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A new genus, *Denhamiana* gen. nov., and two new species of land snail from inland central Queensland (Eupulmonata, Camaenidae)

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ABSTRACT

Denhamiana gen. nov. is established for at least two new species of camaenid land snail from inland mid-eastern Queensland. *D. laetifica* sp. nov. occurs in an area stretching from just west of Eungella, southward through the Denham Range to Pine Mountain, south-east of Nebo, while *D. leichhardti* sp. nov. is hitherto known only from the more westerly Carborough Range. A third species ?*Denhamiana* sp. nov. 'Dipperu' is proposed awaiting more specimens. These camaenids are characterised by a combination of morphological features including a large helicoid shell with bold dark brown spiral bands and dark brown apertural lip, a closed umbilicus and a reproductive system featuring a reduced epiphallus, a short vestigial epiphallic flagellum and a cylindrical, sheathed penis that internally has a penial stimulator and triangular verge. Molecular study of one of the species indicates that the genus is a sister group to *Bentosites* Iredale, 1933 whose species occur in coastal and sub-coastal rainforests in localities between Ayr and Sarina, mid-eastern Queensland. □ *Denhamiana* gen.nov., Eupulmonata, Camaenidae, systematics, new species, Queensland, Australia.

The Camaenidae is one of the most speciose groups of land snails in Australia. The family is common in many parts of the continent apart from the south-west and has radiated prolifically in the rainforests of eastern Australia (Smith 1992; Solem 1998; Stanisic *et al.* 2010). Of particular note are the many large helicoid species (historically referred to as the hadroid radiation) that occur in this part of the continent particularly in the region between Bowen and Sarina in mid-eastern Queensland. Sixteen species of large banded camaenids are currently known from the region: *Bentosites* (5 species), *Marilynessa* (5 species), *Temporena* (3 species) and *Sphaerospira* (3 species) (Stanisic *et al.* 2010). However, all of these species occur chiefly in the wetter rainforests and drier vine forests and thickets of the coastal plain and ranges of the region, including some off-lying islands. *Denhamiana* gen. nov. represents the

first record of large, banded, helicoid snails from the inland vine thickets of sub-coastal central Queensland.

MATERIALS AND METHODS

Material used in this study is held in the collections of the Queensland Museum (QMMO). Studies of shell characters were carried out on specimens in the museum's dry collection (RC) and anatomical studies were based on ethanol preserved samples (SC). Measurements of shell characters (height, diameter) were made using callipers with a precision of 0.01 mm. Whorl counts were made to the nearest 1/8 whorl. At least three representatives of each species from their respective type localities were dissected and studied using a WILD M5 stereo microscope with drawing apparatus in order

to confirm stability of reproductive structures. Classification follows Stanisic *et al.* (2010).

ABBREVIATIONS

Anatomy: BC, bursa copulatrix; DG, prostate; E, epiphallus; EC, epiphallic caecum; EP, epiphallic pore; GD, hermaphroditic duct; GG, albumen gland; GT, talon; P, penis; PP, penial pilaster; PRM, penial retractor muscle; PS, penial sheath; PSS, penial stimulator; PV, penial verge; UT, uterus; UV, free oviduct; V, vagina; VD, vas deferens; X, carrefour; Y, atrium.

General: Ck, creek; MEQ, mid-eastern Queensland; Mt, Mount; Mtn, mountain; mvf, microphyll vine forest; NP, National Park; Ra, range; Rd, road; rf, rainforest; sevt, semi-evergreen vine thicket.

SYSTEMATICS

Order EUPULMONATA

Superfamily HELICOIDEA

Family CAMAENIDAE

Genus *Denhamiana* gen. nov.

Type species. *Denhamiana laetifica* sp. nov., herein designated

Etymology. Named for the Denham Range.

