Pentastomiasis in Australian reptiles

Fact Sheet

January 2019

Introductory statement

Pentastomiasis (also known as Porocephalosis) is a disease caused by infection with pentastomids. Pentastomids are endoparasites of vertebrates, maturing primarily in the respiratory system of carnivorous reptiles (90% of all pentastomid species), but also in toads, birds and mammals. Pentastomids have zoonotic potential although no human cases have been reported in Australia. These parasites have an indirect life cycle involving one or more intermediate host. They may be distinguished from other parasite taxa by the presence of four hooks surrounding their mouth, which they use for attaching to respiratory tissue to feed on host blood. Pentastomid infections are often asymptomatic, but adult and larval pentastomids can cause severe pathology resulting in the death of their intermediate and definitive hosts, usually via obstruction of airways or secondary bacterial and/or fungal infections.

Aetiology

Pentastomiasis in reptiles is caused by endoparasitic metazoans of the subclass *Pentastomida*.

Four genera are known to infect crocodiles in Australia: *Alofia, Leiperia*, *Sebekia*, and *Selfia*; all in the family *Sebekidae*. Three genera infect lizards in Australia: *Raillietiella* (Family: *Raillietiellidae*), *Waddycephalus* (Family: *Sambonidae*) and *Elenia* (Family: *Sambonidae*). Four genera infect snakes in Australia: *Waddycephalus, Parasambonia* (Family: Sambonidae), *Raillietiella* and *Armillifer* (Family: Armilliferidae).

Natural hosts

Definitive hosts

Many species of Australian reptiles, including snakes, lizards and crocodiles are proven definitive hosts for pentastomes (see Appendix 1).

Lizards may be both intermediate and definitive hosts for pentastomids. *Raillietiella* spp. occurs primarily in small to medium-sized lizards and *Elenia australis* infects large varanids. Nymphs of *Waddycephalus* in several lizard species likely reflect incidental infection; it is possible that lizards are an intermediate host for *Waddycephalus*. *Raillietiella frenata* in the NT has recently host-switched from its traditional host, the invasive Asian house gecko (*Hemidactylus frenatus)*, to infect the invasive cane toad (*Rhinella marina*) [1, 2]. It is likely that the distribution of *R. frenata* will spread to encompass that of the cane toad and *R. frenata* may potentially utilise new lizard host species.

Intermediate hosts

Fish are intermediate hosts for all pentastomids that infect Australian crocodiles. In the Americas, *Sebekia* spp. may utilise snakes, lizards, turtles and mammals as additional intermediate hosts [3-5]; it is unknown whether the same is true for Australia.

Intermediate hosts for pentastomids of lizards are largely unknown. For *Raillietiella* spp. where the life cycle is known, an insect (such as a cockroach) is the intermediate host [6].

Intermediate hosts for snake pentastomes are largely unknown but may include insects, amphibians, reptiles and mammals. Frogs and/or lizards are the most plausible intermediate host for *Waddycephalus* [7]; although nymphs of *Waddycephalus* have been recorded in numerous taxa (e.g. dasyurids, elapids, geckos, skinks, frogs and owls), these animals are likely accidental hosts in which the parasite will not develop further.

The diet of Australian snakes known to host *Raillietiella orientalis* (the only raillietiellid known to mature in Australian snakes), indicates insects may be a first intermediate host, but frogs are the most plausible second intermediate host responsible for transferring this parasite to snakes in Australia. Intermediate hosts for *Armillifer* spp. are most likely mammals, considering the diet of the definitive host (pythons).

World distribution

Pentastomiasis occurs on all continents except Antarctica.

Crocodilians: *Alofia* spp. occur in Africa, Samoa, the Philippines, India and Australia; *Leiperia* spp. occur in Africa, the Americas and Australia; *Sebekia* spp. occur in Africa, the Americas, Trinidad, South East Asia, Papua New Guinea and Australia; *Selfia porosus* exclusively infects *C. porosus* in Australia [8]. Data on pentastomiasis prevalence in wild crocodilians is primarily restricted to *Sebekia mississippiensis* in American alligators (*Alligator mississippiensis*); prevalence is high (81-96%) [5, 9, 10].

Lizards and snakes: *Raillietiella* spp. are globally widespread; *Waddycephalus* spp. occur primarily in Australia and occasionally from snakes in Papua New Guinea, Hong Kong, Korea, Komodo Island and Fiji [11, 12]; and *Elenia* spp. are known from Australia and Papua New Guinea. *Parasambonia* spp. are known only from Australia [13]; *Raillietiella* spp. are globally widespread; and *Armillifer* spp. occur widely throughout Africa and Asia.

