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Bothriembryon rocketi sp. nov. (Mollusca, Gastropoda, Bothriembryontidae) from the semi-arid Pilbara region of Western Australia

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Abstract

Bothriembryon Pilsbry, 1894 is a large-bodied genus of native Australian land snail found mostly in the mesic south of Western Australia. These snails are largely absent from more northerly areas of Western Australia although an undescribed species has long been known from the central Pilbara. We describe *Bothriembryon rocketi* sp. nov. from the Hamersley and Barlee Ranges, the northernmost record of the genus in the country. We provide diagnostic genetic and shell morphological characters, as well as ecological notes and review internal anatomy.

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https://zoobank.org/NomenclaturalActs/43377767-ffaa-4a4f-8214-5245f323401c

Introduction

Bothriembryon Pilsbry, 1894 is a genus with a Gondwanan history comprising fifty extant and seven fossil species in the subfamily Bothriembryontinae (Iredale 1939, Breure 1979, Smith 1992, Richardson 1995, ABRS 2010, Breure & Whisson 2012, Stanisic et al. 2018). New species are regularly described from southern Western Australia (Whisson & Breure 2016, Schneider & Morrison 2018, Morrison, Schneider & Whisson 2019, Morrison & Schneider 2019, 2021, 2022, 2023, Morrison 2021). The largely temperate distribution occurs across a diversity of iconic south-western environments such as Wheatbelt woodlands, mountain peaks in the Stirling ranges, offshore granite islands of the Recherche Archipelago and throughout the sandy Swan coastal plain. In contrast, few *Bothriembryon* species are known from the more northerly areas of Australia (i.e. above 25 degrees latitude), an area long associated with diverse and well-characterised camaenid radiations. In Western Australia, this includes the Kimberley region (e.g. Köhler 2011a,b, Burghardt & Köhler 2016), Pilbara region (e.g. Johnson et al. 2004, 2012, 2016; Stankowski 2011; O'Neill et al. 2014) and Cape Range, Muiron and Mon-

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tebello Islands (e.g. Taylor et al. 2015, Johnson et al. 2013). Just three species of *Bothriembryon* are currently known outside of southern Australia, two from insular Shark Bay, *B. costulatus* (Potiez & Michaud, 1838) and *B. onslowi* (J.C. Cox, 1864) and *B. spenceri* (Tate, 1894) from near Alice Springs in the Northern Territory. Here, we describe a new species from the Hamersley and Barlee Ranges in the semi-arid Pilbara.

Methods

A total of 398 lots comprising 468 specimens were examined in this study and are lodged in the Western Australian Museum Mollusc collection. Most of this material was live taken and preserved directly in 70-100% ethanol. Habitat and shell images were captured using Canon EOS 6D/7D digital camera, the latter using a 50mm macro-lens and stacked using Passport II Imaging System and Helicon Focus Lite 7.6.1 software. Live snail images were taken using an Olympus Stylus Camera. SEM images were produced using a Desktop Hitachi TM3030 Plus SEM machine, with the shell fixed in position by carbon tape. Dissections were performed under a Leica WILD M3C Stereo Microscope, pinned genitalia photographed using Canon EOS 6D digital camera and then traced in Adobe Photoshop using a Wacom Intuos graphics tablet. All shell measurements were taken from adults following the methods of Breure (1974), except for whorl counts which followed Kendrick & Wilson (1975). Measurements were made with Digi-Max digital calipers to 0.01 mm for maximum shell height (H) and maximum shell diameter (D). A Leica WILD M3C Stereo Microscope was used to measure the number of shell whorls (W) and protoconch whorls (PW). Finer measurements of aperture height (AH), aperture diameter (AD) and height of last whorl (LW) were taken from calibrated shell images using Image J 1.54D software.

The monophyly of *Bothriembryon rocketi* sp. nov. was initially tested using a concatenated phylogeny based on sequence alignment of three protein-coding genes: mitochondrial loci cytochrome *c* oxidase subunit 1 (COI) and ribosomal rRNA (16S), and one nuclear loci, adenine nucleotide translocase (ANT) (Unpublished data, in prep). The COI dataset was then chosen for this study (Fig. 2), as it captures the relationships found in the larger dataset and provides the most detailed genetic snapshot of the ingroup, *Bothriembryon rocketi* sp. nov.. *Placostylus bivaricosus* was used to root the tree as *Placostylus* is sister to *Bothriembryon*. In total, 389 COI sequences of *Bothriembryon rocketi* sp. nov. were analysed in this study.

Total genomic DNA was extracted from tissue samples using a DNeasy Blood & Tissue Kit (Qiagen) according to manufacturer's instructions. The extractions were then used in 25-µl reactions to amplify fragments of the mitochondrial cytochrome oxidase *c* subunit I (COI) gene. The universal primers LCO/HCO (Folmer et al. 1994) were used. PCRs included a denaturation step at 95 °C for 3 min and a final extension at 72 °C for 5 min. Amplicons were created either with a simple PCR (95 °C for 20 s; 45 °C for 30 s; 72 °C for 40 s) × 40 or by using an initial stage of cycling as above but only for 5 cycles, followed by (95 °C for 20 s; 50 °C for 30 s; 72 °C for 40 s) × 35. Amplified products were outsourced to the Australian Genome Research Facility (Perth) for bidirectional sequencing. Sequences were assembled in Geneious v. 9 (Kearse et al. 2012) and edited by eye as necessary. Consensus sequences were aligned using MAFFT v.7 (Katoh et al. 2002).

