Ponder, Winston F., 1991. The eastern seaboard species of *Jardinella* (Mollusca: Gastropoda: Hydrobiidae), Queensland rainforest-inhabiting freshwater snails derived from the west. *Records of the Australian Museum* 43(3): 275–289. [12 December 1991].

doi:10.3853/j.0067-1975.43.1991.48

ISSN 0067-1975

Published by the Australian Museum, Sydney

# The Eastern Seaboard Species of *Jardinella* (Mollusca, Gastropoda, Hydrobiidae), Queensland Rainforest-inhabiting Freshwater Snails Derived from the West

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ABSTRACT. Three species of the hydrobiid genus *Jardinella*, two of them new, are described from streams and rivers in north-east Queensland. Although associated with rainforests, these species appear to be derived from a western Queensland radiation of the genus.

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Hydrobiid snails are well represented in south-eastern Australia but only one species, *Jardinella thaanumi* (Pilsbry), has been described from north-east Queensland. This species, the type of the genus *Jardinella* Iredale & Whitley, 1938, is found in streams and rivers on the eastern slopes of the Great Dividing Range. This paper provides information on the anatomy and distribution of *J. thaanumi* (Pilsbry) and two new species. Twelve additional species of *Jardinella* live in springs on the western side of the Great Dividing Range (Ponder & Clark, 1990).

## Materials and Methods

Most of the material on which this paper is based was collected in 1980 on a survey of the streams and rivers of the section of north-east Queensland between Townsville and the Daintree River.

Shells were measured by viewing the shells through a drawing apparatus located above a digitising-pad linked to a microcomputer. Selected parameters were digitised and the input converted to millimeters. The parameters measured were maximum shell length; maximum shell width, length of body whorl, length and width of aperture, diameter of umbilical chink, and diameter of protoconch. The convexity ratio (see Ponder *et al.*, 1989, for details), spire angle and the angle of the outer lip of the aperture were calculated by the computer from a series of points input via the digitising pad. The number of protoconch and teleoconch whorls were counted. All shell measurements were either at right angles or parallel to the longitudinal shell axis. Each measured individual was sexed.

The operculum was removed and the following measurements taken:- maximum length, length of the white smear, and distance of the nucleus from the side opposite the growing end.

Four to five specimens from 12 populations were dissected and the pallial cavity and genital systems examined.

The heads of a few individuals were prepared by critical point drying and examined for ciliation patterns using a SEM. Radulae and opercula were mounted using standard methods for examination with the SEM.

Sex and species differences in shell and opercular measurements were tested for using t-Test. A discriminant function analysis was undertaken on shell and opercular measurement data using MDA in the BIOSTAT package (Pimentel & Smith, 1986).

Abbreviations used in this paper are as follows: AMS – Australian Museum, Sydney; ANSP – Academy of Natural Sciences of Philadelphia; QM – Queensland Museum, Brisbane. A table of measurements is given in the Appendix.

## Results

**Anatomy of *Jardinella thaanumi*.** *External features.*

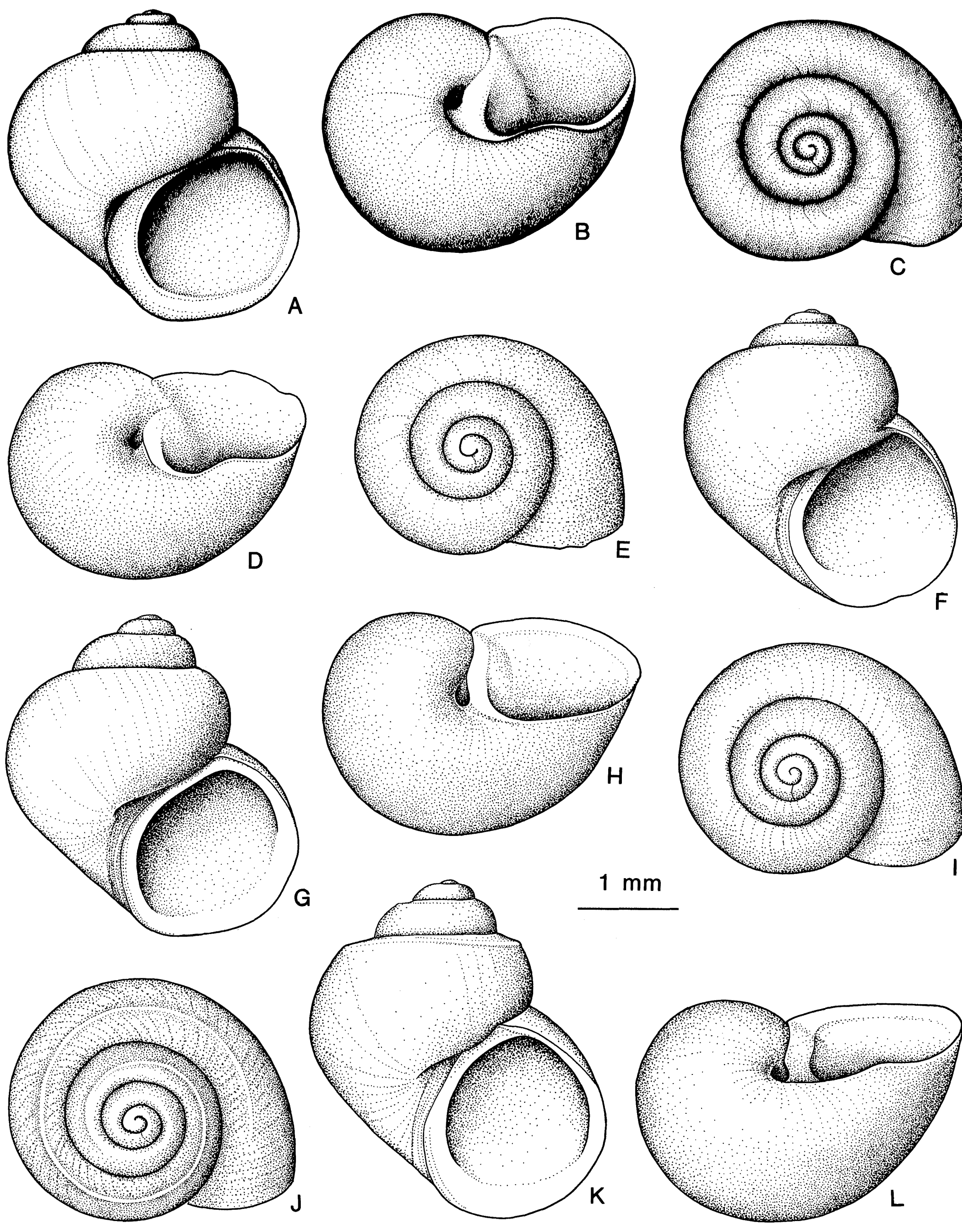


**Fig.1.** Shells of *Jardinella* species. A-F, *J. thaanumi* (Pilsbry); A-C, holotype (ANSP 77959a); D-F, subadult paratype (AMS C.8177). G-I, *J. tumorosa* n.sp., holotype. J-L, *J. tullyensis* n.sp., holotype.

The robust, trochoid shell (Figs 1-2) has a large aperture and a small umbilical chink and is yellow to brown in colour. The paucispiral operculum (Fig.3C) is yellow with a red to red-brown tinge, has an eccentric nucleus and is thin and flat. It usually bears on its inner surface a small white smear, sometimes with traces of two or three small, weak thickenings that suggest rudimentary pegs.

The snout is short, broad and rather indistinctly bilobed anteriorly (Fig.4, sn) with cilia scattered over its surface, especially laterally. The tapering cephalic tentacles (Fig.4, ct) are much longer than the snout in life and the well-developed eyes lie in distinct bulges at the bases of these tentacles. Each tentacle has a narrow midventral tract of cilia and there are scattered cilia over the ventral and dorsal surfaces (Fig.3D, E shows these features for one of the new species described below). The foot (Fig.4B, f) is short and broad with a broadly rounded posterior end and weakly developed anterior lateral lobes. An anterior pedal gland (Fig.4B, apg) is present but is not readily observed in the living animal. The sole of the foot is richly endowed with epithelial and subepithelial glands. The snout, proximal half of the tentacles and the dorsal side of the foot are usually pigmented with pale grey to black. The distal half of the tentacles are usually unpigmented except for a longitudinal narrow grey to black line mid-dorsally. Some specimens are unpigmented.