Occurrences in Australia

Crocodiles: documented in Qld and NT [14-17], likely to occur in WA. Data in wild Australian crocodiles is lacking; in captivity, pentastomids infected 90% of 10 crocodiles at a crocodile farm at Innisfail, Qld [14].

Lizards: reported in SA, WA, NT, Qld and potentially NSW (see Appendix 1).

Snakes: *Waddycephalus* spp. occur in all states and territories [7, 11, 18]; *Parasambonia* spp. occur in NSW and Qld [13]; *Raillietiella* spp. occur in NT, Qld, NSW, SA, and WA [2, 7, 19]; and *Armillifer* spp. occur in NT, Qld, and WA [20].

Epidemiology

The life cycle is unknown for most species of pentastomids. Where known, it is indirect, complex and long (e.g. >8 months in *Raillietiella frenata*), involving one or more intermediate hosts [6]. Pentastomids are long-lived; up to 8 years in some species [21].

Basic life cycle

- Adult female pentastomids continuously lay eggs in the lungs, amounting to millions of eggs per female (female *Raillietiella* spp. can lay eggs continuously for more than one year, the patent period is unknown for all other Australian genera); see Ali and Riley 1983 [6].
- Eggs leave the lungs with host fluid and pass into the mouth or are swallowed into the digestive tract.
- Eggs pass out into the environment when the host expels fluid orally or defecates.
- Eggs remain viable for months, are consumed by an intermediate host and develop into infective larvae.
- Infective larvae enter the definitive host when it consumes an infected intermediate host.
- Infective larvae burrow out of the host's gastrointestinal tract and enter the major vessels of the heart (aorta and pulmonary artery), in *Leiperia* spp., or the respiratory tract (nasal passages, trachea, bronchus, bronchi, bronchioles and lungs), in all other genera.
- Developing pentastomids feed on host blood and develop into mature adults.
- Adult *Leiperia* pentastomids migrate out of the blood vessels and into the respiratory tract (trachea, bronchus, bronchi, bronchioles and lungs).
- Male and female pentastomes mate once (presumably in the respiratory tract, not within the blood vessels), females store sperm and begin laying eggs to complete the life cycle.

Sources of infectious agent

The oral and nasal secretions (i.e. saliva and mucous) and faeces of an infected definitive host contain pentastomid eggs. These eggs will not develop to the blood-feeding adult stage without passing through an intermediate host. Pentastome eggs are very resilient and able to survive at least two weeks of desiccation and six months of refrigeration [22].

Prevalence and effect on host

In captive *C. porosus* and New Guinea crocodiles (*C. novaeguineae*), 15% of ill or deceased crocodiles were afflicted by pentastomiasis (*Sebekia* spp.) [23]. Captive crocodiles overseas have died from pentastomid infections [24]. Young crocodiles are considered particularly susceptible to disease caused by pentastomids [25], though dietary differences between hatchling and adult crocodiles (whereby hatchlings rarely eat fish) may preclude pentastomid infections in wild hatchlings [26].

Morbidity may be caused by larvae migrating from the gastrointestinal tract to infection sites, causing scarring and interfering with organ function [27]. Pentastomids inside the large vessels of the heart could cause vascular blockage. The mouthparts of adult pentastomids may pierce respiratory tissue, leading to pulmonary haemorrhage and/or bacterial infections that may culminate in chronic pneumonia [28, 29]. Heavy infections may possibly cause anaemia, though there are no published accounts of this. There are several cases where snake deaths have been attributed to pentastomid

infections [30-32]. A study suggested that pentastomids might have a negative influence on lizard fitness during times of stress or increased activity [33].

Age of the definitive host may be a factor in infection since the prepatent period is so long. Young reptiles are unlikely to be infected with mature pentastomids.

Heavily infected fish intermediate hosts can die from their infections whilst others show no morbidity.

Clinical signs

Commonly, there are no clinical signs of infection with pentastomids in reptiles.

Signs, when present, may be nonspecific (anorexia, lethargy or sudden death) or indicative of respiratory disease (nasal or oral discharge, open-mouthed, laboured or rapid breathing, abnormal swimming, excessive basking). If there is secondary bacterial infection there may be clinical signs of chronic pneumonia [29, 34].

