

Perlesta ephelida, a new Nearctic stonefly species (Plecoptera, Perlidae)

Scott A. Grubbs^{1,†}, R. Edward DeWalt^{2,‡}

1 Department of Biology and Center for Biodiversity Studies, Western Kentucky University, Bowling Green, KY 42101 USA **2** University of Illinois, Prairie Research Institute, Illinois Natural History Survey, 1816 S Oak St., Champaign, IL 61820 USA

† [urn:lsid:zoobank.org:author:249E192C-5D94-414F-BD08-454913B47C97](https://zoobank.org/urn:lsid:zoobank.org:author:249E192C-5D94-414F-BD08-454913B47C97)

‡ [urn:lsid:zoobank.org:author:6140264D-C2B4-4AA4-8517-DB31958648C2](https://zoobank.org/urn:lsid:zoobank.org:author:6140264D-C2B4-4AA4-8517-DB31958648C2)

Corresponding author: Scott A. Grubbs (scott.grubbs@wku.edu)

Academic editor: Terry Erwin | Received 19 February 2012 | Accepted 9 May 2012 | Published 17 May 2012

[urn:lsid:zoobank.org:pub:FCAD4524-5983-4D2B-AD08-BECC7121C812](https://zoobank.org/urn:lsid:zoobank.org:pub:FCAD4524-5983-4D2B-AD08-BECC7121C812)

Citation: Grubbs SA, DeWalt RE (2012) *Perlesta ephelida*, a new Nearctic stonefly species (Plecoptera, Perlidae). ZooKeys 194: 1–15. doi: 10.3897/zookeys.194.2972

Abstract

A new Nearctic species of Perlidae (Insecta, Plecoptera), *Perlesta ephelida* sp. n., is described from the male, female, and egg stages. This species has been previously reported as, or confused with, *P. shubuta* Stark from several central and eastern U.S. states. *Perlesta ephelida* is distinctive from *P. shubuta* and other regional Nearctic congeners mainly according to male genitalic and egg characteristics. *Perlesta ephelida* is a widely-distributed eastern Nearctic species, whereas *P. shubuta* appears to be restricted to a narrow latitudinal belt in the Gulf Coast region from Louisiana east conservatively to the Florida panhandle. The egg of *P. shubuta* is depicted with scanning electron microscopy for the first time.

Keywords

Perlesta, Perlidae, Plecoptera, stonefly, new species

Introduction

Perlesta shubuta Stark (Plecoptera: Perlidae) is a small-bodied, darkly-pigmented stonefly described from southern Mississippi (Stark 1989). This species has since been reported from Alabama (Graves and Ward 2011), Arkansas, Missouri and Oklahoma (Poulton and Stewart 1991), Florida (Ray et al. 2012), Illinois (DeWalt et al. 2001),

Indiana (DeWalt and Grubbs 2011), Iowa (Heimdal et al. 2004), Kentucky (Tarter et al. 2006), Michigan (Grubbs and Bright 2001), North Carolina (Kondratieff et al. 2011), and West Virginia (Tarter and Nelson 2010). In addition, there are unpublished records for Florida (Pescador et al. 2000) and South Carolina (Pescador et al. 2004) as well as material that resemble *P. shubuta* from several additional central and eastern U.S. states obtained via loans or collected by both authors since the mid-1990s.

The male aedeagus of *P. shubuta* bears a thumb-shaped caecum, a common feature for the genus (Stark 2004) and part of the reason why this species is somewhat difficult to identify with complete certainty. The female subgenital plate is likewise similar to other species. Although the morphology of the egg appears to be distinctive (Stark 1989) it has yet to be studied with scanning electron microscopy to reveal fine structural details of the chorion.

The type locality for *P. shubuta* is a sandy-bottom headwater stream. Poulton and Stewart (1991), DeWalt et al. (2001), and Heimdal et al. (2004), however, reported *P. shubuta* from large stream systems. DeWalt and Grubbs (2011) suggested that the Illinois and Indiana specimens they tentatively determined as *P. shubuta* may represent a new species. Stark (1989) and Poulton and Stewart (1991) both commented on “extremely freckled” and “speckled” nymphs, respectively, from the Ozark and Ouachita Mountain region, and the latter authors stated that “...our specimens are tentatively placed under *P. shubuta* and may represent an undescribed species”.

Our material that we only tentatively identified as *P. shubuta* from throughout the central and eastern U.S. has been obtained mainly from larger systems, including low elevation Appalachian Mountain rivers in Alabama, Maryland and West Virginia, and sandy-bottom lowland rivers in Illinois, Indiana and Michigan. Associated nymphs and exuviae obtained through rearings bear a head mask that is freckled to a much greater degree compared to regional congeners. Because of the uncertainty regarding the identity of *P. shubuta* from localities other than at/near the type locality in southern Mississippi, a comparative study was undertaken to examine available material from across the central and eastern U.S.

Materials and methods

Fresh specimens of *P. shubuta* were obtained from eastern Mississippi and western Alabama in May 2011. A visit to the type locality was unsuccessful. Recently collected material of *P. shubuta*, in addition to all specimens determined tentatively as *P. shubuta*, was reexamined with light microscopy to study fine details of the paraprocts, dorsal and lateral aedeagal spinule patterns, and the subgenital plate. Material were obtained from collections from the Bill P. Stark Collection, Mississippi College, Mississippi (BPS), Brigham Young University, Monte L. Bean Museum, Provo, Utah (BYU), Canadian National Collection, Ottawa (CNC), Illinois Natural History Survey, insect collection series, Champaign, Illinois (INHS), Illinois Natural History Survey, Plecoptera catalog series, Champaign, Illinois (INHSPle), A.J. Cook Arthropod Research Collection, Michigan State

University, East Lansing, Michigan (MSUC), Ohio Biological Survey, Columbus (OBS), Purdue University Research Collections, West Lafayette, Indiana (PURC), the Royal Ontario Museum, Toronto (ROME), University of Michigan Zoology Collection, Ann Arbor, Michigan (UMMZ), Scott A. Grubbs Collection, Western Kentucky University, Bowling Green, Kentucky (WKU), and University of Wisconsin Entomological Research Center, Madison, Wisconsin (WIRC). All material examined is stored in ethyl alcohol.

Scanning electron micrographs (SEM) of eggs and male dorsal terminalia were prepared from the Alabama and Mississippi samples of *P. shubuta*. Egg and male SEMs were also prepared for several, tentatively-identified *P. shubuta* specimens from a broad geographic coverage of the central and eastern U.S.

Taxonomy

Perlesta shubuta Stark

http://species-id.net/wiki/Perlesta_shubuta

Figs 8, 22–24

Perlesta shubuta Stark 1989: 282 [Type locality: USA, Mississippi, Simpson Co., Mill Creek; National Museum of Natural History; male]. DeWalt et al. 2011 [distribution].

Material examined. USA: Alabama: Choctaw Co., Bogue Chitto Creek, 20 km NW Butler, 32.1872, -88.3969, 17.v.2011, S.A. Grubbs, ♂, 2♀ (WKU); tributary to Yantley Creek, 13 km NW Cromwell, 32.3004, -88.3837, 17.v.2011, S.A. Grubbs, ♂ (WKU); Sumter Co., Brockway Creek, 8 km SE Ward, 32.3369, -88.1977, 17.v.2011, S.A. Grubbs, ♂, ♀ (WKU). **Louisiana:** Natchitoches Parish, Kisatchie Bayou, Kisatchie Bayou Campground, Forest Rd. 366, 31.4416, -93.0893, 18.v.1992, at light, R.E. DeWalt, 2♂, ♀ (INHS), same but 9.vi.1992 (reared), R.E. DeWalt, 3♂, ♀ (INHS). **Mississippi:** Clarke Co., tributary to Long Creek, 20 km E Enterprise, 32.1673, -88.6260, 16.v.2011, S.A. Grubbs, ♂, ♀ (WKU); Rolling Creek, 8 km E Stonewell, 32.1470, -88.7076, 16.v.2011, S.A. Grubbs, 2♂, 2♀ (WKU); Simpson Co., Mill Creek, 14 May 1981, B.P. Stark, ♂ (Paratypes – BPS).

Egg. Oblong (Fig. 22). Collar wide but short, highly-infolded, and flanged distally (Figs 23–24). Chorion covered completely by shallow depressions that are visible at higher magnification (1000×; Fig. 23–24).

Comments. If the aedeagus is extruded fully, the combination of the updated taxonomic key provided in Stark (2004) and descriptions of *P. shubuta* by Stark (1989, 2004) are sufficient to identify males of this species. In absence of eggs, however, females cannot be reliably identified to species. The distally-flanged, short egg collar is similar only to *P. nelsoni* Stark, 1989 (see Grubbs 2005, Fig. 7), a species known from southern and central Appalachian drainages from Tennessee north to Pennsylvania and northward into New York (Stark 2004, Kondratieff and Myers 2011). The line drawing of *P. shubuta* provided by Stark (see Stark 1989, Fig. 93) does not show the flanged egg collar.

***Perlesta ephelida* Grubbs & DeWalt, sp. n.**

urn:lsid:zoobank.org:act:C5983849-EE20-4A42-BEB6-B5588AA1500A

http://species-id.net/wiki/Perlesta_ephelida

Figs 1–7, 9–21

Material examined. Holotype: male, in alcohol, **USA: Kentucky:** Warren Co., Trammel Fork, Drakes Creek, Alvaton, 36.8704, -86.3683, 2.vi.1999, S.A. Grubbs (INHS).

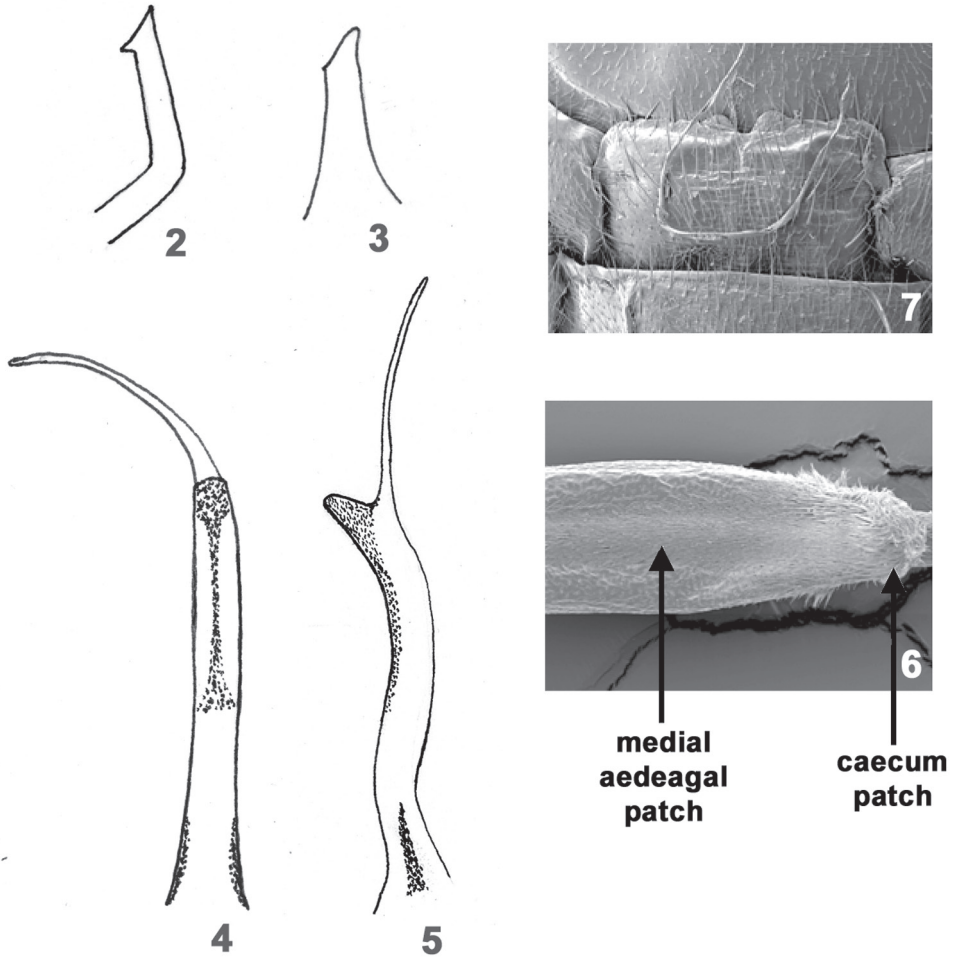
Paratypes. USA: Alabama: Clay Co., Enitachopco Creek, CR 35, 9 km ESE Millersville, 33.1602, -85.8352, 18.v.2008, S.A. Grubbs, 3♂, 2♀ (WKU). **Illinois:** Winnebago Co., Sugar River, Sugar River Forest Preserve, 42.4604, -89.2399, 22.vi.2010, R.E. DeWalt, E.W. Hernandez and M.M. Brown, 15♂ (INHS-516704). **Indiana:** Bartholomew Co., East Fork White River, Azalia Bridge, 1.5 km SW Azalia, 39.0849, -85.8598, 11.vi.2000, S.A. Grubbs, 4♂, 3♀ (WKU), same but 9.vii.2008, S.A. Grubbs, ♀ (WKU); Pulaski Co., Tippecanoe River, 8 km NNE Winamac, 41.1316, -86.5880, 28.vi.2006, R.E. DeWalt, 4♂, 3♀ (INHS-164863); Steuben Co., Pigeon River, Rte. 327, 14 km N Helmer, 41.6513, -85.1744, 23.vi.2006, S.A. Grubbs, 3♂, 4♀, 2 nymphs (WKU). **Kentucky:** Warren Co., same data as Holotype but 24.v.1999, S.A. Grubbs, ♂, 3♀ (WKU), same but 30.v.1999, S.A. Grubbs, ♂ (WKU), same but 19.vi.1999, S.A. Grubbs, ♀ (WKU), same but 20.vi.1999 (reared), S.A. Grubbs, ♀, nymph, exuvia (WKU), same but 22.vi.1999 (reared), S.A. Grubbs, ♀, exuvia (WKU), same but 26.vi.1999, S.A. Grubbs, ♀ (WKU), same but 29.vi.1999, S.A. Grubbs, ♀ (WKU), same but 2.vii.1999, S.A. Grubbs, ♂, ♀ (WKU), same but 9.vii.1999, S.A. Grubbs, ♀ (WKU), same but 20.v.2001, S.A. Grubbs, ♀ (WKU), same but 30.v.2011, S.A. Grubbs, ♂, ♀ (WKU). **Maryland:** Washington Co., Licking Creek, 1 km N Pectonville, 39.6760, -78.0430, 3.viii.1996, S.A. Grubbs, 7♂ (WKU), same but 6.viii.1996, S.A. Grubbs, ♂ (WKU), same but 12.vii.1997, S.A. Grubbs, 25♂, 69♀ (WKU). **Michigan:** Calhoun Co., South Branch Kalamazoo River, M-60, Homer, 42.1469, -84.8023, 25.vii.2006, S.A. Grubbs, 6♂, 8♀ (WKU); Ionia Co., Flat River, 2 km N Belding, Flat River State Game Area, 43.1197, -85.2243, 21.vi.2006, S.A. Grubbs, 3♂, 2♀, 4 nymphs (WKU); St. Joseph Co., Rocky River, 1 km SW Moore Park at Floating Bridge Rd., 42.0056, -85.6461, 9.vi.2010, R.E. DeWalt, M. Pessino and E.W. Hernandez, 6♂, 3♀ (INHS-549882). **Missouri:** Oregon Co., Eleven Point River, Rte.160, Riverton Access, 36.6489, -91.2004, 27.vi.2011, S.A. Grubbs, 2♂, ♀ (WKU). **Ohio:** Portage Co., Cuyahoga River, 6 km E Streetsboro Coits Rd., 41.2493, -81.2694, 25.vi.2006, R.E. DeWalt, 11♂, 14♀ (INHS-163781). **Wisconsin:** Sawyer Co., Namekagon River, NE Hayward, public canoe put-in, 46.0720, -91.4170, 25.vi.2010, R.E. DeWalt, E. Hernandez and M.M. Brown, 5♂, 6♀ (INHS-516414).

Additional material examined. CANADA: Flood River, [5 km S Atikokan], 48.7107, -91.5968, ROM Field Party, 3.vii.1984, 4 nymphs (ROM-9496); Ottawa River, Remic Rapids Champlain Bridge, 45.4078, -75.7544, 3.vii.1935, F. P. Ide, 2 nymphs (CNC-1282). **USA, Alabama:** Calhoun Co., Terrapin Creek, U.S. 278 at CR 33, 4 km NE Piedmont, 33.9550, -85.5712, 17.v.2008, S.A. Grubbs, ♂, ♀ (WKU); Cleburne Co., Tallapoosa River, CR 72, 21 km ENE Heflin, 33.7140,



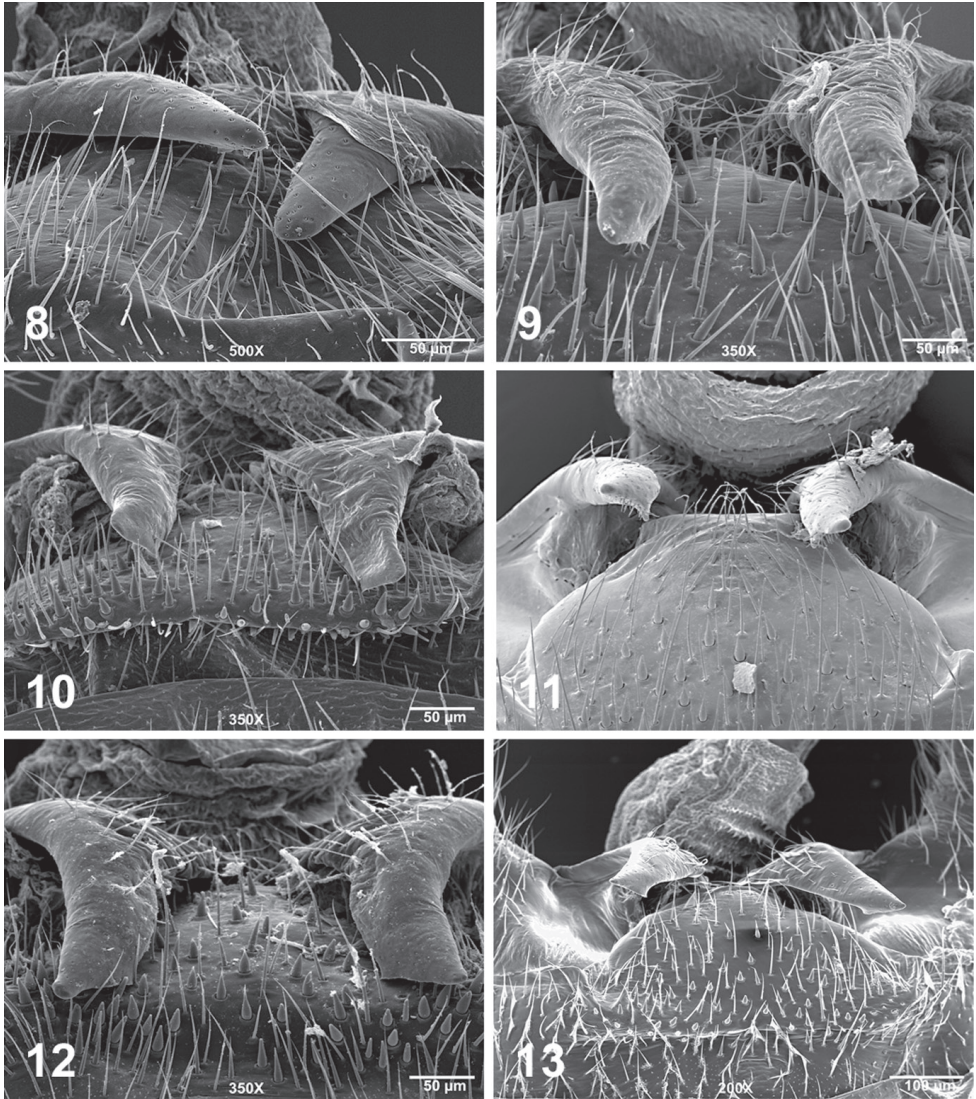
Figure 1. *Perlesta ephelida*. 1. Adult head and pronotum, dorsal.

-85.3733, 8.vi.2007, S.A. Grubbs, ♀ (WKU); Talladega Co., Cheaha Creek, CR 005, 12 km NE Talladega, 33.5319, -86.0415, 18.v.2008, S.A. Grubbs, 5♀ (WKU); Talladega Creek, CR 303, 6 km S Talladega, 33.3826, -86.0790, 18.v.2008, S.A. Grubbs, 3♀ (WKU); Tallapoosa Co., Hillabee Creek, 15 km NE Alexander City, 33.0657, -85.8798, 18.v.2008, S.A. Grubbs, ♀ (WKU). **Arkansas:** Lawrence Co., Spring River, 1 km S Ravenden, 36.2246, -91.2505, 27.vi.2011, S.A. Grubbs, 2♀ (WKU); Sharp Co., Martins Creek, 5 km NE Wilford, 36.2722, -91.3326, 27.vi.2011, S.A. Grubbs, ♂ (WKU). **Illinois:** Clark Co., Big Creek, 6.5 km NNW Marshall, 39.4480, -87.7170, 21.vi.1993, D.W. Webb, 3♂, 2♀ (INHSple-2978); Franklin Co., Big Muddy River, Zeigler, 37.8914, -89.0199, 6.viii.1976, S. Herbert, ♂ (INHS-487359). **Indiana:** Allen Co., Cedar Creek, 1 km W Cedar Canyons at Auburn Rd., 41.2351, -85.1027, 27.vi.2007, R.E. DeWalt, 14♂ (INHS-454376); Cass Co., Eel River, 1 km NE Adamsboro, along CR 600E, 40.7970, -86.2571, 24.v.2006, R.E. DeWalt, ♂, nymph (INHS-164562); Elkhart Co., Little Elkhart River, 5 km E Bristol, Bonnieville Mill County Park, 41.7192, -85.7630, 23.vi.2006, S.A. Grubbs, ♂, 3♀ (WKU); Franklin Co., West Fork Whitewater River, nr. U.S. 52, 1 km W Metamora, 39.4550, -85.1562, 6.vi.2009, S.A. Grubbs, ♀ (WKU); Johnson Co., Sugar Creek, 4.2 km NW Edinburgh, 39.3821, -85.9978, 21.vi.2006, R.E. DeWalt, ♂ (INHS-163722); Kosciusko Co., Cherry Creek, Winona Lake, 41.2270, -85.8220, 30.vi.1947, F. E. Mockford, ♂ (CNC-1288); Monroe Co., Bloomington, 39.1653,



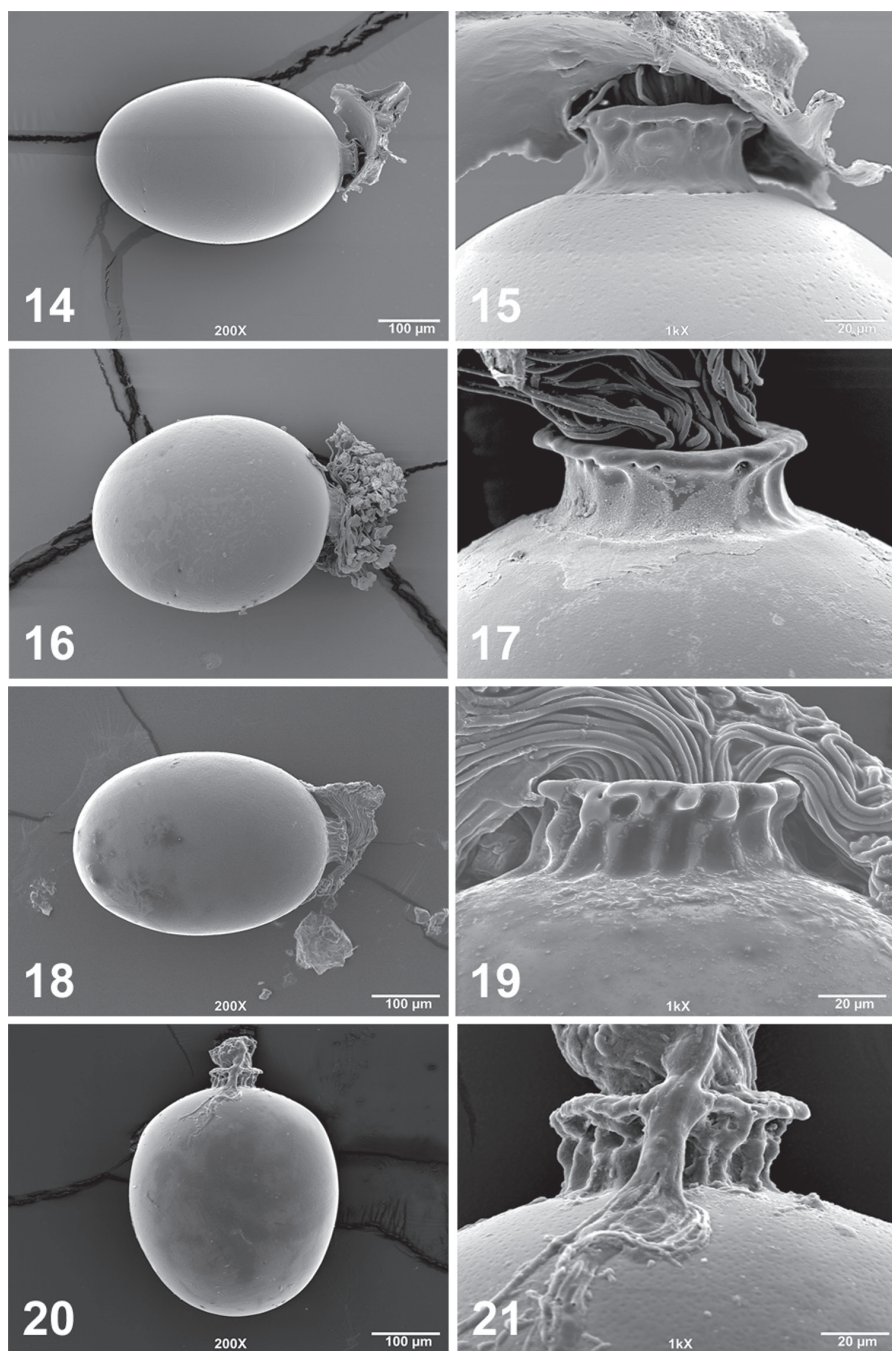
Figures 2–7. *Perlesta ephelida*. **2** Left paraproct, lateral **3** Left paraproct, caudal **4** Aedeagus, dorsal **5** Aedeagus, lateral **6** SEM micrograph, aedeagus, dorsal, 500X **7** SEM micrograph, female terminalia, ventral, 150X.