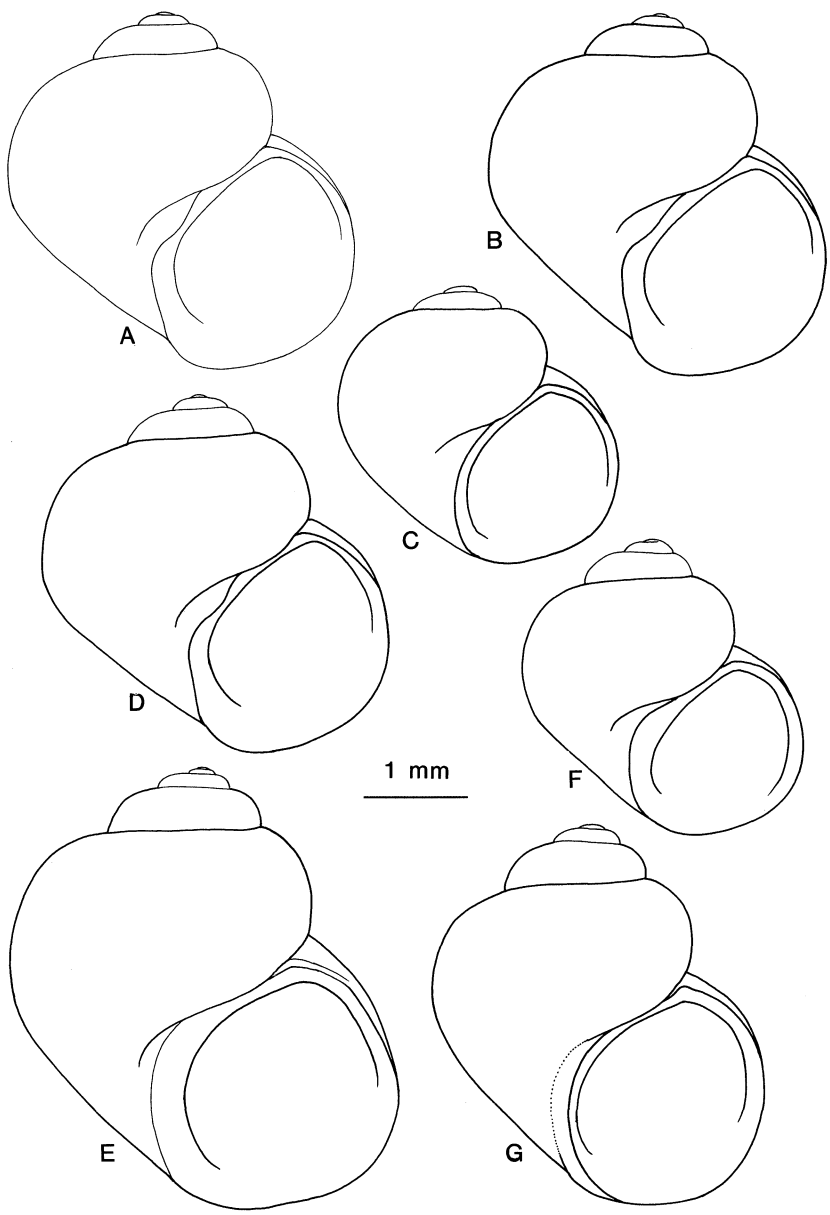


**Fig.2.** Shells of *Jardinella* species, showing some of the variation in size and shape. A-E, *J. thaanumi*, A-D, Barron Falls (AMS C.51466); E, Douglas Creek (AMS C.161649). F,G, *J. tumorosa* n.sp., paratypes (AMS C.161659).

*Pallial cavity*. The ctenidium extends for most of the length of the pallial cavity. It consists of 20-35 (average of material examined 27) triangular filaments that are shorter in height than they are wide. The osphradium is a narrow ridge which extends from about the middle of the ctenidium to a little before the posterior end. There is a well developed hypobranchial gland overlying the rectum in the posterior part of the pallial cavity.

*Alimentary canal*. A pair of well-developed jaws are present and in this respect and in the rest of the morphology of the anteriormost part of the alimentary canal, including the radula, it is typical of most other hydrobiids. The radula (Fig.5A-E) is described in detail below. The midoesophagus is rather broad as it passes through the nerve ring where it has long dorsal folds that are curled upwards and is conspicuously glandular ventrally. It becomes narrower behind the nerve ring and the ventral glandular epithelium is lost. The stomach is large, with the anterior and posterior chambers not particularly well differentiated. The stomach proper is about as high as it is long and has a single digestive gland opening. Internally the stomach contains a gastric shield and much of its surface is cuticularised. The style sac contains a crystalline style and ranges from about two thirds of the length of the stomach proper to slightly shorter. Sections of the digestive gland were unusual in that the gland did not contain large, conspicuous brown excretory spherules. Excretory cells are present, however, and their vacuoles contain tiny excretory granules.

The intestine is separated from the style sac, opening separately into the stomach. The intestine contains a large typhlosole and, as is normal in truncatelloideans, twists back along the style sac before running forward to the posterior pallial wall. The rectum enters the pallial cavity then immediately swings to the left and then to

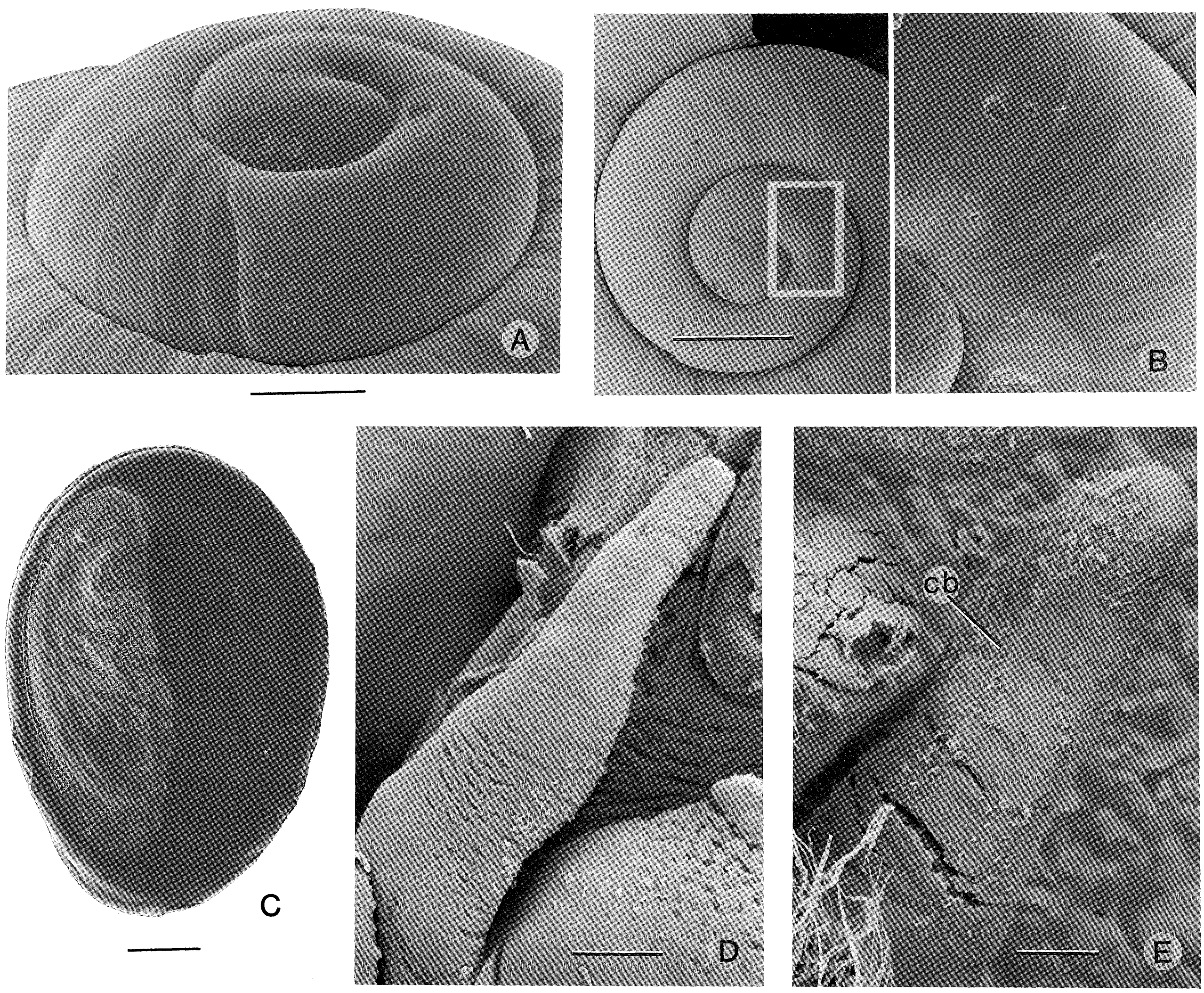


**Fig.3.** A-C, *Jardinella thaanumi* (Pilsbry). A,B, details of protoconch. Dowah Creek, Crystal Cascades, near Cairns. Area boxed in B magnified 4x on right. C, operculum. Douglas Creek on Palmerston Highway. D,E. *Jardinella tumorosa* n.sp., dorsal (D) and ventral (E) views of cephalic tentacles showing ciliation. Paratype. Scales:- A,D, 100 µm; B, 200 µm; C, 300 µm; E, 50 µm.

the right, thus forming a U-shaped loop across the posterior half of the pallial roof, before running along the right side of the anterior roof to terminate just inside the mantle collar where it forms a very short free papilla.

*Male genital system* (Fig.4A). The testis occupies the upper part of about one and a half whorls and consists of a single row of acini, the anterior part overlying the posterior chamber of the stomach. The convoluted seminal vesicle underlies the testis for about one third of a whorl behind the stomach.

The prostate gland is large, bean-shaped and approximately circular in section with approximately one half of the gland behind the posterior wall of the pallial cavity (in some specimens the prostate extends slightly more or slightly less than half of its length into the pallial wall). The very narrow, silvery pallial vas deferens emerges from the ventral side of the prostate gland at the point the gland enters the pallial cavity and runs ventrally along it until reaching the anterior end of the gland. Here it becomes convoluted, sometimes forming a small, tightly coiled ball at the anterior end of the prostate gland. From there it follows an undulating to convoluted path to the base of the penis. The penis (Fig.4A) lies behind the base of the right tentacle. It has a wide, transversely corrugated base (Fig.4A, pp) within which lies the narrow, convolute penial duct. In sections this duct is seen to be surrounded by a few muscle fibres and is lined with a very thin, ciliated epithelium. The basal and middle parts of the penis are lined with a thin, weakly pigmented, cuboidal epithelium which is covered with a thin cuticle. The unpigmented distal end of the penis (Fig.4A, dp) is narrow, tapering and smooth, the penial aperture very minute and terminal. This part of the penis is not cuticularised and the cuboidal to short columnar epithelium contains numerous non-staining (mucus?) gland cells.