Phylogenetic relationships were estimated by employing a Maximum Likelihood-based method of tree reconstruction (ML) using IQ-TREE vs. 2.3 (Nguyen et al. 2015). We applied two data partitions, one for nucleotides at the first and second codon positions and one for third codon positions. We analysed a dataset containing 395 sequences that had a total length of 655 nucleotides. Of these, 218 were parsimony-informative, 42 were singleton sites, and 395 were constant sites. We used the integrated ModelFinder (Kalyaanamoorthy et al. 2017) to identify the best-fit models of sequence evolution for each partition by means of the Bayesian Information Criterion (BIC). The best models were TIM+F+I+G4 for the partition containing condon positions 1 and 2, and HKY+F+G4 for third codon positions. We performed 10,000 Ultrafast Bootstraps (Minh et al. 2013) to estimate the statistical branch support of the best Maximum Likelihood tree. Evolutionary distances were calculated in MEGA v. 11.0.13 using the P-distance method.

Abbreviations of repositories: AM, Australian Museum, Sydney, Australia; RMNH, Naturalis Biodiversity Center, Leiden, the Netherlands, MAGNT, Museum and Art Gallery of the Northern Territory, WAM, Western Australian Museum Perth. Data for material examined have been extracted from electronic databases and distributional maps were plotted using ArcGis 10.1 software.

Taxonomy

Family BOTHRIEMBRYONTIDAE Iredale, 1937
Subfamily BOTHRIEMBRYONTINAE Iredale, 1937
Genus *Bothriembryon* Pilsbry, 1894

Bothriembryon rocketi sp. nov.

Figs. 3–9

https://zoobank.org/NomenclaturalActs/43377767-ffaa-4a4f-8214-5245f323401c

Holotype AUSTRALIA, Western Australia: From label 'Beside road to Hamersley Gorge, 50k, 606077, 7504936 (transformed to 22°33`32.16"S, 118°01`54.18"E), in thicket of *Mulga*, overnight rain small and large snails

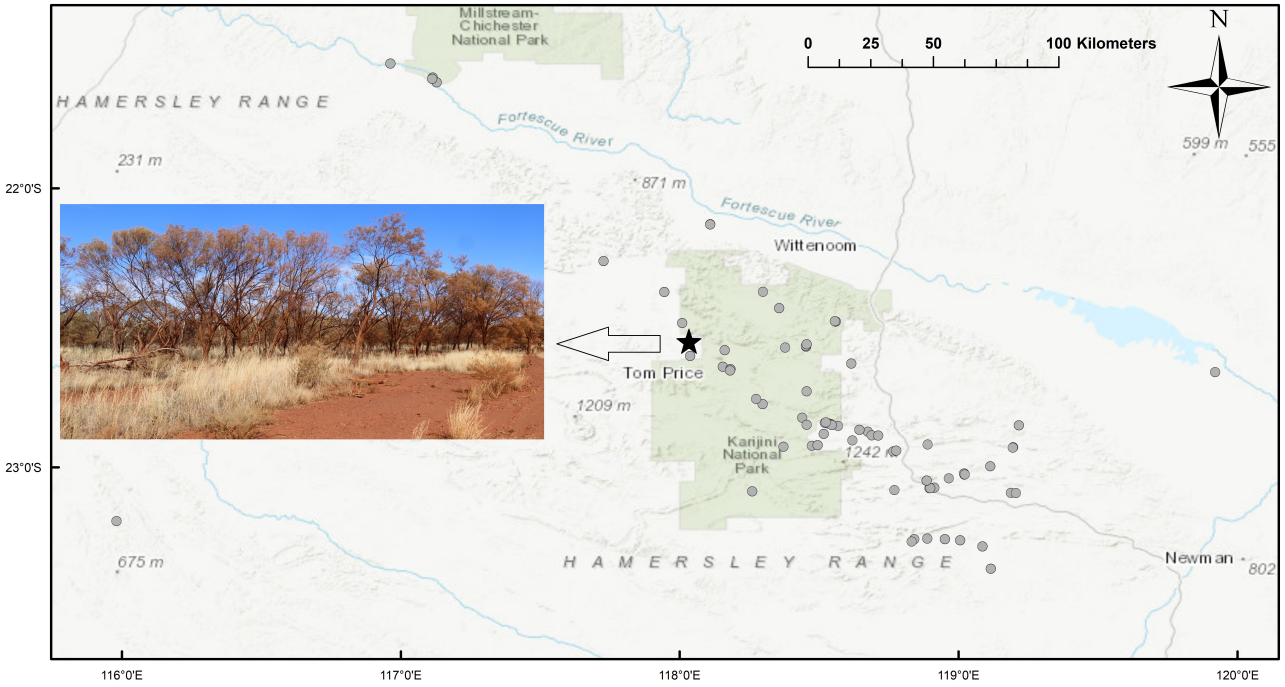

Figure 1. Occurrence records and type locality (star) of *B. rocketi* sp. nov. (Inset: image of type locality)

common on damp ground, 18 August 2005, G.W. Kendrick, M. Maier, wet/dry (WAM S11550).

Paratypes AUSTRALIA, Western Australia: Same as type locality, 1 wet each (WAM S114024-114027), 20 wet (WAM S91426); From type locality at 22°33`33.00"S, 118°01`54.31"E, PB001, 8 May 2023, C.S. Whisson, L.A. Kirkendale, 1 wet/dry (WAM S113830), 1 wet (WAM S113831), 1 wet/dry (WAM S113832), 1 wet/dry (WAM S113833), 7 wet (WAM S113835), 1 wet (WAM S113836), 46 dry (WAM S113846), 2 wet (AM C.604962), 1 wet (NTM P065270), 1 wet (RMNH.MOL.195058).

