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Parasites in feral *Chelodina longicollis* (Shaw, 1794) (Testudines: Pleurodira: Chelidae) in Tasmania

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ABSTRACT

Feral populations of *Chelodina longicollis* (Shaw, 1794) have established in Tasmania but many aspects of their biology in the wild remain unknown. A number of *C. longicollis* specimens were available for examination for parasites. Two species of digenean parasites were found in three of the 11 turtles examined: a *Choanocotyle* sp. and *Thrinascotrema brisbanica* Jue Sue & Platt, 1999. This is the first report of parasites from feral turtles in Tasmania. Due to the lack of native populations of freshwater turtles in Tasmania, these parasites must also have been introduced to Tasmania and have established life cycles in the new environments. The implications of such introductions, without suitable definitive hosts available to assist in establishing parasite infections, is discussed. An updated list of digenean parasites reported from Australian freshwater turtles is presented.

Keywords: Chelidae, Choanocotylidae, Digenea, host–parasite checklist, host–parasite relationship, introduced host, introduced parasite, Thrinascotrematidae.

Introduction

Freshwater turtles are widespread across a range of aquatic habitats on mainland Australia, with the exception of the Australian Alps (Cogger 2014). No freshwater turtles, however, are native to the islands of Tasmania, in southern Australia (Fearn 2013; Cogger 2014), although there is a long history of the introduction of various freshwater turtles to Tasmania (Fearn 2013). Prior to 1971, various species of freshwater turtles were harvested from the wild on mainland Australia, especially from New South Wales and Queensland, for sale in pet stores throughout Australia (Fearn 2013). Following introduction of the *National Parks and Wildlife Act, 1971*, importation of freshwater turtles into Tasmania was illegal (Fearn 2013). However, freshwater turtles are still routinely impounded (Fearn 2013).

One of the more commonly imported freshwater turtles was *Chelodina longicollis* (Shaw, 1794), the eastern snake-necked turtle, which is now apparently widespread across Tasmania, including the Bass Strait Islands (Fearn 2013). Although gravid adult females were often collected from the wild, it was not known whether reproduction was successfully occurring in wild populations, due to the climate in Tasmania, until a clutch of hatched eggs was reported (Fearn 2013). Although *C. longicollis* does not show all the general characteristics associated with a successful invasive vertebrate (see Ehrlich 1989), its generalist carnivorous diet, widespread distribution and association with humans have allowed *C. longicollis* to successfully invade the Tasmanian wilderness. However, the impact that this species has upon aquatic ecosystems in Tasmania remains largely unknown (Fearn 2013).

Australian freshwater turtles have been reported as hosts for multiple helminths, including Cestoda, Digenea, Monogenea, Nematoda and Turbellaria (Pichelin *et al.* 1999). Of the 22 species of freshwater turtles in Australia, acknowledging that there is still significant disagreement among taxonomists as to the status of a number of subspecies (Cogger 2014), 12 species have been reported as hosts to digenean parasites (Pichelin *et al.* 1999; Table 1 and references therein). *Chelodina longicollis*, despite its widespread distribution, has been reported as a host to only four species of Digenea from the regions of southern Queensland and northern New South Wales (Table 1). Zelmer and Platt (2008)

Table 1. Records of digenean parasites collected from freshwater turtles in Australia.