-86.5264, 9.vii.1938, Sherrill, ♀ (CNC-1305); Morgan Co., 39.6206, -86.2819, 28.vi.1933, Musgrave, ♀ (PURC-4261); Newton Co., Beaver Lake Ditch, 0.8 km NE Conrad, 41.1073, -87.4373, 8.vii.1998, E. H. Metzler, ♀ (OBS-2910); Starke Co., Kankakee River, 0.25 km N English Lake, 41.2720, -86.8246, 27.vi.2006, R.E. DeWalt, ♀ (INHS-164854); Tippecanoe Co., Wabash River, Lafayette, 40.4202, -86.8971, 16.vii.1923, G. M. Sterrett, ♂ (CNC-1834). **Iowa:** Buchanan Co., Lime Creek, 3.2 km NE Brandon, 42.3296, -91.9805, 8.vi.2000, D. Heimdal, ♂, ♀ (INHS-36090). **Kentucky:** Allen Co., Long Creek, Rte. 100, 10 km SE Scottsville, Barren River Lake WMA, 36.6965, -86.0469, 14.vi.2001, S.A. Grubbs and J.M. Taylor, ♂, 15♀ (WKU); Bell Co., Cumberland River, NE of Pineville along US-119,



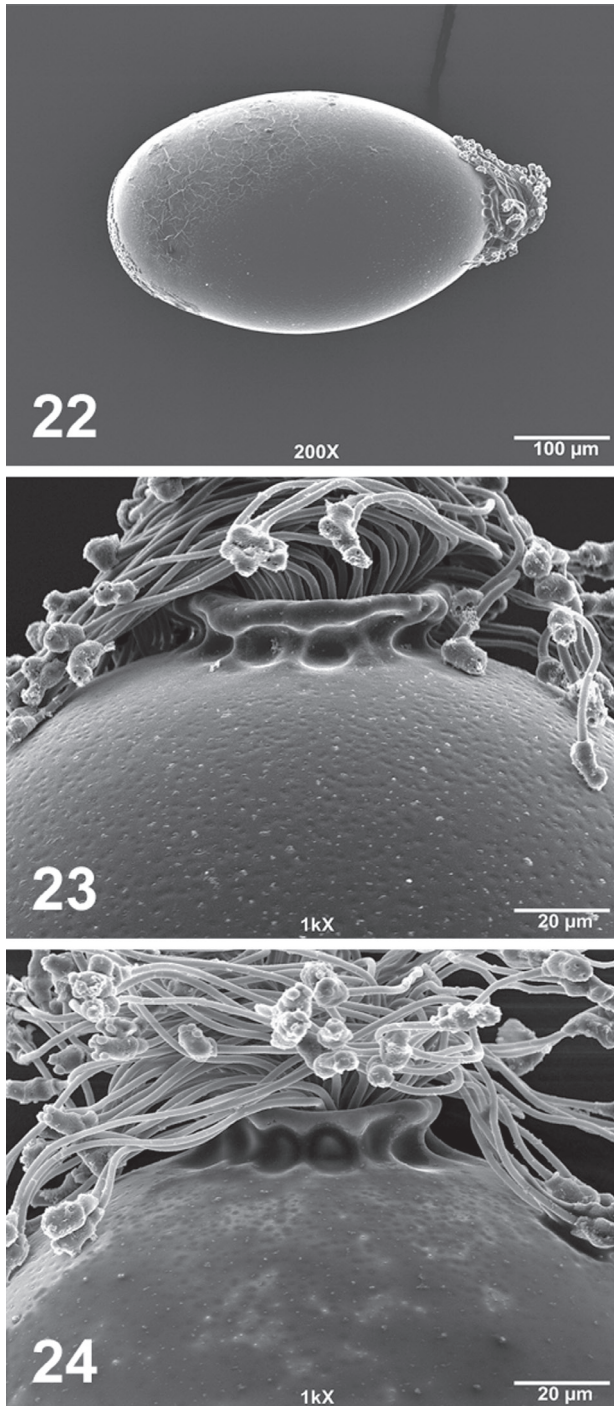
Figures 8–13. Male terminalia, posterodorsal view, SEM micrographs (**8** *Perlesta shubuta*, USA, Mississippi, Clarke Co., Rolling Creek, 16 May 2011, 500X **9–13** *Perlesta ephelida* **9** USA, Alabama, Clay Co., Enitachopco Creek, 18 May 2008, 350X **10** USA, Indiana, Bartholomew Co., East Fork White River, 11 June 2000, 350X **11** USA, Maryland, Washington Co., Licking Creek, 12 July 1997, 350X **12** USA, Michigan, Calhoun Co., South Branch Kalamazoo River, 25 July 2006, 350X **13** USA, Missouri, Oregon Co., Eleven Point River, 27 June 2011, 200X).

36.7226, -83.6398, 7.vi.2007, R.E. DeWalt and L. Fennema, 5♂, ♀ (INHS-454363); Green Co., Little Brush Creek, 5 km WNW Summersville, 37.3344, -85.5913, 3.vi.2006 (reared), S.A. Grubbs, ♂ (WKU); Brush Creek, Rte. 61, 10 km NW Summersville, 37.3909, -85.6105, 3.vi.2006 (reared), S.A. Grubbs, ♀ (WKU);



Figures 14–21. *Perlesta ephelida* egg SEM micrographs (14–15 USA, Kentucky, Warren Co., Trammel Fork, Drakes Creek, 24 May 1999 16–17 USA, Maryland, Washington Co., Licking Creek, 12 July 1997 18–19 USA, Michigan, Calhoun Co., South Branch Kalamazoo River, 25 July 2006 20–21 USA, Arkansas, Lawrence Co., Spring River, 27 June 2011) 14, 16, 18, 20 Entire egg, 200X; 15, 17, 19, 21. Anterior pole and collar, 1000X.

Warren Co., Middle Fork Drakes Creek, 19 km NE Franklin, 36.8187, -86.3944, 10.vi.1999, S.A. Grubbs, ♂, ♀ (WKU); at confluence of Barren River and Green River, 15 km NW Richardsville, 37.1809, -86.6232, 4.vi.1999, S.A. Grubbs, ♂ (WKU); **Maryland:** Allegany Co., Flintstone Creek, Flintstone, 14.viii.1995, 39.7079, -78.5664, S. A. Grubbs, ♀ (WKU), same but 4.vii.1996, S.A. Grubbs, 9♂, 4♀ (WKU), same but 2.viii.1996, S. A. Grubbs, ♂, 3♀ (WKU); Sideling Hill Creek, Scenic U.S. 40, nr. Bellegrove, 39.7044, -78.3284, 3.viii.1996, S.A. Grubbs, 7♀ (WKU), same but 23.vi.1997, S.A. Grubbs, 3♀ (WKU), same but 14.vii.1998, S.A. Grubbs, 3♂ (WKU); Sideling Hill Creek, 1 km NE Bellegrove, 39.7084, -78.3313, 4.vii.1996, S.A. Grubbs, ♂, 6♀ (WKU); Town Creek, 5 km NE Oldtown, Green Ridge State Forest, 39.5744, -78.5468, 4.vii.1996, S.A. Grubbs, 2♂, 10♀ (WKU), same but 8.vi.1998, S.A. Grubbs, 3♂, 2♀ (WKU); Harford Co., Deer Creek, 7 mi NW Bel Air, Rocks State Park, 39.6314, -76.4052, 12.vii.1998, S.A. Grubbs, ♂, 2♀ (WKU); Washington Co., Conococheague Creek, 1 km E Fairview, 39.7163, -77.8256, 14.vii.1998, S.A. Grubbs, 10♂, 24♀ (WKU); Tonoloway Creek, Hancock, 39.6981, -78.1565, 3.viii.1996, S.A. Grubbs, 2♀ (WKU). **Massachusetts:** Hampshire Co., Ware River, Rte. 32, 3 km S Gilbertsville, 42.2847, -72.2161, 28.vi.2006, S.A. Grubbs, ♂ (WKU). **Michigan:** Allegan Co., Rabbit River, 10 km W Wayland, 42.6779, -85.7612, 19.vi.2006, S.A. Grubbs, ♂, ♀ (WKU); Benzie Co., [Platte River], Benzie State Park, 44.7183, -86.1165, 23.viii.1960, R.A. Scheibner, ♀ (MSUC-8317); Berrien Co., Dowagiac Creek, U.S. 31, Niles, 41.8452, -86.2621, 30.vii.1994, S.A. Grubbs, 5♂, 4♀, 2 nymphs (WKU), same but 7.vi.2001, S.A. Grubbs, 4♂, 2♀ (WKU); Dowagiac Creek, M-51, 2 km N Niles, 41.8643, -86.2416, 19.vi.2006, S.A. Grubbs, 8♂, 9♀ (WKU); Galien River, New Buffalo, 41.8084, -86.7154, 22.vi.1957, J. Lowe, 2♂, ♀ (CNC-500); Clare Co., Middle Branch Tobacco River, 11 km NE Clare, 43.9092, -84.7006, 24.vii.2006, S.A. Grubbs, ♂, 2 nymphs, exuviae (WKU); Clinton Co., Vermillion Creek, Bath, 42.8345, -84.3692, 15.vii.1955, R.L. Fischer, ♂ (MSUC-7832); Gladwin Co., Cedar River, 5 km N Beaverton, 43.9308, -84.4760, 24.vii.2006, S.A. Grubbs, ♀ (WKU); Hillsdale Co., East Branch St. Joseph River, 14 km W Hudson, Lost Nation State Game Area, 41.8635, -84.5145, 23.vi.2006, S.A. Grubbs, ♂, ♀ (WKU); East Fork West Branch St Joseph River, 14 km S Hillsdale at Dimmers Road, 41.7960, -84.6380, 27.vii.2000, J. Mandrelle, 5♂, 11♀ (OBS-6338); West Branch St. Joseph River, Boy Scout Camp Property, 5 km E State Rte. 49 at Territorial Road, 41.7071, -84.6903, 27.vi.2000, J. Mandrelle, ♂, 7♀ (OBS-6324); Ingham Co., [Grand River], Lansing, 42.7325, -84.5497, 23.vi.1981, ♂ (MSUC-2368); Isabella Co., Pine River, 8 km N Cedar Lake, Edmond State Game Area, 43.4733, -84.9701, 21.vi.2006, S.A. Grubbs, 3♀ (WKU); Kalamazoo Co., Kalamazoo River, 1.5 km SW Galesburg at 35th St., 42.2803, -85.4285, 19.vi.2010, R.E. DeWalt, M. Pessino and E.W. Hernandez, 3♂, ♀ (INHS-550553); Lake Co., Pere Marquette River, 7 km E Baldwin, 43.8869, -85.9370, 23.vii.2006, S.A. Grubbs, 2♂ (WKU); Lenawee Co., River Raisin, 10 km NE Adrian, 41.9492, -83.9415, 23.vi.2006, S.A. Grubbs, ♂ (WKU); [River Raisin], Clinton, 42.0718, -83.9796, 28.vi.1941, T.H. Frison and H.H. Ross, ♂



Figures 22–24. *Perlesta shubuta* egg SEM micrographs (**22–23** USA, Mississippi, Clarke Co., Rolling Creek, 16 May 2011 **23** USA, Alabama, Choctaw Co., Bogue Chitto Creek, 17 May 2011) **22** Entire egg, 200X **23–24** Anterior pole and collar, 1000X.

(INHSple-3828); Livingston Co., Portage River, 3 km SE Hell at Dexter-Town Hall Rd, 42.4242, -83.9497, 9.vi.2010, R.E. DeWalt, M. Pessino and E.W. Hernandez, 12♂, 12♀ (INHS-514942); Menominee Co., Little Cedar River, 6 km W Carney at G18, 45.5799, -87.6332, 9.vii.2011, R.E. DeWalt, 2♀ (INHS-552590); Montcalm Co., Fish Creek, Carson City, 43.1773, -84.8566, 21.vi.2006, S.A. Grubbs, 3♂ (WKU); Flat River, Greenville, 43.1771, -85.2478, 21.vi.2006, S.A. Grubbs, ♂ (WKU); Flat River, at Hunter Lake, T11N R8W Sec. 33, 43.2921, -85.2592, 8.vii.1966, J. P. Donahue, 3♀ (MSUC-7480); Presque Isle Co., 45.3077, -83.8724, 5.viii.1948, ♂ (MSUC-7839); Saginaw Co., Bad River, 10 km W St. Charles, 43.2987, -84.2689, 21.vi.2006, S.A. Grubbs, ♂ (WKU); St. Clair Co., Bad River, 15 km SE Yale, 43.0926, -82.6181, 22.vi.2006, S.A. Grubbs, 3♂, 2♀ (WKU); St. Joseph Co., Pigeon River, 7 km WSW Pigeon River, 41.7764, -85.7213, 19.vi.2006, S.A. Grubbs, 3♂, ♀ (WKU), same but 21.vii.2006, S.A. Grubbs, ♂, ♀ (WKU); Portage River, Parkville, 42.0146, -85.5480, 19.vi.2006, S.A. Grubbs, ♂, 2♀ (WKU); Prairie River, Centreville, 41.9291, -85.5284, 21.vii.2006, S.A. Grubbs, ♀ (WKU); Washtenaw Co., Huron River 3 km SE Dexter, 42.3283, -83.8531, 22.vi.2006, S.A. Grubbs, 2♂, ♀ (WKU); Huron River, Scio township, 42.3235, -83.8404, 20.vi.1988, T.E. Moore, ♂, ♀ (UMMZ-2807). **Missouri:** St. Francois Co., Big River, Adjacent to picnic grounds, 37.9669, -90.5346, 19.vi.2008, R.E. DeWalt, ♂ (INHS-515558). **Ohio:** Ashland Co., Clear Fork [Mohican] River, SE Pleasant Hill Reservoir, 40.6082, -82.2540, ♀, T. Yamamoto, L. Kohalmi, 1.viii.1968, ROME-9773); Ashtabula Co., Ashtabula River, 1.9 km WNW Gageville, 41.8486, -80.6895, 15.vii.1998, M. Silvaggio, 5♀ (OBS-3047); Columbiana Co., Little Beaver Creek, Wayne Twp. [at Steubenville Rd], 40.6947, -80.7658, 14.vii.1997, E.G. Chapman, 2♀ (OBS-6653); Coshocton Co., Bucklew Run, 5 km E Warsaw at Twp. 28 Rd., 40.3323, -81.9378, 26.vi.1999, S.W. Chordas III and J. Thompson, 5♂, 2♀ (OBS-3212); Defiance Co., Mud Creek, 13 km WNW Defiance, 41.3339, -84.4968, 17.vii.2000, S.W. Chordas III and E.G. Chapman, ♀ (OBS-6372); Lake Co., Paine Creek, SE Lane, 41.7208, -81.1761, 22.vi.1999, ♀ (INHS-163045); Licking Co., North Fork Licking River, 3 km S Utica, 40.2095, -82.4428, 13.vii.1999, S. O'Dee, ♀ (OBS-2904); Miami Co., Rush Creek, 5 km NE Piqua, 40.1821, -84.2151, 17.vii.2000, S.W. Chordas III and E.G. Chapman, ♀ (OBS-3064); Paulding Co., Maumee River, 16 km NW Paulding, 41.1983, -84.7467, 17.vii.2000, S.W. Chordas III and E.G. Chapman, ♂, ♀ (OBS-6330); Pike Co., Pike State Forest, 39.1031, -83.2682, 1.vi.1938, C.R. Neiswander, 2♂, ♀ (INHSple-3907); Richland Co., Rocky Fork Mohican River, SE Mansfield, 40.7025, -82.3666, 27.vii.1999, E.G. Chapman, 2♀ (OBS-6313); Scioto Co., 38.8371, -83.0445, 1.vi.1925, C.H. Kennedy, ♂ (OSU-10765); Vinton Co., Pike Run, at SR 327 deadend, 39.3074, -82.7315, 7.vii.1996, J. McCreery, ♀ (OBS-7229); Wayne Co., Killbuck Creek, 9 km SW Wooster, 40.6945, -81.9798, 22.vi.1999, E.G. Chapman, 8♀ (OBS-6327); Williams Co., East Branch St. Joseph River, 4 km N Pioneer, 41.6950, -84.5107, 27.vii.2000, J. Mandrelle, 3♀ (OBS-6339). **West Virginia:** Morgan Co., Cacapon River, Rte. 9, 39.5286, -78.3478, 12.vi.1998, S.A. Grubbs, 3♂, 3♀ (WKU). **Wisconsin:** Burnett Co., St. Croix River,

Riverside, 46.0772, -92.2461, 25.vi.2010, R.E. DeWalt, E. Hernandez and M.M. Brown, 2♂, 3♀ (INHS-516406); Dane Co., 43.0186, -89.5498, 30.vi.1949, W. McNeel, ♀ (WIRC-7152); Fond Du Lac Co., T13N, R19E, S23, 43.6687, -88.1938, 24.vi.1975, ♀ (WIRC-14414); Jackson Co., Halls Creek, , 44.3594, -90.7845, 18.vi.1968, ♀ (WIRC-14729); Lincoln Co., Prairie River, WI-17, 45.3361, -89.4650, 20.viii.1992, R.W. Baumann and C.R. Nelson, ♂, ♀ (BYU-1); Marinette Co., Menominee River, 18 km NE Amberg at CR-Z, 45.5814, -87.7866, 26.vi. 2010, R.E. DeWalt, E. Hernandez and M.M. Brown, 10♂ (INHS-550141); Price Co., [South] Fork Flambeau River, Fifield, 45.8798, -90.4156, 18.vi.1934, T.H. Frison and C.O. Mohr, ♂ (INHSPle-3908); Vilas Co., Trout River, Trout Lake, 46.0350, -89.7059, 22.vii.1937, T.H. Frison and H.H. Ross, ♂ (INHSPle-3811).

Adult habitus. Head yellow with a dark brown subquadrate ocellar patch and a small, light brown subtriangular patch anterior to the anterior ocellus, pronotum golden-brown with a very faint lighter medial stripe in some specimens (Fig. 1). Wing membrane and veins amber except for pale costal region. Femora dorsally brown, laterally and ventrally yellow; tibia brown. Abdominal terga and sterna yellow. Cerci pale yellow proximally, brown distally.

Male. Forewing length 7.5–8.5 mm. Tergum 10 mesal sclerites brown, sensilla basiconica patch distinct with interspersed long hairs (Figs 9–13). Paraproct broadest basally, apically acute, with distinct subapical tooth directed anteromedially (Fig. 2) and typically seen dorsally (Figs 9–13), in caudal view resembling a hypotenuse triangle and tooth visible (Fig. 3). Penis tube + sac long, caecum moderately-sized and thumb-shaped (Fig. 4), lateral sclerite distinct, dorsal patch broad basally, narrowing to narrow strip before expanding apically over caecum and tube (Fig. 5). At higher magnification the dorsal aedeagal patch hairs are noticeably shorter than the expanded portion over the caecum (Fig. 6).

Female. Forewing length 9.0–11.0 mm. Subgenital plate lobes comprise medial half of 7th sternite, extending scarcely past anterior margin of 8th sternite, outer margins rounded, inner margins rounded and expanded slightly distally, separated by a shallow v-shaped notch (Fig. 7).

Egg. Oval. Collar wide and distinctly stalked, highly-infolded, and flanged distally. Chorion smooth or finely pitted (Figs 14–21). Micropyles located ca. ¼ from posterior pole.

Nymph. Undescribed.

Etymology. The species name is a derivation of the Greek word (“ephelis”) for freckle (Brown 1956), in reference to the heavily-freckled head mask of the nymphs and associated exuviae.

Diagnosis. The males of *P. ephelida* will key to couplets 11 and 12 in Stark (2004), with a paraproct spine visible in lateral view and a group that includes *P. shubuta* Stark, *P. puttmanni* Kondratieff & Kirchner, 2003, and *P. decipiens* (Walsh, 1862). Although the paraproct spine of *P. ephelida* is directly somewhat anteriorly, it is mainly mesally-directed and typically seen in dorsal aspect (Figs 9–13), and superficially similar to *P. puttmanni* (see Kondratieff and Kirchner 2003, Fig. 10). The paraproct spine of *P. shubuta* is

not visible in dorsal aspect and the tips are rounded apically (Fig. 8); the epiproct tips are pointed apically in *P. ephelida* (Figs 9–13). The paraproct spine in *P. puttmanni* is visible caudally (see Kondratieff and Kirchner 2003, Fig. 12), which is also seen in this aspect in *P. ephelida* (Fig. 3), but is not visible in *P. shubuta* (see Stark 2004, Fig. 7.352). The narrow aedeagal dorsal patch of *P. ephelida* (Fig. 4) is slightly broader than *P. puttmanni* (see Stark 2004, Fig. 7.367), whereas both *P. shubuta* (see Stark 2004, Fig. 7.369) and *P. decipiens* (see Stark 2004, Fig. 7.306) bear conspicuously broader patches. The egg of *P. ephelida* possesses a wide, well-developed, and distally-flanged collar (Figs 15, 17, 19, 21), resembling *P. decipiens* (Stark 2004, Fig. 7.397) but easily contrasted from the short collars of *P. shubuta* (Figs 23–24), and *P. puttmanni* (see Kondratieff and Kirchner 2003, Fig. 15). The subgenital plate of *P. decipiens* (see Stark 2004, Fig. 7.379) has prominent truncate lobes and a deep v-shaped notch while the medial notch of *P. ephelida* is shallow and v-shaped (Fig. 7). The female of *P. ephelida* can only be confidently identified if mature eggs are present and associated with a male with a fully-extruded aedeagus.

Remarks. The type locality is a 5th-order gravel-bottom stream positioned in the Western Pennyroyal Karst Plain Level IV Ecoregion. Additional stonefly species obtained from the type locality were *Allocapnia granulata* (Claassen, 1924), *A. nivicola* (Fitch, 1847), *A. recta* (Claassen, 1924), *A. rickeri* Frison, 1929, *Amphinemura alabama* Baumann, 1996, *A. nigritta* (Provancher, 1876), *Strophopteryx fasciata* (Burmeister, 1839), *Taeniopteryx maura* (Pictet, 1841), *Acroneuria frisoni* Stark & Brown, 1991, *Perlinella drymo* (Newman, 1839), *P. ephyre* (Newman, 1839), *Neoperla catharae* Stark & Baumann, 1978, *N. stewarti* Stark & Baumann, 1978, *Clioperla clio* (Newman, 1839), *Isoperla decepta* Frison, 1935, and *Pteronarcys dorsata* (Say, 1823).

Perlesta ephelida is distributed broadly across the central and eastern U.S. from eastern Alabama northeast to Massachusetts, north to the Great Lakes region and Iowa, and northwest to the Interior Highlands region of Arkansas, Missouri, and Oklahoma. *Perlesta ephelida* is expected to be collected from intervening states (e.g. Pennsylvania, Tennessee) where this species has yet to be reported. In contrast, *P. shubuta* appears to be restricted to a narrow latitudinal belt in the Gulf Coast region of the southeastern U.S., known currently from Louisiana east to northern Florida panhandle and likely to South Carolina.

The *P. shubuta* records reported from Illinois (DeWalt et al. 2005, DeWalt and Grubbs 2011), Indiana (DeWalt and Grubbs 2011), Iowa (Heimdal et al. 2004), Michigan (Grubbs and Bright 2001), and Ohio (DeWalt et al. 2012) refer to *P. ephelida*. Similarly, the *P. decipiens* records from Calhoun (Terrapin Creek) and Clay (Enitachopco Creek) counties noted in Grubbs (2011) are now of *P. ephelida*.

Modified key to couplets 11 and 12 in Stark (2004) to identify males of *Perlesta ephelida*:

- 11 Dorsal aedeagal patch covers about 1/3 of tube surface length (Stark 2004, Fig. 7.369); forewing length 6–7 mm ***P. shubuta* Stark**
- Dorsal aedeagal patch covers most of tube surface length (Stark 2004, Fig. 7.367); paraprocts forewing length 8–10 mm **12**

- 12 Paraproct spine directed mesad, visible in caudal aspect (Stark 2004, Fig. 7.344)..... **12a**
- Paraproct spine directed forward, not visible in caudal aspect (Stark 2004, Fig. 7.310)..... ***P. decipiens* (Walsh)**
- 12a Dorsal aedeagal patch narrower ***P. puttmanni* Kondratieff & Kirchner**
- Dorsal aedeagal patch wider..... ***P. ephelida* Grubbs & DeWalt, sp. n.**

Acknowledgments

We thank the following individuals for loan of specimens for this project: Bill P. Stark (BPS), Richard W. Baumann and Shawn Clark (BYU), Ian Smith (CNC), Gary Parsons (MSUC), Brian Armitage (OBS), Norman Johnson (OSU), Arwin Provonsha (PURC), Antonia Guidotti (ROME), Mark F. O'Brien (UMMZ), and Steven Krauth (WIRC). Funding to support this research has been provided by Western Kentucky University Faculty Scholarship Grants and Summer Fellowships to SAG, a United States of America National Science Foundation DEB 09-18805 ARRA award to the authors, and a United States Department of Interior grant X-1-R-1 to RED.

References

- Brown RW (1956) Composition of Scientific Words: A Manual of Methods and a Lexicon of Materials for the Practice of Logotechnics. Smithsonian Institution Press. Washington DC, 882 pp.
- DeWalt RE, Grubbs SA (2011) Updates to the stonefly fauna of Illinois and Indiana. *Illiesia* 7: 31–50.
- DeWalt RE, Webb DW, Kompare TN (2001) The *Perlesta placida* (Hagen) complex (Plecoptera: Perlidae) in Illinois, new state records, distributions, and an identification key. *Proceedings of the Entomological Society of Washington* 103: 207–216.
- DeWalt RE, Favret C, Webb DW (2005) Just how imperiled are aquatic insects? A case study of stoneflies (Plecoptera) in Illinois. *Annals of the Entomological Society of America* 98: 941–950. doi: 10.1603/0013-8746(2005)098[0941:JHIAAI]2.0.CO;2
- DeWalt R, Cao Y, Tweddle T, Grubbs S, Hinz L, Pessino M, Robinson J (2012) Ohio USA stoneflies (Insecta, Plecoptera): species richness estimation, distribution of functional niche traits, drainage affiliations, and relationships to other states. *ZooKeys* 178: 1–26. doi: 10.3897/zookeys.178.2616
- Graves PH III, Ward GM (2011) Mayfly and stonefly distribution in the mainstem Cahaba River, Alabama. *Southeastern Naturalist* 10: 477–488. doi: 10.1656/058.010.0307
- Grubbs SA (2004) Studies on Indiana stoneflies (Plecoptera), with an annotated and revised state checklist. *Proceedings of the Entomological Society of Washington* 106: 865–876.
- Grubbs SA (2005) *Perlesta shawnee*, a new stonefly species from eastern North America. *Aquatic Insects* 27: 63–69. doi: 10.1080/01650420400010485

- Grubbs SA (2011) A review of stonefly (Insecta; Plecoptera) taxonomic research in Alabama, with new state records and an updated checklist. *Illiesia* 7: 24–30.
- Grubbs SA, Bright E (2001) *Arcynopteryx compacta*, a Holarctic stonefly confirmed from Lake Superior, with a review and first checklist of the stoneflies of Michigan. *Great Lakes Entomologist* 34: 77–84.
- Heimdal DP, DeWalt RE, Wilton TF (2004) Annotated list of the stoneflies (Plecoptera) of Iowa. *Proceedings of the Entomological Society of Washington* 106: 761–778.
- Kondratieff BC, Kirchner RF (2003) Two new species of *Perlesta* (Plecoptera: Perlidae) from eastern North America. *Proceedings of the Entomological Society of Washington* 105: 933–939.
- Kondratieff BC, Myers LW (2011) A new species of *Perlesta* (Plecoptera: Perlidae) from New York. *Illiesia* 7: 197–201.
- Kondratieff BC, Zuellig RE, Lenat DR (2011) A new species of *Perlesta* (Plecoptera: Perlidae) from North Carolina with additional records for North Carolina and Virginia. *Illiesia* 7: 297–301.
- Pescador ML, Rasmussen AK, Richard BA (2000) A guide to the stoneflies (Plecoptera) of Florida. Florida Department of Environmental Protection, Division of Water Resource Management, 94 pp.
- Pescador ML, Richard BA, Rasmussen AK (2004) An aquatic invertebrate survey for the Congaree Swamp National Park, Richland County, South Carolina. *Entomology/Center for Water Quality, Florida A&M University*, 103 pp.
- Ray DH, Abad RL, Rasmussen AK, Stark BP (2012) New records and an updated checklist of the stoneflies (Plecoptera) from Florida. *Illiesia* 8: 1–9.
- Stark BP (1989) *Perlesta placida* (Hagen), an eastern Nearctic species complex (Plecoptera: Perlidae). *Entomologica Scandinavica* 20: 263–286. doi: 10.1163/187631289X00339
- Stark BP (2004) Perlidae (The Stones). IN: Stark BP, Armitage BJ (Eds) *Stoneflies (Plecoptera) of Eastern North America. Vol. II. Chloroperlidae, Perlidae, and Perlodidae (Perlodinae)*. *Bulletin of the Ohio Biological Survey New Series* 14: 61–148.
- Tarter DC, Nelson CH (2010) New state, county, and drainage basin records of West Virginia (USA) stoneflies (Plecoptera). *Entomological News* 121: 159–162. doi: 10.3157/021.121.0206
- Tarter DC, Chafee DL, Grubbs SA (2006) Revised checklist of the stoneflies (Plecoptera) of Kentucky, U.S.A. *Entomological News* 117: 1–10. doi: 10.3157/0013-872X(2006)117[1:RCOTSP]2.0.CO;2

The Nearctic-Caribbean species *Leptotrachelus dorsalis* (Fabricius, 1801): Larval descriptions with a diagnosis of immature Ctenodactylini and natural history notes on the genus and tribe (Coleoptera, Carabidae)

Terry L. Erwin^{1,†}, William H. White^{2,‡}

1 Hyper-diversity Group, Department of Entomology, MRC-187, National Museum of Natural History, Smithsonian Institution, Washington, P.O. Box 37012, DC 20013-7012, USA **2** USDA, ARS, Sugarcane Research Laboratory, Houma, LA 70360, USA

Corresponding author: Terry L. Erwin (erwint@si.edu)

Academic editor: L. Penev | Received 30 April 2012 | Accepted 7 May 2012 | Published 17 May 2012

Citation: Erwin TL, White WH (2012) The Nearctic-Caribbean species *Leptotrachelus dorsalis* (Fabricius, 1801): Larval descriptions with a diagnosis of immature Ctenodactylini and natural history notes on the genus and tribe (Coleoptera, Carabidae). ZooKeys 194: 17–32. doi: 10.3897/zookeys.194.3308

Abstract

Adults and larvae of *Leptotrachelus dorsalis* (Fabricius), the Sugarcane Savior Beetle, live in association with grasses, the larvae in the appressed leaf axils. Both adult and larval *L. dorsalis* eat larvae of the Sugarcane Borer, *Diatraea saccharalis* (Fabricius), and perhaps other insects living in the confines of the leaf sheaths of that and other grass-like species. The geographic range of *L. dorsalis* extends from Kansas in the west to the Atlantic seaboard, north as far as Ontario, Canada and south to Cuba; it is an eastern species of North America and the Caribbean. Larval character attributes that are shared with a related ctenodactyline, *Askalaphium depressum* (Bates), provide a preliminary basis for characterization of the immatures of tribe Ctenodactylini.