Description. Shell large, globosely helicoid, yellowish-brown with prominent sub-sutural and supra-peripheral, dark brown bands and several narrower brown spiral bands on upper part of whorls, and one to several narrow brown spiral bands basally; latter part of body whorl with dark brown suffusion becoming more dense behind aperture and extending onto umbilical area; parietal callus shiny, suffused with brown; lip dark brown. Umbilicus closed. Reproductive system with reduced epiphallus, a tiny vestigial epiphallic flagellum and a cylindrical, sheathed penis that internally has a tongue-like penial stimulator and conical verge with the epiphallic pore situated at the base of the verge. Head wart present.

Distribution and habitat. From west of Eungella at Lake Eungella south through the

Denham Range to Dipperu NP, and west to the Carborough Range, mid-eastern Queensland; living in vine thickets on volcanically derived rocks.

Additional collecting in the Kerlong Range, located adjacent and south-west of the Carborough Range, may yet extend the distribution of the genus.

Remarks. *Denhamiana* gen. nov. exhibits a number of features that readily distinguish it from the other so-called hadroid genera of camaenids in eastern Australia. The large shell, striking shell colour of bold, dark brown spiral bands and dark brown suffusion behind the aperture on a yellowish brown background coupled with the unusual penial anatomy are a combination of characters not seen in any other eastern hadroid genus. In particular the development of a penial stimulator is unique among the large banded eastern Australian camaenids in which there is usually a reduced verge that is short and knob-like and occasionally a main central pilaster, but no stimulator. (Solem 1992; Stanisic unpub.).

Denhamiana laetifica sp. nov.

(Figs 1, 2; Table 1)

Etymology. From the Latin *laetifica* = delightful; a name chosen by Matthew Limbert, a student of Samford State School, Queensland and winner of a 'name the snail' competition.

Preferred common name. Denham Range Banded Snail.

Material examined. Holotype: QMMO68577, Denham Ra., c.2 km NNW Mt Robert, MEQ, (21°21'27"S, 148°28'59"E), vine thicket, S. Wright, 23.x.2000. Height of shell 30.53 mm; diameter 34.57 mm; H/D ratio 0.88.

Paratypes: All MEQ. QMMO36102, 7SC/62RC, Eungella Dam, c.2 km SSW, Eungella Dam - Mt Hillalong Rd, (21°10'S, 148°23'E), sevt, under rocks, J. Stanisic, D. & N. Potter, 21.v.1990; QMMO36234, 16SC/32RC, Dipperu NP, scrub S of Pine Mtn, Sarina - Clermont Rd, (21°46'30"S, 148°50'30"E), vine thicket, in logs and hollow trees, J. Stanisic, D. & N. Potter, 22.v.1990; QMMO54313, 10SC/19RC, Dipperu NP, at Pine Mtn, c.20 km SE Nebo, (21°44'45"S, 148°50'35"E), sevt/Araucaria/volcanics, under rocks and logs, J. Stanisic, D. Potter, G. Ingram, C. Eddie, 23.vii.1994.