*Female genital system* (Fig.6A). The ovary is a little shorter than the testis and the narrow, thin-walled upper oviduct runs across the lower right side of the stomach to open to the coiled oviduct just behind the posterior pallial wall. The coiled oviduct (co) lies against the left (inner) side of the albumen gland (ag) and forms a U-shaped loop before doubling back to run just below and parallel to the bursal duct (bd), these two ducts joining at the posterior pallial wall (pw) to form a very short common duct which almost immediately opens to the ventral channel (vc) of the capsule gland. The coiled oviduct is lined with a ciliated, short columnar epithelium. The bursa copulatrix (bc) is an ovoid sac located behind the albumen gland and is lined with large, irregular columnar cells with granular cytoplasm and proximal nuclei. Its rather wide duct

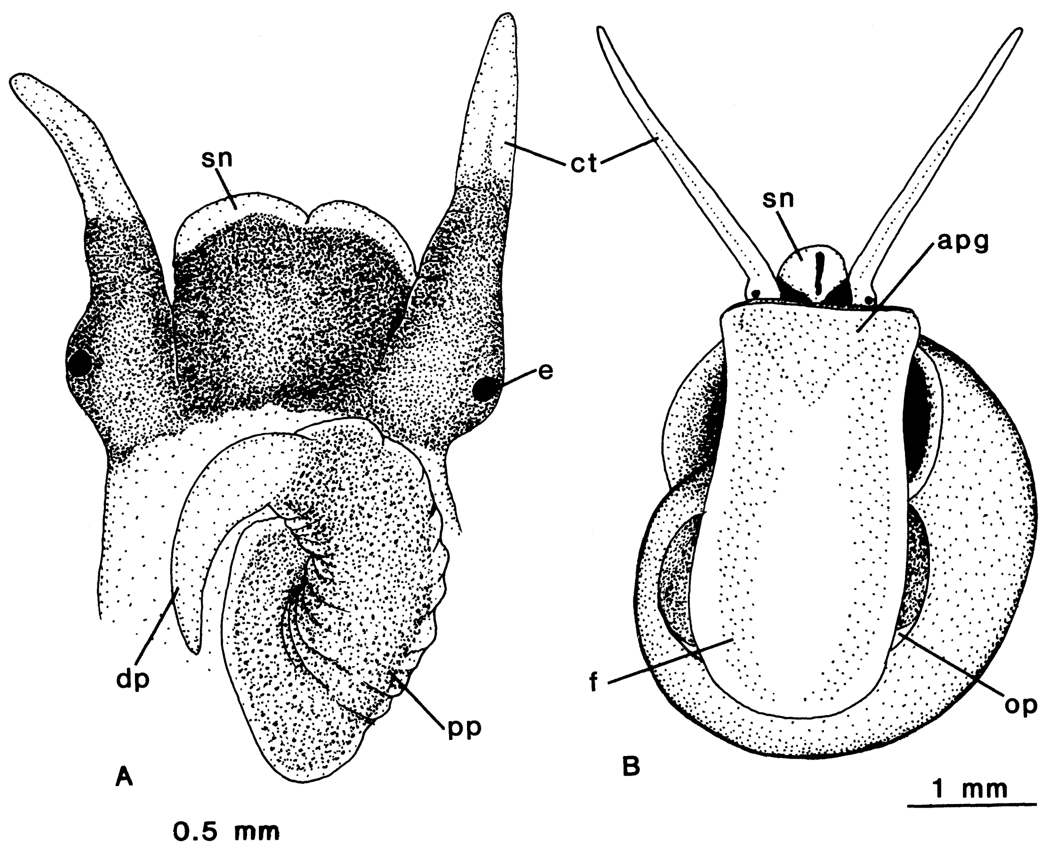


**Fig.4.** Head and foot of *Jardinella thaanumi* (Pilsbry). A, dorsal view of head and penis, from living material; Douglas Creek. B, ventral view of living animal, Barron River Gorge. apg – anterior pedal gland; ct – cephalic tentacle; dp – distal part of penis; e – eye; f – foot; op – operculum; pp – proximal (basal) part of penis; sn – snout.

emerges from about the middle of the anterior side of the bursa. Internally the ciliated columnar epithelium lining the duct is thrown into longitudinal ridges. The bursal duct and, to a lesser extent, the coiled oviduct, is surrounded by a layer of muscle fibres. The seminal receptacle (sr) opens by way of a short duct to the coiled oviduct near the posterior end of the last section of the coiled oviduct just as it begins to run parallel with the bursal duct.

The ventral channel is unusual in that it is lined with a thick columnar epithelium containing mucous cells. The longitudinal fold in the ventral channel is large and thick. The small but distinct genital opening is set back approximately one third of the length of the gland from its anterior end. There is no swollen anterior vestibule like that seen in some western members of the genus.

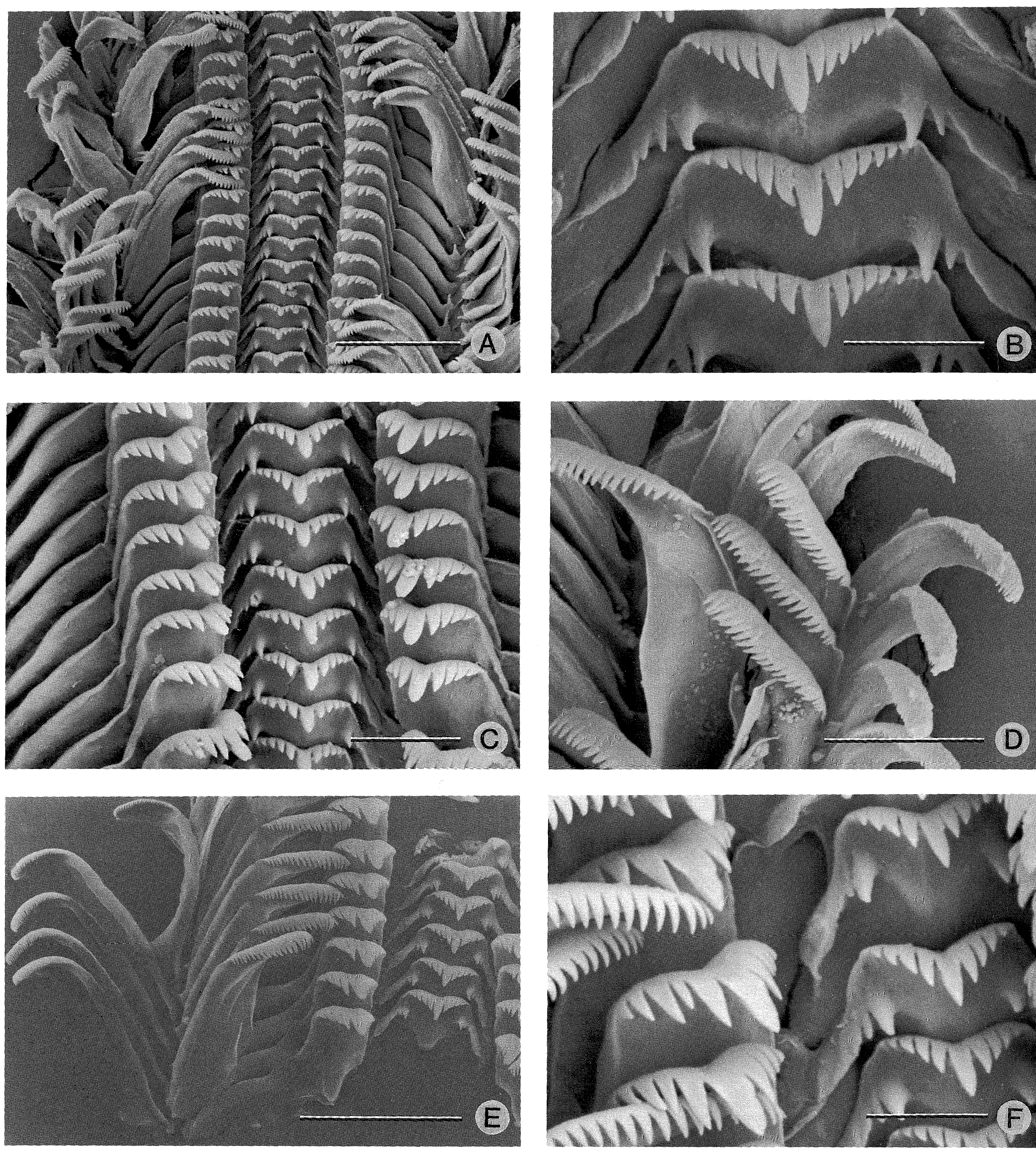


**Fig.5.** Radulae of species of *Jardinella*. A-E, *J. thaanumi*, A, middle part of ribbon showing all teeth; B, detail of central teeth; C, detail of central and lateral teeth; D, detail of marginal teeth; E, teeth on one side of radula showing detail of bases of central and lateral teeth. A-D, Barron River Gorge; E, Douglas Creek. F, *J. tumorosa* n.sp., showing central, lateral and part of inner marginal teeth; paratype. Scales:- A, 50 μm; B,F, 10 μm; C,D, 20 μm; E, 30 μm.