Other Material

Each lot 1 wet specimen: AUSTRALIA, Western Australia: Barlee Range, 23°11`35.0"S, 115°58`50.0"E, 26 July 2002, P. Kendrick (WAM S84106-84107); Gregory Gorge, Fortescue River, 21°33.236`S, 116°57.770`E, beneath limestone scree, 19 December 2005, P. Kendrick (WAM S67175-67182); Dawson Creek, 21°36.243`S, 117°06.865`E, 22 February 2004, P. Kendrick (WAM S84100-84101); 2 km W of Pannawonica, 1 km east of Dawson Creek, road to Crossing Pool, Millstream, 21°36`30"S, 117°06`45"E, 25 June 1985, P. Kendrick (WAM S67183-67190); Millstream-Chichester, Near park entrance on north side of crossing pool, 21°37`17"S, 117°07`42"E, calcrete plain aestivating under *Triodia*, 22 March 2015, R.J. Teale, M.S. Harvey (WAM S91979-91993); Approx. 48 km N of Tom Price, 22.26168°S, 117.72722°E, Site HONS18, 17 February 2007, M. Johnson et al. (WAM S67027-67031); Approx. 38 km NNE of Tom Price, 22.372°S, 117.94493°E, HONS09, 16 February 2007, M. Johnson et al. (WAM S67010-67016); Approx. 27 km NE of Tom Price, 22°36`05"S, 118°02`15"E, Site PRMARO03, 10 May 2008, M. Greenham (WAM S67204-67210); Approx. 28 km E of Tom Price, 22.55917°S, 118.03202°E, Site HONS01, 15 February 2007, M. Johnson et al. (WAM S67000, S67002, S67004); Approx. 70km NE of Tom Price, 22.12988°S, 118.10928°E, Site HONS14, 16 February 2007, M. Johnson et al. (WAM S67017-67026); Approx. 39 km E of Tom Price, 22.58118°S, 118.16117°E, Site HONS02, 15 February 2007, M. Johnson et al. (WAM S67006-67009); Approx. 65 km SE of Tom Price, 23.08642°S, 118.25995°E, Site HONS23, 17 February 2007, M. Johnson et al. (WAM S67032-67034); Approx. 53 km E of Tom Price, 22.77412°S, 118.29747°E, Site HONS32, 18 February 2007, M. Johnson et al. (WAM S67035-67038); Approx. 70km E of Tom Price, 22.55988°S, 118.45528°E, Site HONS71, 22 February 2007, M. Johnson et al. (WAM S67168-67172); Approx. 71 km E of Tom Price, 22.84818°S, 118.45532°E, Site HONS33, 18 February 2007, M. Johnson et al. (WAM S67040-67041); Approx. 78 km E of Tom Price, 22.88085°S, 118.51685°E, Site HONS34, 18 February 2007, M. Johnson et al. (WAM S67042-67045); Approx. 85 km E of Tom Price, 22.62897°S, 118.61562°E, Site HONS70, 22 February 2007, M. Johnson et al. (WAM S67164-67167); Approx. 90 km E of Tom Price, 22.86607°S, 118.6448°E, Site HONS35, 18 February 2007, M. Johnson et al. (WAM S67046-67069); Approx. 97 km E of Tom Price, 22.88683°S, 118.71175°E, Site HONS36, 18 February 2007, M. Johnson et al. (WAM S67070-67072); Approx. 87 km W of Newman, 23.25623°S, 118.88762°E, Site HONS48, 19 February 2007, M. Johnson et al. (WAM S67140-67141); Approx. 81 km W of Newman, 23.25792°S, 118.95107°E, Site HONS47, 19 February 2007, M. Johnson et al. (WAM S67106-67139); Wit-