Diagnosis

The disease can only be diagnosed via direct observation of pentastomid eggs or adults; both life history stages are distinctive and not easily confused with any other disease agent (Figure 1). Diagnostic tests include:

- Tracheal wash, cloacal wash and faecal flotation to detect pentastomid eggs
- Radiograph to detect adult pentastomids in the respiratory tract
- Endoscopic or surgical examination of the respiratory tract
- Presence of live pentastomids exiting the definitive host (from a stressed or dying hosts)
- Direct examination of the respiratory tract and major blood vessels of the heart during necropsy.

There are no consistent clinical pathology changes in reptiles with pentastomiasis.

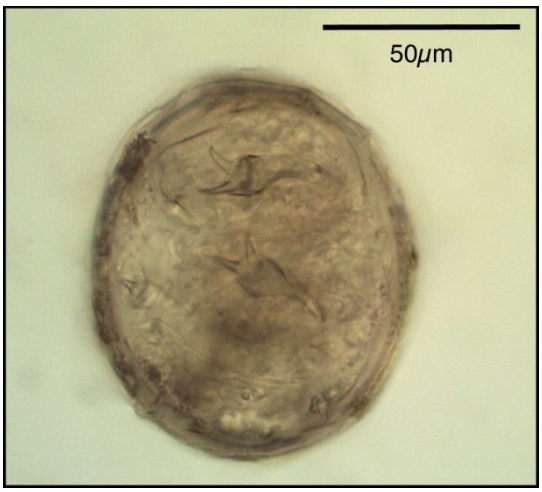

Figure 1. Egg of *Waddycephalus* sp. at 400X magnification. Note "clawed feet" characteristic of pentastomid larvae.

Laboratory diagnostic specimens and procedures

Fresh samples are preferred since the diagnostic features of pentastomid eggs become obscured with dehydration caused by chemical preservation. For practicality, fluid (from tracheal and cloacal washes) and faecal samples (1 mL) preserved in 70% ethanol may suffice. Microscopic examination (using the 40X objective on a compound microscope) of these samples will allow detection of pentastomid eggs [1].

Pathology

Pentastomids have been recovered from the nasal passages, trachea, bronchus, bronchi, bronchioles, lungs and the major blood vessels (aorta and pulmonary artery) of the heart. Size ranges from relatively small (11 mm in *Sebekia multiannulata*) to quite large (75 mm in *Leiperia australiensis*).

Pentastomids pierce lung tissue and may cause substantial lesions at feeding sites [7]. Secondary bacterial and fungal infections may occur. Large pentastomids may cause substantial lesions at feeding sites and puncture the lung. There may be pulmonary oedema and haemorrhage; large or numerous pentastomids can obstruct respiratory passages leading to suffocation [29, 33]. Pentastomids in the major blood vessels of the heart are thought to possibly obstruct blood flow.

Adult pentastomids are visible in respiratory tissue and infected lungs have visible red to black consolidated foci (up to 15 mm) which are composed of pentastomids, eggs, haemorrhage, and inflammatory cells (often surrounding the pentastomid eggs). Pathology includes extensive interstitial pneumonia, emphysema, bronchiectasis, granulomas and hyperplasia of the bronchiolar epithelium [14, 23, 35, 36].

Changes in crocodilians overseas include coagulative necrosis with heterophilic and eosinophilic infiltrates, haemorrhage, oedema, ulceration, collapsed air sacs and hepatic lipidosis [25, 37, 38].

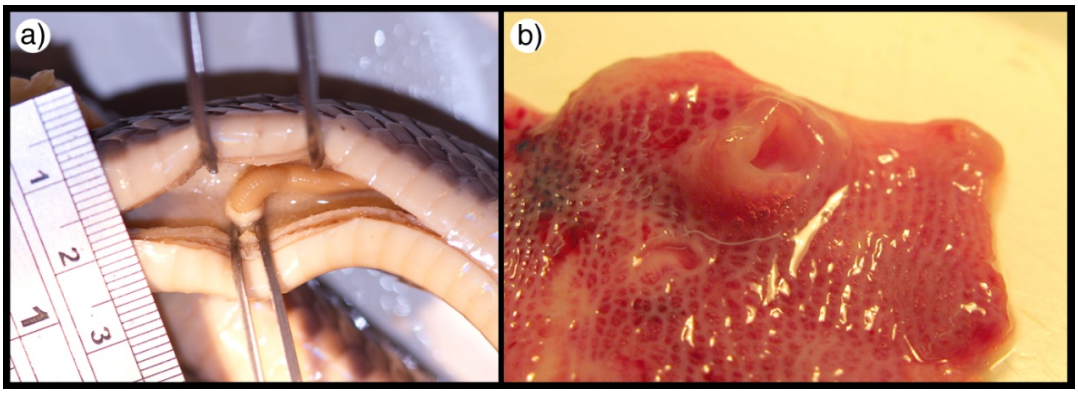

Figure 2. *Waddycephalus* sp. infecting the lungs of the slaty-grey snake (*Stegonotus cucullatus*). **a)** Parasite deeply embedded in lung tissue of an ethanol-preserved snake; **b)** Dissected fresh lung tissue showing attachment site where a *Waddycephalus* was recently removed. Note raised lesions surrounding attachment sites.