Other material. QMMO28519, 1RC, Eungella Dam, c.2 km SSW, Eungella Dam - Mt Hillalong Rd, (21°10'S, 148°23'E), sevt, under rocks, J. Stanisc, D. & N. Potter, 21.v.1990; QMMO35795, 2SC/6RC, Endeavour Ck, Upp Reaches, Clarke Ra, W of Mackay, (21°15'30"S, 148°37'30"E), riverine rainforest, under bark on logs, J. Stanisc, D. & N. Potter, 20.v.1990; QMMO35825, 4RC, Eungella, c.13.5 km SSE, Hazelwood Gorge, (21°14'30"S, 148°26'30"E), vine thicket, under rock, V. Kessner, 20.iii.1992; QMMO36097, 1RC, Eungella Dam, c.1.5 km E, on road to Eungella, W Mackay, (21°10'00"S, 148°23'30"E), rocky outcrop/Ficus, under rocks, J. Stanisc, D. & N. Potter, 21.v.1990; QMMO36230, 2RC, Denham Ra, Homevale - Mt Britton Rd, c.100 km SW Mackay, (21°26'S, 148°35'E), sevt, under rocks, J. Stanisc, D. & N. Potter, 21.v.1990; QMMO36238, 1RC, Sarina, SW at Beautrel Ck, Old Sarina - Marlborough Rd, (22°03'S, 148°59'E), remnant thicket, in logs, J. Stanisc, D. & N. Potter, 22.v.1990; QMMO59242, 7RC, Dipperu NP, at Pine Mtn, c.20 km SE Nebo, (21°45'00"S, 148°50'23"E), sevt/basalt, J. Stanisc, G. Ingram, 13.vii.1995; QMMO59382, 1RC, Dipperu NP, at Pine Mtn, c.20 km SE Nebo, (21°44'45"S, 148°50'35"E), sevt/Araucaria/volcanics, under rocks and logs, J. Stanisc, D. Potter, G. Ingram, C. Eddie, 23.vii.1994; QMMO61415, 5SC/5RC, Dipperu NP, at Pine Mtn, c.20 km SE Nebo, (21°44'45"S, 148°50'35"E), 630m, P. Couper, C. Hoskin, 24.iv.1998; QMMO64903, 1RC, Eungella Dam, W, (21°06'46"S, 148°18'13"E), remnant vine thicket, litter, J. Stanisc, 30.x.1998; QMMO66631, 1RC, Nebo, WNW in Denham Ra., (21°23'04"S, 148°20'31"E), softwood scrub, T. Kitchener, 15.xii.1999; QMMO69882, 1SC, Nebo, NW in Denham Ra, Mt Robert, (21°21'S, 148°29'00"E), 360 m, G. Monteith, D. Cook, 26.iii.2001; QMMO74652, 5RC, Mt Gotthardt Ra, c.5.5k NNE of Mt Cristoe, (21°23'38"S, 148°20'05"E), vine thicket, 400 m, under rocks and in litter, A. Pollock, W. McDonald, 29.vi.2004; QMMO74756, 4RC, Mt Gotthardt Ra., c.4.8k N of Mt Cristoe, (21°24'11"S, 148°19'04"E), vine thicket, 360 m, under logs in litter, A. Pollock, W. McDonald, 29.vi.2004; QMMO74757, 2RC, Mt Gotthardt Ra., c.5.8k NNE of Mt Cristoe, (21°23'45"S, 148°19'53"E), vine thicket, 400 m, under

logs in litter, A. Pollock, W. McDonald, 29.vi.2004; QMMO74764, 1RC, Denham Ra., c.2k NNW of Mt Robert, (21°21'44"S, 148°29'08"E), 360 m, A. Pollock, W. McDonald, 30.vi.2004; QMMO74789, 2RC juveniles, Mt Gotthardt Ra., c.4.8k N of Mt Cristoe, (21°24'11"S, 148°19'04"E), 360 m, under logs in litter, A. Pollock, W. McDonald, 29.vi.2004; QMMO76080, 1SC, Denham Ra, c.2k NNW of Mt Robert, (21°21'S, 148°29'E), 60 m, G. Monteith, D. Cook, 18.xii.2000.

Diagnosis. Shell large, yellowish-brown with prominent sub-sutural and supra-peripheral, dark brown bands and several narrower brown spiral bands on upper part of whorls, and one to several narrow brown spiral bands basally; latter part of body whorl with very prominent, dark brown suffusion behind aperture, extending onto umbilical area; parietal callus shiny, strongly suffused with brown; lip dark brown. Umbilicus closed. Reproductive system with reduced epiphallus, tiny vestigial epiphallic flagellum and a cylindrical, sheathed penis with short penial stimulator and conical verge; epiphallic pore situated laterally at base of verge.

