, Carlisle MS, Carrigan M, Rose K, Spratt D, Gallagher A, Prociv P (2005) *Angiostrongylus cantonensis* as a cause of cerebrospinal disease in a yellow-tailed black cockatoo (*Calyptorhynchus funereus*) and two tawny frogmouths (*Podargus strigoides*). *Journal of Avian Medicine and Surgery* **19**, 289-293.
- Montali R, Spratt D, Rose K (2004) Cerebrospinal *Angiostrongylus cantonensis* in tawny frogmouths in Sydney, Australia, Proceedings of the WDA (Australasian section) Annual meeting, Kinchega National Park, NSW, Australia. Kinchega National Park.
- Nuamtanong S (1996) The evaluation of the 29 and 31 kDa antigens in female *Angiostrongylus cantonensis* for serodiagnosis of human angiostrongyliasis. *Southeast Asian Journal of Tropical Medicine and Public Health* **27**, 291-296.
- Prociv P (1999) Parasitic meningitis: Crossing paths with the rat lungworm (*Angiostrongylus cantonensis*). *Medical Journal of Australia* **170**, 517-518.
- Prociv P, Spratt DM, Carlisle MS (2000) Neuro-angiostrongyliasis: unresolved issues. *International Journal for Parasitology* **30**, 1295-1303.
- Punyagupta S, Bunnag T, Juttijudata P, Rosen L (1970) Eosinophilic meningitis in Thailand. *American Journal of Tropical Medicine and Hygiene* **19**, 950-958.
- Reddacliff L, Bellamy T, Hartley W (1999) *Angiostrongylus cantonensis* infection in grey-headed fruit bats (*Pteropus poliocephalus*). *Australian Veterinary Journal* **77**, 466-468.
- Reece R, Perry R, Spratt D (2013) Neuroangiostrongyliasis due to *Angiostrongylus cantonensis* in gang-gang cockatoos (*Callocephalon fimbriatum*). *Australian Veterinary Journal* **91**, 477-481.
- Salto N, Ghosh H, Gan A (1975) Eosinophilic meningitis (*Angiostrongylosis*): a probable case. *Medical Journal of Australia* **1**, 561-562.
- Senanayake SN, Pryor DS, Walker J, Konecny P (2003) First report of human angiostrongyliasis acquired in Sydney. *Medical Journal of Australia* **179**, 430-431.
- Shamsi S, Miles S, Tozer K, Raidal S, Smales L (2019) The first report of cerebral, pulmonary and gastrointestinal angiostrongyliasis in the water rat *Hydromys chrysogaster* from Queensland, Australia. *Journal of Helminthology* **93**, 772-774.
- Spratt DM (2005) Neuroangiostrongyliasis: disease in wildlife and humans. *Microbiology Australia* **26**, 63-64.
- Stokes VL, Spratt DM, Banks PB, Pech RP, Williams RL (2007) Occurrence of *Angiostrongylus* species (Nematoda) in populations of *Rattus rattus* and *Rattus fuscipes* in coastal forests of south-eastern Australia. *Australian Journal of Zoology* **55**, 177-184.

Tiernan JR, Prociv P (1987) Eosinophilic meningoencephalitis with permanent sequelae. *Medical Journal of Australia* **147**, 294-295.

Vogelnest L (2019) Neural angiostrongyliasis. In 'Current Therapy in Medicine of Australian Mammals.' (Eds L Vogelnest, T Portas.) (CSIRO: Collingwood).

Wright J, Kelly W, Hamilton J, Wadell A (1991) Equine neural angiostrongylosis. *Australian Veterinary Journal* **68**, 58-60.

Yong W, Welch J, Dobson C (1981) Localized distribution of *Angiostrongylus cantonensis* among wild rat populations in Brisbane, Australia. *Southeast Asian Journal of Tropical Medicine and Public Health* **12**, 608-609.

Updated: November 2019

Acknowledgements

We are extremely grateful to the many people who had input into this fact sheet: David Spratt, Wendy Henderson, Nicky Barry and Lyndel Post. Without their ongoing support production of these fact sheets would not be possible.

To provide feedback on this fact sheet

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. If you can help, please contact us at admin@wildlifehealthaustralia.com.au.

Wildlife Health Australia would be very grateful for any feedback on this fact sheet. Please provide detailed comments or suggestions to admin@wildlifehealthaustralia.com.au. We would also like to hear from you if you have a particular area of expertise and would like to produce a fact sheet (or sheets) for the network (or update current sheets). A small amount of funding is available to facilitate this.

Disclaimer

This fact sheet is managed by Wildlife Health Australia for information purposes only. Information contained in it is drawn from a variety of sources external to Wildlife Health Australia. Although reasonable care was taken in its preparation, Wildlife Health Australia does not guarantee or warrant the accuracy, reliability, completeness, or currency of the information or its usefulness in achieving any purpose. It should not be relied on in place of professional veterinary or medical consultation. To the fullest extent permitted by law, Wildlife Health Australia will not be liable for any loss, damage, cost or expense incurred in or arising by reason of any person relying on information in this fact sheet. Persons should accordingly make and rely on their own assessments and enquiries to verify the accuracy of the information provided.



Find out more at www.wildlifehealthaustralia.com.au
email admin@wildlifehealthaustralia.com.au
or call +61 2 9960 6333