Host species	Digenean species	Location in host	Geographical location	Reference
Carettochelys insculpta	*Doodytrema caettochelydis*	Intestine	Northern Territory	Tkach and Snyder (2006)
Chelodina expansa	*Aptorchis megacetabulus*	Small intestine	Northern Territory	Tkach and Snyder (2007*a*)
	Aptorchis megapharynx[A]	Small intestine	Southern Queensland	Jue Sue and Platt (1999*a*)
	Aptorchis pearsoni[B]	Small intestine	Southern Queensland	Jue Sue and Platt (1999*a*)
	Choanocotyle elegans	Small intestine	Queensland	Jue Sue (1998)
	Sigmapera cincta	Small intestine	Southern Queensland	Jue Sue and Platt (1998)
Chelodina longicollis	*Aptorchis pearsoni*	Small intestine	Northern New South Wales	Zelmer and Platt (2008)
	Choanoctyle elegans	Small intestine	Northern New South Wales	Zelmer and Platt (2008)
	Sigmapera cincta	Small intestine	Southern Queensland	Jue Sue and Platt (1998)
	Thrinascotrema brisbanica	Stomach	Northern New South Wales	Zelmer and Platt (2008)
Chelodina oblonga	*Aptorchis kuchlingi*	Intestine	South-west Western Australia	Snyder and Tkach (2011)
	Aptorchis pearsoni	Small intestine	South-west Western Australia	Zelmer and Platt (2008)
	Choanocotyle hobbsi	Small intestine	South-west Western Australia	Zelmer and Platt (2008)
	Choanocotyle juesuei	Small intestine	South-west Western Australia	Zelmer and Platt (2008)
Chelodina rugosa	*Choanocotyle platti*	Small intestine	Northern Territory	Tkach and Snyder (2007*b*)
	Aptorchis megacetabulus	Small intestine	Northern Territory	Tkach and Snyder (2007*a*)
Elseya dentata	*Amphistomum* sp.	Intestine	New South Wales	Krefft (1873)
	Elseyatrema microacetabularis	Intestine	Queensland	Rohde (1984)
	Haplorchis popelkae	Small intestine	Northern Territory	Snyder and Tkach (2009)
	Lobatodiscus australiensis	Intestine	Queensland	Rohde (1984)
	Notopronocephalus peekayi	Intestine	Queensland	Cribb and Pichelin (1997)
Elseya latisternum	*Aptorchis aequalis*	Intestine	Queensland Northern Queensland	Nicoll (1914)[D] Zelmer and Platt (2008), Platt and Jensen (2002)
	Auriculotrema lechneri	Small intestine	Northern Queensland	Platt (2003), Zelmer and Platt (2008)
	Notopronocephalus peekayi	Intestine	Queensland	Cribb and Pichelin (1997)
	Sigmapera cincta	Intestine	Northern Queensland Southern Queensland	Nicoll (1918)[D], Zelmer and Platt (2008) Jue Sue and Platt (1998)
	Thrinascotrema brisbanica	Stomach	Southern Queensland Northern Queensland	Jue Sue and Platt (1999*b*) Zelmer and Platt (2008)
	Uterotrema burnsi	Heart, liver	Northern Queensland	Zelmer and Platt (2008)
	Uterotrema kreffti	Heart	Northern Queensland	Zelmer and Platt (2008)
	Uterotrema sp.	Heart	Northern Queensland	Platt and Blair (1996)
Emydura australis	*Aptorchis aequalis*	Intestine	North Queensland	Nicoll (1918)
	Aptorchis glandularis	Intestine	Northern Western Australia	Tkach and Snyder (2008)
Emydura krefftii	*Aptorchis aequalis*	Small intestine	Queensland North Queensland	Nicoll (1914) Platt and Jensen (2002), Zelmer and Platt (2008)
	Aptorchis anfracticirrus[C]	Large intestine, rectum	Central and northern Queensland	Ferguson (2002)
	Auriculotrema lechneri	Small intestine	Northern Queensland	Platt (2003), Zelmer and Platt (2008)
	Choanocotyle elegans	Small intestine	Central and northern Queensland	Ferguson (2002)
	Choanocotyle nematoides	Large intestine	Central and northern Queensland	Ferguson (2002)

(*Continued on next page*)

Table 1. (*Continued*).