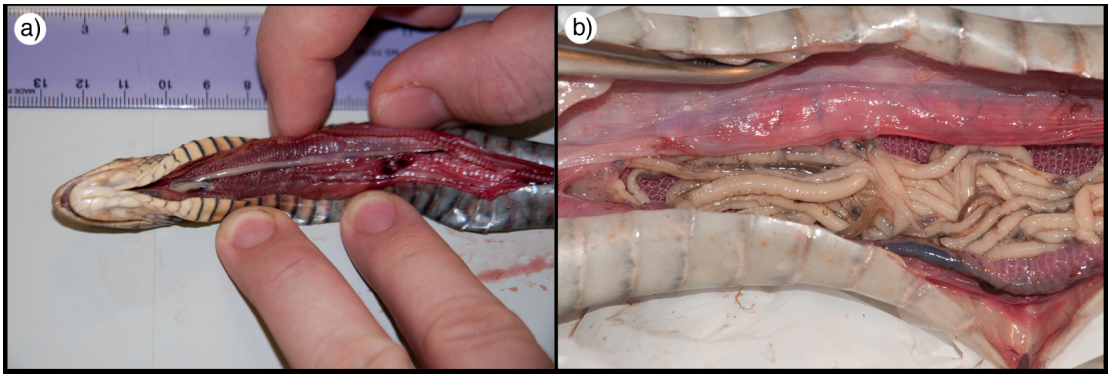

Figure 3. *Raillietiella orientalis* infecting the lungs of the lesser black whip snake (*Demansia vestigiata*). Infection is comprised of **a)** one long female pentastomid; **b)** 68 pentastomids.

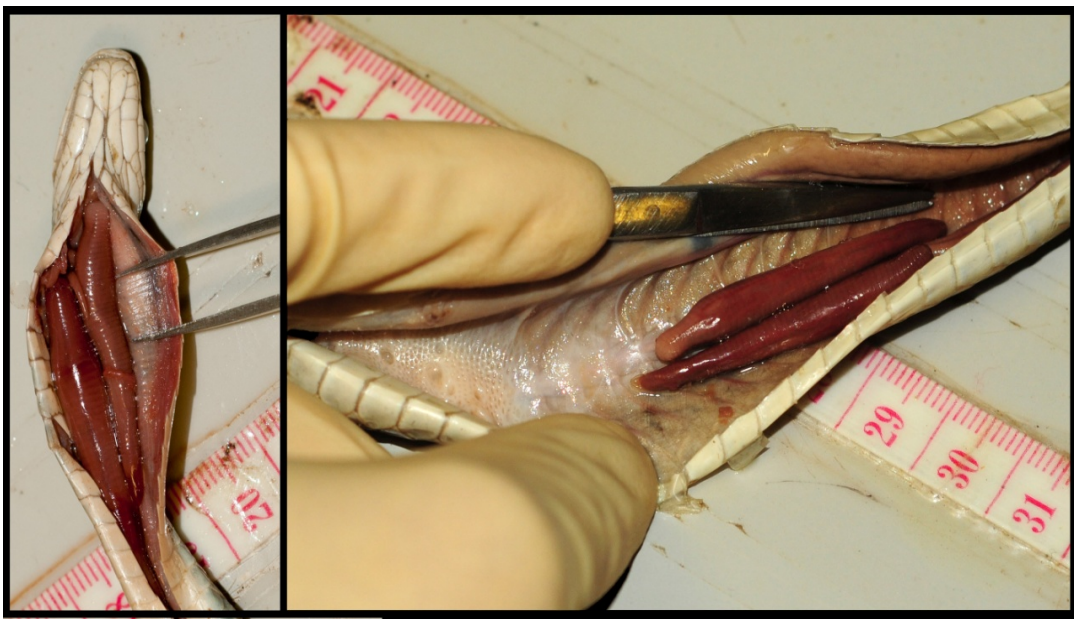

Figure 4. *Waddycephalus* sp. infecting the lungs of the green tree snake (*Dendrelaphis punctulatus*). Note complete occlusion of trachea (left) and multiple visible attachment sites in the lung (right).