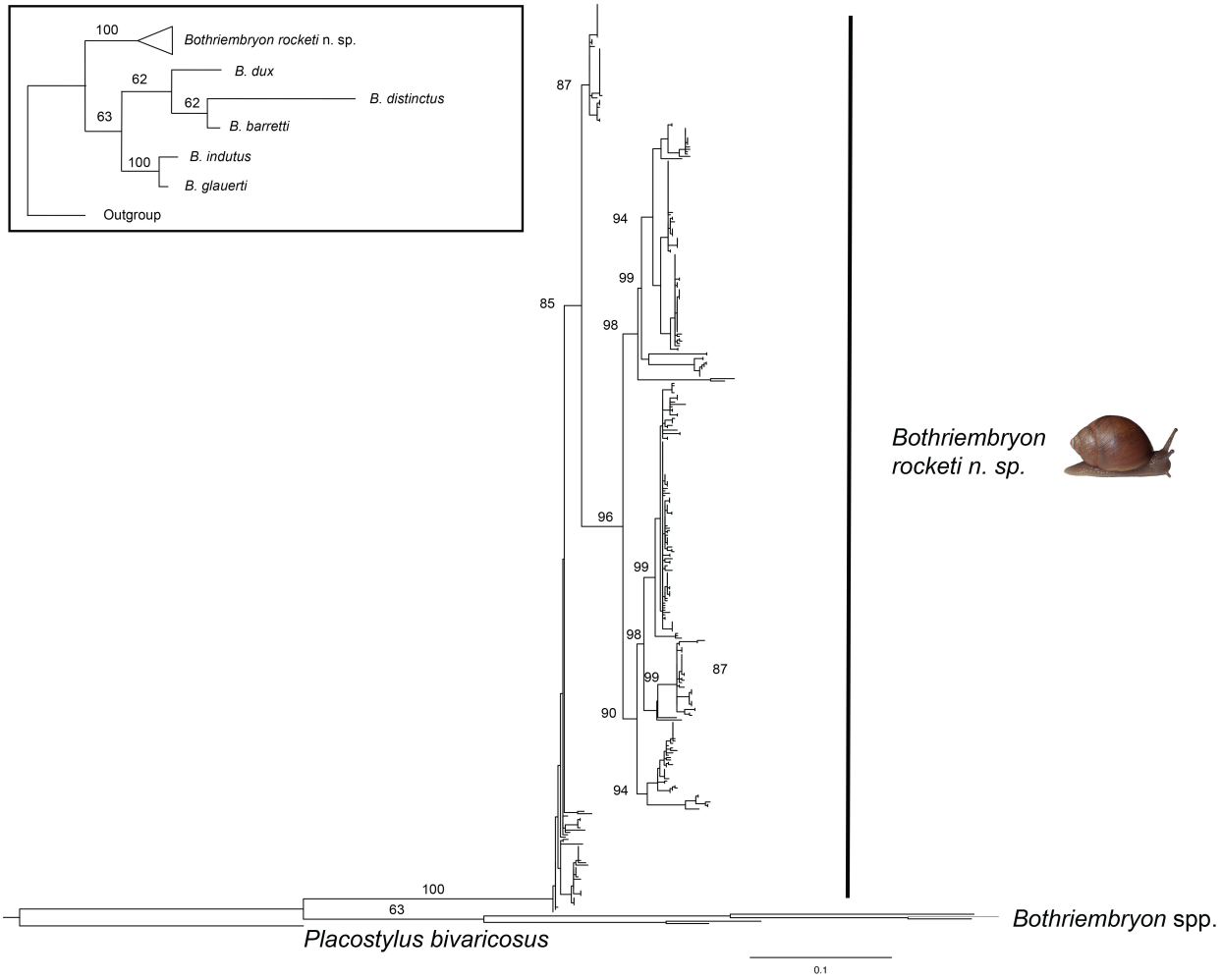

Figure 2. Maximum likelihood phylogram of COI among 389 sampled *B. rocketi* sp. nov. showing bootstrap support values of key clades of interest. Inset: Maximum likelihood phylogram of COI showing placement of *B. rocketi* sp. nov. in a larger phylogenetic context.

tenoom Bypass road (off Roebourne-Tom Price Road), near Fortescue Crossing, 22°07.811`S, 118°06.555`E, *Mulga* flat under logs and litter, 18 August 2005, G.W. Kendrick, M. Maier (WAM S11549, S66673-66676); Marandoo, 22°38`23.94"S, 118°09`17.04"E, Site MAR09, 7 November 2007, M. Greenham (WAM S67211-67216); Pilbara area, 22°39`12"S, 118°10`51"E, Site MARSN01, 2 March 2007, BIOTA staff (WAM S67231-67240); Marandoo, 22°38`56"S, 118°10`56"E, Site MAR02, 6 March 2007, Biota staff (WAM S67336-67342); Marandoo Powerline Corridor, 22°45`21.2"S, 118°16`27.8"E, 16 November 2005, BIOTA staff (WAM S84116); Karijini NP, Knox Gorge, 63 km NE of Tom Price, 22°22`17.36"S, 118°17`55.88"E, Site K4, 30 July 2010, B. Durrant (WAM S65353); Karijini NP, near turn-off to Kalamina Gorge, 22°25`50"S, 118°21`24"E, Site RT20150315.4.1, aestivating under log in soil, *Mulga* woodland, 15 March 2015, R.J. Teale (WAM S87810-87811, S87813-87817); Karijini NP, 64 km ESE of Tom Price, 22°55`36.48"S, 118°22`19.56"E, Site 14, 31 July 2010, B. Durrant (WAM S66692-66693); Karijini NP, Karinjini Drive west of access to rangers quarters, 22°34`17"S, 118°22`41"E, Site MH1009.1, aestivating under log in soil, *Mulga* woodland, 14 March 2015, R.J. Teale (WAM S87809); Karijini NP, track to Juna Downs from Rangers HQ, 22°49`23"S, 118°26`21"E, Site RT20150317.1.2, aestivating under log in soil, *Mulga* woodland, 17 March 2015, R.J. Teale (WAM S87819-87820); Karijini NP, access track to rangers quarters, 22°33`57"S, 118°27`10"E, Site RT20150314.2.1, aestivating under log in soil, *Mulga* woodland, 14 March 2015, R.J. Teale (WAM S66692-66693); Karijini NP, Karinjini Drive west of access to rangers quarters, 22°34`17"S, 118°22`41"E, Site MH1009.1, aestivating under log in soil, *Mulga* woodland, 14 March 2015, R.J. Teale (WAM S87809); Karijini NP, Karinjini Drive west of access to rangers quarters, 22°49`23"S, 118°26`21"E, Site RT20150317.1.1, aestivating under log in soil, *Mulga* woodland, 17 March 2015, R.J. Teale (WAM S87819-87820); Karijini NP, Access track to rangers quarters, 22°33`57"S, 118°27`10"E, Site RT20150314.2.2, aestivating under log in soil, *Mulga* woodland, 14 March 2015, R.J. Teale (WAM S87807-87808); Karijini NP, Access track to rangers quarters, 22°34`05"S, 118°27`12"E, Site RT20150314.1.1, aestivating under log in soil, *Mulga* woodland, 14 March 2015, R.J. Teale (WAM S87806); Karijini NP, road to Visitors Centre, 22°43`42"S,