Keywords

Sugarcane Savior Beetle, Louisiana, commensalism, Sugarcane, *Saccharum officinarum* L., Sugarcane Borer, *Diatraea saccharalis* (Fabricius)

Resumen

Los adultos y larvas de *Leptotrachelus dorsalis* (Fabricius), el Escarabajo Salvador de la Caña de Azúcar, viven asociados a hierbas, las larvas en las axilas de las hojas recostadas. Tanto el adulto como la larva de *L. dorsalis* se comen la larva del Taladrador de la Caña de Azúcar, *Diatraea saccharalis* (Fabricius), y quizás otros insectos más que viven en los confines de la vaina de la hoja de esta y otras especies de gramíneas. La distribución geográfica de *L. dorsalis* se extiende desde Kansas en el oeste hasta el litoral del Atlántico, hacia el norte hasta Ontario, Canadá, y hacia el sur hasta Cuba; es una especie del este de América del Norte y el Caribe.

Los atributos de los caracteres larvales que son compartidos con un ctenodactylino, *Ascalaphium depressum* (Bates), proveen una base preliminar para la caracterización de los inmaduros de la tribu Ctenodactylini.

Keywords

Escarabajo Salvador de la Caña de Azúcar, Louisiana, comensalismo, caña de azúcar, *Saccharum officinarum* L., Taladrador de la Caña de Azúcar, *Diatraea saccharalis* (Fabricius)

Introduction

Leptotrachelus dorsalis (Fabricius) is known to occur in Canada – ON; Cuba; and the USA – AL, AR, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MD, MI, MN, MO, MS, NC, NJ, NY, OH, PA, SC, SD, TN, VA, and WV. According to Lindroth (1969), adults (Fig. 2) are found at the borders of pools and ponds where the vegetation is tall and rich, e.g., in cattail (*Typha latifolia* L.) swamps (Fig. 1) with tufts of *Carex rostrata* Stokes, *Menyanthes* sp., *Solanum dulcamara* L., and others. Adults take cover within the leaf axils of *Typha latifolia* stems. Adults are attracted to lights. In sugarcane, they are found within the canopy (top quarter) of the plant, the region of the sugarcane plant where the Sugarcane Borer, *Diatraea saccharalis* (Fabricius) lays its eggs and where the neonate larvae become established behind the leaf sheaths of elongating internodes. Larvae of *L. dorsalis* are rarely encountered below this region, as young Sugarcane Borer larvae are also rarely encountered in association with the lower mature internodes.



Figure 1. A stand of Cattails, *Typha latifolia* L. (foreground) near the edge of a sugarcane field (background) in the environs of Houma, LA. Insert: Photo credit: Randy Richard of the USDA, ARS Sugarcane Research Unit.

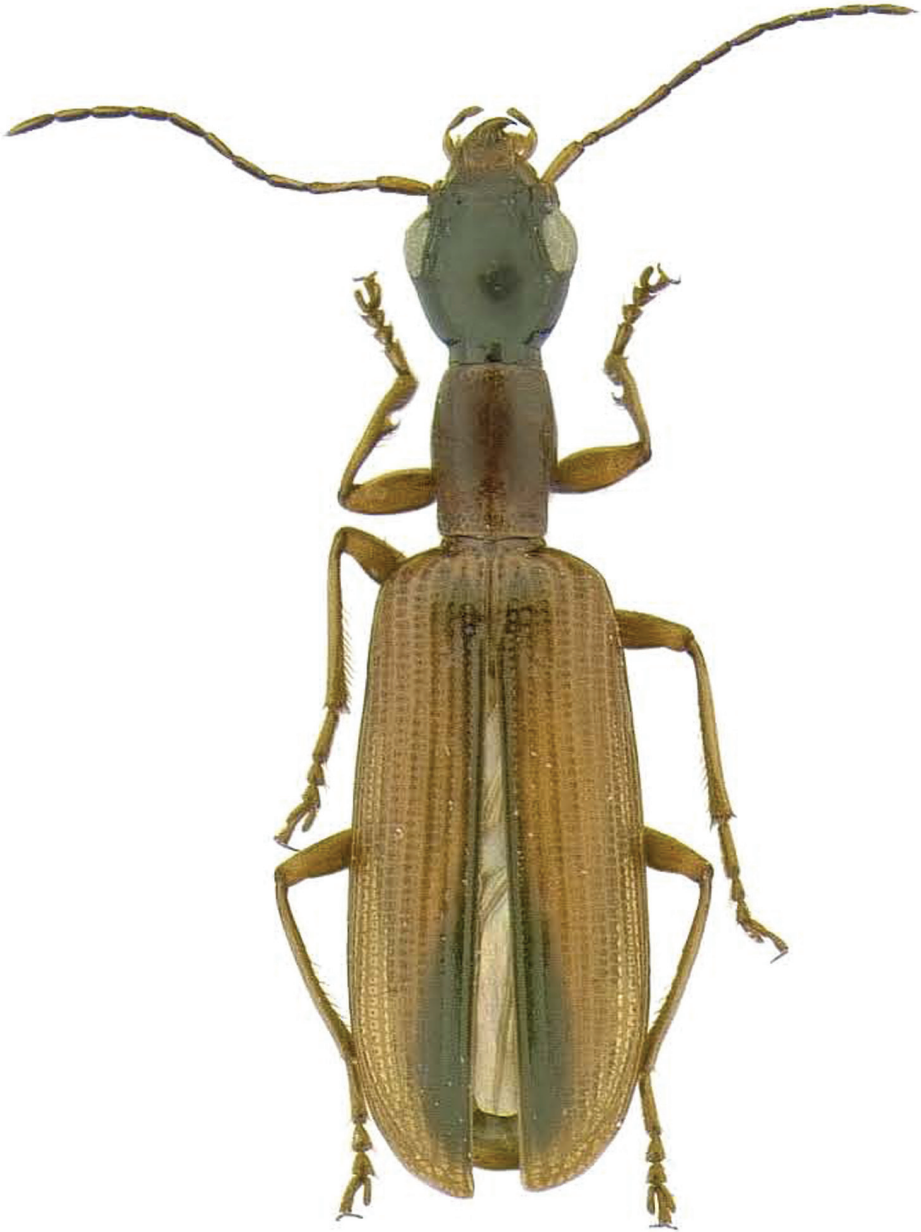


Figure 2. Adult, dorsal aspect, of *Leptotrachelus dorsalis* (Fabricius); adult from Wittman, Talbot County, MD. Apparent body length (ABL) = 8.1mm.

Erwin and Medina (2003) wrote: “Van Emden (1942) described the larva of *Leptotrachelus dorsalis* (Fabricius), Ctenodactylini, the only known larva of the tribe until now. However, at that time “Colliurina” and “Ctenodactylina” were regarded

as subtribes of Colliurini (Colliurini is now classified as an unrelated clade, Odacanthini), thus van Emden inadvertently gave a single combined description for both tribes, and then provided in a key the means of which to separate what he regarded as subtribes, but with very few important features listed. Van Emden provided illustrations for many other genera in his important contribution to knowledge of carabid larvae, but did not provide any for these particular ctenodactyline and odacanthine groups.”

Now that we have reared specimens (all stages except egg), we realize that Van Emden’s description is not that of purely *Leptotrachelus dorsalis* individuals.

Thompson (1979) summarized van Emden’s description, but did not add anything new to it, did not provide illustrations of any Ctenodactylini, nor did he sort the mixed characters of the two tribes. He did provide illustrations (heads of L₁ and L₃ and cerci) of *Colliuris pensylvanicus* L. along with a reasonably complete description. These tribes, Ctenodactylini and Odacanthini, however, are now recognized as not being especially closely related (Erwin 1991).

Bionomics of *Leptotrachelus dorsalis* are discussed in a separate paper (White et al. in press). Here we provide larval and pupal descriptions of the Sugarcane Savior Beetle and notes on the taxonomic complementarity of *Leptotrachelus* and *Askalaphium* larvae as a beginning in understanding the immature forms of Ctenodactylini.

Specimens and methods

Specimens were initially obtained from experiments to determine economic thresholds for Sugarcane Borer in new sugarcane cultivars (White et al. 2008).

Descriptive and larval preparation methods follow those suggested by the classic carabid larval method paper of Bousquet and Goulet (1984), particularly their coding system for setae and pores in L₁ larvae, and their description format, believed to be ancestral in carabids. Additional setal and pore positions were discovered in Ctenodactylini (Erwin and Medina 2003) and were designated in a sequence that follows the methods suggested by Bousquet and Goulet (1984). However, we have not attempted that here since we do have the first instars. Those subsequent designations in Erwin and Medina (2003) may be merely accessory setae common in later instars. All *Leptotrachelus dorsalis* immature specimens illustrated here are from populations in the environs of Houma, LA. They were reared in the laboratory from eggs laid by wild captured adults in sugarcane plantings. Many additional larvae were hand collected in the leaf axils of standing sugarcane, as well.

Tribe Ctenodactylini

(The following is based on larvae of *Askalaphium depressum* (Bates) and *Leptotrachelus dorsalis* (Fabricius), the only confirmed described larvae in the Tribe).

Recognition. (See Erwin and Medina 2003, and Fig. 14 herein for illustrations of *A. depressum*) Head and body depressed, markedly so in *A. depressum*, much less so in *L. dorsalis*. Head wider than prothorax in *A. depressum*, coequal in width in *L. dorsalis*. First instars of *A. depressum* unknown, in first instar of *L. dorsalis* frontal piece with long U-shaped row of short stiff setae likely used as an egg burster. Frontale slightly produced medially, toothed or shallowly bilobed. Neck slightly to moderately constricted, short and broad, cervical groove and keel distinct. Mandible with inner edge of blade and posterior margin of retinaculum moderately serrate (3rd instar). Maxilla with inner lobe present, unisetose, seta 2× length of lobe in *A. depressum*, absent and devoid of seta in *L. dorsalis*. Labium markedly produced medially and unisetose. Antennomere 3 with small tubercle laterad near apex (not a hyaline bulb). Segment IX with two stout curved setae ventrally; urogomphi non-segmented, multi-nodose, infuscated. Pygopod with marked triangular patch of setae postero-ventrally.

Key to the larvae of genera of Carabidae (in part)

(Modified from Thompson 1979)

- 27 (25) Blade of mandible and/or retinaculum denticulate or crenulate **28**
- Blade of mandible and retinaculum not denticulate or crenulate..... **36**
- 28 (27) Cervical groove present, short **29**
- Cervical groove absent **32**
- 29 (28) Antennae distinctly longer than mandibles **Panagaeini (in part)**
- Antennae subequal to mandibular length..... **30**
- 30 (29) Nasale medially produced, equally quatro-dentate; maxilla with inner lobe (L_3); pygopod with dense patch of setae ventrally (L_3); cerci not articulated.. **Ctenodactylini**
- Nasale not produced, margin medially microdentate, two lateral teeth larger than medial dents; maxilla without inner lobe (L_3); pygopod without dense patch of setae ventrally (L_3); cerci articulated **Odacanthini**

Key to the larvae of known genera of Ctenodactylini

- 1 Head and body markedly depressed; head with definitive neck; tarsus multipinose, spines robust; pygopod multisetiferous medio-ventrally, setae curved, decumbent posteriorly ***Askalaphium* Liebke, 1938**
- Head and body slightly depressed; head without definitive neck; tarsus bisetose, setae fine; pygopod without medio-ventral patch of curved setae, general setae normal, straight, not decumbent ***Leptotrachelus* Latreille, 1829**

***Leptotrachelus dorsalis* (Fabricius, 1801)**

http://species-id.net/wiki/Leptotrachelus_dorsalis

Description of first and third instars. *Coloration* (as in Fig. 3). Mostly pale cream color with infuscated head capsule, mandibles, and urogomphi, the latter with pale spots; other mouthparts, antennae, and pronotum slightly darker than rest of body.

Microsculpture. Head capsule without visible sculpticels.

Form. Head (Figs 3, 4, 8). Nasale moderately produced, quarto-dentate, teeth co-equal in length; mandibles robust and with obvious serrations medially on blade and posterior to retinaculum; genae not prominent, very slightly wider than distance across stemmata, slightly narrowed to broad neck. Eyes of 6 barely prominent stemmata. Antennomere slightly shorter than porrect mandible; antennomere 2 slightly shorter than 1, 3, and 4. Mandible with prominent retinaculum, curved dentiform; terebral blade obviously serrate, pensillus absent. Ligula of labium slightly produced, unisetose, labrum ventrally sextasetose. Ratios of palpomere lengths can be deduced from the illustrations.

Thorax. (Figs 3, 5, 9). Prothorax narrowly quadrate (L_1), more broadly quadrate (L_3); meso- and metathorax transverse trapezoid, narrow anteriad, broader posteriorly.

Abdomen. (Figs 3, 6, 7, 10, 11). Segments hexagonal, broad. Urogomphi about one and a half times as long as prothorax is long.

Legs. (Figs 3, 12). Tarsus unispinose at apex and with a single seta at midpoint dorsally.

Chaetotaxy (L_1). Head. Frontale (Fig. 4) with 7 setae (FR1 – FR7) on each side; and 2 pores (FRc & FRE) on each side; egg burster a lyre-shaped row of short setae. Parietale (Figs 4A, 4B) with 19 setae (PA1 – PA19) and 5 pores (PAC, PAj, PAK, PAm, PAn) on each side. Antenna (Fig. 4A): antennomere 1 with 3 pores (unlabeled); antennomeres 2 – 4 with no pores; antennomere 3 with 3 setae (AN1 – AN3) and 1 small



Figure 3. Larva, 3rd instar (top), 2nd instar (bottom), dorsal aspect, of *Leptotrachelus dorsalis* (Fabricius). Apparent body length (ABL) (L_3 = 8.9mm; L_2 = 7.0)

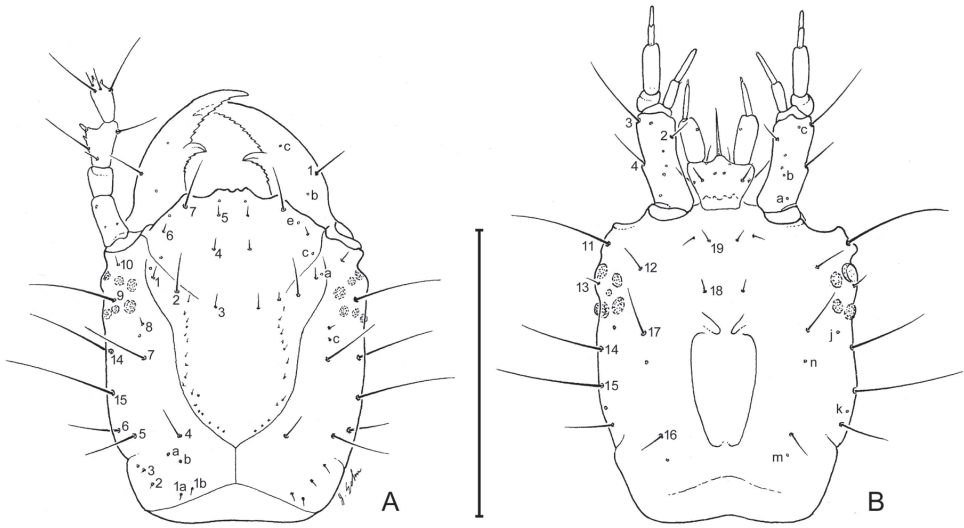


Figure 4. Larval head capsule (L₁) of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Scale line equals 0.5 mm.

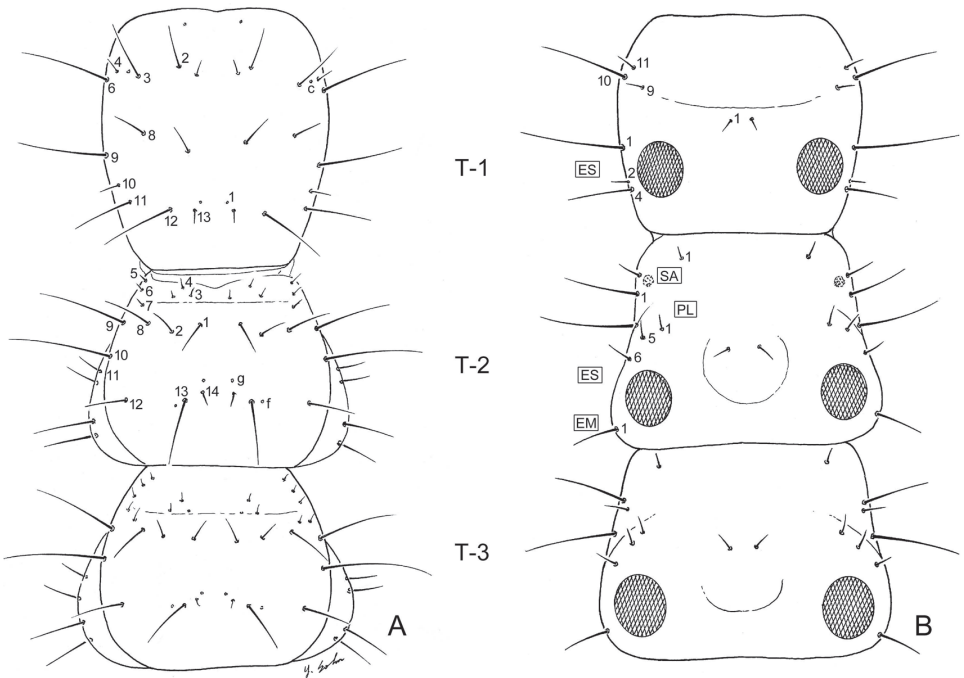


Figure 5. Larval thorax (L₁) of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Prothorax T-1 Mesothorax T-2 Metathorax T-3 Episternum ES Epimeron EM. Scale line equals 0.5 mm.

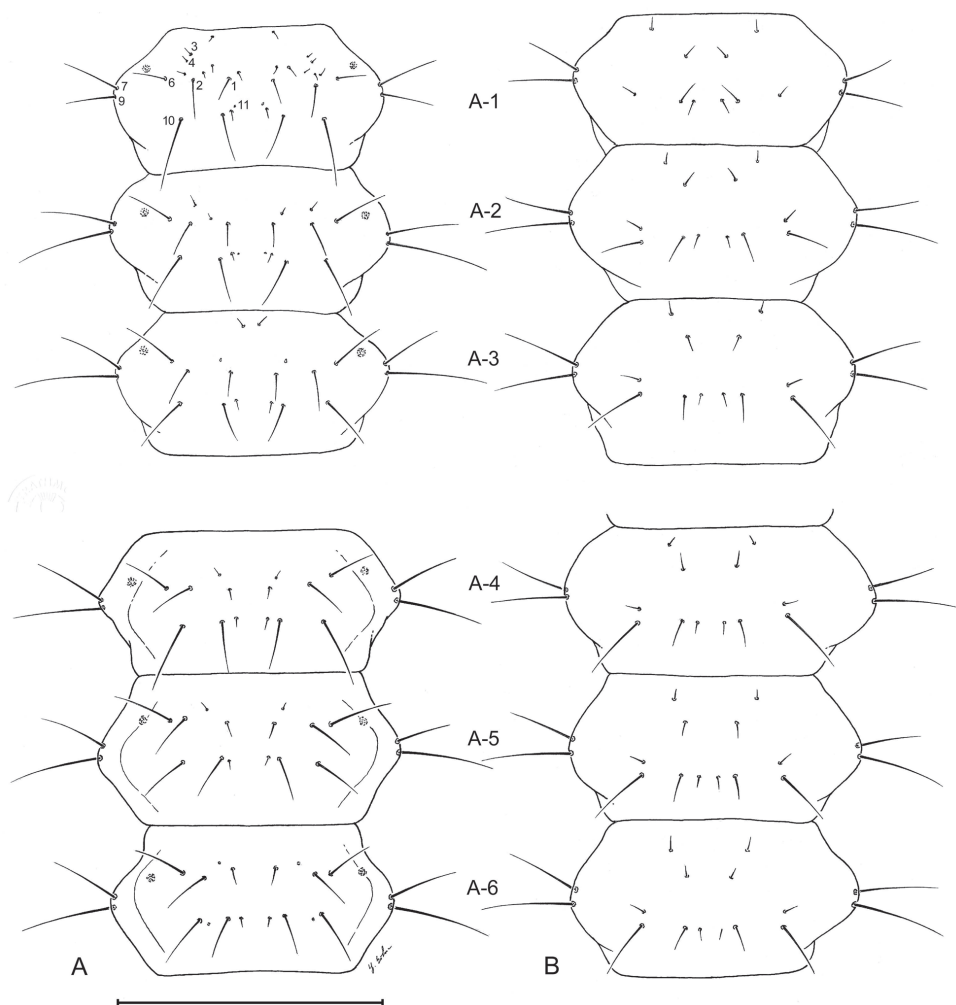


Figure 6. Larval abdomen (L_1), of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Abdominal segments **A-1** through **A-6**. Scale line equals 0.5 mm.

sensilla near base of sensorial appendage (Fig. 4A); antennomere 4 with 4 setae (AN1 – AN4) and 2 small apical sensillae (Fig. 4A). Mandible (Fig. 4A) with 1 seta (MN1) and 2 pores (MNb – MNC). Labium (Fig. 4B): prementum with 3 setae (LA2, LA3, LA7) and 1 pore (LAa) on each side; palpomere 1 with 1 pore (LAb); palpomere 2 and 3 without visible features. Maxilla (Fig. 4B): cardo without setae; stipes with 3 constant setae (MX2, MX3, MX4); 5 pores (MXa – MXc), others not labeled; lacinia and galeomeres without setae and pores; maxillary palpomeres without visible sensory features.

Thorax. Prothorax: Notum (Fig. 5A) with 10 major setae (PR2 – 4, 6, 8 – 13), PR1, 5, 7 absent, and 3 pores (PRc only named one) on each side; pleurite (Fig. 5B) with 3 setae (PL9, 10, 11), and no pores on each side; episternum (Fig. 5B) with 3 setae (unnumbered).

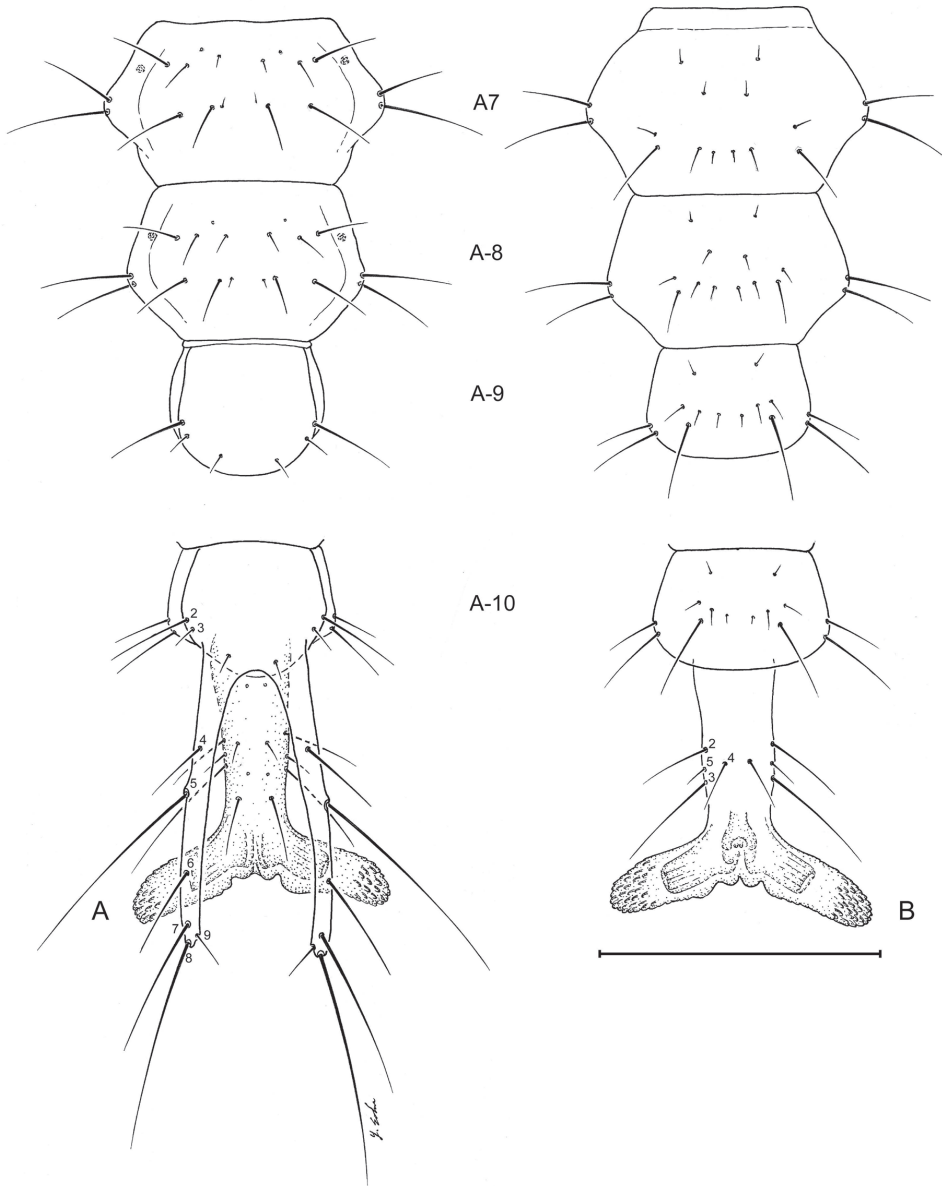


Figure 7. Larval abdomen (L_1), of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Abdominal segments **A-7** through **A-10**; and cerci and pygidium. Scale line equals 0.5 mm.

Mesothorax: Notum (Fig. 5A) with 14 setae (ME1 – ME14), 3 small auxiliary setae, and 1 pores (MEg) on each side; episternum (Fig. 5B) with no setae and no pores; epimeron (Fig. 5B) with 1 seta (EM1); pleurite (Fig. 5B) with 3 posterior seta (PL1, 5, 6); sternum (Fig. 5B) with 1 seta (not numbered) and no pores on each side.

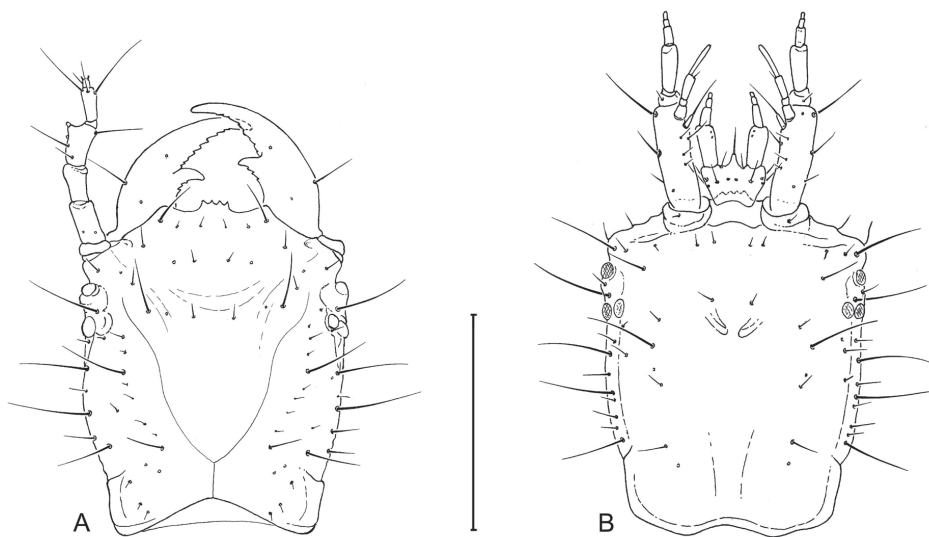


Figure 8. Larval head capsule (L₃) of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Scale line equals 0.5 mm.