The orange-red capsule gland is approximately twice as long as it is wide. It terminates at the posterior pallial wall where it joins with the smaller albumen gland.

*Nervous system.* The cerebral ganglia are connected by a rather long commissure, located at the posterior end of the ganglia, which is about as long as the ganglia are wide. The pleural ganglia abut the cerebral ganglia. The supraoesophageal - pleural connective is variable in length. In the specimens dissected it varies from about equal to the length of the supraoesophageal

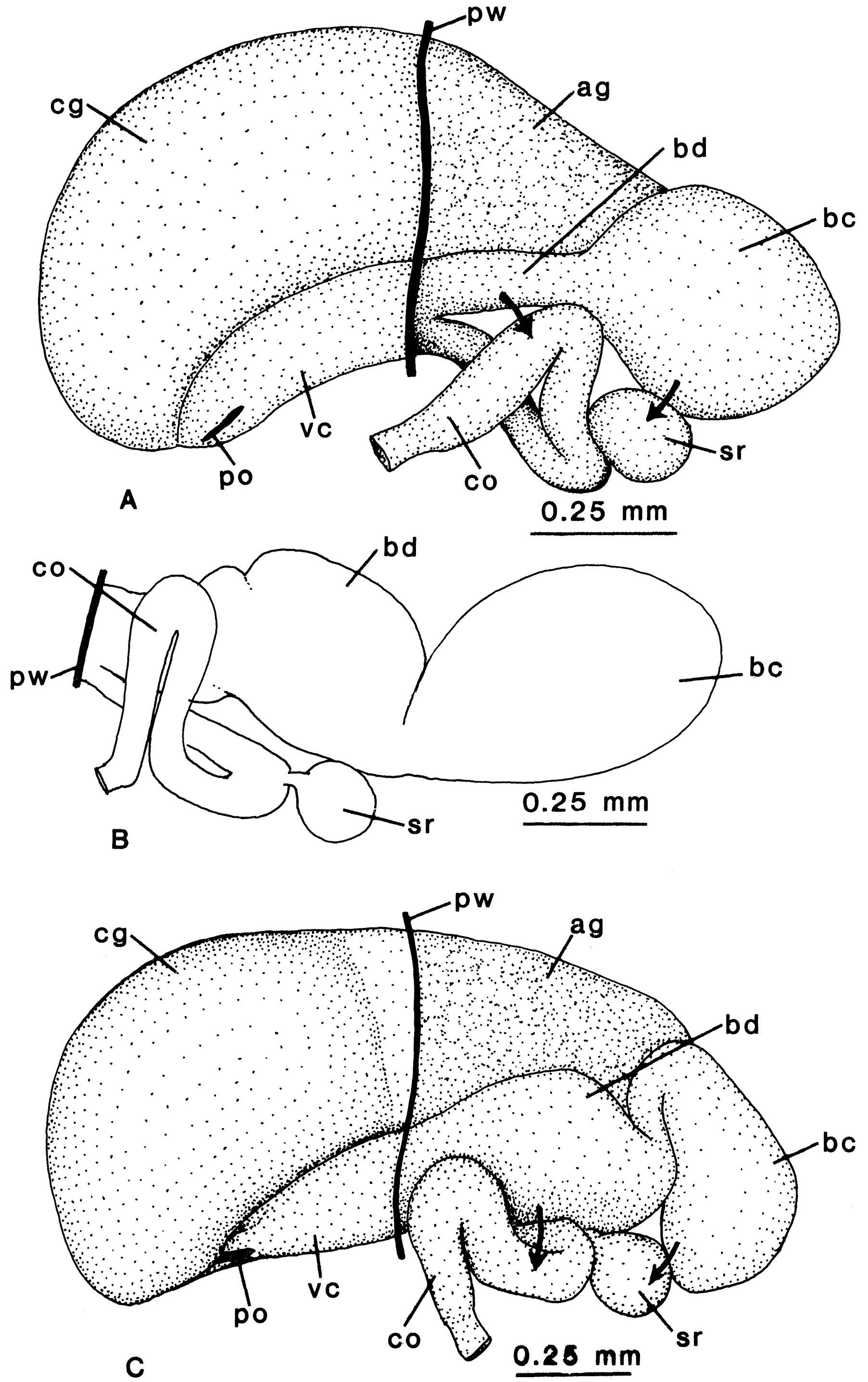


**Fig.6.** Female genital ducts of species of *Jardinella*, viewed from the left side. A, *J. thaanumi* (Pilsbry), Barron River (Stn 45b). B,C, *J. tumorosa* n.sp., B, coiled oviduct, bursa copulatrix and its duct; Pine Creek (Stn 44); C, paratype. The arrows indicate the directions in which parts of the genitalia have been moved. ag – albumen gland; bc – bursa copulatrix; bd – bursal duct; cg – capsule gland; co – coiled oviduct; po – pallial opening of oviduct; pw – posterior wall of pallial cavity; sr – seminal receptacle; vc – ventral channel.

ganglion to about twice the length of the ganglion. The suboesophageal ganglion is connected to the left pleural ganglion by a very short connective. The ovoid pedal ganglia abut one another and each has a small propodial ganglion anteriorly attached by a short connective. There is a statocyst, which contains a single statolith, at the posterior end of each pedal ganglion.

*Reno-pericardial system.* The renal organ is thin-walled except for a thin renal gland on the outer wall. This gland is more than twice as wide as it is long and is orientated with its anterior edge along the posterior pallial wall. Neither the renal organ nor the small pericardium protrude into the pallial roof. A short, narrow, reno-pericardial duct is present.

**Remarks.** This species is considered to be congeneric with the western Queensland species assigned to the genus by Ponder & Clark (1990) because it has the following diagnostic characters: a) the operculum lacks pegs but usually has a white smear on its inner surface; b) the radula has two pairs of cusps on the base of each of the central teeth; c) the penis has the distal portion smooth and differentiated from the rest of the penis, and d) the pallial vas deferens is convoluted.

The robust, trochiform shell with its rather large aperture and short spire is a shell shape well adapted to life in rivers. Similar shell forms are seen in other river-living hydrobiids such as *Beddomeia* and *Posticobia* in Australia, the northern hemisphere Lithoglyphinae (*Lithoglypus* in Europe, *Gilla*, *Somatogyrus*, etc. in North America), as well as the South American *Potamolithus*.

Individuals of *J. thaanumi* from several localities were parasitised by trematodes.

## Taxonomy

### Hydrobiidae

### *Jardinella* Iredale & Whitley

*Jardinella* Iredale & Whitley, 1938: 67.

**Type species.** *Petterdiana thaanumi* Pilsbry, 1900 by original designation.

**Diagnosis.** The genus has been diagnosed and discussed by Ponder & Clark (1990). All three species described below form a distinct group which can be separated from the western members of the genus by the following combination of characters. Shell trochiform, of medium to large size (up to about 4 mm in length), smooth, or with keeled shoulder, with umbilical chink or narrow umbilicus. Penis with long, tapering, non-pigmented distal portion. Pallial oviduct with narrow vestibule, pallial opening at about one third length of capsule gland.

### *Jardinella thaanumi* (Pilsbry)

*Petterdiana Thaanumi* Pilsbry, 1900: 144.–Hedley, 1901: 727, pl.48, fig.11.

*Jardinella thaanumi*.–Iredale & Whitley, 1938: 67.–Iredale, 1943: 203.

**Type material.** HOLOTYPE and PARATYPES: near Cairns, Queensland; type locality restricted to Barron River herein. LECTOTYPE (ANSP, 77959A, selected herein, and 12 PARALECTOTYPES, ANSP, 77959; 2 PARALECTOTYPES AMS, C.8177).