Description. Shell large, globosely helicoid with 5 5/8-6 1/2 normally coiled whorls, rounded above and below the periphery, last descending in front; sutures weakly impressed. Apex and spire moderately to strongly elevated; colour yellowish brown with prominent sub-sutural and supra-peripheral, dark brown bands and several narrower brown spiral bands on upper part of the whorls, and one to several narrow brown spiral bands basally; latter part of body whorl with prominent dark brown suffusion behind aperture, extending onto umbilical area; parietal callus shiny, strongly suffused with



FIG. 1. *Denhamiana laetifica* sp. nov. Shell views, holotype QMMO68577. A, Dorsal; B, apertural; C, ventral. Shell diameter = 34.57 mm.

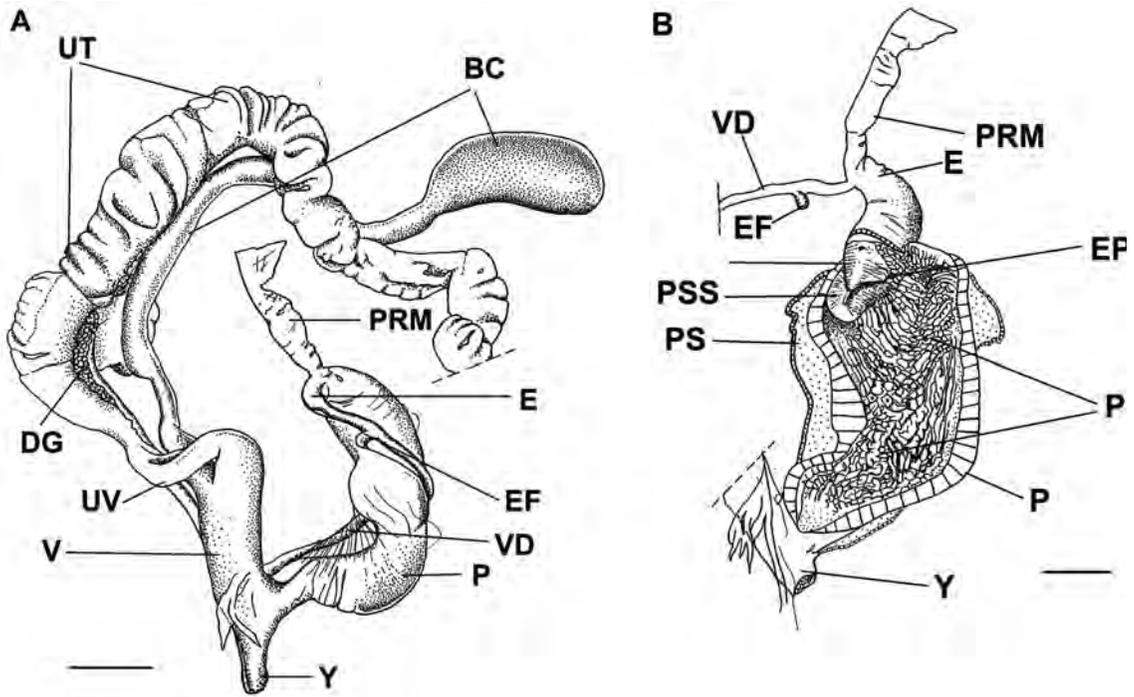


FIG. 2. *Denhamiana laetifica* sp. nov. Genital anatomy, paratype QMMO54313. A, Genital system; B, penial anatomy. Scale lines: A = 4 mm, B = 2 mm.

brown; lip dark brown. Diameter of shell 27.7-37.4 mm, height 26.0-34.1 mm, H/D ratio 0.83-1.08. Protoconch of 1 3/4 whorls, sculptured with very weak radial growth lines. Post-apical whorls with fine, crowded, radially disposed, thread-like periostracal wrinkles. Aperture lunately rounded, lip thickened and reflected.

Umbilicus closed. Based on 86 measured adults (QMMO36102, QMMO36234).