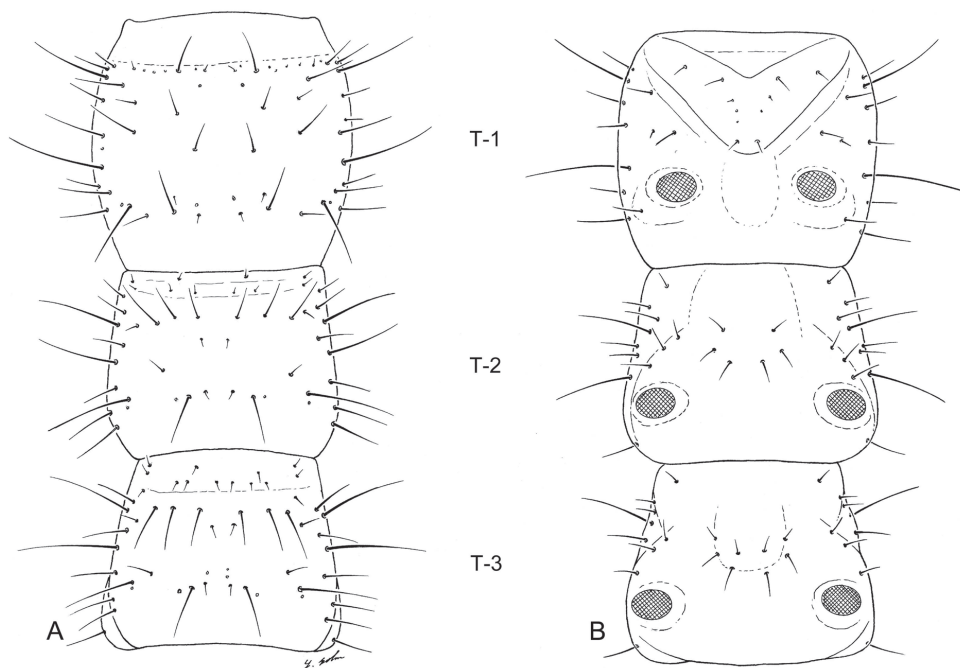


Figure 9. Larval thorax (L₃) of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Prothorax T-1 Mesothorax T-2 Metathorax T-3. Scale line equals 0.5 mm.

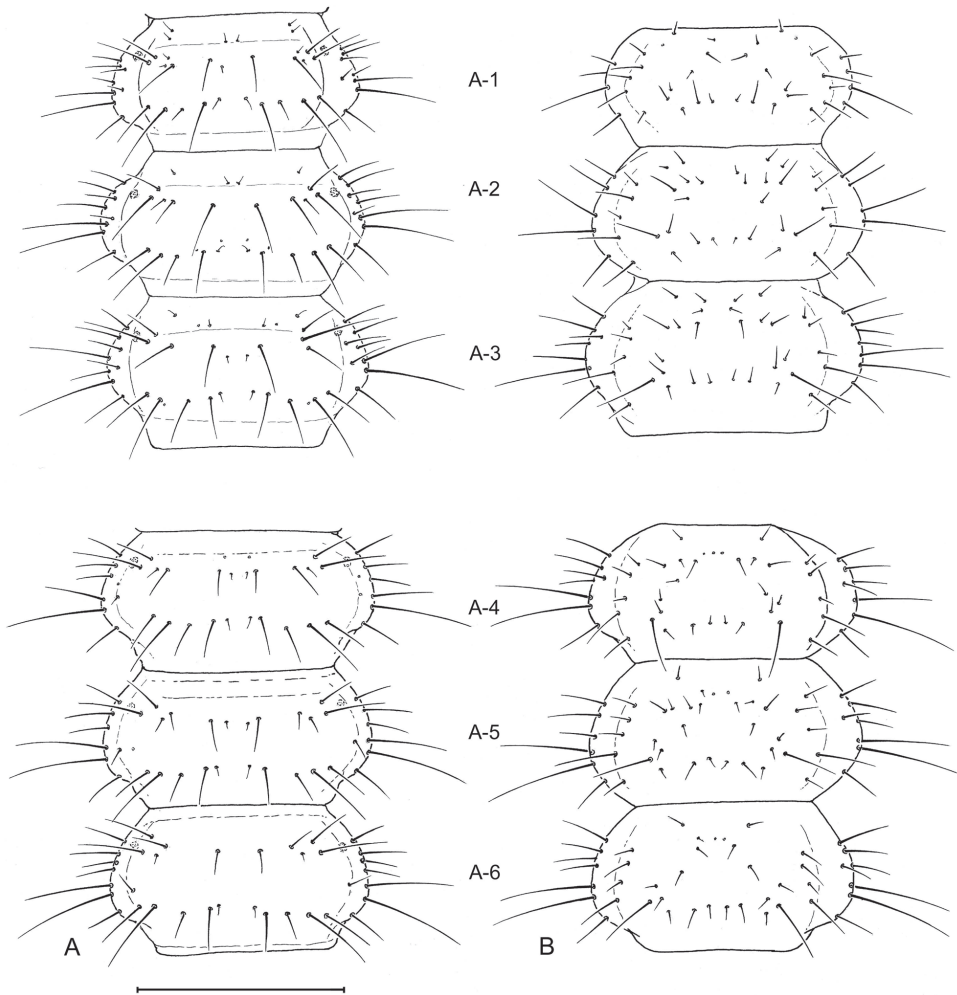


Figure 10. Larval abdomen (L_3), of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Abdominal segments **A-1** through **A-6**. Scale line equals 0.5 mm.

Abdomen. Tergite I (Fig. 7A) with 10 setae (TE1 – TE10, TE8 missing and several accessory setae present) and 1 pore on each side. Tergites II – VIII as in Tergite 1 but with less accessory setae. Tergite IX and urogomphi (Fig. 7A) with 8 setae (UR1 – UR8, UR1 missing) and no pores. Epipleurite (Fig. 7B) with 2 setae (unnumbered) and no pores. Hypopleurite (Fig. 7B) with 7 setae (unnumbered) and no pores. Sterna 1 – 9 (Fig. 7B) with 5 or 6 setae each side (unnumbered) all in the same pattern. Sternum IX with 4 setae (ST2 – ST5) on each side.

Legs. Coxa (Fig. 12) with 1 setae (CO10). Trochanter (Fig. 12) with 8 setae (TR1 – TR8), 2 unnumbered accessory setae and no pores. Femur (Fig. 12) with 6 setae (FE1

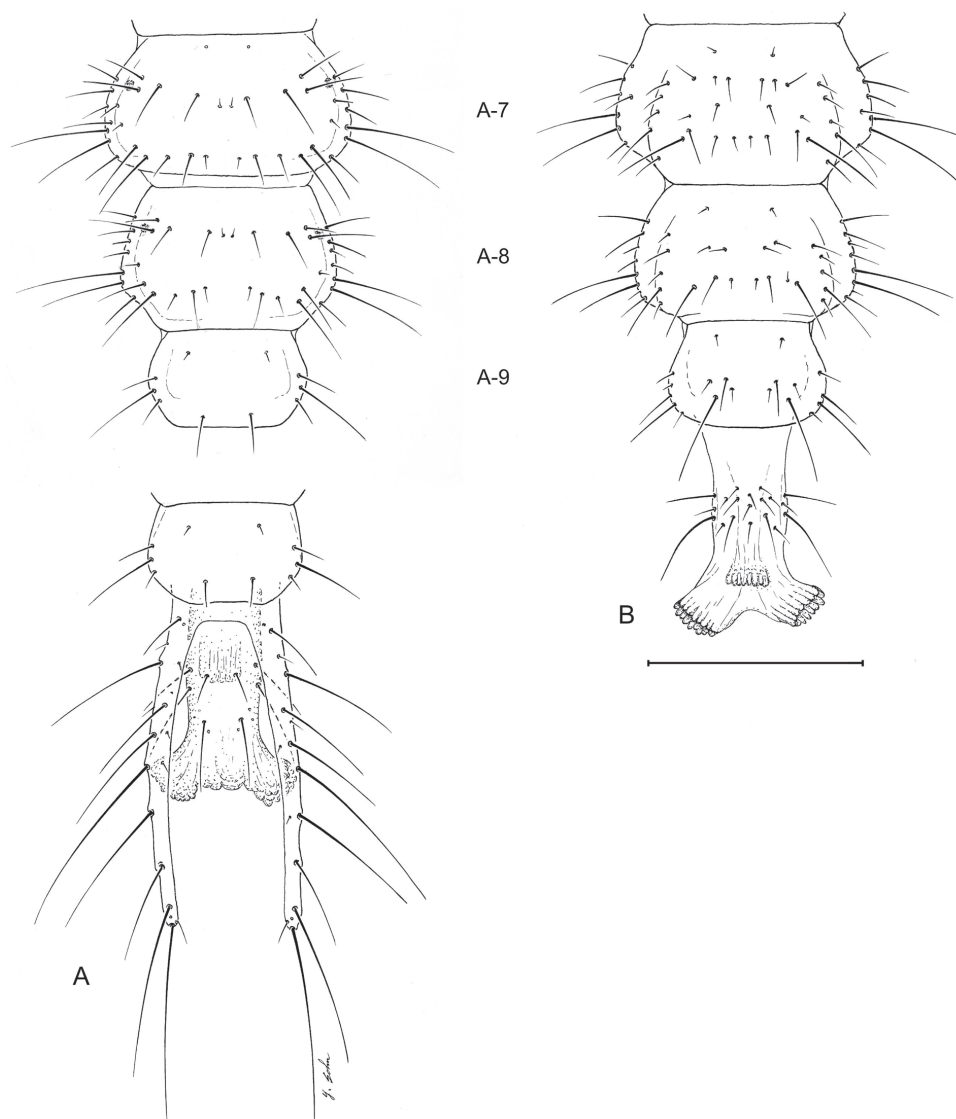


Figure 11. Larval abdomen (L_3), of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** ventral aspect. Abdominal segments **A-7** through **A-10** and cerci and pygidium. Scale line equals 0.5 mm.

– FE6), 1 unnumbered accessory seta and no pores. Tibia (Fig. 12) with 6 setae (TI1 – TI7, TI6 missing) and no pores. Tarsus (Fig. 12) 2 segmented, with 6 setae (T21 – T26) and 1 unnumbered accessory seta and no pores on T2, and 1 constant seta on T1 and 1 unnumbered accessory seta and no pores. Claws (Fig. 12) with 1 seta near base.

Description of pupa. See Fig. 13. Typical of known carabid pupae, not many of which have been illustrated and described. Note the exceedingly setiferous ocular area of head and cerci.

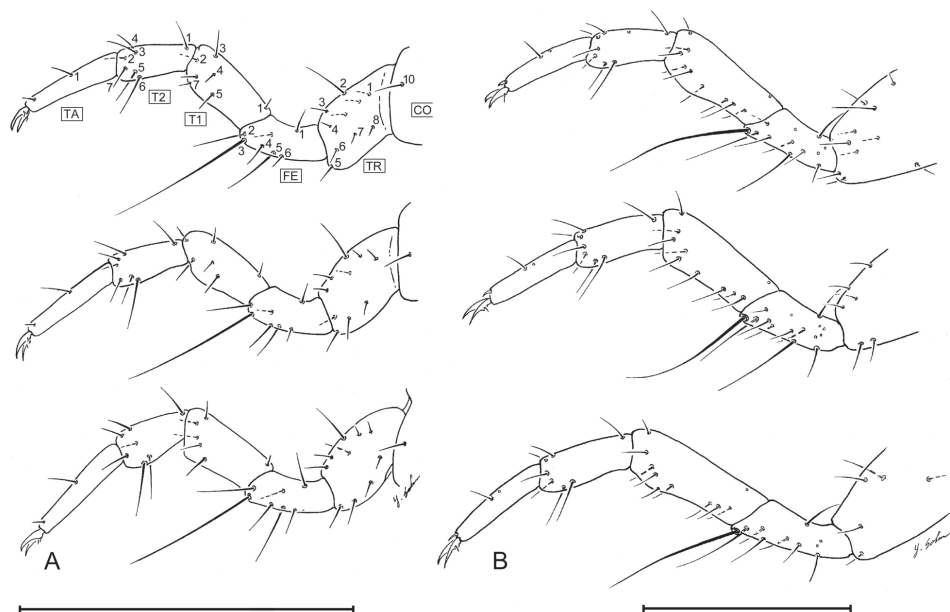


Figure 12. Coxa CO trochanter TR femur FE and tarsus T1, T2, TA of *Leptotrachelus dorsalis* (Fabricius), posterior lateral aspect. **A** L_1 , top – anterior leg; middle – middle leg; bottom – posterior leg **B** L_3 , top – anterior leg; middle – middle leg; bottom – posterior leg. Scale line equals 0.5 mm.

Characteristics of Ctenodactylini larvae. Erwin and Medina (2003) showed that van Emden (1948) mixed attributes of two unrelated tribes, Odacanthini (Colliurini) and his concept of Ctenodactylini. They found that L_3 members of the genus *Leptotrachelus* contain the following larval attributes found in larvae of *A. depressum*: epicranial suture short; cervical groove and keel present; maxilla with inner lobe present; neck not severely constricted; urogomphi nodal, yet not segmented. They located the collection of *L. dorsalis* larvae that van Emden studied (collected at Oxford, Indiana) in the NMNH, however, they are not in very good condition. They also confirmed his observations and added that second and third instars lack a pencillus and the terebral blade is micro serrate, but refrained from making a more detailed comparison until better specimens were discovered. These observations are now testable with the wealth of material found by the junior author in Houma, Louisiana. Our understanding of the structural attributes of the larval stages for the carabid tribe Ctenodactylini is now progressing.

Erwin and Medina (2003) also studied some poorly preserved specimens of *Oda-canta melanura* L. in the NMNH collection. These specimens differ from ctenodactyline larvae in that the mandible has a single seta pensillus and the maxilla lacks an inner lobe, other features are not discernible. Undescribed larvae of some genera of ctenodactylines were also found in the rotten stems and leaf axils of species of the plant genera *Heliconia* L. and *Calathea* G. Mey in low wet places in Amazonian Ecuador and Perú. Adults of *Ctenodactyla* Dejean occur on species of these plants at night. Further

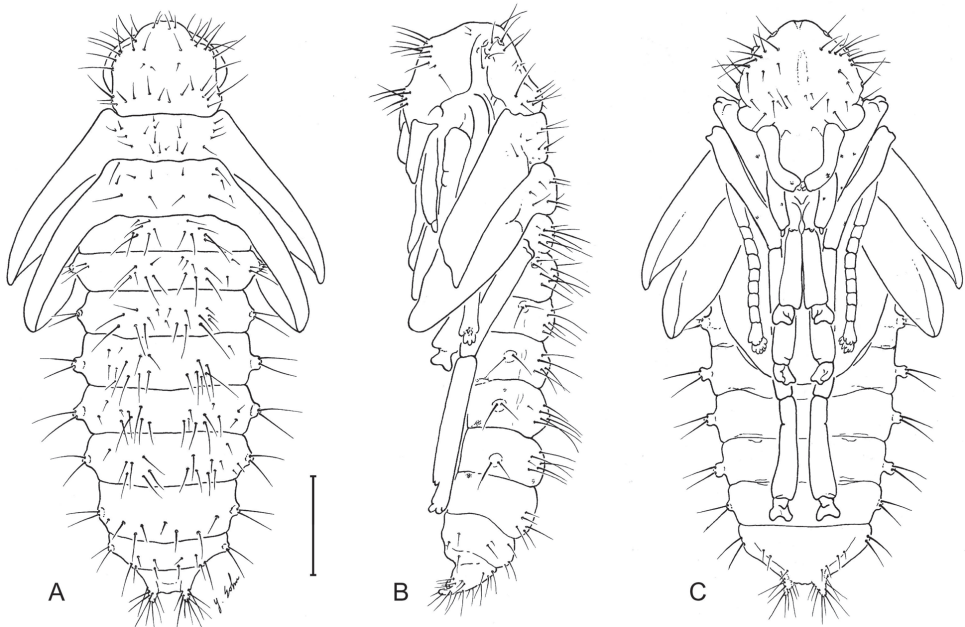


Figure 13. Pupa of *Leptotrachelus dorsalis* (Fabricius). **A** dorsal aspect **B** left lateral aspect **C** ventral aspect. Scale line equals 1.0 mm.

discovery is necessary and subsequent documentation is required to define more accurately the Ctenodactylini, and to explore the patterns that must link these beetles evolutionarily and ecologically to the plants on which they live and the food which they eat.

Conclusions

The hypothesized “home reed,” *Typha latifolia* L., as a microhabitat for this commensal species of carabids is classified in the Poales, Typhaceae. This reed, commonly called bulrushes or cattails, is an obligate wetland species and has been found in a variety of climates, including tropical, subtropical, southern and northern temperate, humid coastal, and dry continental up to 2300 m altitude in North, Middle, and South America. However, we point out that species of *Leptotrachelus* are known to occur commonly as adults on the culms of marsh grasses such as *Panicum dichotomiflorum* (*Leptotrachelus dorsalis*: Steiner 1984) in Maryland, USA, and *Paspalum* sp. (*Leptotrachelus* spp.: Erwin 1991) in the western Amazon Basin. There are currently 40 described species of *Leptotrachelus* in the Western Hemisphere, all with proximity to the spread of sugarcane plantations. In these plantations, there are often water-filled ditches with bulrushes and this is the likely source of the beetles that invade the standing canes; it is also a refuge for the beetles when the sugarcane fields are harvested in the fall and winter and resulting residues are burned off, a usual practice. They maintain their populations there in the

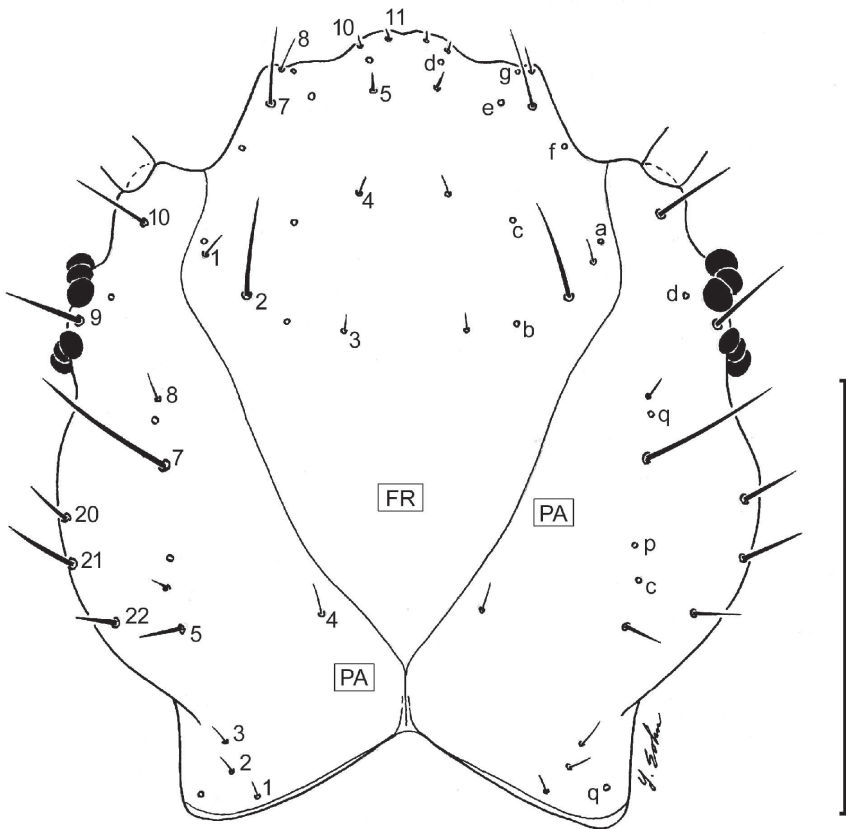


Figure 14. Larval head capsule (L_3), parietale (PA), frontale (FR), dorsal aspect of *Askalaphium depressum* (Bates). This illustration was inadvertently left out of Erwin and Medina (2003); see references therein. Scale line equals 0.5 mm.

bulrushes and reinvade the sugarcane ratoons in the spring, or after the next planting cycle. This makes them excellent biocontrol agents; however, broad spectrum pyrethroid insecticides sometimes used by farmers and predation by the red imported fire ant, *Solenopsis invicta* Buren, can severely reduce beetle numbers.

Acknowledgements

We thank Randy Richard and Elta Duet of the USDA, ARS Sugarcane Research Unit for valuable assistance in the field and laboratory. We also thank Warren Steiner for

specimen preparation and general collection assistance, Young Sohn who provided the excellent larval illustrations, Charyn Micheli for literature research and critical review of the manuscript, as well as Karolyn Darrow for her assistance with rendering and arranging the many illustration plates and photos; all four individuals are part of the important technical staff of the Department of Entomology, Smithsonian Institution. Lourdes Chamorro (USDA Staff in NMNH) also provided a critical review of the manuscript. Funding for this study was received from the American Sugar Cane League of the U.S.A., Inc. and publication costs borne by the National Museum of Natural History, Smithsonian Institution. We also thank two excellent anonymous reviewers who contributed much to the final product, although we are responsible for any errors that might still be maintained in the final product.

References

- Bousquet Y, Goulet H (1984) Notation of primary setae and pores on larvae of Carabidae (Coleoptera: Adephaga). Canadian Journal of Zoology 62: 575–588. doi: 10.1139/z84-085
- Fabricius C (1801) Systema eleutheratorum: secundum ordines, genera, species adiecitis synonymymis, locis, observationibus, descriptionibus. Tome 1, xxiv + 506pp; Tome 2, Bibliopolii Academici Novi, Kiliae, 687pp.
- Erwin TL (1991) Natural history of the carabid beetles at the BIOLAT Biological Station, Rio Manu, Pakitza, Perú. Revista Peruana de Entomologia 33: 1–85.
- Erwin TL, Medina RF (2003) The Neotropical species *Askalaphium depressum* (Bates): Larval description, first diagnosis and illustrations of immature Ctenodactylini, with natural history notes on the genus and tribe (Coleoptera: Carabidae). Zootaxa 273: 1–15.
- Lindroth CH (1969) The ground-beetles (Carabidae, excl. Cicindelinae) of Canada and Alaska. Opuscula Entomologica, Part 6. Supplementum No. 34: 945–1192.
- Steiner WE (1984) A review of the biology of phalacrid beetles. In: Wheeler Q, Blackwell, M (Eds) Fungus-Insect Relationships: Perspectives in Ecology and Evolution. Columbia University Press, New York, 424–445.
- Thompson RG (1979) Larvae of North American Carabidae with a key to the tribes. In: Erwin TL, Ball GE, Whitehead DR, Halpern AL (Eds) Carabid Beetles: Their Evolution, Natural History, and Classification. Proceedings of the First International Symposium of Carabidology. Dr. W. Junk b.v. Publishers, The Hague, 209–291.
- van Emden FI (1942) A key to the genera of larval Carabidae (Col.). Transactions of the Royal Entomological Society of London 92: 1–99.
- White WH, Erwin TL, Viator BJ (in press) *Leptotrachelus dorsalis* (F.) (Coleoptera: Carabidae): A candidate Biological Control Agent of the Sugarcane Borer in Louisiana. Florida Entomologist.
- White WH, Viator RP, Dufrene Jr. EO, Dalley CD, Richard Jr. EP, Tew TL (2008) Re-evaluation of sugarcane borer (Lepidoptera: Crambidae) bioeconomics in Louisiana. Crop Protection 27: 1256–1261. doi: 10.1016/j.cropro.2008.03.011

Two new *Lesteva* Latreille (Coleoptera, Staphylinidae, Omaliinae) from Longwangshan Mountain, East China

Wen-Li Ma^{1,†}, Li-Zhen Li^{1,‡}, Mei-Jun Zhao^{1,§}

¹ Department of Biology, College of Life and Environmental Sciences, Shanghai Normal University, Shanghai, 200234, P. R. China

† urn:lsid:zoobank.org:author:6F888674-8655-48B2-85DD-5A07A70108DC

‡ urn:lsid:zoobank.org:author:BBACC7AE-9B70-4536-ABBE-54183D2ABD45

§ urn:lsid:zoobank.org:author:FBE4FA1F-5BCF-405E-98C1-4F86894643EA

Corresponding author: Li-Zhen Li (lizhenli@shnu.edu.cn)

Academic editor: Volker Assing | Received 30 March 2012 | Accepted 14 May 2012 | Published 17 May 2012

urn:lsid:zoobank.org:pub:4B1886ED-2510-4473-B885-97715F35EF27

Citation: Ma W-L, Li L-Z, Mei-Jun Zhao M-J (2012) Two new *Lesteva* Latreille (Coleoptera, Staphylinidae, Omaliinae) from Longwangshan Mountain, East China. ZooKeys 194: 33–40. doi: 10.3897/zookeys.194.3139

Abstract

Two new species of *Lesteva* Latreille are described and illustrated from Longwangshan Mountain, East China, viz. *L. cala* Ma & Li, **sp. n.** and *L. erythra* Ma & Li, **sp. n.** The latest key to Chinese *Lesteva* is modified to include the species described from continental China since 2000.

Keywords

Coleoptera, Staphylinidae, *Lesteva*, new species, key, Longwangshan, East China

Introduction

Lesteva Latreille is one of the largest omaliine genera of the family Staphylinidae with over 100 species worldwide, among which 18 are known from China (Cameron 1934, Rougemont 2000, Watanabe 2005, Li et al. 2005). So far, eight species have been recorded from Longwangshan mountain, Zhejiang Province, East China (Rougemont 2000 (7 spp.), Li et al. 2005 (1 sp.)).

In April 2004, the staff of the junior author's laboratory surveyed the staphylinid fauna of Longwangshan Mountain, during which a large series of *Lesteva* were collected. On closer examination these beetles were found to belong to two new species. Since there are three hitherto known subgenera of the genus: *Lesteva* Latreille, 1797, *Lestevidia* Jeannel & Jarrige, 1949 and *Lestevina* Bordoni, 1999, we arrange both new species into the subgenus *Lesteva* Latreille based on the definition of subgenera. In the present paper, the new species are described and illustrated, with modified couplets of the latest key (Rougemont 2000) to Chinese *Lesteva*.

Material and methods

All measurements are in millimeters. The following abbreviations are used in the text:

BL – length of the body from the labral anterior margin to the anal end; **FL** – length of the body from the labral anterior margin to the elytral apex; **HL** – length of the head from the clypeal anterior margin to the head base; **HW** – maximum width of the head; **PL** – length of the pronotum along the midline; **PW** – maximum width of the pronotum; **EL** – length of the elytra from the apex of the scutellum to the elytral posterior margin; **EW** – maximum width of the elytra.

The holo- and paratypes are deposited in the Insect Collection of Shanghai Normal University, Shanghai, China (SNUC).

Descriptions

Lesteva (s. str.) *cala* Ma & Li, sp. n.

