A review of North American Recent Radiolucina (Bivalvia, Lucinidae) with the description of a new species

Elizabeth A. R. Garfinkle

Santa Barbara Museum of Natural History, 2559 Puesta del Sol, Santa Barbara, California 93105, USA

urn:lsid:zoobank.org:author:9A8D5F16-96CF-48A9-BE7C-5A2536B869D2

Corresponding author: Elizabeth A. R. Garfinkle (eargarfinkle@aol.com)

Academic editor: B. A. Marshall  |  Received 23 March 2012  |  Accepted 18 June 2012  |  Published 4 July 2012

Citation: Garfinkle EAR (2012) A review of North American Recent Radiolucina (Bivalvia, Lucinidae) with the description of a new species. ZooKeys 205: 19–31. doi: 10.3897/zookeys.205.3120

Abstract
North American members in the genus Radiolucina are reviewed. A lectotype for the type species, Radiolucina amianta, is designated and descriptions and illustrations are provided. A description of a new species, Radiolucina jessicae, from the west coast of Mexico is presented. Key diagnostic species characteristics are outlined and compared among members of the genus.

Keywords
Lucinidae, Panamic Province, neotype, lectotype, new species

Introduction
Members of Lucinidae have been grouped and identified incorrectly in the past because of variable shell and anatomical characteristics. Since the discovery of chemosymbiosis with sulphide-oxidizing bacteria in the early 1980’s, the systematics of Lucinidae has attracted more attention and many new genera and species have been described (Bouchet and Cosel 2004; Glover and Taylor 2007; Hickman 1994; Taylor and Glover 2006). Small species (less than 10 mm) have received less attention than their larger...
counterparts. There are currently over 400 Lucinidae species living in a variety of different habitats (Barnes and Hickman 1999; Roeselers and Newton 2012).

Dall (1901) placed *Phacoides amiantus* Dall, 1901 and *Lucina cancellaris* Philippi, 1846 with the Indo Pacific subgenus *Bellucina* (now known as *Cardiolucina* Sacco, 1901). Later, Britton (1972) described *Radiolucina* as a new subgenus of *Parvilucina*, and included *Phacoides amiantus* Dall, 1901, *Lucina cancellaris* (Philippi 1846), and the fossil species *Phacoides waccamawensis* (Dall, 1903). Recent DNA results (Taylor et al. 2011) show that *Radiolucina amianta* and *Radiolucina cancellaris* are related to *Lucinisica*, not *Parvilucina* or *Cardiolucina* as was thought in the past.

While reviewing the Lucinidae of the Panamic Province, morphological differences among specimens identified as *Radiolucina cancellaris* were discovered. After further research on the genus and examination of pertinent type specimens, a new species of *Radiolucina* was recognized herein named *Radiolucina jessicae*. The three Recent members of North American *Radiolucina* are described and illustrated.

**Materials, methods, and abbreviations**

One hundred *Radiolucina* specimens from Mexico and Florida were examined. Of the 100, 20 were determined to be *Radiolucina jessicae*, two were *Radiolucina amianta*, and 78 were *Radiolucina cancellaris*. Six *Radiolucina jessicae* specimens were rehydrated in water and dish soap, and reconstituted anatomy was examined.

LACM- Natural History Museum of Los Angeles, Los Angeles, USA; NHMUK- The Natural History Museum, London, UK; SBMNH- Santa Barbara Museum of Natural History, Santa Barbara, USA; USNM- Smithsonian National Museum of Natural History, Smithsonian Institution, Washington DC, USA.

In the descriptions below, morphological characteristics outlined in Britton (1972), Taylor and Glover (2000), Cosel (2006), Glover and Taylor (2007), Taylor and Glover (2009), and Coan and Valentich-Scott (2012) have been used.

**Data resources**

The data underpinning the analyses reported in this paper are deposited at GBIF, the Global Biodiversity Information Facility, http://ipt.pensoft.net/ipt/resource.do?r=radiolucina
Taxonomy

Genus Radiolucina Britton, 1972
http://species-id.net/wiki/Radiolucina

Radiolucina Britton, 1972. Type species (original designation): Phacoides (Bellucina) amiantus Dall, 1901.

Description. Shell shape subovate; maximum length: 9.0 mm, maximum height: 8.0 mm; with an average of 13 heavy radial ribs, overlain by thin commarginal lamellae that continue through interspaces, producing a reticulate pattern; posterior end thickened, posterior dorsal area often with low spines; pallial line often discontinuous broken into large and small segments; right valve hinge with two cardinal teeth, left valve hinge with one wide cardinal tooth, one anterior lateral tooth, one posterior lateral tooth.