Differential diagnoses

Other causes of respiratory disease or ill-thrift in reptiles should be included in differential lists, including bacterial, fungal and viral infections.

Treatment

Treatment is not generally recommended except in captive (e.g. farmed or zoo animals) or endangered animals that are showing signs of disease and have a confirmed diagnosis of pentastomiasis. Surgical or endoscopic removal is the most reliable method for eliminating infections [39, 40]. There is no reliable chemotherapeutic treatment but anecdotal reports suggest that Ivermectin may be successful [28]. Treatment with drugs is complicated by the large size and number of pentastomids and the fact that these parasites can dwell in the major vessels of the heart. Killing the parasites with drugs and leaving these dead parasites *in situ* may induce secondary

bacterial infections or cardiovascular distress as the host's immune system attempts to dispose of them [29].

Prevention and control

Pentastome eggs are very resilient; thorough cleaning and disinfection of surfaces that have been in contact with reptile or reptile excretions is recommended. In captivity, carnivorous and insectivorous reptiles should be fed on captive-bred food (as wild caught food may be infected with intermediate stages of the pentastome life cycle). Alternatively, food should be frozen at -10°C for at least 72 hours to kill larvae [14].

With the indirect life cycle, infections should be self-limiting over time in captivity if no new exposures occur. However pentastomids are quite long-lived (e.g. up to 8 years in some species) [21]. Definitive hosts should not be housed with intermediate hosts.

- Personal hygiene such as wearing gloves and washing hands thoroughly with hot soapy water after being in contact with reptiles and their products should preclude human ingestion of pentastomid eggs or larvae.

Research

The majority of Australian studies are taxonomic in nature. Key areas for future research include:

- taxonomy
- life cycle: intermediate and definitive host taxa; duration of each stage of the life cycle
- ecology of infections
- pathology of infections.

Considering the diversity of reptile hosts infected, the wide geographic distribution of reported infections and the fact that multiple species of pentastomids can infect Australian reptiles, there is almost certainly much to be discovered in this field.

Surveillance and management

There is no targeted surveillance or management of this disease in Australia.

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.

There is one case of pentastomiasis reported from a wild salt water crocodile in eWHIS.

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.

Human health implications

Pentastomids are zoonotic parasites but most human cases of pentastomiasis are asymptomatic. In humans, 99% of cases are caused by pentastomids of the genera *Armillifer* (from snakes) and *Linguatula* (from mammals) and are concentrated in the tropics and subtropics of Africa, Southeast Asia and the Middle East [41]. There has never been a human case of pentastomiasis in Australia.

Zoonotic infections may arise from consumption of undercooked reptile flesh, ingestion of water contaminated with reptile faeces, and from direct contact with saliva, mucous or faeces from an infected reptile. Pentastomids do not develop past the larval stage in humans; in rare cases systemic infection with *Armillfer* larvae has caused death [42-45].

Reptiles and their products, including raw meat (and fish) should be handled in a sanitary manner. Reptile meat for consumption should be thoroughly cooked. Advice regarding human health implications of pentastomiasis should be sought from your local public health department.

Statistics

A study found *Raillietiella frenata* in 11 of 72 Asian house geckoes in the NT but no pentastomids in this host in Qld or zigzag velvet geckoes (*Oedura rhombifer*) in the NT [46]. Another study found *R. frenata* in Asian house geckoes from Darwin and surrounds [2].

A NT study found 59% wild snakes were infected with one or more species of pentastomid of the genera *Raillietiella* and *Waddycephalus* [7].

Conclusions

Relatively little is known about pentastomiasis in wild reptiles in Australia. In many species of pentastomid almost nothing is known of the life cycle, the geographical distribution, or the effect on the host. Host-swapping and changes in distribution may result in significant changes in epidemiology of these infections. Further research is required to determine the influence of pentastomiasis on reptile health in Australia, both at the individual and population level.

Acknowledgements

We are grateful to the people who contributed to this fact sheet and would specifically like to thank Crystal Kelehear.