**Additional material examined** (an asterisk indicates material has been examined anatomically): Barron Falls, near Cairns, 16°51'20"S 145°38'50"E, coll. C. Hedley, AMS C.9301; Barron Falls, near Cairns, 16°51'20"S 145°38'50"E, coll. C. Hedley, AMS C.51466; Barron Falls, near Cairns, 16°51'20"S 145°38'50"E, 15 June 1926, coll. T. Iredale & G.P. Whitley, AMS C.161641; Barron River, near Cairns, 16°51'20"S 145°38'50"E, coll. Sgt. B. Shipway AMS C.161642; *Barron River Gorge, near Cairns, 16°51'20"S 145°38'50"E, near bridge, 1 Dec. 1982, coll. I. Loch, AMS C.161643; Cairns district, 16°55'S 145°46'E, 1890-91, coll. C.J. Wild, AMS C.161644; *Dowah Creek, Crystal Cascades, near Cairns, 16°57'45"S 145°40'50"E, 14 Oct. 1981, coll. W.F. Ponder & I. Loch, AMS C.161645; off Palmerston Highway, near Innisfail, 17°32'S 146°01'E, in Goolagong Creek, on stones and leaves, 10 June 1973, coll. I. Loch, AMS C.161666; rapids below Lake Placid, near Cairns, 16°51'20"S 145°38'50"E, lower end of Barron Gorge, 2 Jan. 1959, coll. D. McAlpine, AMS C.161647; Rocky Creek, Atherton, 17°16'S 145°29'E, coll. F. Allen, AMS C.161648; *Fishers Creek, Palmerston Highway, 17°34'20"S 145°53'40"E, tributary of North Johnstone River, in stony creek, amongst leaves and stones in shallow water, 28 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 24), AMS C.161661; *Douglas Creek, at Palmerston Highway, 17°35'55"S 145°43'25"E, 8.6 km south-east from Beatrice River crossing, in small boulder creek, on leaves and stones, 28 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 25), AMS C.161649; Barron River, Hypipamee Crater, 17°25'45"S 145°29'50"E, south-east of Herberton in 'The Crater Nationai Park', on stones and leaves, in small creek next to lookout carpark, 29 Sept. 1980, coll. W. F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 28), AMS C.161663; *Dinner Falls, Barron River, Hypipamee Crater, 17°25'45"S 145°29'50"E, in pools, along sides and in shallow water - rocky and sandy area, none on actual falls, 29 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 28a), AMS C.161662; *Wright Creek, Lake Eacham, 17°16'55"S 145°38'55"E, tributary of Barron River, Lake Eacham National Park, on stones, leaves etc., in swift creek with solid rock bed, also in feeder creek near bridge on Lake Eacham - Gordonvale Road, 29 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 33), AMS C.161660; *Freshwater Creek, below intake, west of Cairns, 16°58'00"S 145°40'30"E, in quiet corners of side creek, swift flow on rock bed, 30 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 41), AMS C.161650; *Dowah Creek, at Freshwater Creek junction, west of Cairns, 16°57'45"S 145°40'50"E, on stones and leaves in pools, 30 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 42), AMS C.161651; Barron River, at Barron Gorge Power Station, 16°59'45"S 145°50'20"E, in small creek on south-west side of gorge near power station, amongst leaves in steep creek and falls, 30 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 45a), AMS C.161664; *Barron River at Barron Gorge Power Station, 16°51'20"S 145°38'50"E, in main gorge, in rocky river bed, in piles of stones behind boulders in swifter flow, 30 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 45b), AMS C.161652, Barron River Gorge, 16°52'S 145°47'E, halfway to hydro station, in river, 7 Oct. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 66), AMS C.161665; ?Bellenden Ker Range, 17°12'S 145°51'E, coll. J. Brazier, AMS C.7460.

**Diagnosis.** Shell with umbilicus closed (umbilical chink only) or very narrowly open in adults; shoulder slightly flattened to convex. Bursal duct parallel sided. Renal gland wider than long and lies behind pallial wall.

**Description.** *Shell* (Figs 1A-F, 2A-E). Trochiform, 2.70-4.03 mm in length [mean 3.43 (M), 3.69 (F)]; 2.64-3.82 mm in width [mean 3.15 (M), 3.46 (F)]; sexually dimorphic in total width and aperture width ($P$ less than 0.05); of medium thickness, semi-opaque, with indistinct, transparent periostracum. Spire angle 74.3-86.6° [mean 80.15 (M), 80.49 (F)]. Protoconch (Fig.3A,B) of about 1.20-1.35 whorls. Teleoconch of 2.75-3.05 convex whorls [mean 2.89 (M), 2.96 (F)]. Convexity ratio 0.20-0.26 (mean 0.23 in both sexes); shoulder convex to slightly flattened. Teleoconch sculpture of faint, prosocline growth lines. Aperture length/shell length ratio 0.57-0.70 [mean 0.65 (M), 0.64 (F)]. Inner lip slightly thickened forming distinct shelf across part of, to most of, lower part of umbilical chink. Outer lip simple, prosocline, angle 30.03-40.42° [mean 35.13 (M), 34.58 (F)]. Width of umbilical chink 0.18-0.46 [mean 0.28 (M), 0.33 (F)], umbilicus narrow and open in juveniles, usually closed in adults. Colour white or yellow-white to pale pink-brown or yellow-brown.

*Shell dimensions*. See Appendix.

*Operculum* (Fig.3C). Operculum thin, pale yellow with red patch to uniform red; 1.38-1.96 mm in length [mean 1.69 (M), 1.79 (F)]. With or without white smear up to 0.82 mm in length [mean 0.51 (M), 0.44 (F)]. Ratio of operculum length to position of nucleus 2.8-3.9 [mean 3.60 (M), 3.45 (F)].

*Radula* (Fig.5A-E). Central teeth each with 4-7 pointed lateral cusps; central cusp pointed, about twice as long as adjacent cusps; 2 pairs of basal denticles, outermost pair smaller than inner pair, very minute third pair in some specimens; dorsal edge concave; basal process narrow, U-shaped. Lateral teeth with cusp formula 3-1-(4-6); primary cusp up to twice as long as adjacent cusps, with rounded distal end, other cusps pointed; with small but distinct basal bulge; outer shaft about twice as long as cutting edge. Inner and outer marginal teeth with many small, sharp cusps restricted to distal end of teeth, those on inner marginal larger than on outer.

*Head-foot* (Fig.4). Cephalic tentacles subtriangular in section, with no dorsal ciliated bands present; midventral ciliated band along most of ventral surface. Snout dark grey to black; anterior end unpigmented; dorsal sides of cephalic tentacles pale to dark grey; sides of foot and opercular lobe pale to dark grey. Visceral coil pigmentation mostly black or dark grey.

**Anatomy.** *Mantle cavity*. Ctenidium with ctenidial apex on right, with 20-35 (n=27; average 27) triangular filaments shorter in height than wide. Free left edge of longest filaments 0.16-0.47 mm long (preserved material, n=22; average 0.29). Osphradium between posterior end and middle of ctendium. Hypobranchial gland well developed. No glandular pad to left of ctendium, or near anus. Rectum with well-developed U-shaped arch in males, less obvious in mature females; anus near mantle edge. Kidney not extending forward into mantle roof.

*Male genital system*. Penis (Fig.4A) with lobes absent; distal end of penis tapering; unpigmented. Vas deferens with several loops/coils.

*Female genital system* (Fig.6A). Pallial oviduct with ventral channel wide posteriorly and narrow anteriorly. Pallial opening at about one third length of capsule gland from anterior end. Seminal receptacle lies at anterior edge of bursa. Bursal duct not swollen, arises from middle of anterior side of bursa. Coiled oviduct and bursal duct separate to posterior mantle wall. Coiled oviduct simple U-shape. Rudimentary penis absent in females.

*Egg capsules*. Transparent, lens-shaped, 0.48-0.53 mm (mean 0.50 mm, n=6) in diameter, laid singly in umbilical chink of females (Stn 25 only).

**Remarks.** The type locality of this species is "near Cairns". The types can be matched with shells from the Barron River and its tributaries and the type locality is here restricted to that river. In shell measurements, including spire angle and aperture angle (Fig.8), the three adults in the type series fall within others attributed to *J. thaanumi*. These specimens have the key characters of *J. thaanumi* in possessing a very narrow to closed umbilicus and the inner lip forms a shelf over the umbilical chink. In addition the shoulder in several specimens in the type series is slightly flattened, a character rarely observed in *J. tumorosa*. The subadult (Fig.1D-F) and juvenile specimens have a very narrow umbilicus, a character typical of *J. thaanumi*. One specimen, segregated as the "holotype", is selected as the lectotype because no reference was made of a holotype in the original description and there has not been a subsequent designation of a lectotype.

The specimen figured by Hedley (1901) is typical of large forms of this species. The locality is given as Bellenden Ker Range, which would place it in the headwaters of the Mulgrave River, the location of the species described below. To date no populations are known from the Mulgrave River or its tributaries that have this shell morphology and it is likely that these specimens (AMS, C.7460), which originated from John Brazier, are mislocalised.

There is considerable variation both within and between populations but, unfortunately the available material does not allow a proper analysis of this variation. Some populations (e.g., Freshwater Creek, Stn 41) are small, others much larger (e.g., Douglas Creek, Stn 25). Some of this interpopulation variation is expressed in the differences in the means for the major shell dimensions (Appendix) and the intrapopulation variation in the standard deviations.

This species is apparently confined to the Barron and Johnstone River systems, both of which flow from the Atherton Tablelands, the Barron River flowing north-east and the Johnstone River flowing south-east. One lot (shells only) in the Australian Museum labelled Port Douglas (C.161646, coll. C.J. Wild, Aug. 1891) may be mislocalised because a number of localities were examined around Port Douglas (see Fig.7) without success. There is, however, an unconfirmed report of a *Jardinella*-like snail from the Bloomfield River, near the Bloomfield River Mission, just north of the Daintree River, Cape York Peninsula (V. Kessner, personal communication).