Comparisons. Parvilucina Dall, 1901 (type species: Lucina tenuisculpta P.P. Carpenter, 1864) attains a larger size and has fine radial ribs, and a short, broad anterior adductor muscle scars compared to Radiolucina, which has strong radial ribs and a long, narrow anterior adductor muscle scar.

Pleurolucina Dall, 1901 (type species: Lucina leucocyma Dall, 1886) has heavy commarginal lamellae with few broad, weak radial ribs compared to Radiolucina. It is similar to Radiolucina in that they both have a long, narrow anterior adductor muscle scar.

Liralucina Glover & Taylor, 2007 (type species: Phacoides sperabilis Hedley, 1909) has an average of 35 flat, radial ribs compared to Radiolucina, which has average 13 strong, radial ribs.

There is evidence (Coan and Valentich-Scott 2012) that Radiolucina dates back to the Miocene.

Literature. Britton (1972), Hickman (1994), Taylor and Glover (2000), Glover and Taylor (2007), Taylor and Glover (2009), Coan and Valentich-Scott (2012).

Radiolucina amianta (Dall, 1901)
http://species-id.net/wiki/Radiolucina_amianta
Figures 1, 4, 5a

Phacoides (Bellucina) amiantus Dall, 1901: 826-827.
Parvilucina (Radiolucina) amianta. — Britton, 1972: 9-10
Lucina (Bellucina) amiantus Bretsky. — 1976: 273

Shell shape. Subovate, extended anteriorly and posteriorly, length longer than height, slightly inflated; maximum length: 6.0 mm, maximum height: 6.0 mm.
**Figure 1.** A–D *Radiolucina amianta* (SBMNH 357639, USA, Florida, Santa Petersburg, Tampa Bay) length = 5.4 mm  
A Exterior of right valve  
B Exterior of left valve  
C Interior of left valve  
D Interior of right valve  
E Close up of hinge of left valve  
F Close up of anterior adductor muscle scar of left valve  
G Close up of ribs of right valve  
H Close up of pallial line of left valve.  
E–H scale bar = 1 mm.
Sculpture and color. About 11 (n=2) non-bifurcating radial ribs, overlain by thin commarginal lamellae that continue through interspaces, producing a reticulate pattern; occasional intercalary ribs present; interspaces shallow, thin towards beak and progressively widening ventrally; anterior and posterior ends smooth with fine commarginal striae, posterior sometimes with spines of varying heights protruding from shell; inner shell margin finely crenulate; interior color tan, shiny.

Hinge. Hinge plate thick, curved on either side of cardinal teeth; beaks prosogyrate; cardinal teeth small, right valve posterior tooth thin, anterior tooth thick, left valve middle tooth wide; lateral teeth large, posterior tooth vertical, anterior tooth horizontal; ligament sunken above cardinal teeth.

Adductor scars and pallial line. Pallial line continuous; anterior adductor scar long, narrow, diverging from pallial line for about a quarter of its length; posterior adductor scar small, wide, pallial line joins at most ventral point.

Type specimens and type locality. Dall did not designate a single specimen as the holotype. To stabilize nomenclature, I herein designate the lectotype to be the right valve (USNM 64276), which is the same specimen as figured by Dall 1901, plate XXXIX fig. 10, with the type locality of Yucatan Strait, North Atlantic Ocean (approximately 21.3°N, 86.2°W), 1170 m (Fig. 4). An additional right valve (USNM 1183662) in the original lot is a paralectotype.

Distribution. Western Atlantic from North Carolina to Florida, West Indies, Gulf of Mexico, Caribbean Central America, South America south to Uruguay (Mikkelsen and Bieler 2007).

Remarks. In describing *Phacoides (Bellucina) amiantus*, Dall noted that it seemed to be the same species that Tuomey and Holmes (1857) had described as *Lucina costata* from the Pleistocene of South Carolina (non *Lucina costata* d’Orbigny, 1846). Boss et al. (1968: 25) misinterpreted Dall’s proposal as a new name, but it is expressly a new species. Moreover, it is not at all clear that these represent the same species.

Literature. Dall (1901), Bretsky (1976), Mikkelsen and Bieler (2007), Tunnell et al. (2010).

*Radiolucina cancellaris* (Philippi, 1846)
http://species-id.net/wiki/Radiolucina_cancellaris
Figure 2, 5b

*Lucina cancellaris* Philippi, 1846: 21.
*Radiolucina cancellaris* — Olsson 1961: 547.
*Radiolucina cancellaris* — Keen 1971: 1064.
*Radiolucina cancellaris* neotype — Coan and Valentich-Scott 2012: 359.