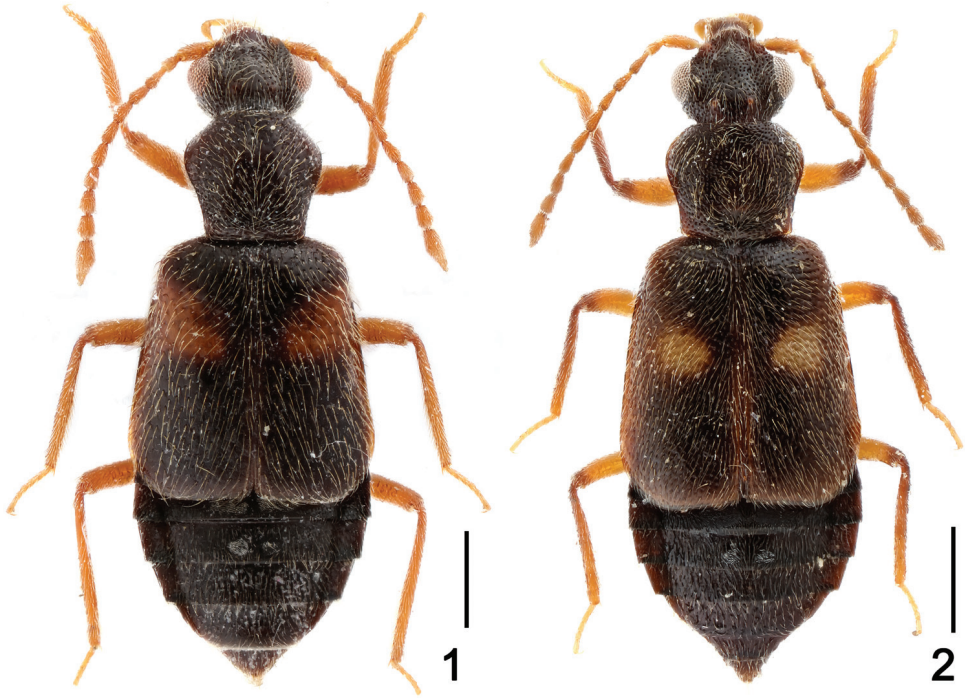
urn:lsid:zoobank.org:act:4F0B6E1B-ECA0-49AB-92DD-5E6377941C98

http://species-id.net/wiki/Lesteva_cala

Figs 1, 3–5

Type locality. Longwangshan Mountain, East China

Type material (38 ♂♂, 35 ♀♀). **Holotype:** CHINA: Zhejiang Prov.: ♂, Anji County, Mt. Longwangshan, 25.iv.2004, alt. 950–1,200 m, Liang Tang leg. **Paratypes:** CHINA: Zhejiang Prov., Anji County, Mt. Longwangshan: 5 ♂♂, 3 ♀♀, same label data as holotype; 3 ♀♀, 25.iv.2004, alt. 950–1,200 m, Jing-Wen Zhu leg.; 1 ♀, 25.iv.2004, alt. 950–1,200 m, Jia-Yao Hu leg.; 1 ♀, 25.iv.2004, alt. 950–1,200 m, Jing Chen leg.; 2 ♀♀, 25.iv.2004, alt. 950–1,200 m, Li-Long Zhu leg.; 2 ♂♂, 2 ♀♀, 24. iv.2004, alt. 300–500 m, Jing-Wen Zhu leg.; 2 ♂♂, 24.iv.2004, alt. 300–500 m, Jia-Yao Hu leg.; 3 ♂♂, 2 ♀♀, 24.iv.2004, alt. 300–500 m, Jing Chen leg.; 5 ♂♂, 24.iv.2004, alt. 300–500 m, Xin-Jin Li leg.; 8 ♂♂, 4 ♀♀, 24.iv.2004, alt. 300–500 m, Liang Tang leg.; 3 ♀♀, 24.iv.2004, alt. 300–500 m, Huang & Chi leg.; 1 ♂, 3 ♀♀, 24.iv.2004, alt. 300–500 m, Li-Long Zhu leg.; 4 ♂♂, 5 ♀♀, 23.iv.2004, alt. 300–500 m, Li-Long Zhu leg.; 3 ♂♂, 2 ♀♀, 23.iv.2004, alt. 300–500 m, Jing-Wen



Figures 1–2. Male habitus of *Lesteva* 1 *L. cala* 2 *L. erythra*. Scales: 0.5 mm.

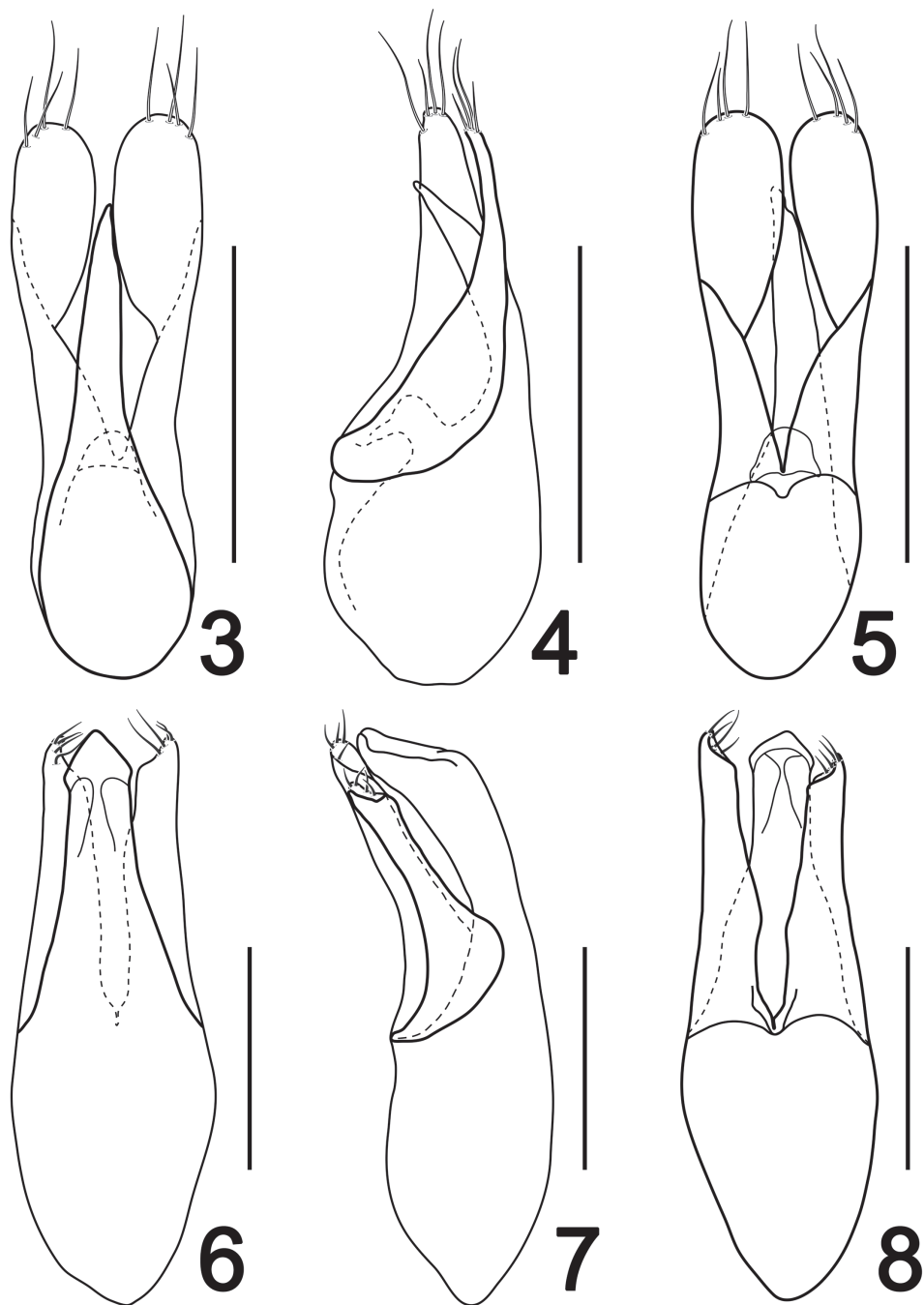
Zhu leg.; 2 ♂♂, 4 ♀♀, 23.iv.2004, alt. 300–500 m, Liang Tang leg.; 1 ♂, 23.iv.2004, alt. 300–500 m, Jing Chen leg.; 1 ♂, 23.iv.2004, alt. 300–500 m, Li & Hu leg.

Description. Measurements and ratios: BL 3.3–3.9. Holotype: HL 0.59, HW 0.61, PL 0.63, PW 0.67, EL 1.24, EW 1.20, HL/HW 0.97, HW/PW 0.91, PL/PW 0.94.

Habitus as in fig. 1. Black, mouth-parts, antennae and legs uniformly rufo-testaceous. Each elytron with a dark red subhumeral macula. Pubescence pale, evident and recumbent on whole body.

Head sub-triangular, coarsely and sparsely punctate, widest across eyes and slightly broader across compound eyes than long; vertex moderately depressed; eyes prominent; ocelli distinct, distance between them slightly larger than that from lateral margin of each ocellus to mesal margin of eye; postocular margins about half length of longitudinal diameter of eye; antennae moderately long, overlapping base of pronotum by two terminal segments when pulled posteriad; antennomeres I broad at middle, antennomeres II much shorter and narrower than I, antennomeres III–XI gradually thickened; relative length of each antennomere from base to apex as 10 : 6 : 7.5 : 6.5 : 5.5 : 5.5 : 6 : 5.5 : 6.5 : 6 : 12.

Pronotum subcordate, moderately convex, widest near anterior third, slightly wider than head; lateral margins arcuate at anterior two-thirds and nearly straight at posterior third; punctuation and pubescence similar to those on head; disc with shallow U-shaped depressed area. Scutellum subtriangular, surface with fine punctuation and pubescence.



Figures 3–8. Aedeagus of *Lesteva* (3, 6 dorsal view 4, 7 lateral view 5, 8 ventral view). 3–5 *L. cala* 6–8 *L. erythra*. Scales: 0.2 mm.

Elytra subtrapezoidal, gradually dilated posteriorly, posterior angles broadly rounded; punctuation and pubescence distinctly finer and sparser than those on pronotum.

Abdomen broad, widest at segment IV (first visible abdominal segment), then distinctly narrowed posteriorly. Tergites with dense, fine punctuation and decumbent pubescence; tergites IV–V each provided with one pair of tomentose admesal patches.

Male. Sternite VIII transverse, posterior margin broadly emarginate. Aedeagus (Figs 3–5) length 0.33 mm; median lobe narrow and much shorter than parameres, gradually narrowed apically; parameres symmetrical, each distinctly roundly broadened in apical half, with four long apical setae.

Female. Protarsomeres I–IV not dilated. Otherwise similar to male.

Distribution. East China: Zhejiang Province.

Bionomics. The type series were obtained by sifting leaf litter and wet moss at the streamside of the Longwangshan Mountain in late April.

Etymology. The specific name ‘*cala*’ is a latinized Greek adjective and means ‘beautiful’.

Remarks. The new species is close to *L. huabeiensis* Rougemont from Beijing in sharing similar elytral maculae, but it can be readily separated by the aedeagus with parameres much longer than the median lobe, *L. huabeiensis* has the aedeagus with the median lobe slightly shorter than the parameres. *Lesteva cala* also resembles *L. pulcherrima* Rougemont in the similar form of parameres, but differs in having a much narrower median lobe of the aedeagus and dark coloration of the body.

***Lesteva* (s. str.) *erythra* Ma & Li, sp. n.**

urn:lsid:zoobank.org:act:22C2925D-7A2A-4FCA-8B04-2FB0D208CA4F

http://species-id.net/wiki/Lesteva_erythra

Figs 2, 6–8

Type locality. Longwangshan Mountain, East China

Type material (44 ♂, 36 ♀). **Holotype:** CHINA: Zhejiang Prov.: ♂, Anji County, Mt. Longwangshan, 24.iv.2004, alt. 300–500 m, Xin-Jin Li leg. **Paratypes:** CHINA: Zhejiang Prov., Anji County, Mt. Longwangshan: 10 ♂♂, 8 ♀♀, 25.iv.2004, alt. 950–1,200 m, Jing-Wen Zhu leg.; 7 ♂♂, 4 ♀♀, 25.iv.2004, alt. 950–1,200 m, Liang Tang leg.; 5 ♂♂, 5 ♀♀, 25.iv.2004, alt. 950–1,200 m, Li-Long Zhu leg.; 2 ♀♀, 25.iv.2004, alt. 950–1,200 m, Xin-Jin Li leg.; 1 ♂, 3 ♀♀, 25.iv.2004, alt. 950–1,200 m, Jing Chen leg.; 11 ♂♂, 4 ♀♀, 24.iv.2004, alt. 300–500 m, Jing-Wen Zhu leg.; 1 ♀, 24.iv.2004, alt. 300–500 m, Liang Tang leg.; 1 ♀, 24.iv.2004, alt. 300–500 m, Jia-Yao Hu leg.; 1 ♀, 24.iv.2004, alt. 300–500 m, Jing Chen leg.; 3 ♀♀, 24.iv.2004, alt. 300–500 m, Li-Long Zhu leg.; 7 ♂♂, 1 ♀, 23.iv.2004, alt. 300–500 m, Jing-Wen Zhu leg.; 1 ♂, 23.iv.2004, alt. 300–500 m, Li-Long Zhu leg.; 1 ♂, 3 ♀♀, 23.iv.2004, alt. 300–500 m, Liang Tang leg.

Description. Measurements and ratios: BL 2.8–3.5. Holotype: HL 0.54, HW 0.52, PL 0.56, PW 0.54, EL 1.24, EW 1.17, HL/HW 1.04, HW/PW 0.93, PL/PW 1.04.

Habitus as in Fig. 2. Black, elytra usually paler, darkish brown, suture and lateral margins reddish; mouth-parts fuscous brown; antennae and legs reddish brown, except for apex of femora and large part of tibia which are infusate; each elytron with one small round orange-yellow spot near middle. Pubescence pale, evident and recumbent on whole body.

Head subtriangular, widest across eyes and slightly broader across compound eyes than long, densely and coarsely punctate, vertex moderately depressed; eyes prominent; ocelli distinct, distance between them equal to that from lateral margin of each ocellus to mesal margin of eye; postocular margins less than half length of longitudinal diameter of eye; antennae elongate, extending beyond posterior margin of pronotum by three segments when pulled posteriad, antennomeres I moderately robust, antennomere II much shorter and narrower than I, antennomeres III–XI gradually thickened; relative length of each antennomere from base to apex as 9 : 5.5 : 6 : 5.5 : 6 : 6 : 5 : 5.5 : 5.5 : 5 : 10.

Pronotum subcordate, slightly convex, widest near anterior third, slightly wider than head; lateral margins arcuate at anterior two-thirds and nearly straight at posterior third; more coarsely and densely punctate than on head, with slightly deep U-shaped depression on disc. Scutellum subtriangular, scattered with fine punctation and pubescence.

Elytra subtrapezoidal and rather flat, gradually dilated posteriorly, posterior angles broadly rounded, coarsely and sparsely punctate, covered with fine pubescence as on pronotum.

Abdomen broad, widest at segment IV (first visible abdominal segment), then distinctly narrowed posteriorly. Tergites with dense, fine punctation and decumbent pubescence; tergites IV–V each with one pair of tomentose admesal patches.

Male. Sternite VIII transverse, with apical margin distinctly emarginate. Aedeagus (Figs 6–8) length 0.50 mm; median lobe moderately broad, gradually narrowed apically; parameres slightly asymmetrical, subequal in length as median lobe, with four short apical setae.

Female. Protarsomeres I–IV not dilated. Otherwise similar to male.

Distribution. East China: Zhejiang Province.

Bionomics. All the type specimens were obtained from the same habitat as the preceding species.

Etymology. The specific epithet '*erythra*' means 'reddish', referring to the body color of the new species.

Remarks. The new species is placed close to *L. flavopunctata* Rougemont in sharing a similar form of the elytral spots, but can be readily separated by the body being somewhat spindle-shaped. *Lesteva erythra* also resembles *L. flavopunctata* in having a similar aedeagal form, but differs by the aedeagus with the parameres subequal in length as median lobe, while *L. flavopunctata* has the aedeagus with the parameres shorter than the median lobe.

Modified couplets of Rougemont's key

Note. Rougemont's key (Rougemont 2000) for the identification of Chinese *Lesteva* species is modified as follows to include the taxa described from continental China since 2000.

- 19(20) Elytra each with a well or poorly defined oblique pale macula; legs entirely testaceous.....**21**
- 20(19) Elytra each with a round spot situated near middle; body fuscous, deep black, or metallic blue; at least tibia more or less infusate**27**
- 21(22) Pronotum and elytra (excluding maculae) bicolorous.....**23a**
- 22(21) Pronotum and elytra (excluding maculae) concolorous, black.....**25a**
- 23a(23b) Elytra subtrapezoidal; Elytral maculae situated in anterior half of elytra**23**
- 23b(23a) Elytral somewhat parallel-sided; Elytral maculae extending from humeral angles to 1/3 of suture from posterior margin***L. ochra* Li, 2005**
- 23(24) Head and pronotum brown or pitchy; elytra testaceous, maculae pale testaceous. Outline of fore-body: Fig. 4; aedeagus: Fig. 17
.....***L. huabeiensis* Rougemont, 2000**
- 24 (23) Head and pronotum black; elytra dark brown, maculae reddish; male unknown**sp. C**
- 25a(25b) Smaller(3.3–3.9mm); elytra about as broad as their length; surface of pronotum with a distinct U-shaped depression. Outline of fore-body: Fig. 1; aedeagus: Fig. 3–5.....***L. cala* Ma & Li, sp. n.**
- 25b(25a) Larger(3.9–4.3mm); elytra distinctly elongate; surface of pronotum devoid of clear impressions.....**25**
- 25(26) Elytral maculae smaller, obscure, dark red; puncturation of pronotum and elytra coarse, deep, interstices narrower than diameter of punctures. Outline of fore-body: Fig. 5; aedeagus: Fig. 23a, b, c.....***L. submaculata* Rougemont, 2000**
- 26 (25) Elytral maculae large, bright orange, clearly defined and occupying most of anterior half of elytra; puncturation of pronotum deep but sparse, interstices larger than diameter of punctures; puncturation of elytra fine, sparse and shallow, surface of whole fore-body shiny. Outline of fore-body: Fig. 6; aedeagus: Fig. 21a, b.***L. elegantula* Rougemont, 2000**
- 27(28) Femora testaceous, tibiae more or less infusate; each elytron with a round orange spot; smaller species (≤ 3.5 mm).....**27a**
- 28(27) Femora and tibiae entirely black, or with a blue metallic reflex; larger species (4.5–5.0mm).....**29**
- 27a(27b) Body parallel-sided; parameres shorter than median lobe of the aedeagus....
.....***L. flavopunctata* Rougemont, 2000**
- 27b(27a) Body somewhat spindle-shaped; parameres almost as long as median lobe of the aedeagus. Outline of fore-body: Fig. 2; aedeagus: Fig. 6–8.
.....***L. erythra* Ma & Li, sp. n.**

Acknowledgements

We thank all the collectors for their fieldwork. Zi-Wei Yin and the two anonymous reviewers are thanked for comments on a previous version of the manuscript. The present study is supported by the National Natural Science Foundation of China (No. 31101659) and Shanghai Normal University (No. SK201234).

References

- Bordoni A (1999) Designazione delle specie-tipo di alcuni sottogeneri di Coleoptera Staphylinidae. Bollettino della Società Entomologica Italiana 131: 119–120.
- Cameron M (1934) Report on Coleoptera of the family Staphylinidae. Memoirs of the Connecticut Academy of Arts and Sciences 10: 17–21.
- Jeannel R, Jarrige J (1949) Biospeologica. LXVIII. Coléoptères staphylinides (Première Série). Archives de Zoologie Expérimentale et Générale 86: 255–392.
- Latreille PA (1797) Précis des caractères génériques des insectes, disposés dans un ordre naturel. Brive: F. Bourdeaux, xiv + 201 + 7pp
- Li XJ, Li LZ, Zhao MJ (2005) A New Species of the Genus *Lesteva* (Coleoptera, Staphylinidae, Omaliinae) from China. Entomotaxonomia 27(2): 111–113.
- Rougemont GM de (2000) New species of *Lesteva* Latreille, 1796 from China (Insecta, Coleoptera, Staphylinidae). Annalen des Naturhistorischen Museums in Wien 102(B): 147–169.
- Watanabe Y (2005) A New Species of the Genus *Lesteva* (Coleoptera, Staphylinidae) from Taiwan. Elytra 33(1): 30–33.

Annotated type catalogue of *Bothriembryon* (Mollusca, Gastropoda, Orthalicoidea) in Australian museums, with a compilation of types in other museums

Abraham S.H. Breure¹, Corey S. Whisson²

¹ Netherlands Centre for Biodiversity Naturalis, P.O. Box 9517, Leiden, the Netherlands ² Western Australian Museum, Locked Bag 49, Welshpool, WA 6106

Corresponding author: Abraham S.H. Breure (ashbreure@gmail.com)

Academic editor: E. Neubert | Received 20 January 2012 | Accepted 8 May 2012 | Published 17 May 2012

Citation: Breure ASH, Whisson C (2012) Annotated type catalogue of *Bothriembryon* (Mollusca, Gastropoda, Orthalicoidea) in Australian museums, with a compilation of types in other museums. ZooKeys 194: 41–80. doi: 10.3897/zookeys.194.2721

Abstract

Type material of 41 Australian *Bothriembryon* taxa present in Australian museums is critically listed, indicating systematic issues that need to be resolved in further studies. Information on additional type material of 22 taxa in non-Australian museums is compiled. The seven fossil taxa known so far are included in this catalogue. Based on the current systematic position, 38 species are treated in this paper. *B. jacksoni* Iredale, 1939, *B. notatus* Iredale, 1939, *B. praeceksus* Iredale, 1939 and *B. serpentinus* Iredale, 1939 are elevated to species level. *B. gratwicki* (Cox, 1899) is listed as status to be determined.

Keywords

Australia, Bothriembryontidae, types

Introduction

The land snail genus *Bothriembryon* Pilsbry, 1894, is endemic to Australia but forms part of the Gondwanan element in the superfamily Orthalicoidea. This genus has received little in-depth attention, the last review being B.J. Smith (1992) summarizing all known data. Given the fact that *Bothriembryon* species are mostly patchy in their distribution, and in some areas species complexes have been identified, a revision of the genus is needed using modern techniques (Breure and Whisson, in preparation). An inventory of as much type material as possible would facilitate revisionary work; data of primary types for 63 taxa are presented herein. The aim of this paper is (1) to

present additional data on the types of *Bothriembryon* in Australian museums (see also Kendrick and Wilson 1975, Wells 1977, B.J. Smith 1992); (2) to summarize recently published data for some European museums (Neubert and Janssen 2004, Köhler 2007, Breure and Ablett 2012), and add additional data from American and European museums; (3) to indicate systematic issues for several species to be clarified by further studies.

Methods

For each taxon the original publication—in which the taxon was proposed—is mentioned, as well as papers in which reference is made to the type material. The type locality is quoted from the original publication in the original wording and language, with clarifying notes between square brackets. These localities have been mapped using SimpleMappr (Short-house 2010). The text of the original, or oldest, label is quoted, together with information from subsequent labels if containing information necessary for a correct interpretation. It should be noted that Iredale is considered to be somewhat remiss about marking his type material and that the designations of Iredale's material in the Sydney museum has been done at a later stage by McMichael, presumably together with Iredale (A. Miller, pers. commun.). As a consequence this material has incorrectly been considered as holo- or paratypes by later authors (Wells 1975, B.J. Smith 1992). The original dimensions are quoted, as well as the dimensions of the type specimens; these have been taken with a digital calliper, using the methods figured by Breure (1974: fig. 2) for shell dimensions and Kendrick and Wilson (1975: fig. 1) for whorl counts; measurements up to 10 mm have an accuracy of 0.1 mm, those above 10 mm are accurate to 0.5 mm. Comparing the current measurements to those quoted from the original publication, one should be aware that the diameter especially may have been measured differently. In the case of syntypes, only the largest specimen has been measured. The number of specimens originally available, if quoted by the original author, is mentioned under remarks. Remarks are further given to describe any individual characteristics of the type specimens or any other details of the type lot. The current systematic position is given, following Breure and Romero (in press) for the classification at the family level, and B.J. Smith (1992) for the species level unless otherwise stated.

Abbreviations used for depositories of material are: AM, Australian Museum, Sydney, Australia; ANSP, Academy of Natural Sciences, Philadelphia, USA; CPC, Geoscience Australia, Canberra, Australia; MHNG, Muséum d'Histoire Naturelle, Genève, Switzerland; MNHN, Muséum National d'Histoire Naturelle, Paris, France; MV, Museum of Victoria, Melbourne, Australia; NHMUK, Natural History Museum, London, U.K.; SAMA, South Australian Museum, Adelaide, Australia; SMF, Senckenberg Natur-Museum, Frankfurt am Main, Germany; TWCMS, Great Northern Museum (formerly Hancock Museum), Newcastle-upon-Tyne, U.K.; UMZC, University Museum of Zoology, Cambridge, U.K.; WAM, Western Australian Museum, Perth, Australia; ZMB, Museum für Naturkunde, Humboldt-Universität, Berlin, Germany. Other abbreviations used are: D, shell diameter; H, shell height; W, number of whorls. This paper follows the structure of Breure (2011) and Breure and Ablett (2011), with

an additional section on types in non-Australian museums; given the recent papers by e.g. Neubert and Janssen (2004), Köhler (2007), and Breure and Ablett (2012), this sections presents only a compilation of information. Figs 1–2 presents the type localities of species. The dimensions of the specimens figured are presented in the text.

Systematics

Systematic list of nominal taxa of *Bothriembryon* in Australian museums

Fossil taxa are indicated with an asterisk (*).

Family Bothriembryontidae Iredale, 1939

Remarks. This genus was hitherto classified with the Bulimulidae (Pilsbry 1900, Breure 1979, B.J. Smith 1992). Recent phylogenetic studies of the superfamily show that the Gondwanan group within the Orthalicoidea (Placostylidae sensu Neubert et al. 2009, *Bothriembryon*, *Prestonella*, *Plectostylus*, and *Discoleus*) appears to be monophyletic (Breure et al. 2010, Breure and Romero in press). Thus the oldest family name, i.e. Bothriembryontidae, is used herein for this group.

Bothriembryon Pilsbry, 1894

balteolus Iredale, 1939; *barretti* Iredale, 1930; *bradshawi* Iredale, 1939; **consors* Kendrick, 1978; *distinctus* Iredale, 1939; **douglasi* Kendrick, 1978; *esperantia* Iredale, 1939; *eventus* Iredale, 1939; *franki* Iredale, 1939; **gardneri* Kendrick, 1978; *glauerti* Iredale, 1939; *grantianus* Iredale, 1939; *gratwicki* (Cox, 1899); *hullianus* Iredale, 1939; *humilis* Pilsbry, 1900; *indictus* Iredale, 1939; *irvineanus* Iredale, 1939; *jacksoni* Iredale, 1939; *kendricki* Hill, Johnson & Merrifield, 1983; **kremnobates* Kendrick, 2005; *notatus* Iredale, 1939; *perditus* Iredale, 1939; *perobesus* Iredale, 1939; *perspectus* Iredale, 1939; *praecelsus* Iredale, 1939; **praecursor* McMichael, 1968; *revectus* Iredale, 1939; *richeanus* Iredale, 1939; **ridei* Kendrick, 1978; *sedgwicki* Iredale, 1939; *serpentinus* Iredale, 1939; *solidus* Pilsbry, 1900; *whitleyi* Iredale, 1939; *wrightianus* Iredale, 1939.

Alphabetic list of taxa by species name

Bothriembryon balteolus Iredale, 1939

http://species-id.net/wiki/Bothriembryon_balteolus

Fig. 6A

Bothriembryon balteolus Iredale 1939: 21, pl. 2 fig. 9; Wells 1977: 52; B.J. Smith 1992: 101.

Type locality. [Western Australia] “Esperance Mallee Belt district, 50 miles south of Norseman, Madura, Salmon Gums”.

Label. “Mallee belt / Esperance / WA”.

Dimensions. “length 21 mm, breadth 15 mm”; lectotype H 21.5, D 13.6, W 5.0.

Type material. WAM S15154, lectotype; AM C100716, paralectotype; AM C127557, three paralectotypes; AM C127558, two paralectotypes; WAM S15151, nine paralectotypes; WAM S15152, two paralectotypes; WAM S15153, two paralectotypes.

Remarks. Wells (1977: 52) designated specimen WAM 9876 (now WAM S15154) as lectotype. Iredale’s description was based on “Many shells...”.

Current systematic position. Bothriembryontidae, *Bothriembryon balteolus* Iredale, 1939.

***Bothriembryon barretti* Iredale, 1930**

http://species-id.net/wiki/Bothriembryon_barretti

Fig. 7A

Bothriembryon barretti Iredale 1930: 119, fig.; Iredale 1939: 35, pl. 2 figs 41–42; B.J. Smith 1992: 101.

Type locality. [South Australia] “Nullabor Plain”.

Label. “Nullabor Plains” “near Hampton / WA / fide Iredale 1939”.