Host species	Digenean species	Location in host	Geographical location	Reference
	Notopronocephalus peekayi	Intestine	Central and northern Queensland	Ferguson (2002)
	Pretestis laticaecum	Intestine	Central Queensland	Ferguson *et al.* (2001), Ferguson (2002)
	Sigmapera cincta	Small intestine	Central and northern Queensland	Ferguson (2002)
	Uterotrema burnsi	Heart, liver	Northern Queensland Northern Queensland	Platt and Blair (1996) Zelmer and Platt (2008)
	Uterotrema kreffti	Heart	Queensland	Platt and Blair (1996)
Emydura macquarii	*Aptorchis aequalis*[C]	Small intestine	Southern Queensland	Jue Sue and Platt (1999*a*), Platt and Jensen (2002)
	Aptorchis elegans	Intestine	Central and northern Queensland	Ferguson and Smales (2006)
	Buckarootrema goodmani	Small intestine	Southern Queensland	Platt and Brooks (2001)
	Choanocotyle elegans	Small intestine	Queensland Central and northern Queensland	Jue Sue (1998), Ferguson and Smales (2006)
	Choanocotyle nematoides	Large intestine	Queensland Central and northern Queensland	Jue Sue (1998) Ferguson and Smales (2006)
	Notopronocephalus ppekayi	Intestine	Central and northern Queensland	Ferguson and Smales (2006)
	Pretestis laticaecum	Intestine	Central Queensland	Ferguson and Smales (2006)
	Sigmapera cincta	Small intestine	Southern Queensland Central and northern Queensland	Jue Sue and Platt (1998) Ferguson and Smales (2006)
	Uterotrema australispinosa	Heart	Southern Queensland	Platt and Pichelin (1994), Platt and Blair (1996)
Emydura macquarii dhara	*Aptorchis aequalis*	Small intestine	Northern New South Wales	Platt and Jensen (2002), Zelmer and Platt (2008)
	Choanocaotyle nematoides	Large intestine	Northern New South Wales	Zelmer and Platt (2008)
	Sigmapera cincta	Small intestine	Northern New South Wales	Zelmer and Platt (2008)
	Uterotrema australispinosa	Heart	Northern New South Wales	Zelmer and Platt (2008)
Emydura macquarii macquarii	*Aptorchis aequalis*	Small intestine	Southern Queensland	Zelmer and Platt (2008)
	Buckarootrema goodmani	Small intestine	Southern Queensland	Zelmer and Platt (2008)
	Choanocotyle nematoides	Large intestine	Southern Queensland	Zelmer and Platt (2008)
	Sigmapera cincta	Small intestine	Southern Queensland	Zelmer and Platt (2008)
	Uterotrema australispinosa	Heart	Southern Queensland	Zelmer and Platt (2008)
Emydura signata	*Notopronocephalus peekayi*	Intestine	Queensland	Cribb and Pichelin (1997)
Emydura sp.	*Uterotrema* sp.	Heart	New South Wales	Platt and Blair (1996)
Emydura victoriae	*Buckarootrema minuta*	Small intestine	Northern Territory	Snyder and Tkach (2006)
	Haplorchis popelkae	Small intestine	Northern Territory	Snyder and Tkach (2009)
	Paradeuterobaris victoriae	Intestine	Northern Territory	Snyder and Tkach (2006)

[A]Originally described as *Dingularis megapharynx* by Jue Sue and Platt (1999*a*) but transferred to *Aptorchis* by Platt and Jensen (2002).
[B]Originally described as *Dingularis pearsoni* by Jue Sue and Platt (1999*a*) but transferred to *Aptorchis* by Platt and Jensen (2002).
[C]Originally described as *Dingularis anfracticirrus* by Jue Sue and Platt (1999*a*) but synonymised with *Aptorchis aequalis* by Platt and Jensen (2002).
[D]Host originally called *Emydura latisternum*.

found that *C. longicollis* had high parasite species richness (for the entire parasite community) but low individual parasite infection levels, although they sampled turtles from only a single location.

Parasites are able to be cointroduced to new locations with their hosts (Verneau *et al.* 2011; Lymbery *et al.* 2014). Once established, parasites can then transmit to native hosts, making them coinvading parasites, as defined by Lymbery *et al.* (2014). Given that digenean parasites have a minimum of two hosts in their life cycle, a final and at least one intermediate, transmission of these parasites in a new system may involve adaptation to novel hosts at all levels. Freshwater turtles have been reported to introduce parasites to native hosts elsewhere in the world (Iglesias *et al.* 2015), but this has not yet been reported in Australia. This study aims to determine if the feral populations of *C. longicollis* in Tasmania are host to parasites and identify those parasites as far as possible.

Materials and methods

In total, 11 *C. longicollis* individuals were available for dissection at the Queen Victoria Museum and Art Gallery (QVMAG), Launceston, Tasmania (Table 2). The turtles had been collected opportunistically as either road-kill or live-capture by members of the public ($n = 5$) or by trapping by wildlife authorities at dam sites known to contain a *C. longicollis* population (Tarleton; $n = 6$) between April 2013 and February 2016. All turtles were frozen until dissection, which took place in April 2019, and all examined turtles were female.