Shell shape. Subovate, inflated; maximum length: 7.2 mm, maximum height: 8.0 mm; beaks prosogyrate.
Figure 2. A–D. *Radiolucina cancellaris* neotype (SBMNH 149738, Mexico, Sonora, Cabo Haro) length = 5.5 mm A Exterior of right valve B Exterior of left valve C Interior of left valve D Interior of right valve

E–F, H *Radiolucina cancellaris* (SBMNH 20044, Mexico, Sonora, Cabo Haro) E Close up of hinge of left valve F Close up of anterior adductor muscle scar of left valve G *Radiolucina cancellaris* (SBMNH 129044, Mexico, Sinaloa, Téacapan) Close up of ribs of right valve H Close up of pallial line of left valve. E–H scale bar = 1 mm.
Sculpture and color. Average 12 (10–15 n=76) non-bifurcating radial ribs, overlain by thin commarginal lamellae that continue through interspaces, producing a reticulate pattern; interspaces sunken, thin towards beak, progressively widening ventrally; anterior end smooth, with fine commarginal striae; posterior end with a series of average 13 (12–15 n=20) thick spines of varying heights protruding from shell; inner ventral margin crenulations thin, closely spaced; interior color white to cream, shiny.

Hinge. Hinge plate thick, straight with slight curve; cardinal teeth small, right valve posterior thin, anterior thick, left valve middle tooth wide; lateral teeth large, posterior vertical, anterior horizontal; ligament sunken above the cardinal teeth.

Adductor scars and pallial line. Pallial line discontinuous, broken into small and large segments, with one small circular indentation directed ventrally; anterior adductor scar large, narrow, diverging from pallial line for about a quarter of its length; posterior adductor scar small, wide, pallial line joins at most ventral point.

Type specimens and type locality. Neotype, SBMNH 149738 (Coan and Valentich-Scott 2012), length 6 mm, height 6 mm. Cabo Haro, Sonora, Mexico, 37–73 m.

Distribution. Known from Isla Cedros, Pacific coast of Baja California (28.2°N) [Keen, 1971], into the Golfo de California as far north as near its head at Puerto Peñasco, Sonora (31.3°N) [LACM], México, to Isla San Lorenzo, Lima, Perú (12.1°S) [LACM]; intertidal zone to 212 m [LACM]. Also in the Pliocene of Ecuador and the Pleistocene of Baja California.

Literature. Britton (1972), Coan and Valentich-Scott (2012), Dall (1901), Keen (1971), Olsson (1961).

Remarks. Shell shape and ribs vary at different stages of growth. Due to this, it can be difficult to distinguish variants of Radiolucina cancellaris. The number of ribs is consistent during growth (average 12); however sometimes they were thinner or thicker, and inconsistently extended to the ventral margin. Bifurcation and/or intercalary ribs are sometimes present depending on the stage of growth.

Radiolucina jessicae Garfinkle, sp. n.
urn:lsid:zoobank.org:act:6EA53845-C2D9-4376-B460-7729CDDD3D60
http://species-id.net/wiki/Radiolucina_jessicae
Figure 3, 5c

Radiolucina cf. cancellaris Coan and Valentich-Scott, 2012: 360

Diagnosis. Subovate, extended anteriorly and posteriorly, slightly inflated; with about 11 primary radial ribs, excluding intercalary ribs; commarginal ribs continuing through interspaces creating a rectangular pattern; posterior end with fine commarginal striae and spines of varying heights protruding from shell; pallial line discontinuous, broken into a series of short and long sections with one large segment directed ventrally.

Shell shape. Subovate, long, extended anteriorly and posteriorly, length longer than height; slightly inflated; maximum length: 6.0 mm, maximum height: 5.3 mm; beaks pointed, prosogyrate.
Figure 3. A–D *Radiolucina jessiae* sp. n., holotype (SBMNH 353469, Mexico, Baja California Sur, Bahia Concepcion) length = 4.5 m A Exterior of right valve B Exterior of left valve C Interior of left valve D Interior of right valve E–H *Radiolucina jessiae* new species, paratype (SBMNH 149936) E Close up of hinge of left valve F Close up of anterior adductor muscle scar of left valve G Close up of ribs of right valve H Close up of pallial line of left valve. E–H scale bar = 1 mm.
Sculpture and color. Average 13 (9–16 n=20) radial ribs, occasional bifurcate usually on larger specimens; commarginal ribs continuing through interspaces, with 6-10 thick intercalary ribs extending to ventral edge of valve, present in most specimens, more pronounced in larger specimens; interspaces shallow and thin towards beak, progressively widening ventrally; anterior side smooth with fine commarginal striae; posterior side also smooth with fine commarginal striae, with a series of average nine (4–15 n=20) thick spines of varying heights protruding from shell; exterior color tan to white, also with brown along ribs; interior color tan, white to cream, shiny; inner shell margin crenulations thin, closely spaced.