Genitalia. Penis (P) with thin sheath (PS), long, cylindrical with slightly expanded apical bulb, internally with a conical verge (PV) and short, tongue-like stimulator (PSS); walls of upper penial

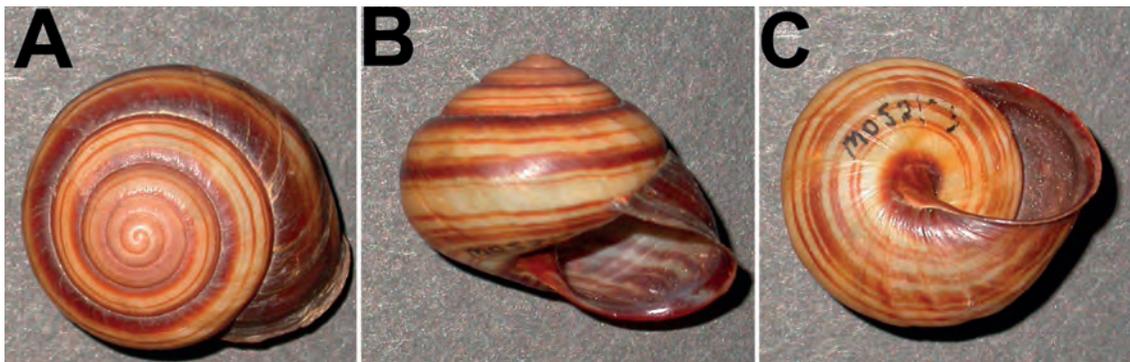


FIG. 3. *Denhamiana leichhardti* sp. nov. Shell views, holotype QMMO52123. A, Dorsal; B, apertural; C, ventral. Shell diameter = 30.94 mm.

New genus, *Denhamiana* gen. nov.

TABLE 1. Comparison of shell measurements for populations of *Denhamiana* gen.nov. [Range, mean and standard error].

	Number	Height	Diameter	H/D ratio	Whorls
<i>D. laetifica</i> sp. nov.	60	26.04-34.06	30.12-37.36	0.83-1.00	5 5/8-6 1/2
QMMO36102		Mean 31.21	Mean 33.98	Mean 0.92	Mean 6 1/8
Eungella Dam		SE ± 0.021	SE ±0.019	SE ±0.005	
<i>D. laetifica</i> sp. nov.	26	26.54-32.54	27.68-31.50	0.91-1.08	5 3/4-6 3/8
QMMO36234		Mean 29.19	Mean 29.38	Mean 0.99	Mean 6
S of Pine Mtn		SE ±0.029	SE ±0.028	SE ±0.195	
<i>D. leichhardti</i> sp. nov.	10	23.08-25.58	30.46-34.18	0.80-0.97	5 3/8- 5 3/4
QMMO53996		Mean 24.40	Mean 32.43	Mean 0.86	Mean 5 5/8
Carborough Ra.		SE ±0.085.	SE ±0.249	SE ±0.052	

chamber with short, thin longitudinal pustules (PP) giving rise to irregular longitudinal pilasters (PP) that descend into the atrium (Y). Epiphallus (E) with very short muscular ascending arm enveloped in penial sheath and a short thin descending arm; epiphallus entering penis through a simple pore (EP) situated laterally to base of verge. Penial retractor muscle (PRM) inserted on junction of two arms of the epiphallus. Vas deferens (VD) with descending arm attached to penial sheath with connective tissue. Very tiny vestigial epiphallallic flagellum (EF) situated at epiphallus-vas deferens junction, extremely tightly bound to vas deferens. Vagina (V) less than half length of penis, internally with several longitudinal pilasters. Free oviduct (UV) shorter than vagina; bursa copulatrix (BC) simple with clavate head, extending to the base of the albumen gland (GG). Based on five dissected specimens (QMMO36102, QMMO36234, QMMO53996, QMMO54313, QMMO69882).

Habitat and ecology. *Denhamiana laetifica* sp. nov. is restricted to vine thickets in the Denham Range; it has been found aestivating under logs, rocks and in hollow trees.