The mouth, nasal tubes and eyelids were flushed with water using a plastic pipette and the washing collected in a Petri dish. As the host specimens were to be deposited in the museum collection, a full dissection of the head region, as per Snyder and Clopton (2005), could not be completed. The body cavity of each turtle was opened and all internal organs removed and examined for parasites. All parasites were collected and fixed in 70% ethanol. Digenean specimens collected were stained in acetocarmine, dehydrated in a graded ethanol series, cleared in xylene and mounted permanently in Canada balsam. Measurements were taken from a compound microscope with an eyepiece micrometer. Photographs were taken using a 9MP eyepiece camera (AmScope MU900). Wholemount specimens have been deposited in the QVMAG (QVM 2019:19:0006–0009). Attempts to obtain molecular sequences for digenean specimens were unsuccessful due to fungal contamination of the collected tissue sample.

Results

Three of the 11 turtles examined were infected with digeneans; no other parasites were found. Two morphologically different digeneans were collected and were identified as belonging to the genera *Choanocotyle* Jue Sue & Platt, 1998 and *Thrinascotrema* Jue Sue & Platt, 1999 following comparison of morphological measurements and overall structure with descriptions from the literature (Jue Sue 1998; Jue Sue and Platt 1999*b*; Tkach and Snyder 2007*b*; Tkach 2008*a*, 2008*b*; Tables 3 and 4).

Table 2. Collection data for specimens of *Chelodina longicollis* examined at the Queen Victoria Museum and Art Gallery, Launceston, Tasmania.

Date of collection	Location of collection	Sex	Curved dorsal shell length (mm)	Ventral plastron length (mm)	Weight (g)	QVM no.	Parasites found	QVM no.
29 April 2013	Sassafras	F	167	128	354.1	2019:3:0056	*Thrinascotrema brisbanica*	2019:19:0008
16 May 2013	Spreton	F	179	136	427.4	2019:3:0057	*Thrinascotrema brisbanica*	2019:19:0009
20 May 2013	Tarleton	F	160	120	352.5	2019:3:0058	–	
20 May 2013	Tarleton	F	175	130	460.2	2019:3:0059	–	
20 May 2013	Tarleton	F	177	131	455.4	2019:3:0060	–	
20 May 2013	Tarleton	F	165	124	400.2	2019:3:0061	–	
20 May 2013	Tarleton	F	167	139	405.4	2019:3:0062	–	
20 May 2013	Tarleton	F	170	126	402.3	2019:3:0063	–	
6 January 2014	Bell Bouy Beach	F	217	160	775	2019:3:0054	*Thrinascotrema brisbanica* *Choanocotyle* sp.	2019:19:0006 2019:19:0007
3 November 2015	Robiganna	F	218	169	950	2019:3:0053	–	
24 February 2016	King Island	F	250	202	1600	2019:3:0055	–	

Table 3. Measurements of members of the family Choanocotylidae compared with measurements of specimens collected in this study.