Dimensions. “length, 27 mm; breadth, 15.5 mm”; figured specimen H 28.1, D 16.5, W 5.3.

Type material. AM C56628, two syntypes, C. Barrett leg.

Remarks. The additional label information “near Hampton” (see also Iredale 1939: 36) probably refers to Hampton Tableland; this extends along the Eyre Highway between Eyre and Eucla.

Current systematic position. Bothriembryontidae, *Bothriembryon barretti* Iredale, 1930.

***Bothriembryon bradshawi* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_bradshawi

Fig. 5F

Bothriembryon bradshawi Iredale 1939: 24, pl. 2 fig. 14; Wells 1977: 52; B.J. Smith 1992: 102.

Type locality. [Western Australia] “Tambellup”.

Label. “Tambellup / WA”.

Dimensions. “Length, 19.5 mm., breadth, 12 mm”; figured specimen H 19.0, D 11.4, W 4.7.

Type material. AM C100749, syntype; AM C59096, nine syntypes; AM C59208, 30+ syntypes; WAM S15148, four syntypes; WAM S15149, two syntypes; WAM S15150, one syntype (all ex E.R. Bradshaw).

Remarks. Iredale's description is based on "A good series" of shells. According to Wells (1977) the WAM collection holds five paratypes.

Current systematic position. Bothriembryontidae, *Bothriembryon bradshawi* Iredale, 1939.

***Bothriembryon inflatus castaneus* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_inflatus_castaneus

Fig. 4C

Bothriembryon inflatus castaneus 'Deshayes' Pilsbry 1900: 5, pl. 1 fig. 18 [not fig. 11];

Kendrick and Wilson 1975: 315, pl. 1 figs 3a–3b; B.J. Smith 1992: 105.

Bothriembryon castaneus Pilsbry; Iredale 1939: 19, pl. 2 fig. 2.

Type locality. [Western Australia] "Recherche Archipelago (*Dr. Cox*)". See Remarks.

Label. "Reserch [sic] / Archipelago / W. Australia".

Dimensions. "Alt. 22, diam. 13 (...) mill."; figured specimen H 23.1, D 13.8, W 5.1.

Type material. AM C87458, syntype (Cox coll.).

Remarks. Kendrick and Wilson (1975), in their valuable study on type specimens of *Bothriembryon*, have argued why the type locality as given by Pilsbry is unlikely; they presume that the specimen originated from Doubtful Island in the Bremer Bay area. It should be noted that this locality is ca. 170 km east from Albany, Bald Head, which is the type locality of *Helix melo* Quoy and Gaimard, 1832, and of their variety *Helix melo castanea* (see next section). Should material from these two localities prove to be sufficiently distinct for systematic separation, it is worth noting that the name *castaneus* Pilsbry, 1900 is a homonym of *castanea* Quoy and Gaimard, 1832. The material is accompanied by a label "selected as type / by Iredale 1939 / p. 19", but this is not regarded as a valid lectotype designation by Iredale.

Current systematic position. Bothriembryontidae, *Bothriembryon melo* (Quoy and Gaimard, 1832).

***Bothriembryon consors* Kendrick, 1978**

http://species-id.net/wiki/Bothriembryon_consors

Figs 3C–E

Bothriembryon consors Kendrick 1978: 54, fig 4F–H.

Type locality. "Windy Harbour, Western Australia. Shallow quarry NE of lighthouse beside track to Salmon Bay. Lat. 34°49'14"S, long. 116°00'52"E. Probably Pleistocene age. See Remarks.

Label. "Windy Harbour, W.A. Shallow / quarry NE of lighthouse beside track / to Salmon Beach", in Kendrick's handwriting.

Dimensions . “height of 29.9 mm, maximum diameter 13.8 mm”; holotype H 30.0, D 13.6, W 5.3.

Type material. WAM 72421a, holotype; WAM 72421b–e, j and k, 70901a–b, 70160d, nine paratypes.

Remarks. Although the formulation differs, this is the same locality where *Bothriembryon gardneri* Kendrick, 1978 has been found.

Current systematic position. Bothriembryontidae, *Bothriembryon consors* Kendrick, 1978.

***Bothriembryon decrensensis* Cotton, 1940**

http://species-id.net/wiki/Bothriembryon_decrensensis

Fig. 5B

Bothriembryon decrensensis Cotton 1940: 40; B.J. Smith 1992: 105.

Type locality. [South Australia] “Cape Cassini, Kangaroo Island”.

Label. “Cape Cassini / K.I.”

Dimensions. “height 16 mm., width 10 mm”; holotype H 15.5, D 10.37, W 4.7 .

Type material. SAMA D13773, holotype; SAMA D15588, 26 paratypes.

Remarks. We tentatively follow the opinion of B.J. Smith (1992) that this taxon is synonymous with *Bothriembryon mastersi* (Cox, 1867). However, a more detailed study should corroborate this view.

Current systematic position. Bothriembryontidae, *Bothriembryon mastersi* (Cox, 1867).

***Bothriembryon distinctus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_distinctus

Fig. 7C

Bothriembryon distinctus Iredale 1939: 36, pl. 2 fig. 43; Wells 1977: 53; B.J. Smith 1992: 101.

Type locality. [Western Australia] “Cardanumbi, west of Eyre”.

Label. “Cardanumbi / WA”.

Dimensions. “length of the type 27 mm., breadth 15.5 mm”; figured specimen H 26.3, D 14.5, W 6.5.

Type material. AM C100727, syntype; AM C127568, three syntypes; WAM S15147, seven syntypes.

Remarks. Iredale (1939) based himself on “A series of shells”. B.J. Smith (1992) synonymized this taxon with *B. barretti* Iredale, 1930 after comparison of type specimens.

Current systematic position. Bothriembryontidae, *Bothriembryon barretti* Iredale, 1930.

***Bothriembryon douglasi* Kendrick, 1978**

http://species-id.net/wiki/Bothriembryon_douglasi

Figs 3G–H

Bothriembryon douglasi Kendrick 1978: 55, fig. 6A–E.

Type locality. “Sea cliff at the Carrarang-Tamala boundary fence, Edel Land, Shark Bay, Western Australia. Lat. 26°32'26"S, long. 113°26'42"E.

Label. “Sea cliff at the Carrarang- / Tamala boundary fence, Edel Land / from top 25 feet / (7.5 m) of the cliff”, in Kendrick’s handwriting.

Dimensions. “height of 34.2 mm, maximum diameter 19.6 mm”; holotype H 34.2, D 19.1, W 5.7.

Type material. WAM 661036a, holotype; 661036b–c, 681434c, d, g, j, and o, seven paratypes. All material B.R. Wilson and G.W. Kendrick leg., 4.iii.1966.

Current systematic position. Bothriembryontidae, *Bothriembryon douglasi* Kendrick, 1978.

***Bothriembryon esperantia* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_esperantia

Fig. 6B

Bothriembryon esperantia Iredale 1939: 21, pl. 2 fig. 8; Wells 1977: 53; B.J. Smith 1992: 103.

Type locality. [Western Australia] “Esperance”.

Label. “Esperance / WA”.

Dimensions. “Length 23 mm., breadth 15 mm”; figured specimen H 23.9, D 15.0, W 5.2.

Type material. AM C48681, 40+ syntypes; AM C100731, syntype; MV F333, 36 syntypes; MV F26930, four syntypes; WAM S15146, four syntypes.

Remarks. Iredale gives two sets of measurements (“The largest measures 26 mm. by 16 mm.”), but does not mention the total number of specimens he examined.

Current systematic position. Bothriembryontidae, *Bothriembryon esperantia* Iredale, 1939.

***Bothriembryon leeuwinensis eventus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_leeuwinensis_eventus

Fig. 7H

Bothriembryon leeuwinensis eventus Iredale, 1939: 25, pl. 2 fig. 18; Wells 1977: 53; B.J. Smith 1992: 105.

Type locality. [Western Australia] “Margaret River”.

Label. “Margaret River / SWA”.

Dimensions. “the type measuring 23 mm. in length by 14 mm. in breadth”; figured specimen H 22.0, D 12.2, W 4.9.

Type material. AM C100771, syntype; AM C127657, three syntypes; WAM S15124, 11 syntypes.

Remarks. Iredale (1939) refers to “Another series from Margaret River”; this may refer to the village “Margaret River”, or to a location along the Margaret River watercourse. In the latter case it is more likely to be in the coastal area.

Current systematic position. Bothriembryontidae, *Bothriembryon leeuwinensis* (E.A. Smith, 1894).

***Bothriembryon franki* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_franki

Fig. 8B

Bothriembryon franki Iredale 1939: 29, pl. 2 fig. 25.

Bothriembryon fuscus franki Iredale; Smith 1992: 103.

Type locality. [Western Australia] “Denmark”.

Label. “Denmark / Deep River / WA”.

Dimensions. “Length 40 mm., breadth 21 mm.”; figured specimen H 40.0, D 19.6, W 5.2.

Type material. AM C100728, syntype; AM C127672, 35 syntypes; MV F3332, nine syntypes; MV F26911, four syntypes; WAM S15145, six syntypes.

Remarks. The text in Iredale (1939) has led to some confusion with later authors. Under the heading “*Bothriembryon fuscus* Thiele 1930” Iredale described shells (“a very large series”) from Denmark as *Bothriembryon franki* (see the legend of his pl. 2; not *B. fuscus franki* as Smith (1992) suggested). The type locality Deep River is ca. 100 km W Denmark in the Walpole area. The shells he referred to as collected by S.W. Jackson at “Deep River, Nornalup Inlet” were suggested to be identical with *B. fuscus*, which was described by Thiele from Torbay. Wells (1977) erroneously listed the Deep River specimens as types of *fuscus* Thiele. Smith (1992) listed the same specimens as syntypes of *fuscus* from Torbay. See also *Bothriembryon fuscus* on p. 65.

Current systematic position. Bothriembryontidae, *Bothriembryon fuscus* Thiele, 1930.

***Bothriembryon gardneri* Kendrick, 1978**

http://species-id.net/wiki/Bothriembryon_gardneri

Figs 3A–B, F

Bothriembryon gardneri Kendrick 1978: 51, fig. 4A–E.

Type locality. “Point d’Entrecasteaux, Western Australia. Shallow quarry on crest of low ridge of calcarenite on north side of track from Windy Harbour to Salmon Beach. Lat. 34°49'14"S, long. 116°00'52" E“. Probably of Pleistocene age. See Remarks.

Label. “Pt d’Entrecasteaux, WA. / Shallow quarry on low ridge, N side of / track from Windy Harbour to Salmon Beach”, in Kendrick’s handwriting.

Dimensions. “height of 43.5 mm, maximum diameter 19.5 mm”; holotype H 43.5, D 18.4, W 5.8

Type material. WAM 701603a, syntype; 701603b–c, 66794a–b, 66798a, h and w, seven syntypes; FMNH 194694/3, three paratypes. All material G. Gardner, J.K. Penglase, G.W. Kendrick leg, 1.viii.1970.

Remarks. Although the formulation differs, this is the same locality where *Bothriembryon consors* Kendrick, 1978 has been found.

Current systematic position. Bothriembryontidae, *Bothriembryon gardneri* Kendrick, 1978

***Bothriembryon glauerti* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_glauerti

Fig. 8C

Bothriembryon glauerti Iredale 1939: 29, pl. 2 fig. 24; Wells 1977: 53; B.J. Smith 1992: 103.

Type locality. [Western Australia] “Stirling Ranges”.

Label. “Stirling Range” (see Remarks).

Dimensions. “The type measures 38 mm. in length by 22 mm. in breadth”; figured specimen H 36.7, D 20.8, W 5.5.

Type material. WAM S14466, syntype; WAM S15144, three syntypes, F.R. Bradshaw leg.

Remarks. According to the old WAM registration book (No. 10127) this material was collected by F.R. Bradshaw at Bluff Knoll. This more specific locality was not mentioned by Iredale (1939); the type locality is now restricted to Bluff Knoll. Iredale did not mention on how many specimens his description was based. The relationships between this taxon and *Bothriembryon fuscus* Thiele, 1930, *B. franki* Iredale, 1939 and *B. indutus* (Menke, 1843) need further study.

Current systematic position. Bothriembryontidae, *Bothriembryon glauerti* Iredale, 1939.

***Bothriembryon rhodostomus grantianus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_rhodostomus_grantianus

Fig. 6E

Bothriembryon rhodostomus grantianus Iredale 1939: 21, pl. 2 fig. 5; Wells 1977: 54; B.J. Smith 1992: 107.

Type locality. [Western Australia, Recherche Archipelago] “Charley Island”.

Label. “Charley I / Recherche Arch’o / WA”, “?Type / (?measurements) / Fig’d Spem”.

Dimensions. “length, 40 mm. by breadth, 20 mm.”; figured specimen H 36.5, D 21.2, W 5.5.

Type material. AM C100721, syntype; WAM S15118, four syntypes, A.F. Basset Hull leg., 1921.

Remarks. The AM label indicates that this is the specimen figured by Iredale, but shows doubt about the status of the specimen. Iredale (1939) gives several sets of dimensions, but the ones quoted above are for the “type”; see introduction why we regard Iredale’s specimens generally as syntypes. The possible subspecific status of this taxon needs further confirmation.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (Gray, 1834).

***Bulimus (Liparus) gratwicki* Cox, 1899**

http://species-id.net/wiki/Bulimus_gratwicki

Fig. 8D

Bulimus (Liparus) gratwicki Cox 1899: 435, figs 1–3; Smith 1992: 103.

Type locality. “About 50 miles east of Israelite Bay, Western Australia, two miles from the edge of the cliffs”.

Label. “50 miles E of / Israelite Bay / WA”, taxon label in Cox’ handwriting. See Remarks.

Dimensions. “Length 30 mm. Width about the middle of the body whorl 10 mm”; holotype H 29.5, D 10.3, W 7.4.

Type material. AM C6376, two syntypes; AM C127559, eight syntypes (ex Cox coll.).

Remarks. According to B.J. Smith (1992) the two specimens in lot C6376 are syntypes; they are accompanied by a type written label stating “Type figd P.L.S.N.S.W. XXIV, p. 435 / Isrealite [sic] Bay, W.A. / Pres. Dr. J. C. Cox”. These specimens are, however, smaller than Cox stated and both are unlikely to have been figured. The largest specimen of lot C127599 fits the dimensions given by Cox better and matches the figure. These specimens are accompanied by the label mentioned above with Cox’ handwriting; a second label read reads “fr: near Israelite Bay / W.A.” and also bears the

taxon name in the handwriting of Cox. The status of this taxon needs further clarification. The type locality is well known for fossil marine deposits; all museum material was collected as shells only, and the shape of this taxon is aberrant within the genus *Bothriembryon*, leaving doubt about its systematic classification.

Current systematic position. Status to be determined.

***Bothriembryon rhodostomus hullianus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_rhodostomus_hullianus

Fig. 6G

Bothriembryon rhodostomus hullianus Iredale 1939: 20, pl. 2 fig. 4; Wells 1977: 54; B.J. Smith 1992: 106.

Type locality. [Western Australia, Recherche Archipelago] “Gunton Island”.

Label. “Gunton I / Recherche Arch’o / WA”.

Dimensions. “35 mm. in length by 18 mm. in breadth”; figured specimen H 31.7, D 18.3, W 6.0.

Type material. AM C100718, syntype; WAM S15116, four syntypes, A.F. Basset Hull leg., 1921.

Remarks. The AM specimen is labelled “holotype” (not in Iredale’s but in McMichael’s hand), but does not confirm with the original measurements; moreover, Iredale (1939) states he had more specimens (“shells”). Therefore we consider it a syntype. The possible subspecific status of this taxon needs further confirmation.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (Gray, 1834).

***Bothriembryon physoides humilis* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_physoides_humilis

Fig. 9B

Bothriembryon physoides humilis Pilsbry 1900: 10, pl. 2 figs 33–34; B.J. Smith 1992: 104. *Bothriembryon kingii* (Gray); Iredale 1939: 31, pl. 2 fig. 28.

Type locality. “Western Australia, King George Sound”.

Label. “King George Sound”.

Dimensions. “Alt. 17.5, diam. 10 (...) mill.”; lectotype H 17.2, D 10.1, W 4.8.

Type material. AM C100774, lectotype; AM C1062, two paralectotypes; ANSP 65568, two paralectotypes (dry) and three bodies (alcohol).

Remarks. In his original description, Pilsbry (1900) listed the dimensions of two shells, which originated from Hedley resp. Cox. The latter specimen was apparently regarded by Iredale (1939) as “the type of Pilsbry’s var. *humilis*”. This is to be regarded

as a lectotype designation (ICZN Art. 74.6); Smith (1992) erroneously regarded it as holotype. Later, Baker (1963: 228) erroneously selected the shell figured in Pilsbry 1900 pl. 2 fig. 34 as lectotype (ANSP 65568a).

Current systematic position. Bothriembryontidae, *Bothriembryon kingii* (Gray, 1825).

***Bothriembryon barretti indictus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_barretti_indictus

Fig. 7B

Bothriembryon barretti indictus Iredale 1939: 36; B.J. Smith 1992: 101.

Type locality. [Western Australia] “Eucla”.

Label. “Eucla / SWA”.

Dimensions. “30 mm. in length by 15 mm. in width”; figured specimen H 28.8, D 15.6, W 5.7.

Type material. AM C100730, syntype; AM C127539, three syntypes; AM C532, three syntypes.

Remarks. Iredale (1939) states “The narrow form was figured by Pilsbry [1900], f. 63, and his specimen is here refigured as type of a subspecies, *B. b. indictus* nov.”. Since Iredale mentioned to have had more shells available, we consider all material as syntypes.

Current systematic position. Bothriembryontidae, *Bothriembryon barretti* Iredale, 1930.

***Bothriembryon irvineanus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_irvineanus

Fig. 7F

Bothriembryon irvineanus Iredale 1939: 24, pl. 2 fig. 15; Wells 1977: 53 (as *irvineanus* [sic]); B.J. Smith 1992: 104.

Type locality. [Western Australia] “Cape Naturaliste”.

Label. “Cape Naturaliste / SWA”.

Dimensions. “Length of type, 26 mm.: breadth, 16 mm.”; figured specimen H 24.2, D 19.6, W 5.1.

Type material. AM C100773, syntype; AM C127707, nine syntypes; WAM S15143, three syntypes, Mrs. Irvine leg., 1892.

Remarks. Iredale (1939) based himself on “a series” of shells; we consider therefore all material as syntypes.

Current systematic position. Bothriembryontidae, *Bothriembryon irvineanus* Iredale, 1939.

***Bothriembryon jacksoni* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_jacksoni

Fig. 9C

Bothriembryon jacksoni Iredale 1939: 31, pl. 2 fig. 30; Wells 1977: 53; B.J. Smith 1992: 105.

Type locality. [Western Australia] “Deep River, Frankland River, Nornalup”.

Label. “Deep River / SWA”.

Dimensions. “The length of the type is 27 mm., the breadth 15 mm.”; figured specimene H 27.2, D 14.2, W 5.4.

Type material. AM C100725, syntype; WAM S15142, six syntypes, S.W. Jackson leg., xii.1912.

Remarks. Iredale (1939) did not explicitly state on how many specimens his description was based. This taxon is part of the *Bothriembryon kingii* species complex that extends from the Walpole area in the west to near Hopetoun in the east. Smith (1992) placed this species in the synonymy of *B. kingii* (Gray, 1825). However, we are of the opinion that this species group needs further study to ascertain the systematic position of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon jacksoni* Iredale, 1939.

***Bothriembryon kendricki* Hill, Johnson & Merrifield, 1983**

http://species-id.net/wiki/Bothriembryon_kendricki

Fig. 4F

Bothriembryon kendricki Hill et al. 1983: 238, figs 3–4; B.J. Smith 1992: 104.

Type locality. [Western Australia] “King’s Park, Perth”.

Label. “King’s Park, Perth”.

Dimensions. “height 16.24 mm; width 11.86 mm”; holotype H 16.2, D 11.86, W 4.0.

Type material. WAM S14552, holotype; WAM S4009, eight paratypes; WAM S15125, nine paratypes; WAM S15126, two paratypes; WAM S15127, seven paratypes; WAM S15128, one paratype; WAM S15129, four paratypes; WAM S15130, two paratypes; WAM S15131, five paratypes; WAM S15132, four paratypes; WAM S15133, one paratype; WAM S15134, four paratypes; WAM S15135, one paratype; WAM S15136, 18 paratypes; WAM S15137, four paratypes; WAM S15138, 12 paratypes; WAM S15139, seven paratypes; WAM S15140, one paratype; WAM S15141, one paratype; WAM S15526, four paratypes.

Remarks. The paratypes are—if not from the type locality—from several localities in and around Perth; see Hill et al. 1983: 239.

Current systematic position. Bothriembryontidae, *Bothriembryon kendricki* Hill, Johnson & Merrifield, 1983.

***Bothriembryon kremnobates* Kendrick, 2005**

http://species-id.net/wiki/Bothriembryon_kremnobates

Figs 3I–J

Bothriembryon kremnobates Kendrick 2005: 310, fig. 1A.

Type locality. “Roe Plains, Madura district, Western Australia (...) Late Pliocene”.

Label. “Roe Plains, Madura district, / W.A. Pit 0.5 km N of Hampton Microwave / Repeater Tower. Carbonate sand with PTO / large shells; 0.7–1.1 m / above base of formation / (Roe Calcarenite). Note matrix / within shell is same as Roe / Calcarenite”, in Kendrick’s handwriting.

Dimensions. “Shell height 21.5, max. diameter 14.7 (mm)”; holotype H 21.5, D 14.7, W 5.4.

Type material. WAM 81.847, holotype, V.A. Ryland and G.W. Kendrick leg., 29.ix–4.x.1980; WAM 81.1762, one paratype; WAM 81.1774, one paratype. Paratypes V.A. Ryland, G.W. and W.E. Kendrick leg., 20–23.ix.1976.

Current systematic position. Bothriembryontidae, *Bothriembryon kremnobates* Kendrick, 2005.

***Bulimus mastersi* Cox, 1867**

http://species-id.net/wiki/Bulimus_mastersi

Fig. 5A

Bulimus mastersi Cox 1867: 39; B.J. Smith 1992: 105.

Type locality. “Port Lincoln, South Australia (*Masters*)”.

Label. “Flinders Is., S.A.”, in a later handwriting.

Dimensions. “Long. 0.74, diam. 0.45 unc. [H 18.8, D 11.43 mm]”; figured specimen H 17.4, D 11.77, W 4.7.

Type material. SAMA D11341, one possible syntype.

Remarks. The specimen is slightly smaller than Cox’ original dimensions, and the label is different from that given by Cox (1867). It is considered a possible syntype as there remains some doubt if this shell was part of the original series.

Current systematic position. Bothriembryontidae, *Bothriembryon mastersi* (Cox, 1867).

***Bothriembryon multispirus* Macpherson, 1951**

http://species-id.net/wiki/Bothriembryon_multispirus

Fig. 7E

Bothriembryon multispirus Macpherson 1951: 30; B.J. Smith 1992: 101.

Type locality. [Western Australia] “20 miles west of Cocklebidly Waterhole”.

Label. “20 miles west of Cocklebidly Water / Hole, W.A.”.

Dimensions. “Length 24 mm.; breadth 12 mm.”; holotype H 24.2, D 12.7, W 6.7.

Type material. MV F5716, holotype; F3068, F3073 four resp. two paratypes, Russell Grimwade expedition, ix.1947.

Remarks. B.J. Smith (1992) placed this taxon in the synonymy of *Bothriembryon barretti* Iredale, 1930, based on examination of the types.

Current systematic position. Bothriembryontidae, *Bothriembryon barretti* Iredale, 1930.

***Bothriembryon notatus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_notatus

Fig. 9D

Bothriembryon notatus Iredale 1939: 31, pl. 2 fig. 29; Wells 1977: 54; B.J. Smith 1992: 104.

Type locality. [Western Australia] “Pallinup River”.

Label. “Pallenup R / SWA”.

Dimensions. “Length 24 mm., breadth 11 mm.”; figured specimen H 23.6, D 10.9, W 5.2.

Type material. AM C100726, syntype; AM C127661, four syntypes; WAM S15121, seven syntypes; WAM S15122, six syntypes; WAM S15123, six syntypes.

Remarks. This taxon is part of the *Bothriembryon kingii* species complex that extends from the Walpole area in the west to near Hopetoun in the east. Smith (1992) placed this species in the synonymy of *B. kingii* (Gray, 1825). However, we are of the opinion that this species group needs further study.

Current systematic position. Bothriembryontidae, *Bothriembryon notatus* Iredale, 1939.

***Bulimus onslowi* Cox, 1864**

http://species-id.net/wiki/Bulimus_onslowi

Fig. 5H

Bulimus onslowi Cox 1864: 185; Kendrick and Wilson 1975: 308, pl. 5 figs 1a–b; B.J. Smith 1992: 106.

Type locality. “Dirk Hartog’s Island, Shark Bay, Western Australia”.

Label. See Remarks.

Dimensions. “Long. 0.85, diam. 0.60 unc. [H 21.6, D 15.2 mm]”; figured specimen H 21.7, D 13.9, W 4.6.

Type material. AM C84882, syntype.

Remarks. Kendrick and Wilson (1975) have discussed the type specimen, clarifying that the original label has been lost and that “the dimensions differ slightly from those given by Cox”.

Current systematic position. Bothriembryontidae, *Bothriembryon onslowi* (Cox, 1864).

***Bulimus indutus pallidus* Tate, 1879**

http://species-id.net/wiki/Bulimus_indutus_pallidus

Fig. 7D

Bulimus indutus pallidus Tate 1879: 135; B.J. Smith 1992: 101. Not *Bulimus pallidus* C.B. Adams, 1845.

Type locality. [South Australia, Nullarbor Plain] “Bunda Plateau”.

Label. “Nullarbor Plain”.

Dimensions. Not given; figured specimen H 31.0, D 17.0, W 5.8.

Type material. AM C477, three syntypes.

Remarks. The specimens are labelled as “paratypes”; however, it is unclear on which evidence this is based and the specimens are herein considered as syntypes.

Current systematic position. Bothriembryontidae, *Bothriembryon barretti* Iredale, 1930.

***Bothriembryon perditus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_perditus

Fig. 7I

Bothriembryon perditus Iredale 1939: 32, pl. 2 fig. 32; Wells 1977: 54; B.J. Smith 1992: 106.

Type locality. [Western Australia] “70 miles east of Israelite Bay”.

Label. “70M E of / Israelite Bay / WA”.

Dimensions. “Length of type 24 mm., breadth 12 mm.”; figured specimen H 23.2, D 11.6, W 5.3.

Type material. AM C100720, syntype; AM C127567, three syntypes; WAM S15120, seven syntypes, E. Gatewick leg.

Remarks. From his description it is clear that Iredale (1939) based himself on more than one specimen.

Current systematic position. Bothriembryontidae, *Bothriembryon perditus* Iredale, 1939.

***Bothriembryon perobesus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_perobesus

Fig. 9G

Bothriembryon perobesus Iredale 1939: 28, pl. 2 fig. 22; Wells 1977: 54; B.J. Smith 1992: 106.

Type locality. [Western Australia] “the mouth of the Moore River”.

Label. The material is accompanied by three labels. A very thin fragile old paper label with fine ink reads “Moore River, WA”; an old thicker card label with thicker black ink says “mouth of Moore River” and a lined paper label with pencil says “Moore River (mouth of)”.

Dimensions. “The height of the shell is 25 mm., while its breadth is 19 mm.”; holotype H 24.2, D 17.9, W 4.9

Type material. WAM S14467, holotype.

Remarks. Iredale (1939) mentioned to have “One specimen” available; therefore we consider this as the holotype. The current taxonomic status of the species needs confirmation.

Current systematic position. Bothriembryontidae, *Bothriembryon perobesus* Iredale, 1939.

***Bothriembryon rhodostomus perspectus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_rhodostomus_perspectus

Fig. 6F

Bothriembryon rhodostomus perspectus Iredale 1939: 21, pl. 2 fig. 7; Wells 1977: 54; B.J. Smith 1992: 107.

Type locality. [Western Australia, Recherche Archipelago] “Woody Isle”.

Label. “Woody I / Recherche Arch’o / WA”.

Dimensions. “length, 31 mm by 17 mm., and 30 mm. by 18 mm.”; figured specimen H 34.5, D 20.0, W 5.9.