Remarks. *Denhamiana laetifica* sp. nov. is distinguished by its large shell with dark brown bands,

very prominent brown suffusion on last part of the body whorl extending onto umbilical area and parietal callus. Penial stimulator short in comparison with *D. leichhardti* sp. nov.

***Denhamiana leichhardti* sp. nov.**
(Figs 3, 4; Table 1)

Etymology. Named in honour of Australian explorer and naturalist F. W. Ludwig Leichhardt in celebration of the bicentenary of his birthday.

Preferred common name. Leichhardt's Banded Snail.

Material Examined. Holotype: QMMO52123, Carborough Ra., c.70 km W Nebo, nr Lake Elphinstone, MEQ, (21°33'05"S, 148°14'10"E), vine thicket/volcanics, J. Stanisic, D. Potter, C. Eddie, G. Ingram, 22.vii.1994. Height of shell 25.20 mm; diameter 30.94 mm; H/D ratio 0.81.

Paratypes: All MEQ. QMMO53996, 2SC/14RC, same data as holotype; QMMO66200, 4SC/48RC, Carborough Ra., c.70 km W Nebo, nr Lake Elphinstone, MEQ, (21°33'04"S, 148°14'04"E), vine thicket/volcanics, J. Stanisic, G. Ingram, 25.vii.1997.

Other material. All MEQ. QMMO64905, 2RC, Carborough Ra., c.70 km W Nebo, nr Lake Elphinstone, (21°32'38"S, 148°13'50"E), degraded vine thicket/quartzite, J. Stanisic, 01.x.1998.

Diagnosis. Shell large, yellowish brown with prominent sub-sutural and supra-peripheral, dark brown bands and several narrower brown spiral bands on upper part of whorls, and one to

several narrow brown spiral bands basally; latter part of body whorl with dark brown suffusion behind aperture, extending onto umbilical area; parietal callus shiny, weakly suffused with brown; lip dark brown. Umbilicus closed. Reproductive system with reduced epiphallus, tiny vestigial epiphallic flagellum and a cylindrical, sheathed penis with very large penial stimulator and conical verge; epiphallic pore situated laterally at base of verge.

Description. Shell large, globosely helicoid with 5 3/8-5 3/4 normally coiled whorls, rounded above and below the periphery, last descending in front; sutures weakly impressed. Apex and spire moderately to strongly elevated; colour yellowish brown with prominent sub-sutural and supra-peripheral, dark brown bands and several narrower brown spiral bands on upper part of the whorls, and one to several narrow brown spiral bands basally; latter part of body whorl with dark brown suffusion behind the aperture, extending onto umbilical area; parietal callus shiny, suffused with brown; lip dark brown. Diameter of shell 30.5-34.2 mm height 24.3-31.2 mm, H/D ratio 0.80-0.97. Protoconch of 1 3/4 whorls, sculptured with very weak radial growth lines. Post-apical whorls with fine, crowded, radially disposed, thread-like periostracal wrinkles. Aperture lunately rounded, lip thickened and reflected. Umbilicus closed. Based on 10 measured adults (QMMO53996).

Genitalia. Penis (P) with thin sheath (PS), long, cylindrical with slightly expanded apical bulb internally with a conical verge (PV) and long, tongue-like stimulator (PSS); walls of upper penial chamber with numerous short, rectangular pustules (PP) giving rise to thin fleshy ridges; lower chamber tapered with distinct longitudinal pilasters (PP) descending to atrium (Y). Epiphallus (E) with very short muscular ascending arm enveloped in penial sheath internally with one prominent and several minor longitudinal pilasters; and a short thin descending arm; epiphallus entering penis through a simple pore (EP) situated laterally to base of verge. Penial retractor muscle (PRM) inserted on junction of two arms of epiphallus. Vas deferens (VD) with

descending arm attached to penial sheath with connective tissue. Very tiny vestigial epiphallic flagellum (EF) situated at epiphallus-vas deferens junction, extremely tightly bound to vas deferens. Vagina (V) less than half length of penis, internally with several longitudinal pilasters. Free oviduct (UV) shorter than vagina; bursa copulatrix (BC) simple with clavate head, extending to base of the albumen gland (GG). Hermaphroditic duct (GD) convoluted, talon (GT) with finger-like head, carrefour (X), prominent, embedded in surface of albumen gland. Based on three dissected specimens (QMMO53996, QMMO66200).