	Choanocotyle sp.	*Auriculotrema lechneri*	*C. elegans*	*C. nematoides*	*C. hobbsi*	*C. juesuei*	*C. platti*
Host	*Chelodina longicollis*	*Emydura krefftii*	*Chelodina expansa Emydura macquarii*	*Emydura macquarii*	*Chelodina oblonga*	*Chelodina oblonga*	*Chelodina rugosa*
Location	Tasmania	Northern Qld	SE Qld	SE Qld	WA	WA	NT
Reference	This study	Platt (2003)	Jue Sue (1998)	Jue Sue (1998)	Platt and Tkach (2003)	Platt and Tkach (2003)	Tkach and Snyder (2007*b*)
Total body L	6038 (5375–6875)	3497 (2468–4896)	4180 (3840–5970)	16.35 mm	10.68 mm (7.75–16.23)	3961 (3050–4765)	7105.6 (6510–8080)
Max W	356 (250–600)	306 (209–438)	460 (360–450)	600	419 (376–480)	305 (256–386)	477.7 (300–640)
OS L	365 (330–420)	149 (123–183)	599 (483–609)	275	482 (355–592)	387 (345–438)	
OS W	263 (190–350)	173 (147–220)	819 (672–806)	396	672 (551–796)	488 (392–551)	1004.5 (740–1230)
Ph L	170 (160–180)	129 (98–138)	210 (147–294)	143	177 (138–213)	121 (103–138)	205 (170–230)
Ph W	103 (100–110)	116 (83–130)	202 (147–231)	165	168 (140–188)	119 (113–138)	191 (150–220)
VS L	147 (140–160)	104 (85–155)	205 (197–252)	187	205 (183–240)	134 (120–155)	242.7 (200–280)
VS W	134 (110–160)	104 (85–153)	199 (160–202)	176	203 (185–240)	130 (115–143)	228.6 (190–260)
Ovary L	94 (75–113)	102 (73–173)	126 (105–168)	209	210 (168–251)	122 (110–138)	172 (150–190)
Ovary W	156 (150–163)	111 (70–215)	130 (105–168)	253	247 (228–277)	122 (95–143)	195.5 (170–230)
Ant T L	225 (210–250)	136 (90–183)	168 (168–231)	352	451 (375–589)	226 (193–261)	257 (210–350)
Ant T W	135 (120–250)	96 (63–140)	134 (97–168)	319	262 (214–326)	153 (135–180)	212.5 (170–270)
Post T L	235 (210–270)	142 (100–198)	168 (168–231)	352	458 (397–592)	239 (213–271)	265.5 (200–345)
Post T W	133 (100–190)	100 (63–153)	126 (97–168)	341	252 (198–326)	145 (128–165)	217.5 (165–270)
Cirrus sac L	417 (350–500)	333 (250–413)	525 (588–714)	1375	794 (668–997)	430 (363–530)	754.5 (670–810)
Cirrus sac W	110 (100–120)	61 (50–80)	113 (113–137)	154	167 (150–188)	93 (78–110)	168.1 (135–190)
Egg L	33 (29–35)	40 (33–45)	35 (33–36)	34 (32–35)	35–40	35–38	34 (30–40)
Egg W	18 (18–20)	20 (15–23)	19 (18–21)	21 (20–22)	18–19	16–20	17.6 (15–20)

L, length; W, width; OS, oral sucker; Ph, pharynx; VS, ventral sucker; Ant T, anterior testis; Post T, posterior testis.

Family **CHOANOCOTYLIDAE** Jue Sue & Platt, 1998

Choanocotyle sp. (Fig. 1)

Seven individual digeneans, collected from the intestine of a turtle from Bell Bouy Beach (Table 2), were identified as members of the family Choanocotylidae based on the elongate body shape and enlarged oral sucker (Jue Sue 1998). Four of the seven digeneans were mature, with a fully developed reproductive system and uterus filled with eggs; these specimens were 6038 (5375–6875) μm in length. The remaining three specimens were considered immature, with an underdeveloped reproductive system and fewer eggs in the uterus; these specimens were 3208 (3000–3625) μm in length. Measurements for the mature specimens are presented in Table 3.

Remarks

The family Choanocotylidae contains two genera, both reported from the intestinal system of freshwater turtles in Australia: *Choanocotyle* and *Auriculotrema* Platt, 2003 (Tkach 2008*a*). Differences between the genera relate to the shape of the oral sucker (presence or absence of lappets; flared when protracted versus non-retractable) and the distribution of the testes (separate or adjacent) (Tkach 2008*a*). As the oral sucker on all specimens was retracted and the testes were separate from each other, as opposed to adjacent, the specimens are referred to *Choanocotyle*. Comparison of the measurements of the specimens collected in this study with those reported for species of *Choanocotyle* (Table 3) showed overlap with both *C. elegans* Jue Sue & Platt, 1998 and *C. juesuei* Platt & Tkach, 2003 in most features. The overall quality of the specimens collected in this study, in combination with the low number of mature specimens and the lack of molecular sequences, prevented an identification to a particular species. Thus, the specimens are identified as *Choanoctyle* sp.

Table 4. Measurements of *Thrinascotrema brisbanica* collected from *Chelodina longicollis* in this study compared with measurements from the literature.

Host	*Chelodina longicollis*	*Elseya latisternum*[A]
Location	Tasmania	Queensland
Reference	This study	Jue Sue and Platt (1999*b*)
Length	1581 (1575–1588)	1487
Width	438(375–500)	587
Oral sucker L	205 (190–220)	281
Oral sucker W	185 (160–210)	277
Pharynx L	90 (88–93)	109
Pharynx W	93 (88–98)	122
Ventral sucker L	165 (150–180)	298
Ventral sucker W	175 (160–190)	307
Cirrus sac L	525 (500–550)	357
Cirrus sac W	85 (70–100)	118
Anterior seminal vesicle L	80	50
Anterior seminal vesicle W	63	71
Posterior seminal vesicle L	63	84
Posterior seminal vesicle W	58	76
Testis L	235 (210–280)	198
Testis W	140 (100–200)	174
Ovary L	93 (75–110)	92
Ovary W	80 (50–110)	59
Egg L	24 (23–25)	–
Egg W	17 (15–18)	–

[A]Holotype measurements are presented as this specimen 'has fewest uterine eggs' (Jue Sue and Platt 1999*b*, p. 221) and, thus, is closest to immature specimens collected in this study.
L, length; W, width.