Type material. AM C100719, syntype; WAM S15117, two syntypes, A.F. Basset Hull leg., 1921.

Remarks. Iredale (1939) gave two sets of measurements. The specimen in the AM collection does not confirm to these measurements, but bears an original label with the indication “type”; we consider it a syntype but not the holotype. The possible subspecific status of this taxon needs further confirmation.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (Gray, 1834).

***Bothriembryon praecelsus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_praecelsus

Fig. 5I

Bothriembryon praecelsus Iredale 1939: 22, pl. 2 fig. 11; Wells 1977: 54; B.J. Smith 1992: 102.

Type locality. [Western Australia] “Kellerberrin”.

Label. “Kellerberrin”.

Dimensions. “length 29 mm., breadth 20 mm.”; figured specimen H 27.1, D 17.9, W 4.8

Type material. WAM S14468, holotype.

Remarks. Iredale (1939) mentioned to have “One specimen” available; therefore we consider this as the holotype. This species, which was synonymized by Smith (1992) with *Bothriembryon bulla* (Menke, 1843), is now thought to be extinct (DEC 2010).

Current systematic position. Bothriembryontidae, *Bothriembryon praecelsus* Iredale, 1939.

***Bothriembryon praecursor* McMichael, 1968**

http://species-id.net/wiki/Bothriembryon_praecursor

Fig. 3M

Bothriembryon praecursor McMichael 1968: 149, pl. 11 figs 7–9; Crespin 1974: 125.

Type locality. [Northern Territory] “4 miles east-north-east of Deep Well homestead, near Alice Springs, N.T.”.

Label. No labels, see Remarks.

Dimensions. “Maximum height 14.00, maximum diameter 9.00 (mm)”; holotype H 14.17, D 9.03, W 3+.

Type material. CPC6906, holotype; CPC6907–CPC6909, three paratypes.

Remarks. This is a fossil species from Tertiary age; no further details are known about the dating of the horizon where the shells were found. “The holotype is an isolated steinkern of an immature shell” (McMichael 1968); the top of the shell is damaged. The paratypes are larger, up to 20.0 mm. The specimens are not accompanied with labels, but Crespin (1974) provides as data “6.5 km ENE of Deep Well hstd [homestead], near Alice Springs, N.T. (loc. Rd21)” [Holotype and paratypes 1–2], “18 km NE of Deep Well hstd, near Alice Springs, N.T. (loc. NT409)” [Paratype 3].

Current systematic position. Bothriembryontidae, *Bothriembryon praecursor* McMichael, 1968.

***Bothriembryon revectus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_revectus

Fig. 9E

Bothriembryon revectus Iredale 1939: 33, pl. 2 fig. 37; B.J. Smith 1992: 106.

Type locality. [Western Australia] “Bow River”.

Label. “Bow River / SWA”.

Dimensions. “23 mm. in length by 11 mm. in breadth”; figured specimen H 21.8, D 11.2, W 5.2.

Type material. AM C100723, syntype; AM C127676, seven syntypes; AM C127678, 15 syntypes; AM C127677, two syntypes; WAM S15119, four syntypes, S.W. Jackson, 27.x.1912.

Remarks. Iredale (1939) mentioned to have “some shells” available for his description.

Current systematic position. Bothriembryontidae, *Bothriembryon revectus* Iredale, 1939.

***Bothriembryon richeanus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_richeanus

Fig. 9F

Bothriembryon richeanus Iredale 1939: 24, pl. 2 fig. 16; B.J. Smith 1992: 107.

Type locality. [Western Australia] “Cape Riche”.

Label. “Cape Riche / SWA”.

Dimensions. “24 mm. in length, 13 mm. in breadth”; figured specimen H 23.4, D 12.5, W 5.1.

Type material. AM C100772, syntype; AM C127709, three syntypes; WAM S15109, one syntype (ex Brazier coll.).

Remarks. Iredale (1939) based himself on “a series” of shells.

Current systematic position. Bothriembryontidae, *Bothriembryon richeanus* Iredale, 1939.

***Bothriembryon ridei* Kendrick, 1978**

<http://species-id.net/wiki/Bothriembryon Ridei>

Figs 3K–L

Bothriembryon ridei Kendrick 1978: 56, fig. 6 F–H.

Type locality. “Western side of Dorre Island, Western Australia; limestone cliffs opposite Disaster Cove. Lat. 24°59'52"S, long. 113°07'12"E. Probable Pleistocene age.”

Label. “Dorre Is., W.A., West / side opposite Disaster Cove”, in Kendrick’s handwriting.

Dimensions. “height of 36.3 mm, maximum diameter 22.7 mm”; holotype H 36.6, D 22.5, W 5.8.

Type material. WAM 60.434a, holotype; 60.434b, d–e, 66.660a, 74.531a, five paratypes. W.D.L. Ride leg.

Current systematic position. Bothriembryontidae, *Bothriembryon ridei* Kendrick, 1978.

***Bothriembryon sedgwicki* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_sedgwicki

Fig. 5G

Bothriembryon sedgwicki Iredale 1939: 22, pl. 2 fig. 12; B.J. Smith 1992: 107.

Type locality. [Western Australia] “Nangeenan via Merredin”.

Label. “Nangeenan / WA”.

Dimensions. “Height 17 mm., breadth 11 mm.”; figured specimen H 15.9, D 10.3, W 4.5.

Type material. AM C100831, syntype; AM C127706, two syntypes; AM C127707, 11 syntypes; WAM S15108, seven syntypes, E. Sedgwick leg.

Remarks. Iredale (1939) had “a series including juveniles” available for his description.

Current systematic position. Bothriembryontidae, *Bothriembryon sedgwicki* Iredale, 1939.

***Bothriembryon serpentinus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_serpentinu

Fig. 4G

Bothriembryon serpentinus Iredale 1939: 22, pl. 2 fig. 10; Wells 1977: 55; B.J. Smith 1992: 104.

Type locality. [Western Australia] “Serpentine Falls, Darling Range”.

Label. “Serpentine Falls / WA”.

Dimensions. “28 mm. in length and 16 mm. in breadth”; figured specimen H 27.5, D 15.4, W 5.2.

Type material. AM C100724, syntype; AM C127679, six syntypes; WAM S15107, 50 syntypes, Glauert leg., 1.vi.1927.

Remarks. The original description was based on “A large series of shells”. Smith (1992) mentioned 60 paratypes in the WAM collection. He synonymized this taxon

with *Bothriembryon indutus* (Menke, 1843). We consider *B. serpentinus* a distinct taxon, but this needs confirmation by anatomical and molecular research.

Current systematic position. Bothriembryontidae, *Bothriembryon serpentinus* Iredale, 1939.

***Bothriembryon kingii solidus* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_kingii_solidus

Fig. 9H

Bothriembryon kingii solidus Pilsbry 1900: 9, pl. 2 fig. 28; B.J. Smith 1992: 107.

Bothriembryon sayi (Pfeiffer); Iredale 1939: 33, pl. 2 fig. 34.

Type locality. “Western Australia, exact habitat unknown”; restricted to Margaret River (Iredale 1939: 33).

Label. “Western / Australia”.

Dimensions. Not given. Figured specimen H 31.8, D 13.2, W 6.0.

Type material. AM C100722, syntype; AM C127708, two syntypes (ex Cox coll.).

Remarks. As it is clear that this material was seen by Pilsbry, this material is herein considered as syntypes. It is not clear whether Iredale referred to “Margaret River” as a place or as geographical feature. The latter Margaret River flows near Cape Mentelle into the Indian Ocean; Cape Freychinet—type locality of *Bothriembryon sayi* (Pfeiffer, 1847)—is ca. 20 km to the south.

Current systematic position. Bothriembryontidae, *Bothriembryon sayi* (Pfeiffer, 1847).

***Liparus spenceri* Tate, 1894**

http://species-id.net/wiki/Liparus_spenceri

Fig. 7K

Liparus spenceri Tate 1894: 192; Tate 1896: 202, pl. 17 fig. 3; B.J. Smith 1992: 107.

Type locality. [Northern Territory, near Alice Springs] “Glen of Palms by the junction with Palm Creek” (Tate 1896: 202).

Label. “Glen of Palms C.A.”.

Dimensions. “Length, 20; width 12.5 (...) mm”; holotype H 20.0, D 13.36, W 4.5.

Type material. SAMA D3171, holotype; SAMA D11333, 12 paratypes; SAMA D15578, four paratypes.

Remarks. This material was collected during the Horn Scientific Expedition to Central Australia in 1894. Further type material is present in the Natural History Museum in London (Breure and Ablett 2012).

Current systematic position. Bothriembryontidae, *Bothriembryon spenceri* (Tate, 1894).

***Bothriembryon whitleyi* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_whitleyi

Fig. 7J

Bothriembryon whitleyi Iredale 1939: 27, pl. 2 fig. 21; B.J. Smith 1992: 107.

Type locality. [Western Australia] “Geraldton”.

Label. “Geraldton / WA”.

Dimensions. “Height 16 mm., breadth 12.5 mm.”; figured specimen H 14.4, D 10.0, W 4.5.

Type material. AM C100729, syntype; AM C127615, 31 syntypes; AM C127713, three syntypes; WAM S1368, six syntypes; WAM S15106, one syntype, G.P. Whitley leg.

Remarks. The shell in Fig. 7J is somewhat smaller than Iredale (1939) stated, but agrees with the specimen figured by him; the description is based on “A nice series”. This species is now thought to be extinct (DEC 2010).

Current systematic position. Bothriembryontidae, *Bothriembryon whitleyi* Iredale, 1939.

***Bothriembryon rhodostomus wrightianus* Iredale, 1939**

http://species-id.net/wiki/Bothriembryon_rhodostomus_wrightianus

Fig. 6D

Bothriembryon rhodostomus wrightianus Iredale 1939: 21, pl. 2 fig. 6; Wells 1977: 54; B.J. Smith 1992: 107.

Type locality. [Western Australia, Recherche Archipelago] “Rabbit Island”.

Label. “Rabbit I. / Recherche Arch’o / WA”.

Dimensions. “length 36 mm. by breadth 21.5 mm.”; figured specimen H 29.4, D 16.6, W 4+ (see Remarks).

Type material. AM C100717, syntype; AM C48677, 19 syntypes; MV F26933, four syntypes; WAM S15110, five syntypes, A.F. Basset Hull leg., 1921.

Remarks. The top of the specimen figured by Iredale (1939) is damaged; it may be noted that the measurements deviate from the published ones and the description was based on “a fine series”. The possible subspecific status of this taxon needs further confirmation.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (Gray, 1834).

Compilation of *Bothriembryon* type material in non-Australian museums

Additional to the data presented above, the following type specimens have been located in non-Australian museums. References to recently figured type specimens have been added; some other taxa are (re-)figured. Taxa are listed as originally published, arranged alphabetically on species name.

***Bulimus angasianus* Pfeiffer, 1864**

http://species-id.net/wiki/Bulimus_angasianus

Bulimus angasianus Pfeiffer 1864: 528; Breure and Ablett 2012: 5, figs 2A–B.

Type material. NHMUK 1870.10.26.176, six syntypes; TWCMS T0230.1–3, three syntypes.

Current systematic position. Bothriembryontidae, *Bothriembryon angasianus* (Pfeiffer, 1864).

***Bulimus baconi* Benson, 1854**

http://species-id.net/wiki/Bulimus_baconi

Fig. 4E

Bulimus baconi Benson 1854: 99.

Type material. UMZC 2397, holotype.

Remarks. We follow B.J. Smith (1992) for the systematic position of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon bulla* (Menke, 1843).

***Bothriembryon gunni brachysoma* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_gunni_brachysoma

Fig. 7L

Bothriembryon gunni brachysoma Pilsbry 1900: 19, pl. 3 fig. 53.

Type material. ANSP 8461, holotype.

Remarks. This taxon was placed in the synonymy of *Bothriembryon tasmanicus* (Pfeiffer, 1853) by Iredale (1937: 313). We tentatively follow his judgement, but further study should clarify the status of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon tasmanicus* (Pfeiffer, 1853).

***Bulimus (Liparus) brazieri* Angas, 1871**

http://species-id.net/wiki/Bulimus_brazieri

Bulimus (Liparus) brazieri Angas 1871: 19, pl. 1 fig. 28; Breure and Ablett 2012: 7, figs 2C–E, 2ii

Type material. NHMUK 1870.11.5.8, lectotype, and one paralectotype (Angas coll.).

Current systematic position. Bothriembryontidae, *Bothriembryon brazieri* (Angas, 1871).

***Helix melo castanea* Quoy & Gaimard, 1832**

http://species-id.net/wiki/Helix_melo_castanea

Fig. 4B

Helix melo castanea Quoy and Gaimard 1832: 109, pl. 9 figs 6–7; Kendrick and Wilson 1975: 315, pl. 1 figs 2a–2b.

Type material. MNHN 24645 (see Remarks).

Remarks. This taxon was described as “Varietas castanea; vitta alba cincta” by Quoy and Gaimard (1832); together with their figures we consider this an indication according to Art. 11.4.3. ICZN. This taxon has been ascribed incorrectly to Deshayes (1838: 245), who merely copied the text and figures of Quoy and Gaimard, e.g. by Pilsbry (1900: 5; see above under *Bothriembryon inflatus castaneus*). As Kendrick and Wilson have shown (1975: 310), the specimen on which Quoy and Gaimard based the name *castanea* was from the same locality as their *Helix melo*. See also *Bothriembryon inflatus castaneus* Pilsbry, 1900.

Current systematic position. Bothriembryontidae, *Bothriembryon melo* (Quoy and Gaimard, 1832).

***Bothriembryon inflatus conispira* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_inflatus_conispira

Fig. 4D

Bothriembryon inflatus conispira Pilsbry 1900: 6, pl. 10 figs 15–17.

Type material. ANSP 8453, lectotype.

Remarks. This taxon was considered a synonym of *Bothriembryon bulla* (Menke, 1843) by B.J. Smith (1992: 102); it was grouped by Richardson (1995) with *B. melo* (Quoy and Gaimard, 1832). We here tentatively follow the latter opinion; however, further study is needed to clarify the status of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon melo* (Quoy and Gaimard, 1832).

***Bulimus dux* Pfeiffer, 1861**

http://species-id.net/wiki/Bulimus_dux

Bulimus dux Pfeiffer 1861: 24; Breure and Ablett 2012: 15, figs 3A–B.

Type material. NHMUK 19598, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon dux* (Pfeiffer, 1861).

***Bothriembryon fuscus* Thiele, 1930**

http://species-id.net/wiki/Bothriembryon_fuscus

Fig. 8A

Bothriembryon fuscus Thiele 1930: 588, fig. 68; Köhler 2007: 142, fig. 76.

Type material. ZMB 67610, holotype.

Remarks. As Köhler (2007) correctly stated, this species was described from a single (but immature) preserved specimen.

Current systematic position. Bothriembryontidae, *Bothriembryon fuscus* Thiele, 1930.

***Bulinus gunnii* Sowerby II in Strzelecki, 1845**

http://species-id.net/wiki/Bulinus_gunnii

Fig. 3N

Bulinus gunnii Sowerby II in Strzelecki 1845: 298, pl. 9 fig. 5 [sic, 6].

Liparus gunnii Sowerby; Harris 1897: 3.

Bulimus [sic] *gunnii* (Sowerby); Kershaw 1987: 1, fig. 1.

Type material. NHMUK PI OR 96907, holotype.

Remarks. This taxon is probably of Pliocene age, found at Hobart, Tasmania in Yellow Limestone (Travertine). Kershaw (1987) copied Sowerby's figure and discussed the relationship between this taxon and *Bothriembryon tasmanicus* (Pfeiffer, 1853). A photograph of the holotype of *B. gunnii* is here presented for the first time since its original publication.

Current systematic position. Bothriembryontidae, *Bothriembryon gunnii* (Sowerby II in Strzelecki, 1845).

***Bothriembryon melo hartogensis* Kobelt, 1901**

http://species-id.net/wiki/Bothriembryon_melo_hartogensis

Fig. 5D

Bothriembryon melo hartogensis Kobelt 1901 [1899–1902]: 770, pl. 112 figs 15–16;
Neubert and Janssen 2004: 212, pl. 14 fig. 160.

Type material. SMF 25909/1a, holotype.

Remarks. We follow B.J. Smith (1992) for the systematic position of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon costulatus* (Lamarck, 1822).

***Bulimus inflatus* Lamarck, 1822**

http://species-id.net/wiki/Bulimus_inflatus

Fig. 5C

Bulimus inflatus Lamarck 1822: 122; Mermod 1951: 728, fig. 78.

Helix costulata ‘Férussac’ Lamarck 1822: 122 (in synonymy).

Type material. MHNG INVE 51162, five syntypes.

Remarks. Kendrick and Wilson (1975: 307–308) resolved the nomenclatural status of both Lamarckian taxa and have pointed out that the type material of *Bulimus inflatus* Lamarck is the same as *Helix costulata* Lamarck; see art. 11.6 jo. 50.7 jo. 72.4.3. ICZN. They considered Mermod’s treatment of this taxon as a lectotype designation (Kendrick and Wilson 1975: 317, pl. 3 figs 4a–4b). “Mermod was most likely acting as first reviser, but his intention was certainly not to designate a lectotype, even if his statement might be considered as an inadvertent lectotype designation.” (Y. Finet, pers. commun.). B.J. Smith (1992: 102–103) erroneously attributed this material to *Helix costulata* and considered the type material of *Bulimus inflatus* “presumably lost”.

Current systematic position. Bothriembryontidae, *Bothriembryon costulatus* (Lamarck, 1822).

***Bulimus kingii* J.E. Gray, 1825**

http://species-id.net/wiki/Bulimus_kingii

Bulimus kingii J.E. Gray 1825: 414; Breure and Ablett 2012: 22, figs 2F–G, 2i

Type material. NHMUK 195910, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon kingii* (J.E. Gray, 1825).

***Bulimus (Liparus) leeuwinensis* E.A. Smith, 1894**

http://species-id.net/wiki/Bulimus_leeuwinensis

Bulimus (Liparus) leeuwinensis E.A. Smith 1894: 94; Breure and Ablett 2012: 24, figs 3C–E.

Type material. NHMUK 1891.11.21.128, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon leeuwinensis* (E.A. Smith, 1894).

***Bothriembryon inflatus maculiferus* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_inflatus_maculiferus

Fig. 6C

Bothriembryon inflatus maculiferus Pilsbry 1900: 5, pl. 1 figs 12–14; Baker 1963: 229.

Type material. ANSP 8450a, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (J.E. Gray, 1834).

***Bothriembryon martensi* Kobelt, 1901**

http://species-id.net/wiki/Bothriembryon_martensi

Fig. 6H

Bothriembryon martensi Kobelt 1901 [1899–1902]: 764, pl. 112 figs 3–4; B.J. Smith 1992: 106; Köhler 2007: 143, fig. 77.

Type material. ZMB 101818a, lectotype.

Remarks. This taxon was placed in the synonymy of *Bothriembryon rhodostomus* (Gray, 1834) by B.J. Smith (1992: 106), apparently not based on examination of the type material. The figure shown by Köhler (2007; here reproduced) is a shell much larger ($H = 44.5$) than any of the taxa currently considered to be *B. rhodostomus*, and the colouration is with darker tones. We tentatively follow here Smith's judgement, but further studies should clarify the status of this taxon.

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (J.E. Gray, 1834).

***Helix melo* Quoy & Gaimard, 1832**

http://species-id.net/wiki/Helix_melo

Fig. 4A

Helix melo Quoy and Gaimard 1832: 109, pl. 9 figs 4–5.

Type material. MNHN 24644, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon melo* (Quoy and Gaimard, 1832).

***Bothriembryon onslowi minor* Pilsbry, 1900**

http://species-id.net/wiki/Bothriembryon_onslowi_minor

Fig. 5E

Bothriembryon onslowi minor Pilsbry 1900: 12, pl. 3 figs 45–46; Kendrick and Wilson 1975: 309.

Type material. ANSP 78504, two syntypes.

Remarks. Kendrick and Wilson (1975) have argued that Iredale (1939) made a mistake when he raised this taxon to full specific status; they considered *minor* Pilsbry a junior subjective synonym of *Bothriembryon costulatus* (Lamarck). They also assumed that Pilsbry's material was collected at Dirk Hartog Island; however, without positive evidence. Examining one of the syntypes the sculpture of the upper whorl shows a characteristic pattern of strong granules on the upper part of the whorls, and less strong, oblong granules on the lower part which are vanishing on the penultimate and ultimate whorl. This pattern may also be observed in *B. mastersi* (Cox) and relatives. Since Pilsbry's material did not have locality data and this sculpture is not observed in any of the species from Shark Bay, it cannot a priori be excluded that his specimens originated from a different place than the Shark Bay region. Therefore we only tentatively assign this taxon to *B. costulatus*, awaiting further study to clarify the status of *B. minor*.

Current systematic position. Bothriembryontidae, *Bothriembryon ?costulatus* (Lamarck, 1822).

***Bothriembryon kingii naturalistarum* Kobelt, 1901**

http://species-id.net/wiki/Bothriembryon_kingii_naturalistarum

Fig. 7G

Bothriembryon kingii naturalistarum Kobelt 1901 [1899–1902]: 781, pl. 113 figs 22–23; Neubert and Janssen 2004: 219, pl. 14 fig. 161.

Type material. SMF 25891a/1, syntype.

Current systematic position. Bothriembryontidae, *Bothriembryon naturalistarum* Kobelt, 1901.

***Bulimus physoides* Reeve, 1849**

http://species-id.net/wiki/Bulimus_physoides

Bulimus physoides Reeve 1849 [1848–1850]: pl. 70 fig. 507; Breure and Ablett 2012: 31, figs 2H–I.

Type material. NHMUK 1975224, three possible syntypes (Cuming coll.).

Remarks. See the remarks in Breure and Ablett (2012) about the type status of the specimens and the relation with *Bulimus physodes* Menke, 1843. B.J. Smith (1992: 105) has synonymized Menke's taxon with *Bothriembryon melo* (Quoy and Gaimard, 1832); E.A. Smith (1894: 95) mentioned several differences between the two taxa and gave Menke's taxon full species status. We tentatively follow the opinion of B.J. Smith, but further studies are needed to solve the systematic arrangement of both taxa.

Current systematic position. Bothriembryontidae, *Bothriembryon melo* (Quoy and Gaimard, 1832).

***Bulimus rhodostomus* J.E. Gray, 1834**

http://species-id.net/wiki/Bulimus_rhodostomus

Bulimus rhodostomus J.E. Gray 1834: 65; B.J. Smith 1992: 106; Breure and Ablett 2012: 35, figs 3F–G.

Type material. NHMUK 1874.10.28.1, lectotype; 1975222, one paralectotype (ex Gray).

Current systematic position. Bothriembryontidae, *Bothriembryon rhodostomus* (J.E. Gray, 1834).

***Bulimus tasmanicus* Pfeiffer, 1853**

http://species-id.net/wiki/Bulimus_tasmanicus

Bulimus tasmanicus Pfeiffer 1853: 260; Breure and Ablett 2012: 41, figs 3H–I.

Type material. NHMUK 1981204, one syntype.

Current systematic position. Bothriembryontidae, *Bothriembryon tasmanicus* (Pfeiffer, 1853).

***Helix trilineata* Quoy & Gaimard, 1832**

http://species-id.net/wiki/Helix_trilineata

Fig. 9A

Helix trilineata Quoy and Gaimard 1832: 107, pl. 9 figs 1–3.

Type material. MNHN 24642, lectotype.

Current systematic position. Bothriembryontidae, *Bothriembryon kingii* (Gray, 1825).

Acknowledgements

We are grateful to the following colleagues, who generously supplied information or photographs: Dan Gordon, Yves Finet, Robert Hamilton-Bruce, Virginie Héros, Frank Köhler, John Laurie, Amanda Lawless, Philippe Maestrati, Alison Miller, Adnan Moussali, Eike Neubert, Richard Preece, Mandy Reid, Chris Rowley, Jonathan Todd. The visit of ASHB to Western Australia was made possible by generous support from the Diederik van Schagen Fund. Frank Köhler critically reviewed the manuscript and made useful improvements possible.

References

- Angas GF (1871) Descriptions of thirty-four new species of shells from Australia. Proceedings of the Zoological Society of London (1871): 13–21.
- Baker HB (1963) Type land shells in the Academy of Natural Sciences of Philadelphia, II. Land Pulmonata, exclusive of North America north of Mexico. Proceedings of the Academy of Natural Sciences of Philadelphia 115: 191–259.
- Benson WH (1854) Characters of a new European *Pupa*, and of a new Australian *Bulimus*. Annals and Magazine of Natural History (2) 13: 97–99. doi: 10.1080/03745485709495086
- Breure ASH (1974) Caribbean land molluscs: Bulimulidae. I. *Bulimulus*. Studies on the Fauna of Curaçao and other Caribbean Islands 45: 1–80.
- Breure ASH (1979) Systematics, phylogeny and zoogeography of Bulimulinae (Mollusca). Zoologische Verhandelingen Leiden 168: 1–215.
- Breure ASH, Ablett JD (2012) Annotated type catalogue of the Bothriembryontidae and Odontostomidae (Mollusca, Gastropoda, Orthalicoida) in the Natural History Museum, London. ZooKeys 182: 1–70. doi: 10.3897/zookeys.182.2720
- Breure ASH, Groenenberg DSJ, Schilthuizen M (2010) New insights in the phylogenetic relations within the Orthalicoida (Mollusca: Gastropoda), based on 28S sequence data. Basteria 74: 25–31.
- Breure ASH, Romero PE (in press) Support and surprises: molecular phylogeny of the land snail superfamily Orthalicoida (Gastropoda, Stylommatophora) using a three-locus gene analysis with a divergence time analysis and ancestral area reconstruction.

- Cotton BC (1940) The land shells of Kangaroo Island. The South Australian Naturalist 19: 40–43.
- Cox JC (1864) Descriptions of twenty-six new species of Australian land-shells. Annals and Magazine of Natural History (3) 14: 185.
- Cox JC (1867) Characters of four new species of Australian land-shells. Proceedings of the Zoological Society of London (1867): 39–40.
- Cox JC (1899) Description of a new species of *Liparus* from West Australia. Proceedings of the Linnean Society of New South Wales 24: 435–436.
- Crespin I (1974) Catalogue of additional type and figured specimens other than Protista in the Commonwealth Palaeontological Collection, Canberra. Bulletin Bureau of Mineral Resources, Geology and Geophysics 160: 1–161.
- DEC (2010) Declared threatened fauna. http://www.dec.wa.gov.au/component/option,com_docman/task,doc_download/gid,4295/Itemid/ [accessed 25 October 2011]
- Harris GF (1897) Catalogue of Tertiary Mollusca in the Department of Geology, British Museum (Natural History), I. The Australasian Tertiary Mollusca. Longmans and Co., London, xxvi + 407 pp.
- Hill A, Johnson MS, Merrifield H (1983) An electrophoretic and morphological examination of *Bothriembryon kendricki* (Pulmonata: Bulimulidae), a new species previously considered conspecific with *B. bulla* (Menke). Australian Journal of Zoology 31: 227–242. doi: 10.1071/ZO9830227
- Iredale T (1930) Notes on some desert snails. Victorian Naturalist (Melbourne) 47: 118–120.
- Iredale T (1937) A basic list of the land Mollusca of Australia. The Australian Zoologist 8: 287–333.
- Iredale T (1939) A review of the land Mollusca of Western Australia. Records of the Western Australian Museum and Art Gallery 2(1): 1–88. [Published 1.viii.1939; same text republished 21.viii.1939 in Journal of the Royal Society of Western Australia 25:1–88 (read before the Society on 13.ix.1938, but publication delayed)].
- Kendrick GW (1978) New species of fossil nonmarine molluscs from Western Australia and evidence of late Quarternary climatic change in the Shark Bay district. Journal of the Royal Society of Western Australia 60: 49–60.
- Kendrick GW (2005) A new species of *Bothriembryon* (Mollusca: Gastropoda: Bulimulidae) from the Pliocene Roe Calcarene, Eucla Basin, Western Australia. Records of the Western Australian Museum 22: 309–313.
- Kendrick GW, Wilson BR (1975) Nomenclatural notes on the land snail genus *Bothriembryon* Pilsbry, 1894 (Pulmonata: Bulimulidae), with redescriptions of the types and two other species. Records of the Western Australian Museum 3: 295–325.
- Kershaw RC (1987) Type localities for six species of Tasmanian land molluscs (Pulmonata: Stylommatophora). Papers and Proceedings of the Royal Society of Tasmania 121: 57–68.
- Kobelt W (1899–1902) Die Familie Buliminidae. In: Kuster HC, Kobelt W (eds.) Systematisches Conchylien-Cabinet von Martini und Chemnitz 1 (13, 2): 398–1051.
- Köhler F (2007) Annotated type catalogue of the Bulimulidae (Pulmonata, Orthalicoida, Bulimulidae) in the Museum für Naturkunde Berlin. Mitteilungen aus dem Museum für Naturkunde Berlin, Zoologische Reihe 83: 125–159.
- Lamarck JBPA de (1822) Histoire naturelle des animaux sans vertèbres 6 (2). Verdières, Paris, 232 pp.