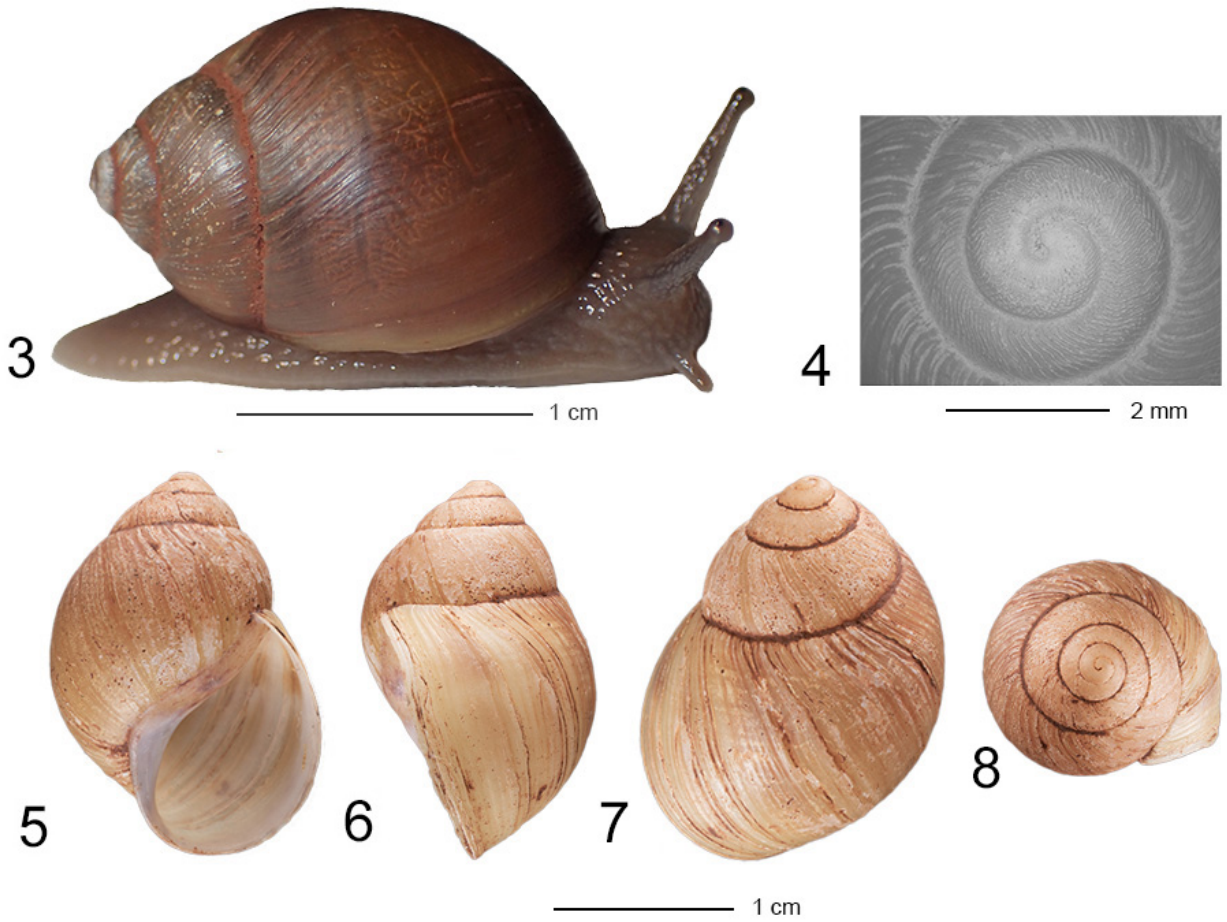

Figure 3–8. Plate of *Bothriembryon rocketi* sp. nov. 3: crawling paratype WAM S113832 4: SEM of protoconch of paratype WAM S113830 5-8: apertural, lateral, dorsal and apex view of holotype WAM S11550

118°27`20"E, Site RT20150318.2.1, aestivating under log in soil, *Mulga* woodland, 18 March 2015, R.J. Teale (WAM S87821, S87823); Juna Downs Station, 73 km ESE of Tom Price, 22°55`24.36"S, 118°28`25.98"E, Site 03, 26 April 2010, B. Durrant (WAM S66684); Juna Downs Station, 75 km ESE of Tom Price, 22°55`16.14"S, 118°29`40.20"E, Site 04, 27 July 2010, B. Durrant (WAM S66647-66655); Karijini NP, 75 km E of Tom Price, 22°50`29.70"S, 118°31`14.46"E, Site 01, in litter, 28 July 2010, B. Durrant (WAM S65356); Karijini NP, 75 km E of Tom Price, 22°50`23.02"S, 118°31`25.22"E, Site 02, 25 April 2010, B. Durrant (WAM S65341, S117342-117343); Karijini NP, 77 km E of Tom Price, 22°50`37.56"S, 118°31`57.00"E, Site 16, 1 May 2010, B. Durrant (WAM S66635, S66637-66639, S66641-66643, S66645), Site 16, 1 August 2010, B. Durrant (WAM S65354, S66628-66634); Karijini NP, 77 km E of Tom Price, 22°50`40.86"S, 118°32`24.90"E, Site 17, 1 August 2010, B. Durrant (WAM S66685, S66687-66689); Karijini NP, 78 km E of Tom Price, 22°50`56.58"S, 118°32`43.08"E, Site 12, 24 July 2010, B. Durrant (WAM S66656-66657, S66659-66670); Karijini NP; Dales Gorge near ladder for access to circular pool, 22°28`36"S, 118°33`25"E, Site RT20150313.1.2, *Triodia* on gorge face, 13 March 2015, R.J. Teale (WAM S87803-87805); Karijini NP, Dales Gorge, 82 km ENE of Tom Price, 22°28`40.41"S, 118°33`32.42"E, Site K3, 30 July 2010, B. Durrant (WAM S66681); Karijini NP, Dales Gorge, 82 km ENE of Tom Price, 22°28`41.51"S, 118°33`35.25"E, Site K1, 30 July 2010, B. Durrant (WAM S66350, S66678); Karijini NP, bottom of Dales Gorge, 0.79km downstream of Circular Pool, 22°29`00"S, 118°33' 55"E, 13 March 1986, P. Kendrick (WAM S67194-67195, S67217); Karijini NP, 80 km E of Tom Price, 22°51`08.52"S, 118°34`04.50"E, Site 08, 23 July 2010, B. Durrant (WAM S66683); Area C West, 85.8 km NW of Newman, 22°54`14"S, 118°37`09"E, thick grasses, minor drainage line, 17 September 2011, S. Ford, R. Lyoyd (WAM S81520); East Pilbara, Juna Downs Pastoral lease, about 55.5km S of Auski Roadhouse, 22°52`21"S, 118°40`29"E, *Mulga* thickets, under moist log, 17 June 2008, E.S. Volschenck, L. Quinn (WAM S59329, WAM S59327, S117345-117346); East Pilbara, Juna Downs Pas-