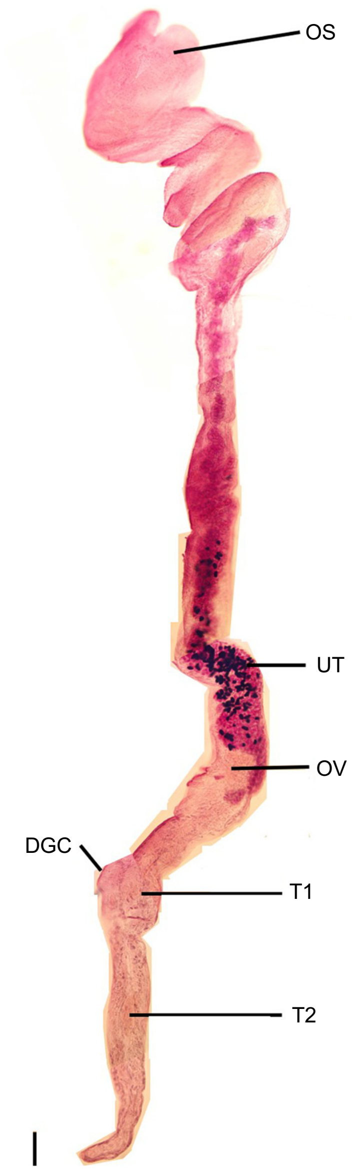

Fig. 1. Composite photograph of *Choanoctyle* sp. collected from *Chelodina longicollis* in Tasmania. DGC, dorsal genital complex; OS, oral sucker; OV, ovary; T1, anterior testis; T2, posterior testis; UT, uterus with eggs. Scale bar: 200 µm.

Family **THRINASCOTREMATIDAE** Jue Sue & Platt, 1999

Thrinascrotrema brisbanica (Fig. 2)

Individual digeneans were collected from turtles collected from Sassafras, Spreyton and Bell Buoy Beach (Table 2). These digeneans were collected from the intestinal system and were identified as members of the family Thrinascotrematidae based on overall body shape (Jue Sue and Platt 1999*b*). The specimens were immature, with only one specimen containing a few eggs. Measurements for the specimens are presented in Table 4.

Remarks

The family Thrinascotrematidae contains a single species, *Thrinascotrema brisbanica* (Tkach 2008*b*). Comparison of the measurements of the specimens collected in this study with the immature holotype of *T. brisbanica* (Table 4) showed overlap in all measurements. No molecular sequences are available for *T. brisbanica* and, due to the low number of samples collected in this study, molecular sequencing was not attempted. Consequently, the specimens collected from *C. longicollis* in Tasmania are identified as *T. brisbanica*.

Discussion

This is the first report of parasites infecting feral populations of *C. longicollis* in Tasmania. Although it is not always easy to