Habitat and ecology. *Denhamiana leichhardti* is restricted to the Carborough Range; living in vine thicket under logs and rocks. The Carborough Range is small in comparison to the Denham Range and has fewer patches of thicket consequently it has a much more circumscribed distribution than *D. laetifica* sp. nov.

Remarks. *Denhamiana leichhardti* sp. nov. differs from *D. laetifica* sp. nov. in having a smaller shell with less brown suffusion and a greater number of brown spiral bands. Anatomically the very large, tongue-like penial stimulator readily separate this species from *D. laetifica*.

? *Denhamiana* sp. nov 'Dipperu'

Material. All MEQ: QMMO4989, 1RC, Dipperu NP, c.30 km S Nebo, (21°53'S, 148°44'E), vine thicket, Qld Dept Forestry, 14.ix.1971; QMMO55772, 4RC, Dipperu NP, c.30 km S Nebo, (21°54'39"S, 148°39'07"E), vine thicket, J. Covacevich, K. McDonald, 25.iv.1995; QMMO55774, Dipperu NP, c.30 km S Nebo, (21°53'55"S, 148°44'01"E), vine thicket, J. Covacevich, K. McDonald, 25.iv.1995; QMMO60963, 1RC, Bee Creek, "Morpeth" Station, just S Dipperu NP, (22°00'00"S, 148°45'30"E), 150-200 m, A. J. Emmott, v.1995; QMMO74759, 2RC juveniles, Nebo, S at Bee Ck, c.1 km, S of Grahams Lagoon, 21°58'29"S, 148°42'40"E), mvf, 140 m, in litter, A. Pollock, W. McDonald, 28.vi.2004.

Remarks. The above specimens from Dipperu NP may represent an additional species. Only one preserved specimen was available for anatomical study and details of the penis interior revealed a very large penial stimulator similar to that of *D. leichhardti* but a penial wall sculpture of fine pustules throughout, and lacking the very ordered longitudinal pattern visible in the lower