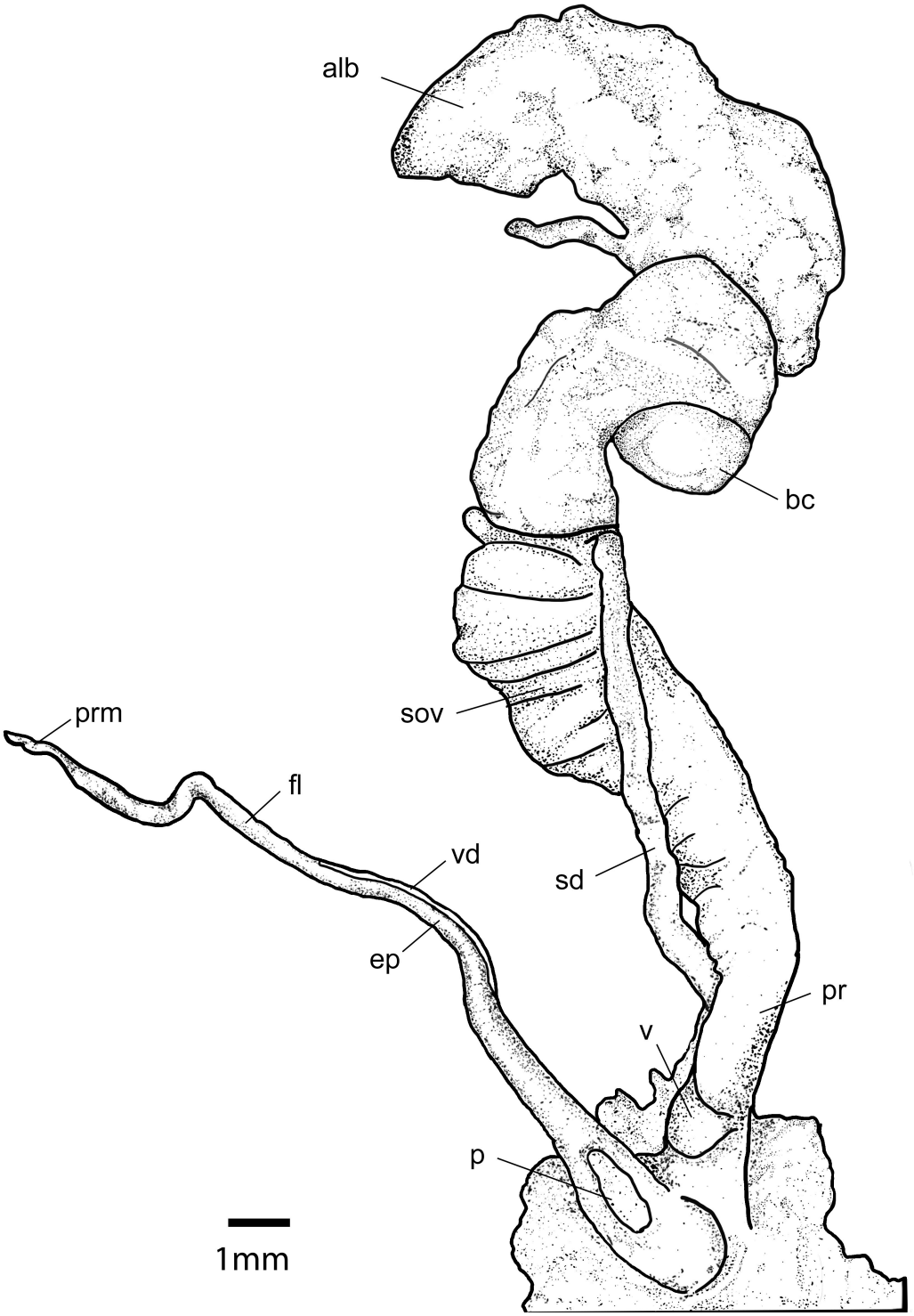

Figure 9. Genital anatomy of *Bothriembryon rocketi* sp. nov. WAM S59327 (abbreviations: alb – albumen gland, bc – bursa copulatrix, ep – epiphallus, fl – flagellum, p – penis, pr – prostate gland, prm – penis retractor muscle, sd – spermathecal duct, sod – spermoviduct, v – vagina, vd – vas deferens).

toral lease, About 55.5km S of Auski Roadhouse, 22°53`09"S, 118°41`18"E, Site EE08:0360, *Mulga* thickets, under moist log, 1 September 2008, L. Quinn (WAM S59328); Juna Downs, 22°56`36"S, 118°45`57"E, Site B172, 12 November 2005, R.J. Teale, M. Greenham (WAM S84084); West Angelas, The Governor, 23°04`56"S, 118°46`12"E, Site HSN01, 3 October 2005, M.M (WAM S67294); Juna Downs, 22°56`26"S, 118°46`35"E, 12 November 2005, R.J. Teale, M. Greenham (WAM S84085-84086); Near Deposits E and F, 23°15`59.5"S, 118°49`55.5"E, Site HDS48, 14 November 2005, R.J. Teale, M. Greenham (WAM S84097); South of deposit F, 23°15`29.3"S, 118°50`28.4"E, Site HDS47, 14 November 2005, R.J. Teale, M. Greenham (WAM