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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Appendix 1

Table 1. Known lizard species that host pentastomids in Australia

Host family	Host species	Pentastome species	Locality	Reference
Agamidae	*Pogona barbata* (Bearded dragon)	*Raillietiella amphiboluri*	Zoo (London)	Mahon 1953 [47]
Gekkonidae	*Diplodactylus vittatus* (Eastern stone gecko)	*Waddycephalus sp.*	NSW or Qld[†]	Johnston 1911 [48], Krefft 1871 [49]
Gekkonidae	*Gehyra australis* (Northern dtella)	*Raillietiella frenata*	NT	Barton 2007 [46]
Gekkonidae	*Hemidactylus frenatus* (Asian house gecko)[‡]	*Raillietiella frenata*	NT	Kelehear et al. 2011 [2], Barton 2007 [46]
Gekkonidae	*Hemidactylus frenatus* (Asian house gecko)[‡]	*Waddycephalus sp. nymph*	NT	Barton 2007 [46]
Gekkonidae	*Heteronotia binoei* (Binoe's gecko)	*Waddycephalus sp. nymphs (encapsulated)*	Qld	Riley and Spratt 1987 [19]
Gekkonidae	*Nephrurus laevissimus* (Pale knob-tailed gecko)	*Raillietiella scincoides*	WA	Bursey and Goldberg 1999 [50]
Scincidae	*Hemiergis decresiensis* (Three-toed earless skink)	*Waddycephalus sp. nymph (encapsulated in lungs)*	SA	Riley and Spratt 1987 [19]
Scincidae	*Ctenotus taeniolatus* (Australian striped skink)	*Waddycephalus sp.*	NSW or Qld	Johnston 1911 [48], Krefft 1871 [49]
Scincidae	*Tiliqua scincoides* (Blue-tongued lizard)	*Raillietiella scincoides*	SA	Ali et al. 1984 [51]
Varanidae	*Varanus varius* (Lace monitor)	*Elenia australis*	Qld	Heymons 1939 [52]

[‡]Non-native lizard species.

Table 2. Known pentastomid species that infect crocodilians within Australia

Host species	Pentastome species	Reference
Freshwater crocodile (*C. johnstoni*)	*Leiperia australiensis*	Riley and Huchzermeyer 1996 [15]
	Sebekia johnstoni	Riley et al. 1990 [16]
	Sebekia multiannulata	Riley et al. 1990 [16]
Estuarine crocodile (*C. porosus*)	*Alofia merki*	Riley 1994 [17]
	Leiperia australiensis	Riley and Huchzermeyer 1996 [15]
	Sebekia johnstoni	Riley et al. 1990 [16]
	Sebekia multiannulata	Riley et al. 1990 [16]
	Sebekia purdieae	Riley et al. 1990 [16]
	Selfia porosus	Riley 1994 [17]

Table 3. Known Australian snakes are definitive hosts for pentastomids

Host family	Host species	Pentastome genus
Colubridae	*Boiga irregularis*	*Armillifer*
Colubridae	*Dendrelaphis calligastra*	*Waddycephalus*

Colubridae	*Dendrelaphis pictus*	*Waddycephalus*
Colubridae	*Dendrelaphis punctulatus*	*Raillietiella; Waddycephalus*
Colubridae	*Stegonotus cucullatus*	*Waddycephalus*
Colubridae	*Tropidonophis mairii*	*Raillietiella; Waddycephalus*
Elapidae	*Acanthophis praelongus*	*Raillietiella; Waddycephalus*
Elapidae	*Austrelaps superbus*	*Parasambonia; Waddycephalus*
Elapidae	*Demansia papuensis*	*Raillietiella*
Elapidae	*Demansia psammophis*	*Parasambonia; Waddycephalus*
Elapidae	*Demansia vestigiata*	*Raillietiella; Waddycephalus*
Elapidae	*Notechis scutatus*	*Waddycephalus*
Elapidae	*Pseudechis australis*	*Raillietiella*
Elapidae	*Pseudechis porphyriacus*	*Parasambonia; Waddycephalus*
Elapidae	*Pseudonaja nuchalis*	*Waddycephalus*
Elapidae	*Pseudonaja textilis*	*Raillietiella; Waddycephalus*
Elapidae	*Tropidechis carinatus*	*Parasambonia*
Pythonidae	*Aspidites melanocephalus*	*Waddycephalus*
Pythonidae	*Liasis fuscus*	*Raillietiella*
Pythonidae	*Liasis olivaceus*	*Armillifer*
Pythonidae	*Morelia amethistina*	*Armillifer*
Pythonidae	*Morelia spilota*	*Armillifer; Waddycephalus*
Pythonidae	*Morelia spilotes variegata*	*Waddycephalus*
Pythonidae	*Morelia viridis*	*Armillifer*

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