### *Jardinella tumorosa* n.sp.

**Material examined.** HOLOTYPE and PARATYPES: Mulgrave River, at Mulgrave River Forestry Road, 17°14'20"S 145°46'25"E, in small tributary on east side of river, 29

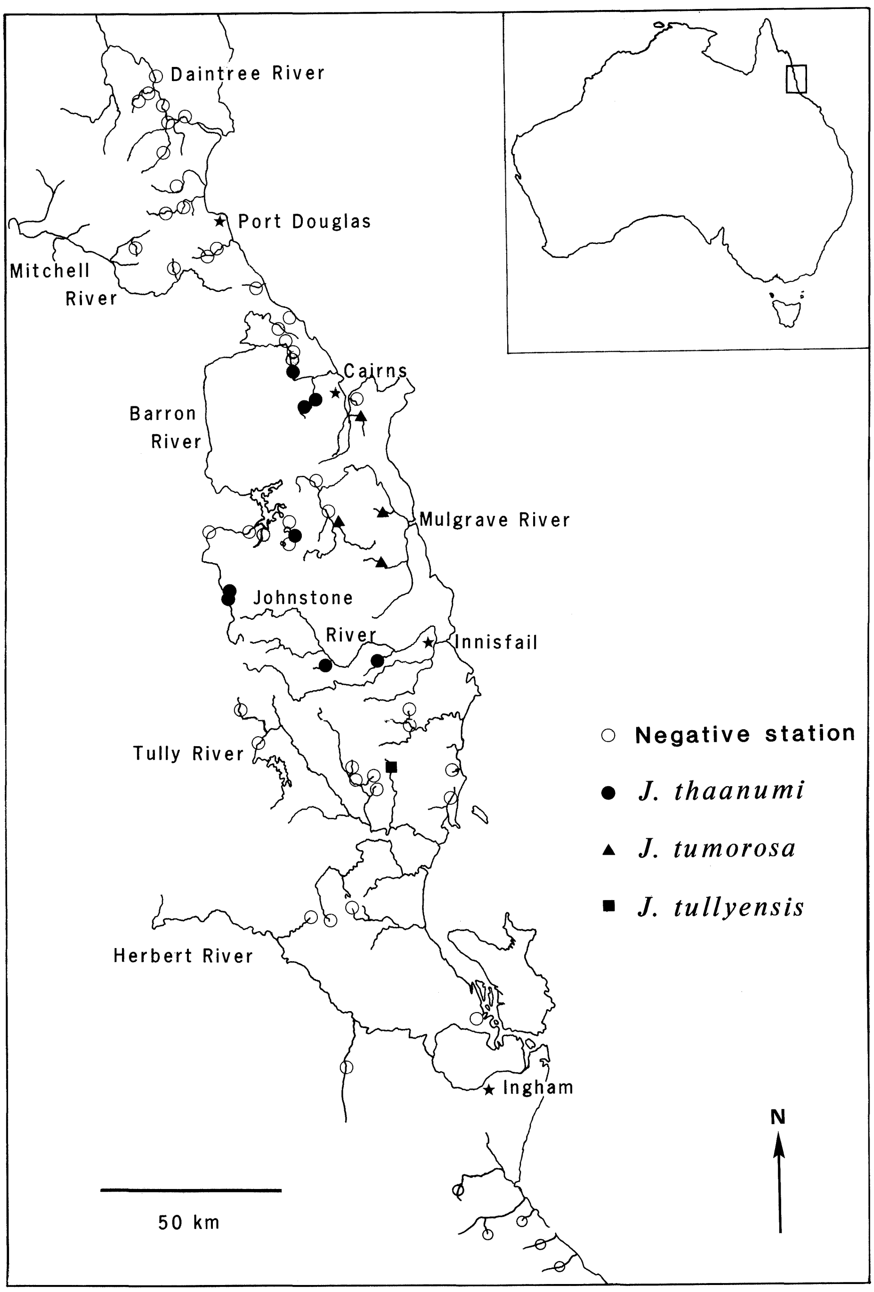


**Fig.7.** Distribution map of the species of *Jardinella*. The open circles indicate negative sites specifically searched for *Jardinella*.

Sept. 1980, coll. W.F. Ponder, I. Loch, H .& E. Vokes & J. Stanisic (Stn 36).

HOLOTYPE – Stn 3, AMS C.161655. PARATYPES, 90 – Stn 36, AMS C.161659 (73); AMS C.161667 (13); QM MO24080 (4).

**Additional material examined.** Little Mulgrave River, on Mareeba - Cairns Road, 17°08'10"S 145°42'45"E, at bridge just before junction with Big Mulgrave, 18 Oct. 1975, coll. P.H. Colman, AMS C.161653; Fishery Falls, Fishery Creek, south of Cairns, 17°11'35"S 145°52'40"E, tributary of lower part of Mulgrave River, 29 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 38), AMS C.161656; The Boulders, west of Babinda, 17°20'40"S 145°52'20"E, east of Bartle Frere in wide, swift stream, 29 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 40), AMS C.161668; Pine Creek, north-west end of Malbon Thompson Range, north-west of Little Mulgrave River, 16°59'45"S 145°50'20"E, stony creek with sluggish flow about 1 km east of Yarrabah Road, 30 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 44), AMS C.161654.

Specimens from all populations examined anatomically.

**Diagnosis.** Shell with narrow, open umbilicus in adults; shoulder convex or (rarely) slightly flattened. Bursal duct swollen; renal gland narrower than long and protruding for about one third of its length into posterior pallial roof.

**Description.** *Shell* (Figs 1G-I, 2F,G). Trochiform, 2.80-3.74 mm in length [mean 3.22 (M), 3.19 (F)]; 2.59-3.23 mm in width (mean 2.90 in both sexes); not sexually dimorphic in size (*P* greater than 0.05 for all measured shell characters); of medium thickness, semi-opaque, with indistinct, transparent periostracum. Spire angle 73.01°-82.44° [mean 77.07 (M), 77.85 (F)]. Protoconch of 1.25-1.35 whorls. Teleoconch of 2.75-3.10 convex whorls [mean 2.98 (M), 2.95 (F)]. Convexity ratio 0.19-0.27 [mean 0.22 (M), 0.23 (F)]; shoulder convex or, rarely, slightly flattened. Teleoconch sculpture of faint, prosocline growth lines. Aperture length/shell length ratio 0.56-0.65 [mean 0.63 (M), 0.60 (F)]. Inner lip lightly to moderately thickened, forming a narrow reflection across lower umbilical chink in some specimens but lacking distinct shelf seen in *J. thaanumi*. Outer lip simple, prosocline, angle 21.64-29.51° [mean 24.72 (M), 26.89 (F)]. Umbilical chink 0.21-0.37 mm in width [mean 0.25 (M), 0.28 (F)], umbilicus narrowly open. Colour pale pink-brown.

*Shell dimensions*. See Appendix.

*Operculum*. Operculum thin, pale yellow, usually also with red colouration; 1.18-1.78 mm in length [mean 1.64 (M), 1.58 (F)]. With or without white smear up to 0.74 mm in length [mean 0.45 (M), 0.48 (F)]. Ratio of operculum length to position of nucleus 2.79-3.44 [mean 3.11 (M), 3.15 (F)].

*Radula* (Fig.5F). Similar to that of *J. thaanumi*; differing in tending to have smaller numbers of cusps on central and lateral teeth [central teeth formula (4-5)-1-(4-5); lateral teeth (3-4)-1-(4-5)] and primary cusp on lateral teeth pointed.

*Head-foot*. As in *J. thaanumi*; pigmentation lacking

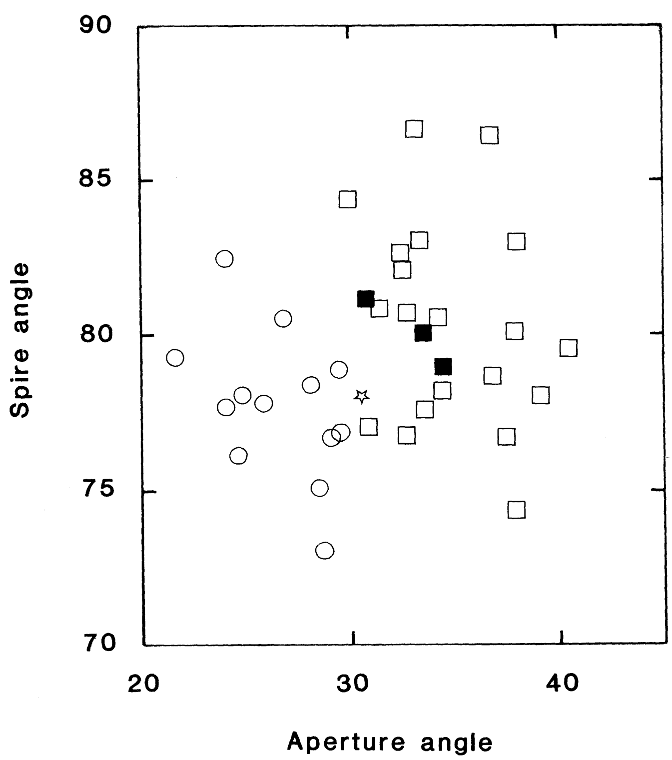


**Fig.8.** Plot of aperture angle against spire angle for specimens of *Jardinella* at terminal growth. Open squares – *J. thaanumi* (closed squares are the three adults in the type series); circles – *J. tumorosa*; star – *J. tullyensis* (holotype).

in some specimens. Tentacle ciliation (Fig.3D,E) as in *J. thaanumi*.

**Anatomy.** As in *J. thaanumi* except for following characters: ctenidium filaments 25-33 (n=8; average 28.8), left free edge of longest filaments 0.23-0.41 mm in length (n=8; average 0.28 mm). Bursal duct (Fig.6B,C, bd) extremely expanded (balloon-like) and displacing much of albumen gland. Bursal duct typically enters bursa at dorsal anterior corner of bursa (not middle of anterior face as in *J. thaanumi*) (see note about Stn 44 below). Renal gland longer than wide; anterior third, together with anterior part of renal organ, in posterior pallial roof.

*Egg capsules*. Unknown.