S84093-84094); 120km NNW of Newman, BHP Mining Area C, 22°55`08.05"S, 118°53`21.08"E, Site 16A, *Ficus*, 1 May 2009, P. Bolton (WAM S59407); West Angelas Mine, 23°04`32"S, 118°53`44"E, Site HDS21, *Mulga* flat, 11 November 2005, R.J. Teale, M. Greenham (WAM S84102); Mudlark, 91.9km NW of Newman, 23°2`52"S, 118°53`5.5"E, Site SN20120213.MUK07-03, narrow gorge lined with *Mulga*, 6 February 2012, N. Watson (WAM S83358); South of deposit F, 23°04`32"S, 118°53`55"E, Site HDS24, 11 November 2005, R.J. Teale, M. Greenham (WAM S67295-67302, S84095-84096); Mudlark, 91.3km NW of Newman, 23°2`53.9"S, 118°53`9.7"E, Site SN20120213.MUK21-01-02, 15 February 2012, N. Watson (WAM S66612-66616, S83356); West Angelas Mine (New Governor), 23°04`23.3"S, 118°54`47.0"E, Site HSN08, 6 October 2005, M.M (WAM S84111, S84115); West Angelas (The Governor), 23°02`23.5"S, 118°57`55.3"E, Site HSN09, 6 October 2005, M.M (WAM S84112); Approx. 75 km W of Newman, 23.26185°S, 119.00603°E, Site HONS45, 19 February 2007, M. Johnson et al. (WAM S67093-67105); Approx. 65 km W of Newman, 23.28407°S, 119.0855°E, Site HONS44, 19 February 2007, M. Johnson et al. (WAM S67073-67092); Approx. 62 km W of Newman, 23.36377°S, 119.11607°E, Site HONS63, 20 February 2007, M. Johnson et al. (WAM S67152-67163); Pebble Mouse Creek, 23°01`23"S, 119°01`12"E, Site HDS43, 13 November 2005, R.J. Teale, M. Greenham (WAM S84089, S84091); Approx. 80 km NW of Newman, ,23°01`24"S, 119°01`15"E, Site HDS42, 13 November 2005, R.J. Teale, M. Greenham (WAM S67279-67293); Pebble Mouse Creek, 23°01`37"S, 119°01`17"E, Site HDS44, 13 November 2005, R.J. Teale, M. Greenham (WAM S84103); Pebble Mouse Creek, 23°01`34.0"S, 119°01`20.0"E, Site HDS45, 13 November 2005, R.J. Teale, M. Greenham (WAM S84092); Approx. 74 km NW of Newman, Corridor, 22°59`49.3"S, 119°06`49.9"E, Site HDS41, 13 November 2005, R.J. Teale, M. Greenham (WAM S67274-67278); NW of Newman, Hope Downs, 23°05.511`S, 119°11.282`E, Site HD4-15, eucalypts and mixed shrubs, 20 September 2008, Ninox Wildlife Consulting (WAM S59302); Weeli Wolli Spring, 22°55`48.1"S, 119°11`40.5"E, Site WWSN01, 13 November 2005, R.J. Teale, M. Greenham (WAM S84099); Weeli Wolli Spring, 22°55`44"S, 119°11`45"E, Site WWSN02, calcrete, 13 November 2005, R.J. Teale, M. Greenham (WAM S67335, S84098); NW of Newman, Hope Downs, 23°05.552`S, 119°12.352`E, Site HD4-14B, mid slope, 21 September 2008, Ninox Wildlife Consulting (WAM S66672); Weeli Wolli Creek, 22°51`°S, 119°13`E, April 1995, R.J. Teale (WAM S67255-67273); Roy Hill Station, 22°39`33.76"S, 119°55`11.3"E, Site EE09:195, *Acacia* shrubland, 29 October 2009, Ecologia Environmental (WAM S66682, S66694).

Diagnosis

Shell characterized by moderately globose shape and short acuminate spire, monotone light brown colour and rather wide and deep umbilicus behind prominent white triangular columellar wall.

Description

Animal: Foot, head and tentacles light brown with side and base of foot slightly paler. Cephalic tentacles with small, black eye spots at distal end. No nape stripe visible. Posterior foot acuminate. Overall texture of the body is typically reticulate (Fig. 3).

Shell (type series): Shell globose with slightly convex sides, diameter 12.42–16.14 mm (mean 13.98 mm, SD 0.87), height 16.61–23.59 mm (mean 19.59 mm, SD 1.62) with 4.10–5.10 whorls (mean 4.58, SD 0.22) and a H/D ratio of 1.29–1.53 (mean 1.40, SD 0.05)(Table 1). Protoconch of 1.75–2.15 whorls (mean 1.92, SD 0.12) with coarse, oblique wrinkles extending from suture, which on the first whorl coalesce into a thimble, honeycomb pattern near suture, on remaining protoconch the wrinkles are typically separate and often deflected. Teleoconch consists of regular, incrassate growth striae and infrequent malleate sculpture. Body whorl large, prominent with short, acuminate spire (mean LW/H 0.86, SD 0.02). Aperture large, ovate, nearly two-thirds of shell height (mean AH/H 0.62, SD 0.03) with simple lip. Parietal callus prominent, white triangular, edge easily discernible from body whorl, terminating at lip junction. Columella wall white, partly reflected toward the rather wide and deep umbilicus. Sutures well impressed. Shell colour uniformly light brown, with some inconspicuous axial streaks of a slightly darker brown at irregular distances.