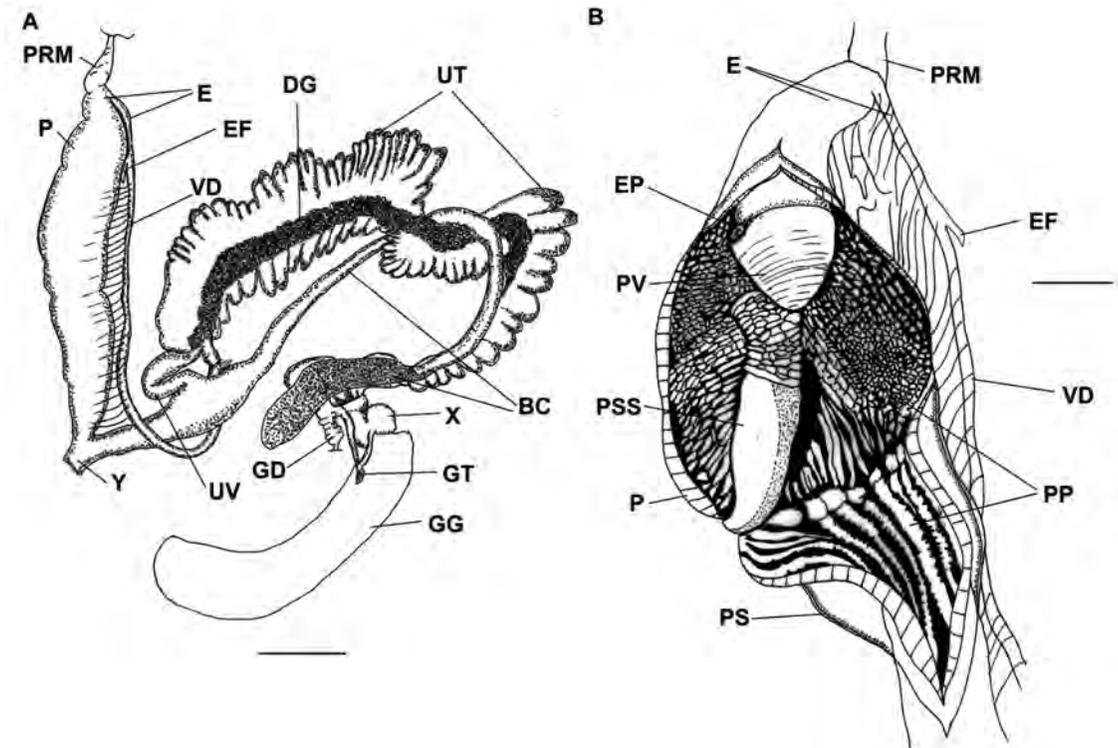


FIG. 4. *Denhamiana leichhardti* sp. nov. Genital anatomy, paratype QMMO53996. A, Genital system; B, penial anatomy. Scale lines: A = 4 mm, B = 2 mm.

half of the penial chamber of *D. leichhardti*. The shell has the reduced brown colouring of *D. leichhardti* and fewer but more distinct brown bands. More live adult material is needed before a final determination as to its specific status can be made.

DISCUSSION

The description of *Denhamiana* gen. nov. represents the first records of a genus of large banded species west of the Clarke Range and northern part of the Connors Range, mid-eastern Queensland. In having a closed umbilicus the shell is most similar to some *Bentosites* spp. from more coastal environs (see Stanisić *et al.* 2010). *Denhamiana laetifica* (as Camaenidae BL 28) was included in the molecular study of the east coast camaenid radiation by Hugall and Stanisić (2011). The resulting phylogram indicated that this species was distantly related to this group of species. More so than any other

species of the *Sphaerospira* s. l. lineage (Hugall *et al.* 2003). However, *Denhamiana* differs significantly from *Bentosites* by having a more complex penial anatomy that features a penial stimulator in addition to a prominent verge. *Bentosites* spp. have a short knob-like verge and, usually, several longitudinal pilasters. Quite possibly *Denhamiana* represents a basal offshoot of this group long since isolated by climate induced attrition of mesic habitats in central Queensland. Unfortunately, the extensive land clearing that has taken place in this part of the Brigalow Bioregion will have an unexpected anthropogenic influence on the future direction of this evolutionary process.

The reduced epiphallus and vestigial epiphallic flagellum of *Denhamiana* are unusual in the general context of the greater mass of Australian camaenids, but it is a combination seen in a number of other central and southern Queensland hadroid genera. [NB. The epiphallus

is herein interpreted as that part of the terminal male genitalia situated apicad of the penis and ending at the point of intersection with the vestigial flagellum]. The vestigial epiphallic flagellum is so closely bound to the vas deferens that it was missed by this author in earlier dissections of these camaenids. Solem's (1992) illustrations of *Sphaerospia fraseri*, *Varohadra rainbirdi* [now considered a synonym of *Mariynessa yulei* (Forbes 1851)] from and *Varohadra bernhardi* [now considered a synonym of *Figuladra incei lessoni* (Pfeiffer 1846)] do not show this structure but dissections by the author show this to be present in all of these species (Stanisic, unpub.).

Perhaps the most striking fact to come out of this study is that the earliest record of these species dates from 1971. This is quite remarkable considering all the land snail collecting that had been carried out in the central Queensland area since the mid-1800's (Cox 1868; Iredale 1937, 1938). The fact that land snails with such visually striking and large shells should only be collected late in the 1900's and be described in the 21st century, most poignantly underscores the lack of basic survey work that has been conducted for invertebrates in this country.

ACKNOWLEDGEMENTS

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