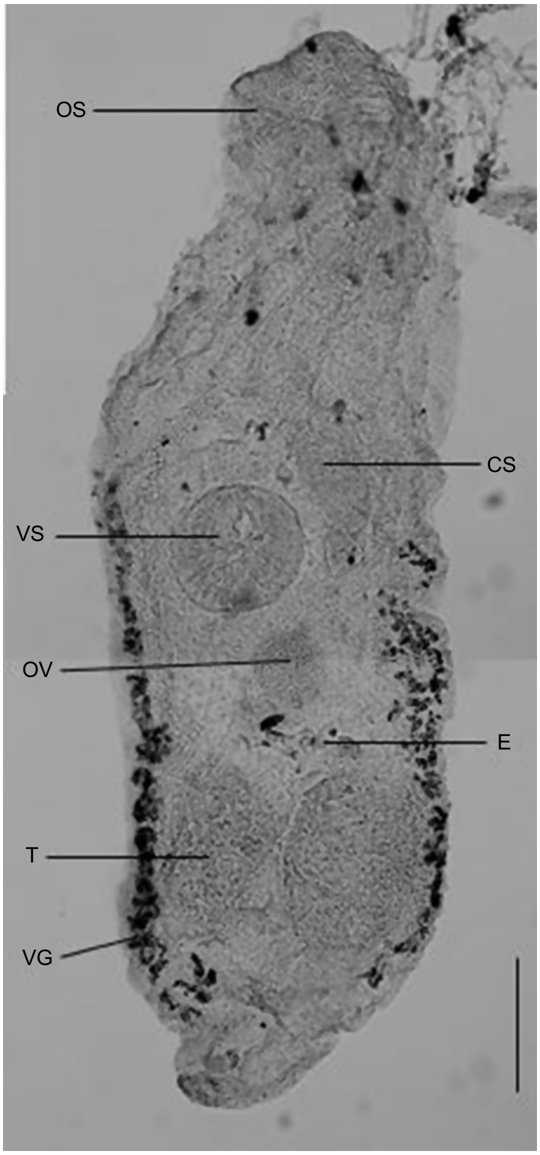

Fig. 2. Composite photograph of *Thrinascotrema brisbanica* from *Chelodina longicollis* in Tasmania. CS, cirrus sac; E, egg in uterus; OS, oral sucker; OV, ovary; T, testis; VG, vitelline gland; VS, ventral sucker. Scale bar: 250 μm.

determine the origin of parasites in alien host species, due primarily to a lack of previous studies (Lymbery *et al.* 2014), in this case the origin of the parasites must also be alien as turtles do not naturally occur in Tasmania (Fearn 2013; Cogger 2014). Both genera of parasites are specific to freshwater turtles and thus cannot have been acquired by these turtles in Tasmania but must have been introduced with their hosts. As a number of turtle species have been introduced into Tasmania (Fearn 2013), the actual source of these parasites remains unknown and it is possible that the parasites have been transmitted to *C. longicollis* from another host species. However, *C. longicollis* has been reported as a host for both *C. elegans* and *T. brisbanica* in northern New South Wales by Zelmer and Platt (2008) and could be the original source for these parasites in Tasmania.

The introduction of parasites with their hosts to a new location can have deleterious effects on native host populations due to parasite spillovers (Verneau *et al.* 2011; Lymbery *et al.* 2014; Iglesias *et al.* 2015). As no turtles are native to Tasmania, this impact would be expected to be minimal. However, the life cycles for representatives of both these genera have three hosts: the turtle definitive/final host, a freshwater snail as a first intermediate host and various aquatic invertebrates (snails) and vertebrates (tadpoles) as a second intermediate host. The impact of parasites in ecosystems may occur at any of these levels of the life cycle (Verneau *et al.* 2011). In experimental infections of *T. brisbanica* (Jue Sue and Platt 1999*b*), heavy infections of the larval stages in the digestive gland of the freshwater snail *Glytophysa gibbosa* (Gould, 1846) (Planorbidae) caused the death of the host. Species of *Glyptophysa* Crosse, 1872 are found in Tasmania (Ponder *et al.* 2020) and could be the intermediate host transmitting these parasites. As snails are important elements of freshwater ecosystems, impacts on snail populations may have indirect effects upon the overall ecology of that system. Although yet to be reported in Australia, digenean larval parasites are known to cause deformities in metamorphosing tadpoles, potentially increasing their risk of predation by the definitive host (Johnson *et al.* 1999). Further research needs to be undertaken to determine the impacts of these digeneans on both the first and second intermediate hosts.