**Remarks.** The shell of this species is virtually identical to *J. thaanumi* but, unlike most adult specimens of that species, it has an open umbilicus. The shape of the bursal duct, however, is a readily discernible character that can be used to separate females of the two species, *J. tumorosa* having a swollen bursal duct whereas that of *J. thaanumi* is parallel-sided. This character was consistent in all five populations of *J. tumorosa* and was apparent even in submature females. The bursal duct in all populations examined of *J. thaanumi* was also consistent for that species. Specimens of *J. tumorosa* from Stn 44 (outside the Mulgrave River catchment) had a similar, swollen bursal duct to that of typical specimens but differed in that the bursal duct joined the bursa in the middle to lower part of its anterior edge (Fig.6B) rather than the upper part of the anterior edge. The ctenidial filament count of *J. tumorosa* corresponds to the high part of the range for *J. thaanumi* with a correspondingly higher average than for all of the *J. thaanumi* populations summed. The renal organ also differs markedly in the two species – it does not penetrate the pallial roof and the long axis of the renal gland is orientated across the coiling axis of the animal in *J. thaanumi* (parallel to the posterior pallial wall) whereas the opposite situation is seen in *J. tumorosa*. The radula also differs in tending to have a smaller number of cusps on the central and lateral teeth and in the primary cusp on the lateral teeth being pointed, not rounded, distally. Despite these differences the overall similarity with *J. thaanumi* suggests a relatively recent divergence of these taxa.

This species lives in a coastal wedge in the middle of the range of *J. thaanumi*. It is confined to the Mulgrave River which drains the highest mountains in Queensland, Bellenden Ker and Bartle Frere. These mountains are residual features of considerable age, being composed of Permian granitoids (Henderson & Stephenson, 1980).

As noted above the shells of *J. thaanumi* and *J. tumorosa* are very similar. Comparisons of the two species (three populations of *J. thaanumi* and two of *J. tumorosa* pooled) show that several variables are significantly different (*P* less than 0.05). These include shell length, shell width, aperture length, aperture width, length of body whorl and the length of the white smear on the operculum – these all reflecting the generally larger size of two of the populations of *J. thaanumi*. Other characters are not size related – these including the angle of the outer lip of the aperture (larger in *J. thaanumi*), the spire angle (larger in *J. tumorosa*) and the number of protoconch whorls (slightly larger in *J. tumorosa*). The number of teleoconch whorls is not significantly different but when plotted against a size related variable such as shell length or shell width the two species are reasonably well separated. A good separation is obtained by plotting spire angle against aperture angle (Fig.8). Discriminant function analysis using shell and opercular measurement data also separates the two species, although there is some overlap. The extent of overlap is reduced by removing the variables which show almost no differences (convexity, umbilical chink width, opercular length and opercular nucleus) from the data set.

**Etymology.** *Tumorosus* (Latin), bloated, inflated, referring to the diagnostic swollen bursal duct.

### *Jardinella tullyensis* n.sp.

**Material examined.** HOLOTYPE and PARATYPES: Boulder Creek, north of Tully, 17°53'10"S 145°55'20"E, tributary of Bluegum Creek, tributary of Banyan Creek, tributary of Tully River, under stones and leaves on sides of stream, 28 Sept. 1980, coll. W.F. Ponder, I. Loch, H. & E. Vokes & J. Stanisic (Stn 21). HOLOTYPE – AMS C.161657. PARATYPES, 3 – AMS C. 161658 (2); QM MO24081 (1).

**Diagnosis.** Shell with narrow, open umbilicus; shoulder flat, narrow, separated from rest of shell by sharp angulation. Bursal duct unknown. Renal gland narrower than long and protruding for about one third of its length into posterior pallial roof.

**Description.** *Shell* (Fig.1J-L). Trochiform, 3.51 mm in length; 3.09 mm in width; rather thin, semitransparent, with indistinct, transparent periostracum. Spire angle 78°. Protoconch of about 1.25 whorls. Teleoconch of 3 convex whorls; convexity ratio 0.26; shoulder flat, separated from rest of whorl by sharp angulation. Teleoconch sculpture of faint, prosocline growth lines. Aperture length/shell length ratio 0.60. Inner lip well developed, forming a narrow shelf across lower part of umbilicus. Outer lip simple, prosocline, angle 30.5°. Umbilical chink 0.33 mm in width, umbilicus open, narrow.

*Dimensions of holotype*. See Appendix.

*Operculum*. Operculum thin, pale yellow, with some red colouration; 1.76 mm in length; with white smear 0.59 mm in length. Ratio of operculum length to position of nucleus 3.2.

*Radula*. Not examined.

*Head-foot*. Similar to *J. thaanumi* but lacking pigment.

**Anatomy.** (Holotype and two subadults examined). Similar to type species. Ctenidium within large end of range for *J. thaanumi*, holotype with 35 filaments and largest filaments 0.47 mm along free right edge (cf. 0.16-0.47 mm in *J. thaanumi* and 0.23-0.41 mm in *J. tumorosa*). Subadults with 30 filaments and 0.23-0.25 mm long on left free edge. Genital system (both male and female) immature in available material. Renal gland longer than wide, renal organ protrudes into mantle roof for about half length of renal gland.

**Remarks.** This species is differentiated because of the distinctly shouldered shell which is present in all specimens in the sample. None of the other specimens of *Jardinella* examined have developed this character, although some weak shouldering is present in some material of *J. thaanumi*. The unpigmented head-foot occurs in some specimens/populations of both *J. thaanumi* and *J. tumorosa*. The ctenidium of the one adult is larger than in the other two species. It has more filaments than any of the examined material of *J. tumorosa* and is equalled in this regard by only one population of *J. thaanumi* (Stn 25) but these have narrower filaments (0.31-0.39 mm). Two specimens of *J. thaanumi* examined from Stn 33 however, have filaments 0.47 mm wide but have fewer (28) filaments. The next longest filaments seen in *J. thaanumi* are those in Stn 25 (see above).

This taxon is known from only one adult (has a mature shell aperture, even if reproductively immature) and a few immature specimens collected in a small rainforest stream. It will, no doubt, be found in additional localities associated with the Tully River.

**Etymology.** Named for Tully, the town nearby the collecting site and the name of the river into which Boulder Creek flows.

## Discussion

*Jardinella thaanumi* has been thought (Pilsbry, 1900; Hedley, 1901) to be a relative of the Tasmanian *Beddomeia* group, which forms a separate radiation from the rest of the Australian Hydrobiidae (Ponder, 1991). Iredale (1943), however, suggested that it may not be related to the Tasmanian genera. These snails are distinguished by their typically low-spired shells (like *Jardinella*), the lack of a white smear or pegs on the inner surface of the operculum and the possession of a single pair of cusps on the base of each central tooth of the radula. *Jardinella* belongs to the main hydrobiid radiation in Australia which is typified by the genus *Fluvidona*. This group typically has a conical or pupoid shell, an operculum bearing a white smear and/or pegs and the radula has more than one pair of cusps on the base of each central tooth.

Anatomically *Jardinella* is a typical member of the Hydrobiidae, the only unusual feature being the conspicuously glandular ventral lining of the midoesophagus that appears to be similar histologically to the tissue seen in an oesophageal gland. Most hydrobiids do not possess such glandular tissue although I have seen it in a poorly developed state in some other Australian hydrobiids.

The discovery of hydrobiids in western Queensland which are apparently congeneric with the coastal species of *Jardinella* has recently been reported (Ponder & Clark, 1990). A cladogram was produced by Ponder & Clark (1990) showing the relationships of the western Queensland species to *J. thaanumi* (based on data provided in this paper) and that species was included in the same subgroup as the more derived members of the radiation from the eastern part of western Queensland. This analysis suggests that the coastal species of *Jardinella* were derived from the western radiation. The location of the most plesiomorphic members of that radiation in springs in the western and south-western parts of Queensland suggests that this radiation commenced in the west and moved eastwards.

The apparent western derivation of the eastern species of *Jardinella* appears to be in contrast to the normally accepted idea that rainforest faunas are relictual. If a western origin occurred in the Pliocene or later, this would suggest that the genus diversified in an arid to semi-arid environment in permanent (mainly artesian) springs (Ponder & Clark, 1990). It is unlikely, given the pattern of anatomical diversification in the present western fauna, that the eastern fauna was derived from the west as early as the Miocene when a continuous rainforest habitat may have been available. However, wet periods during the Pliocene and Pleistocene would probably have provided corridors of semi-continuous freshwater habitat through the Great Dividing Range. A species of *Jardinella* is known from Carnarvon Gorge at the top of the eastern watershed and lives in the headwaters of the eastwards-flowing Fitzroy River. Whereas the Carnarvon Gorge is situated well south of the known distribution of north-eastern species of *Jardinella*, and the species found there today are morphologically very dissimilar, the existence of *Jardinella* species in non-artesian springs in the Great Dividing Range in the eastern headwaters appears to lend support to the hypothesis that *Jardinella* crossed the Great Divide further north and invaded the coastal rivers.

If the scenario presented above is accepted, the presence of hydrobiids as part of the freshwater fauna in north-east Queensland is a rather recent phenomenon. This observation is supported by the relatively small amount of divergence between the recognised eastern taxa compared with that seen in the western fauna (Ponder & Clark, 1990). Were hydrobiids always absent from the coastal rivers? The presumably continuous wet habitat in at least parts of this area should have provided refuges for at least some relictual species. So far none have been found. The group has a northern distribution. Hydrobiids are found in the Atea Plateau in the Papua New Guinea highlands (Smith, 1980) and, apart from the present day north-western Queensland spring-associated fauna, Miocene hydrobiid fossils are known from western Queensland and the Northern Territory (McMichael, 1968; Ponder & Clark, 1990).