Internal Anatomy

Genitalia (WAM S59327): Penis without a sheath, slightly swollen at the base, subcylindrical and passing without external differentiation into the epiphallus. The flagellum is slender and rather long (ca. one third of the phallus), the retractor muscle is distally attached. The vas deferens is free of the phallus and shorter in length than the penis and epiphallus together. The vagina is relatively short. The spermathecal duct is sub-cylindrical, flattened, wrapped around and attached to the spermoviduct and terminates with a thick, globose bursa copulatrix, somewhat embedded in the upper spermoviduct (Fig. 9).

Etymology

The specific epithet is in reference to the beloved pet dog of Mel Watts and Rob Ranalli, who submitted the winning bid to name this species during the Foundation for the WA Museum's Night at the Museum 2022 Gala auction.

Natural History

The type locality (at 22°33`32.2"S, 118°01`54.2"E) was revisited in May 2023 during dry conditions (Fig. 1). It is described as a flat drainage area with open mulga thicket (to 10m) and an understorey of low grasses (including invasive Buffalo grass), shrubs and smaller *Acacia*

Table 1. Shell measurements of *Bothriembryon rocketi* sp. nov. type material.

	H	D	AH	AD	LW	PW	W	H/D	AH/AD	AH/H	LW/H
Holotype	22.78	16.14	13.75	9.90	19.05	2.10	4.75	1.41	1.39	0.60	0.84
Average (n = 44)	19.59	13.98	12.14	8.15	16.91	1.92	4.58	1.40	1.49	0.62	0.86
SD	1.62	0.87	0.74	0.55	1.22	0.12	0.22	0.05	0.06	0.03	0.02
Minimum	16.61	12.42	10.62	7.18	14.37	1.75	4.10	1.29	1.39	0.56	0.83
Maximum	23.59	16.14	13.75	9.90	19.96	2.15	5.10	1.53	1.62	0.71	0.90

Table 2. Summary of P-distances between *Bothriembryon* species used in this study (COI).

	P. bivaricosus	*B. barretti*	*B. dux*	*B. indutus*	*B. glauerti*	*B. distinctus*	*B. rocketi* sp. nov.
	min, max, mean	min, max, mean	min, max, mean	min, max, mean	min, max, mean	min, max, mean	min, max, mean
P. bivaricosus							
B. barretti	0.14656						
B. dux	0.15228	0.05495					
B. indutus	0.17405	0.14351	0.14443				
B. glauerti	0.18502	0.14832	0.15094	0.13914			
B. distinctus	0.17557	0.15267	0.14757	0.18168	0.16361		
B. rocketi sp. nov.	0.13893, 0.17099, 0.15243	0.13130, 0.15267, 0.14166	0.12402, 0.15071, 0.13883	0.16336, 0.19389, 0.17796	0.16055, 0.19113, 0.17600	0.14656, 0.16641, 0.15540	0.00, 0.08244, 0.04273

(non-*Mulga*). The site has been impacted by cattle, with large scale pasture crops observed approximately 600 metres away.

Live specimens were found buried to 5cm around roots at the base of *Mulga* trees. All were aestivating with a clear mucus seal across aperture, often covered with agglutinated faecal matter and dirt. Activated snails in the laboratory were observed stuck to objects (e.g. bark and other snails) using a clear mucus seal around the edge of aperture (rock-sealer) or in some cases, created another clear mucus seal across the entire aperture (free-sealer).

Barcode Gap and Sequence Data

The maximum intraspecific evolutionary divergence in COI for *B. rocketi* sp. nov. was 8.24% (average 4.27%). Interspecific evolutionary divergences for *B. rocketi* sp. nov. ranged between 12.40% and 19.39% (Table 2). Sequence data is available on GenBank (Accession Numbers OR912558-OR912952, Supplementary Table 1).

Remarks

This species has one of the most widespread distributions known for the genus, comparable only to *B. dux* and *B. barretti* along the Nullarbor. It is found across most of the Hamersley Range from Gregory Gorge at the northwest end intermittently through to Spearhole Creek in the south and Roy Hill to the east (based on COI sequences, Fig. 1). It is also known on northern drainages in lower Millstream-Chichester Park. There is an isolated record at the western end of Barlee Range. The distribution is estimated at approximately 20,000 km2 and follows drainages into and proximal to the Fortescue River, excluding the Barlee Range record. The latitudinal span of 125 km in an arid landscape is notable. The shell of *B. rocketi* sp. nov. differs from *Bothriembryon onslowi* by the monotone brown shell colour, deep umbilicus and lack of spiral sculpture on teleoconch. It differs from *B. spenceri* by the thicker shell, non-convex teleoconch whorls that lack spiral sculpture and thicker, non-flared outer lip. Anatomically, the female genitalia of *B. rocketi* sp. nov. is similar to several semi-arid nullarbor *Bothriembryon* (Kershaw 1986), having a spermathecal duct that adheres to the spermoviduct, and a globose bursa copulatrix in close proximity to the upper spermoviduct.

The first record of *Bothriembryon* from the Pilbara was in July 1956 when dead shells were collected by Dr. Barry Wilson from Dale's Gorge in the Karijini National Park (WAM S3774). The Pilbara population was first regarded as an unnamed taxa by Solem (1988, 1998) and later, as two unnamed taxa by Slack-Smith (1993) on account of the seemingly disjunct populations in the Hamersley and Chichester Ranges.

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Supplementary Data

Supplementary Table 1 (available from the corresponding author): GenBank accession numbers and registration numbers for sequences used in this study.

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