The genus *Choanocotyle* has five described species, of which four have been described from species of *Chelodina* across Australia (see Table 1). *Chelodina longicollis* was reported as a host for *C. elegans* in northern New South Wales by Zelmer and Platt (2008). Although specimens were morphologically identified by Zelmer and Platt (2008), no morphological measurements were provided for comparison (specimens were deposited in the Queensland Museum, but due to the current relocation of the Queensland Museum collection (2019–2021), specimens could not be borrowed for comparison with the specimens collected in this study). Measurements of many features of *C. elegans* collected from other turtles in south-eastern Queensland (Table 1) did overlap with the specimens collected in this study. However, measurements also overlapped with *C. juesuei*, collected from *Chelodina oblonga* Gray, 1841 in Western Australia. As the origins of the turtles examined in Tasmania are unknown, although they are more likely to have originated on the mainland east coast (see Fearn 2013), the possibility of infection with either species cannot be ruled out. *Choanocotyle juesui* and *C. elegans* have previously been noted to overlap in a number of morphological measurements (Platt and Tkach 2003). Infection in different host species located on either side of the Australian continent was considered sufficient to describe them as different species (Platt and Tkach 2003). Shamsi *et al*. (2021), however, recently found that the molecular sequences for cercaria collected from freshwater snails in the Murray Darling Basin, on the eastern side of Australia, were the same as sequences from *C. hobbsi* Platt & Tkach, 2003, collected from turtles in Western Australia. Unfortunately, molecular sequences are not yet available for either *C. elegans* or *C. juesuei* to determine if they are, in fact, separate species. And, unfortunately, molecular sequence attempts in this study were unsuccessful. But, given the similar molecular sequences found by Shamsi *et al*. (2021), combined with the history of trade in pet turtles across Australia (Fearn 2013) and the obvious capacity of these parasites to establish and transmit in new locations (as evidenced by this study), differences in host species and geographical locations alone may not be enough to differentiate species. Future research may synonymise *C. elegans* and *C. juesuei*; and the identification of the specimens infecting *C. longicollis* in Tasmania may be confirmed as *C. elegans*.

Thrinascotrema brisbanica Jue Sue & Platt, 1999 was reported from the stomach of *Elseya latisternum* (Gray, 1867), collected near Brisbane, south-eastern Queensland, by Jue Sue and Platt (1999*b*). Dissections of other species of turtles (including a *C. longicollis*) from the same region did not recover any further infections (Jue Sue and Platt 1999*b*); however, dissections of a further 10 *C. longicollis* from northern New South Wales by Zelmer and Platt (2008) found *T. brisbanica* (specimens were deposited in the Queensland Museum, but could not be borrowed for comparison with the specimens collected in this study). Infections were also reported in *E. latisternum* from northern Queensland, substantially increasing its geographical distribution (Zelmer and Platt 2008). The morphology of *T. brisbanica*, as described by Jue Sue and Platt (1999*b*) is distinctive, with an obvious excretory vesicle extending almost to the anterior end of the body and a spined ventral sucker. Despite the immaturity of the specimens collected in this study, both features were discernible, confirming the identification. Given the small number of specimens, and their small size, collected in this study, molecular characterisation was not attempted. However, future research should attempt molecular characterisation of specimens collected from Tasmania and from other hosts in different geographical locations to confirm the species identification.

Although Zelmer and Platt (2008) found that *C. longicollis* had a rich parasite fauna, only two parasite species were collected in this study. However, introduced individual host animals are often not highly infected, which reduces the richness of parasites in the introduced population (Lymbery *et al*. 2014). Additionally, the sporadic introduction events, combined with animals being kept as pets before release (Fearn 2013) would reduce the number of parasites able to be introduced. For parasites with an indirect life cycle, lack of a suitable intermediate host could also prevent the establishment of a parasite (Lymbery *et al*. 2014). And, finally, the environmental tolerances of parasites, especially when introduced to an area at the extreme edge of the host's distribution (Tasmania is at the southern end of the natural distribution of *C. longicollis*: Cogger 2014), are unknown and some of the parasites, especially those with direct life cycles, may not be able to survive. It is possible, however, for introduced hosts to acquire new parasites in an introduced location, altering the dynamics of the parasite community (Lymbery *et al*. 2014), but without native turtle species this is unlikely to have occurred.

The origin of the parasites in these turtles in Tasmania cannot be confirmed. However, given the immature status of several specimens, it seems clear that these parasites are capable of transmission within the Tasmanian environment. Although parasites with simple direct life cycles are usually predicted to be more easily introduced to new locations, a number of helminths with indirect life cycles have been shown capable of establishing and transmitting in new systems. Further research is required to examine feral populations of *C. longicollis* in Tasmania to determine whether any other parasites have been cointroduced. The results of this study have implications for feral hosts and their parasites, showing that parasites are capable of cointroducing without the requirement for suitable native definitive hosts present.

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Data availability. Specimens have been deposited in the collection of the Queen Victoria Museum and Art Gallery, Launceston, Tasmania.

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