- Macpherson JH (1951) Land Mollusca of the Russell Grimwade expedition. Memoirs of the National Museum Melbourne 17: 29–31.
- McMichael DF (1968) Non-marine Mollusca from Tertiary rocks in Northern Australia. Bulletin Bureau of Mineral Resources, Geology and Geophysics 80: 135–159.
- Neubert E, Janssen R (2004) Die Typen und Typoide des Natur-Museums Senckenberg, 84: Mollusca: Gastropoda: Pulmonata: Orthalicoidea: Bulimulidae (2), Orthalicidae, Placostylidae. Archiv für Molluskenkunde 133: 193–297.
- Pfeiffer L (1853) Monographia heliceorum viventium: sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum, 3. Brockhaus, Lipsiae, 711 pp.
- Pfeiffer L (1861) Description of fifty-seven new species of land-shells, from the collection of H. Cuming, Esq. Proceedings of the Zoological Society of London (1861): 20–29.
- Pfeiffer L (1864) Description of ten new species of land-shells, from the collection of George French Angas, Esq. Proceedings of the Zoological Society of London (1863): 526–529.
- Pilsbry HA (1900) Australasian Bulimulidae: *Bothriembryon*, *Placostylus*. Helicidae: *Amphidromus*. Manual of Conchology (2) 13: 1–253.
- Quoy JCR, Gaimard JP (1832) Mollusques, 1. In: Dumont d'Urville JSC, Voyage de la corvette l'Astrolabe, exécuté par l'ordre du Roi, pendant les années 1826–1827–1828–1829, Zoologie 2: 1–320. J. Tastu, Paris.
- Richardson CL (1995) Bulimulidae: catalog of species. Tryonia 28: 1–458.
- Shorthouse DP (2010) SimpleMappr, a web-enabled tool to produce publication-quality point maps. <http://www.simplemappr.net> [accessed 18 November 2011]
- Smith BJ (1992) Non-marine Mollusca. In: Houston WWK (Ed) Zoological Catalogue of Australia, 8. Australian Government Publishing Service, Canberra, xii + 405 pp.
- Smith EA (1894) On the land-shells of Western Australia. Proceedings of the Malacological Society of London 1: 84–99.
- Strzelecki PE de (1845) Physical description of New South Wales and Van Diemen's Land, accompanied by a geological map, sections and diagrams, and figures of the organic remains. Longman, Brown, Green, and Longmans, London, xix + 482 pp.
- Tate R (1879) Descriptions of new species of South Australian pulmoniferous snails. Transactions and Proceedings and Report of the Philosophical Society of Adelaide, South Australia 1878–1879: 133–136.
- Tate R (1894) Brief diagnoses of Mollusca from Central Australia. Transactions of the Royal Society of South Australia 18: 191–194.
- Tate R (1896) Mollusca. In: Spencer WB (Ed) Report on the work of the Horn Scientific Expedition to Central Australia, 2. Zoology: 181–226. Melville, Mullen and Slade, London and Melbourne.
- Wells FE (1977) Type specimens in the Department of Molluscs, Western Australian Museum. Records of the Western Australian Museum 6 (1): 33–61.

Plates

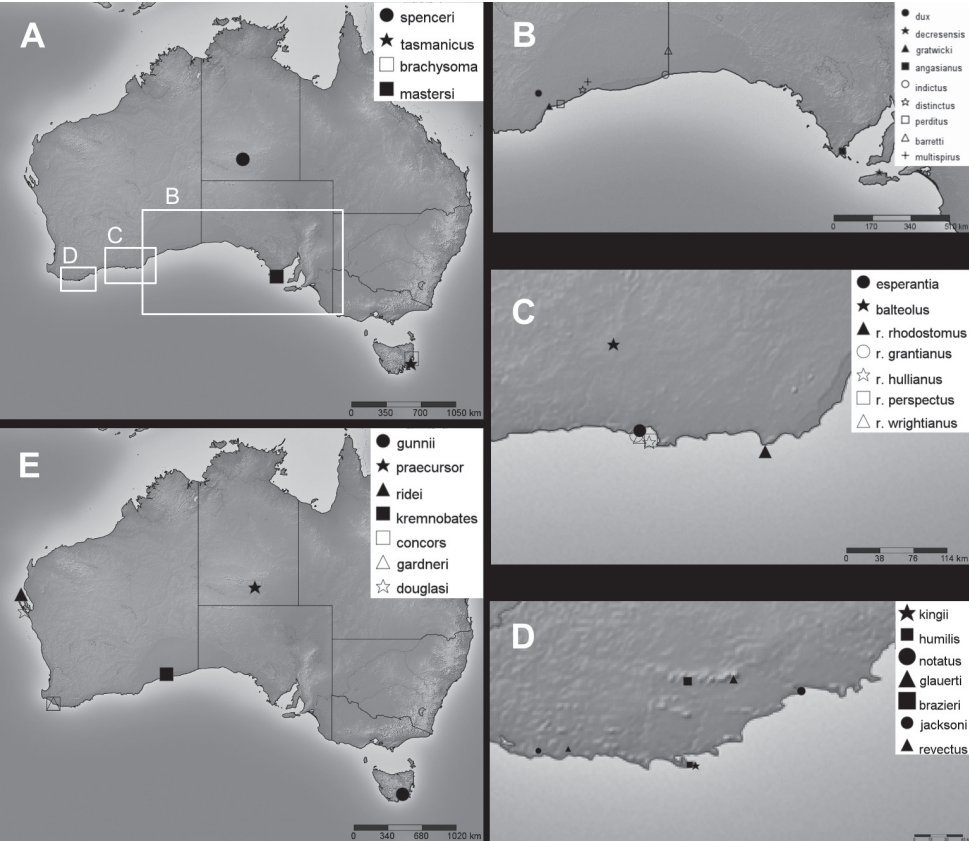


Figure 1. Type localities of *Bothriembryon* taxa, dealt with in this study, for which accurate type locality data are available. **A** Species of central and south-east Australia **B** Species from the eastern South Coast **C** Species from Esperance region **D** Species from Stirling Range and Albany regions **E** Fossil species.

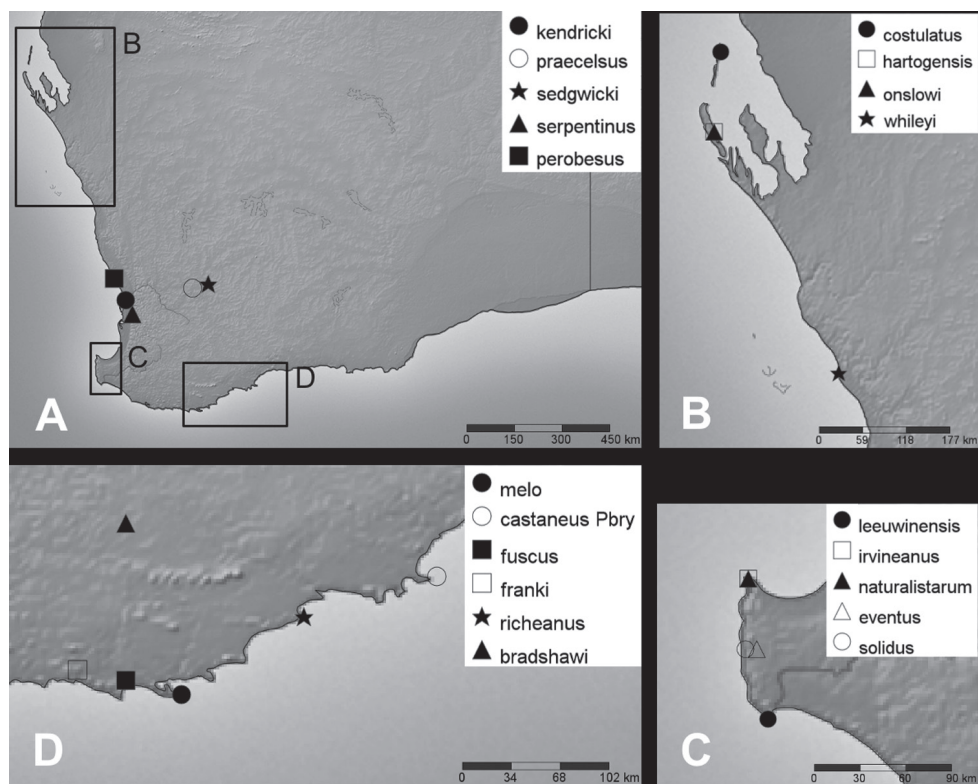


Figure 2. Type localities of *Bothriembryon* taxa (continued). **A** *Bothriembryon* species in Western Australia **B** Species of Shark Bay and adjacent region **C** Species of the Cape Leeuwin and Cape Naturaliste region **D** Species of Albany region.

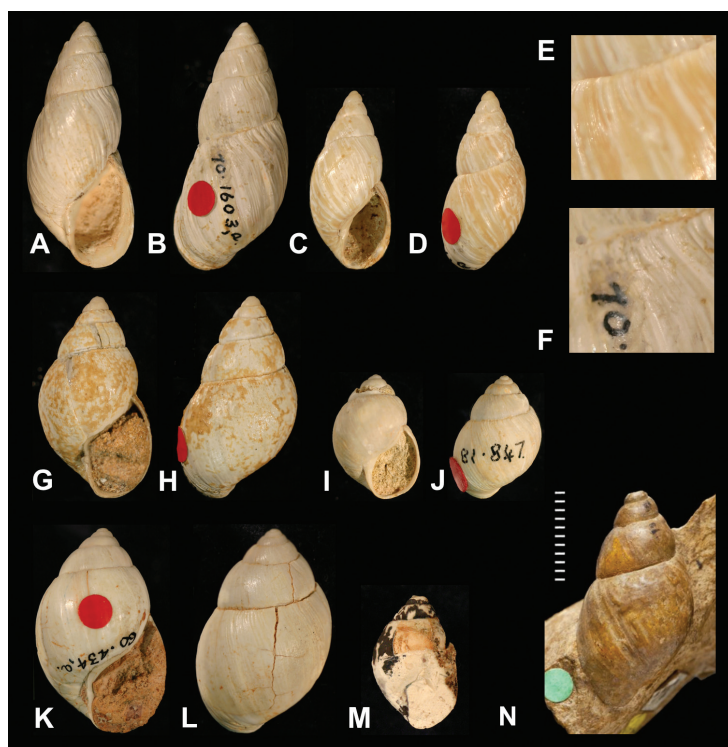


Figure 3. Fossil *Bothriembryon* species. **A, B, F** *B. gardneri* Kendrick, 1978, holotype, WAM 701603a (H = 43.5); **F** sculpture on dorsal side of last whorl **C–E** *B. consors* Kendrick, 1978, holotype, WAM 72421a (H = 30.0); **E** sculpture on dorsal side of last whorl **G–H** *B. douglasi* Kendrick, 1978, holotype, WAM 661036a (H = 34.2) **I–J** *B. kremnobates* Kendrick, 2005, holotype, WAM 81.847 (H = 21.5) **K–L** *B. ridei* Kendrick, 1978, holotype, WAM 60.434a (H = 36.6) **M** *B. praecursor* McMichael, 1968, holotype, CPC 6906 (H = 14.17) **N** *B. gunnii* (Sowerby II, 1845), holotype, NHMUK PI OR 96907 (H = 25.1).

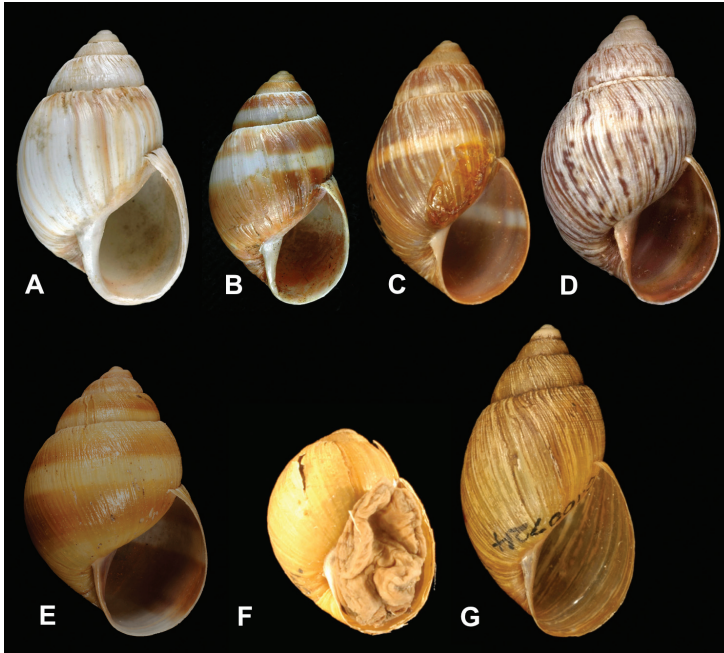


Figure 4. A–D *Bothriembryon melo* (Quoy and Gaimard, 1832) **A** Lectotype, MNHN 24644 (H = 24.7) **B** Paralectotype, *Helix melo castanea* Quoy and Gaimard, 1832, MNHN 24645 (H = 20.6) Photos: P. Maestrati **C** Syntype of *Bothriembryon inflatus castaneus* Pilsbry 1900, AM C87458 (H = 23.1) Photo: A. Miller **D** Lectotype of *B. inflatus conispira* Pilsbry, 1900, ANSP 8453 (H = 25.2) Photo: A. Lawless **E** *B. bulla* (Menke, 1843), holotype of *Bulimus baconi* Benson, 1854, UMZC 2397 (H = 23.6) Photo: R. Preece **F** *B. kendricki* Hill, Johnson & Merrifield, 1983, holotype, WAM S14552 (H = 16.2) **G** *B. serpentinus* Iredale, 1939, syntype, AM C100724 (H = 27.5).

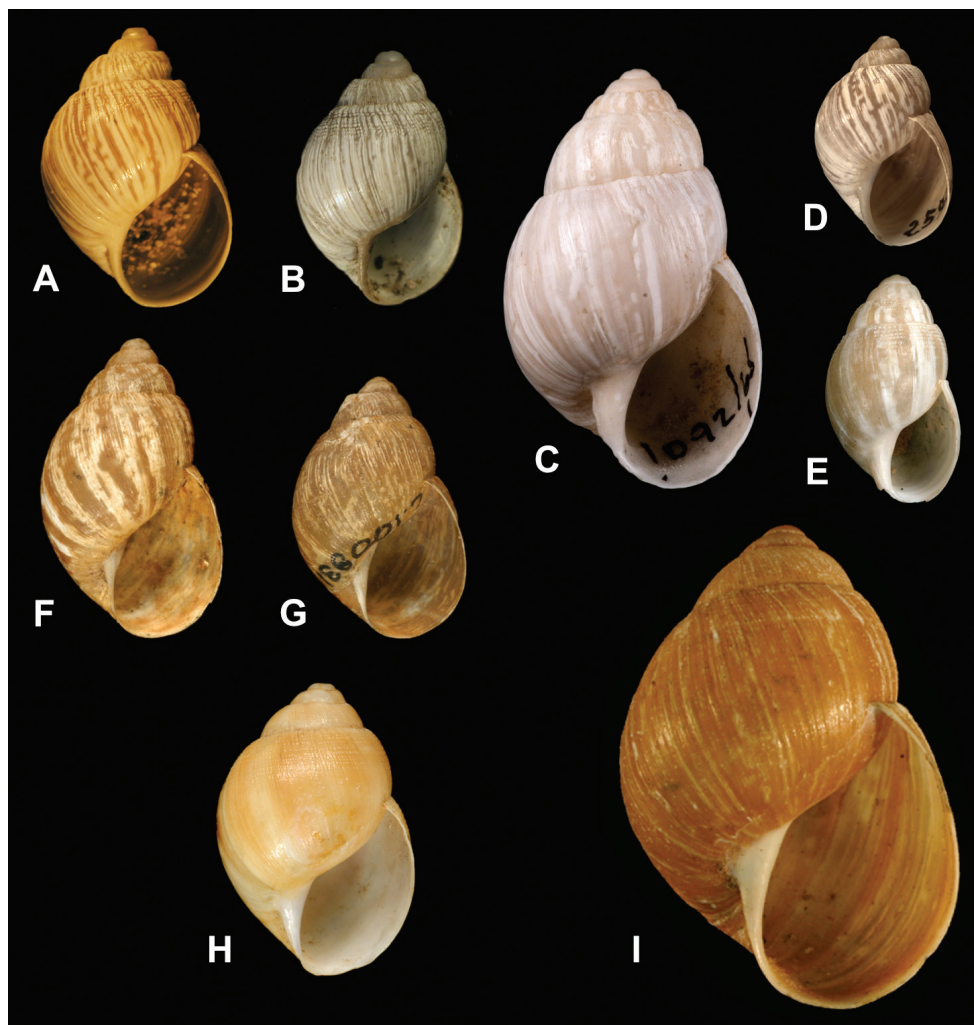


Figure 5. A–B *Bothriembryon mastersi* (Cox, 1867) **A** Possible syntype, SAMA D11341 (H = 17.4) **B** Holotype of *B. decresensis* Cotton, 1940, SAMA D13773 (H = 15.5) Photo: R. Hamilton-Bruce **C–E** *B. costulatus* (Lamarck, 1822) **C** Syntype of *Bulimus inflatus* Lamarck, 1822, MHNG INV 51162 (H = 26.0) Photo: Y. Finet **D** Holotype of *B. onslowi hartogensis* Kobelt, 1901, SMF 25909/1a (H = 12.9) Photo: E. Neubert **E** Syntype of *B. onslowi minor* Pilsbry, 1900, ANSP 78504 (H = 14.4) Photo: A. Lawless **F** *B. bradshawi* Iredale, 1939, syntype, AM C100749 (H = 19.0) **G** *B. sedgwicki* Iredale, 1939, syntype, AM C100831 (H = 15.9) **H** *B. onslowi* (Cox, 1864), syntype, AM C84882 (H = 21.7) **I** *B. praeceus* Iredale, 1939, holotype, WAM S14468 (H = 27.1).

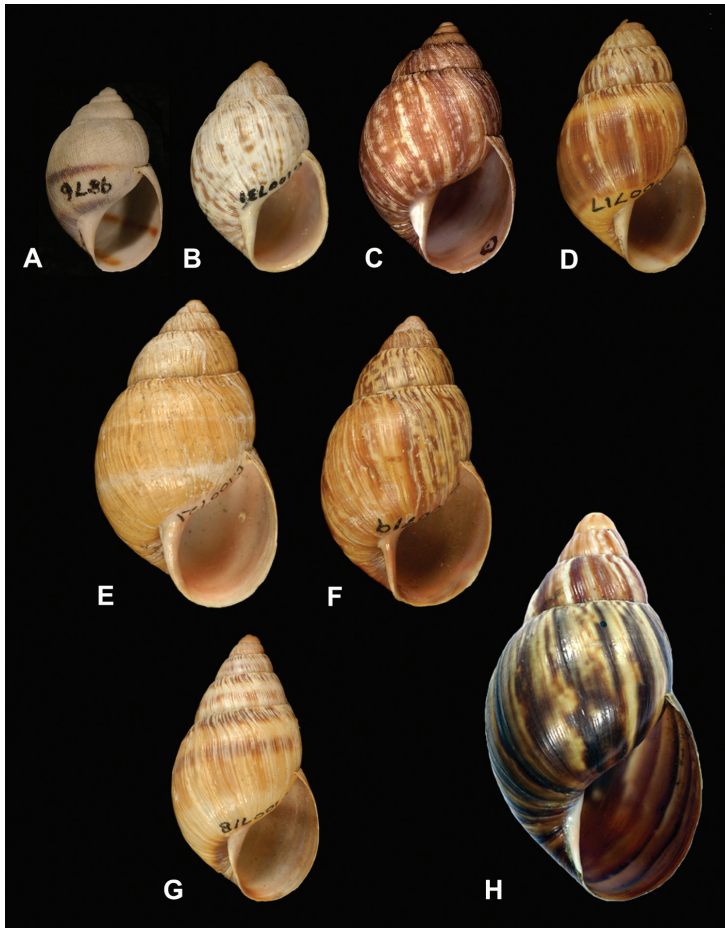


Figure 6. **A** *Bothriembryon balteolus* Iredale, 1939, lectotype, WAM S15154 (H = 21.5) **B** *B. esperantia* Iredale, 1939, syntype, AM C48681 (H = 23.9) **C–G** *B. rhodostomus* (Gray, 1834) **C** Lectotype of *B. inflatus maculiferus* Pilsbry, 1900, ANSP 8450 (H = 28.3) Photo: A. Lawless **D** Syntype of *B. rhodostomus wrightianus* Iredale, 1939, AM C100717 (H = 29.4) **E** Syntype of *B. rhodostomus grantianus* Iredale, 1939, AM C100721 (H = 36.5) **F** Syntype of *B. rhodostomus perspectus* Iredale, 1939, AM C100719 (H = 34.5) **G** Syntype of *B. rhodostomus hullianus* Iredale, 1939, AM C100718 (H = 31.7) **H** Lectotype of *B. martensi* Kobelt, 1901, ZMB 101818a (H = 44.5).

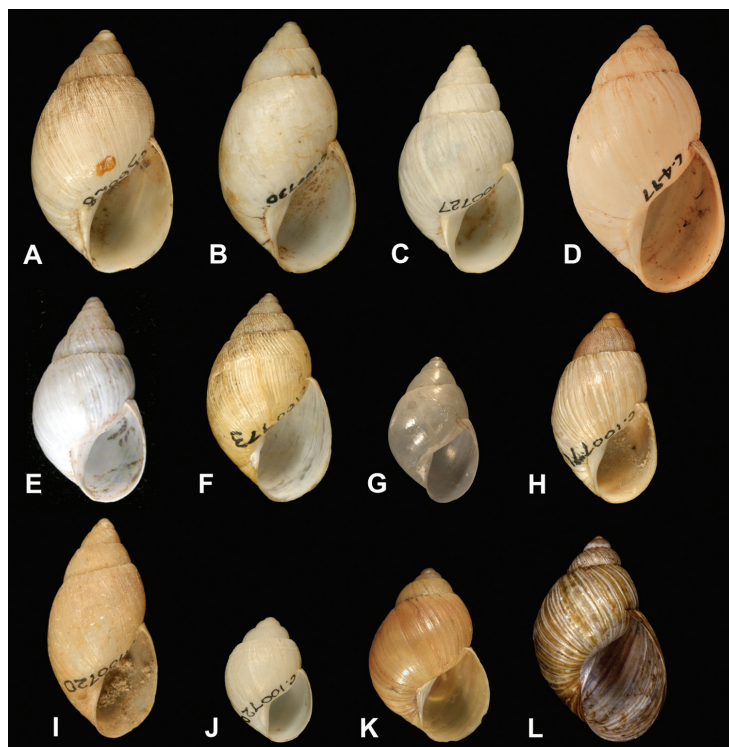


Figure 7. A–E *Bothriembryon barretti* Iredale, 1939 **A** Syntype, AM C56628 (H = 28.1) **B** Syntype of *B. indictus* Iredale, 1939, AM C100730 (H = 28.8) **C** Syntype of *B. distinctus* Iredale, 1939, AM C100727 (H = 26.3) **D** Syntype of *Bulimus industus pallidus* Tate, 1879, AM C477 (H = 31.0) **E** Holotype of *B. multispirus* Macpherson, 1951, MV F5716 (H = 24.2) **F** *B. irvineanus* Iredale, 1939, syntype, AM C100773 (H = 24.2) **G** *B. naturalistarum* Kobelt, 1901, syntype, SMF 25891/1a (H = 17.0) Photo: E. Neubert **H** *B. leeuwinensis* (E.A. Smith, 1894), syntype of *B. leeuwinensis eventus* Iredale, 1939, AM C100771 (H = 22.0) **I** *B. perditus* Iredale, 1939, syntype, AM C100720 (H = 23.2) **J** *B. whitleyi* Iredale, 1939, syntype, AM C100729 (H = 14.4) **K** *B. spenceri* (Tate, 1894), holotype, SAM D3171 (H = 20.0) **L** *B. tasmanicus* (Pfeiffer, 1853), holotype of *B. gunni brachysoma* Pilsbry, 1900, ANSP 8461 (H = 20.4) Photo: A. Lawless.

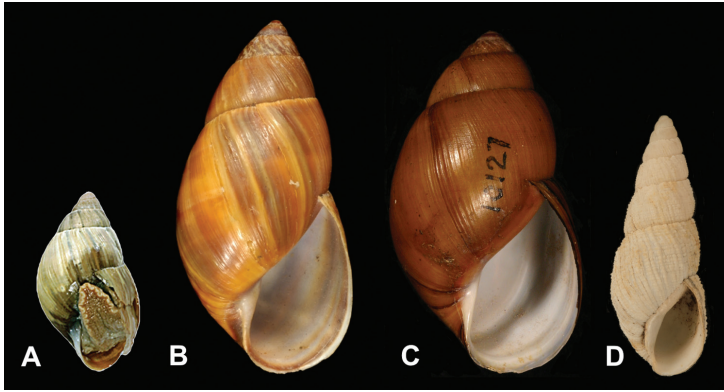


Figure 8. **A–B** *Bothriembryon fuscus* Thiele, 1930 **A** Holotype, ZMB 67610 (H = 20.0) Photo: F. Köhler **B** Syntype of *B. franki* Iredale, 1939, AM C100728 (H = 40.0) **C** *B. glauerti* Iredale, 1939, syntype, WAM S14466 (H = 36.7) **D** *Bulimus (Liparus) gratwicki* Cox, 1899, syntype, AM C127559 (H = 29.5).

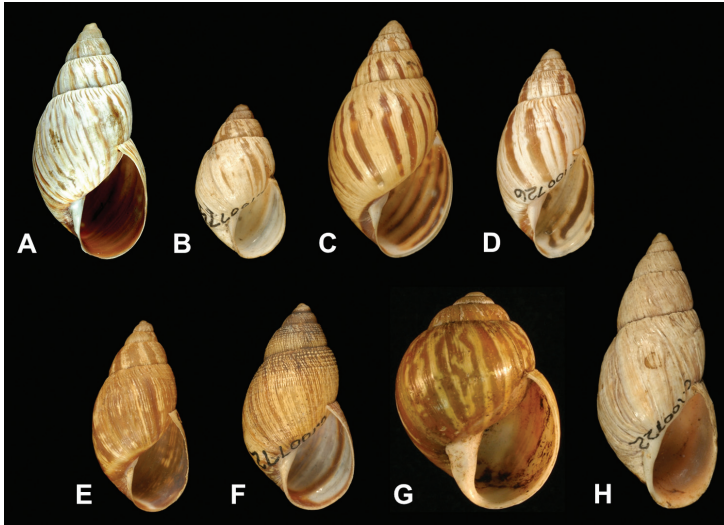


Figure 9. **A–E** Species complex of *Bothriembryon kingii* (J.E. Gray, 1825) **A** Lectotype of *Helix trilineata* Quoy and Gaimard, 1832, MNHN 24642 (H = 27.1) Photo: P. Maestrati **B** Lectotype of *B. physoides humilis* Pilsbry, 1900 AM C100774 (H = 17.2) **C** *B. jacksoni* Iredale, 1939, syntype, AM C100725 (H = 27.2) **D** *B. notatus* Iredale, 1939, syntype, AM C100726 (H = 23.6) **E** *B. revectus* Iredale, 1939, syntype, AM C100723 (H = 21.8) **F** *B. richeanus* Iredale, 1939, syntype, AM C100772 (H = 23.4) **G** *B. perobesus* Iredale, 1939, holotype, WAM S14467 (H = 24.2) **H** *B. sayi* (Pfeiffer, 1847), syntype of *B. kingii solidus* Pilsbry, 1900, AM C100722 (H = 31.8).