There has been insufficient collecting in north-east Queensland to make definitive statements about the distribution of the group. However, as prediction should be the test of any robust hypothesis, I predict that additional species of *Jardinella* will be found in permanent springs and streams in the northern parts of the Great Dividing Range providing further links between the eastern and western members of the genus. In addition I predict that if additional freshwater hydrobiid taxa are found in north-eastern Queensland then they will either be derived members of the *Jardinella* radiation or relictual species that are not part of this radiation but more closely related to taxa in south-eastern Australia or New Guinea.

ACKNOWLEDGMENTS. I thank Dr J. Stanisic, Mr I. Loch and Drs E. and H. Vokes for their help and company in the field. Mr B. Jenkins and Mr G. Clark assisted with some of the technical aspects of this paper. The distribution map and locality data were compiled by Ms A. Miller and Mrs S. Weidland did the shell drawings. Mr G. Avern and Mr R. De Keyzer prepared material for, and photographed material with, the SEM. This work was supported in large part by a grant from ARGS (A 18516186) and ARC (A 18831777).

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Accepted 3 August 1990

## APPENDIX

TABLE OF MEASUREMENTS. Measurement data for shells and opercula of *Jardinella* species. The means and standard deviations (S.D.) are given for sexed populations, the number of individuals measured in parentheses. AA – aperture angle; AL – length of aperture; AW – width of aperture; BL – length of body whorl; CV – convexity ratio; OC – length of white smear on operculum; OL – length of operculum; ON – distance of opercular nucleus from the edge opposite the growing edge; PD – protoconch diameter; PW – protoconch whorls; SA – spire angle; SL – shell length; SW – shell width; TW – number of teleoconch whorls; WU – width of umbilicus.

| | SL | SW | AL | AW | BW | WU | CV | SA | AA | PD | PW | TW | OL | ON | OC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *J. thaanumi* | | | | | | | | | | | | | | | |
| Lectotype | | | | | | | | | | | | | | | |
| | 3.25 | 3.03 | 2.00 | 1.98 | 2.92 | 0.16 | 0.22 | 78.71 | 36.25 | 0.39 | 1.25 | 3.00 | – | – | – |
| Adult paralectotypes | | | | | | | | | | | | | | | |
| | 3.40 | 3.05 | 2.14 | 2.09 | 3.01 | 0.21 | 0.23 | 81.30 | 30.60 | 0.39 | 1.25 | 3.00 | – | – | – |
| | 2.84 | 2.69 | 1.78 | 1.61 | 2.62 | 0.24 | 0.29 | 80.12 | 35.25 | 0.43 | 1.25 | 2.90 | – | – | – |
| Figured subadult | | | | | | | | | | | | | | | |
| | 3.06 | 2.77 | 1.95 | 1.76 | 2.73 | 0.15 | 0.22 | 84.20 | 28.60 | 0.44 | 1.25 | 2.60 | – | – | – |
| Barron River Gorge (males) | | | | | | | | | | | | | | | |
| MEAN (6) | 3.27 | 2.98 | 2.09 | 1.90 | 2.95 | 0.26 | 0.23 | 79.25 | 35.85 | 0.38 | 1.23 | 2.90 | 1.64 | 0.46 | 0.56 |
| S.D. | 0.31 | 0.18 | 0.11 | 0.15 | 0.26 | 0.05 | 0.02 | 2.37 | 2.46 | 0.03 | 0.02 | 0.09 | 0.15 | 0.04 | 0.05 |
| (females) | | | | | | | | | | | | | | | |
| MEAN (4) | 3.38 | 3.15 | 2.15 | 1.96 | 3.05 | 0.28 | 0.22 | 79.06 | 34.96 | 0.39 | 1.25 | 2.94 | 1.67 | 0.50 | 0.67 |
| S.D. | 0.21 | 0.21 | 0.18 | 0.19 | 0.18 | 0.03 | 0.02 | 1.38 | 2.70 | 0.02 | 0.00 | 0.08 | 0.06 | 0.04 | 0.09 |
| Douglas Creek (Stn 25) (males) | | | | | | | | | | | | | | | |
| MEAN (2) | 3.89 | 3.64 | 2.55 | 2.24 | 3.51 | 0.35 | 0.23 | 82.84 | 32.96 | 0.42 | 1.25 | 2.88 | 1.85 | 0.52 | 0.36 |
| S.D. | 0.03 | 0.05 | 0.01 | 0.01 | 0.01 | 0.06 | 0.02 | 0.21 | 0.48 | 0.05 | 0.00 | 0.08 | 0.02 | 0.01 | 0.07 |
| (females) | | | | | | | | | | | | | | | |
| MEAN (8) | 3.85 | 3.61 | 2.46 | 2.32 | 3.47 | 0.36 | 0.23 | 81.20 | 34.40 | 0.41 | 1.26 | 2.97 | 1.84 | 0.53 | 0.33 |
| S.D. | 0.12 | 0.09 | 0.10 | 0.09 | 0.10 | 0.06 | 0.01 | 4.14 | 3.34 | 0.02 | 0.04 | 0.07 | 0.07 | 0.04 | 0.04 |
| Dowah Creek (Stn 42) (males) | | | | | | | | | | | | | | | |
| MEAN (4) | 2.78 | 2.56 | 1.70 | 1.58 | 2.47 | 0.18 | 0.25 | 80.97 | 30.40 | 0.39 | 1.25 | 2.71 | 1.35 | 0.40 | 0.38 |
| S.D. | 0.35 | 0.29 | 0.22 | 0.23 | 0.33 | 0.06 | 0.03 | 0.81 | 2.27 | 0.03 | 0.00 | 0.06 | 0.21 | 0.06 | 0.28 |
| (females) | | | | | | | | | | | | | | | |
| MEAN (6) | 2.70 | 2.50 | 1.65 | 1.51 | 2.41 | 0.21 | 0.23 | 83.21 | 30.89 | 0.40 | 1.25 | 2.64 | 1.33 | 0.39 | 0.24 |
| S.D. | 0.32 | 0.21 | 0.20 | 0.16 | 0.25 | 0.08 | 0.01 | 4.30 | 2.88 | 0.01 | 0.00 | 0.20 | 0.10 | 0.03 | 0.14 |
| *J. tumorosa* | | | | | | | | | | | | | | | |
| Types | | | | | | | | | | | | | | | |
| Holotype (female) | | | | | | | | | | | | | | | |
| | 3.30 | 2.94 | 1.86 | 1.75 | 2.78 | 0.29 | 0.27 | 76.70 | 29.10 | 0.41 | 1.25 | 3.10 | 1.65 | 0.54 | 0.50 |
| Figured paratype (female) | | | | | | | | | | | | | | | |
| | 2.83 | 2.78 | 1.67 | 1.72 | 2.47 | 0.21 | 0.23 | 80.50 | 26.90 | 0.37 | 1.25 | 3.00 | 1.57 | 0.46 | 0.38 |
| Figured paratype (female) | | | | | | | | | | | | | | | |
| | 3.74 | 3.23 | 2.24 | 2.17 | 3.23 | 0.27 | 0.22 | 82.40 | 24.10 | 0.40 | 1.25 | 3.10 | 1.78 | 0.53 | 0.74 |
| Summary data (males) | | | | | | | | | | | | | | | |
| MEAN (2) | 3.22 | 2.90 | 2.03 | 1.79 | 2.79 | 0.25 | 0.22 | 77.07 | 24.72 | 0.39 | 1.30 | 2.98 | 1.64 | 0.53 | 0.46 |
| S.D. | 0.22 | 0.12 | 0.09 | 0.08 | 0.16 | 0.03 | 0.03 | 0.97 | 0.11 | 0.04 | 0.05 | 0.03 | 0.03 | 0.03 | 0.10 |
| Summary data (females) | | | | | | | | | | | | | | | |
| MEAN (11) | 3.19 | 2.90 | 1.92 | 1.82 | 2.75 | 0.28 | 0.23 | 77.85 | 26.89 | 0.40 | 1.27 | 2.95 | 1.58 | 0.50 | 0.48 |
| S.D. | 0.26 | 0.18 | 0.15 | 0.14 | 0.21 | 0.05 | 0.02 | 2.43 | 2.53 | 0.04 | 0.04 | 0.13 | 0.15 | 0.05 | 0.11 |
| Pine Creek (Stn 44) (males) | | | | | | | | | | | | | | | |
| MEAN (5) | 3.17 | 2.88 | 1.92 | 1.80 | 2.78 | 0.27 | 0.24 | 82.18 | 27.27 | 0.36 | 1.25 | 2.99 | 1.59 | 0.49 | 0.47 |
| S.D. | 0.12 | 0.14 | 0.10 | 0.06 | 0.10 | 0.07 | 0.02 | 1.93 | 2.71 | 0.01 | 0.00 | 0.10 | 0.09 | 0.02 | 0.07 |
| (females) | | | | | | | | | | | | | | | |
| MEAN (4) | 3.30 | 3.04 | 2.13 | 1.88 | 2.69 | 0.22 | 0.20 | 79.99 | 22.03 | 0.37 | 1.25 | 3.06 | 1.67 | 0.51 | 0.41 |
| S.D. | 0.24 | 0.21 | 0.16 | 0.15 | 0.39 | 0.06 | 0.01 | 2.44 | 4.33 | 0.03 | 0.00 | 0.08 | 0.10 | 0.02 | 0.09 |
| *J. tullyensis* | | | | | | | | | | | | | | | |
| Holotype (female) | | | | | | | | | | | | | | | |
| | 3.51 | 3.09 | 2.10 | 1.92 | 2.96 | 0.33 | 0.26 | 78.00 | 30.50 | 0.40 | 1.25 | 3.00 | 1.76 | 0.55 | 0.59 |