Hinge. Hinge plate thin, slightly curved on either side of cardinal teeth; right valve posterior and anterior cardinal teeth about equal in size, left valve middle tooth wide; lateral teeth large, posterior vertical and anterior horizontal; ligament long, sunken above cardinal teeth.

Adductor muscle and pallial scars. Pallial line discontinuous, broken into series of large, small segments, with one large segment directed ventrally; anterior adductor scar is large, narrow, diverging from pallial line for about half its length; posterior adductor scar small, wide, pallial line joins anteriorly to most ventral point.
Anatomy from rehydrated dried specimens. Inhalant aperture usually smaller than exhalant, elongate, often narrow; tissue bridge between apertures usually narrow; ventral mantle fusion thin, narrow; mantle fusion variable, usually not fused below anterior adductor muscle; rectum curves dorsally around posterior adductor muscle and ends at exhalant aperture.

Type locality and type specimens. North America, Mexico, Baja California Sur, Bahía Concepción, Bahía Coyote; 26°43’50"N, 111°53’30"W; 12 m.

Holotype. SBMNH 353469, length: 4.5 mm. Paratypes. SBMNH 149936, 6 unpaired valves; LACM 3231, 4 unpaired valves; NHMUK 20120066, 2 unpaired valves; USNM 1179317, 2 unpaired valves.

Distribution. East Pacific, W side of Isla El Muerto, Baja California, Mexico (30°4.00’N, 114°33.00’W) to Bahía Concepción, Baja California Sur, Mexico (26°39.00’N, 111°48.00’N). Also known from Sonora, Guaymas, Bahía San Carlos, Sonora, Mexico (27°56.1.00’N, 111°5.00’W) to San Carlos, Gulf of Panama (8°29.00’N, 79°56.00’W). Usually collected among gravel and shells; known from 13–27 m deep.

Etymology. Named in honor of Jessica Sanford from Santa Barbara, California for being an inspiring scientist, meaningful mentor, and wonderful friend.

Comparisons. See comparisons of *Radiolucina amianta*, *Radiolucina cancellaris*, and *Radiolucina jessicae* in Table 1.

*Radiolucina waccamawensis* (Dall 1903), from the Pliocene of the Waccamaw district, South Carolina, has about 10 strong radial ribs with deep interspaces, compared to *Radiolucina jessicae* which has about 13 radial ribs with shallow interspaces, and about eight intercalary ribs. The morphologic characters of *Radiolucina waccamawensis* are closer to *Radiolucina cancellaris*.

Discussion. Different morphologic characters among different ages of *Radiolucina cancellaris* are common, specifically ontogenetic changes in shape, rib number, and hinge teeth. Further research and use of additional characters, specifically DNA studies, (Taylor et al. 2011) could present more details and explanation for the variable characters observed, and could possibly reveal more new species within the *Radiolucina cancellaris* complex.
**Table 1.** Comparisons of key characteristics of North American *Radiolucina* species.

| *Radiolucina* species | Radial ribs/ interspaces | Hinge plate | Pallial line | Adductor muscle scars |
|-----------------------|--------------------------|-------------|--------------|----------------------|
| amianta               | About 11 radial, non-bifurcating with occasional small intercalary ribs; interspaces shallow | Thick, curved on either side of cardinal teeth | Continuous | Anterior long, narrow, diverging from pallial line for about a quarter of its length; posterior small, wide, pallial line joins at most ventral point |
| cancellaris           | About 12 radial, non-bifurcating; interspaces sunken | Thick, straight with slight curve over entire length | Discontinuous, broken into a series of large and small segments with 1 small circular indentation directed ventrally | Anterior large, narrow, diverging from pallial line for about a quarter of its length; posterior small, wide, pallial line joins at most ventral point |
| jessicae              | About 13 radial, with occasional bifurcation and thick intercalary ribs; interspaces shallow | Thin, slightly curved on either side of cardinal teeth | Discontinuous, broken into a series of large and small segments with 1 large segment directed ventrally | Anterior large, narrow, diverging from pallial line for about half its length; posterior wide, pallial line joins anterodorsally to most ventral point |

**Acknowledgements**

I appreciate Paul Valentich-Scott (SBMNH) for the opportunity to write this paper and thank him for guiding and inspiring me in the world of bivalves. I deeply thank Dr. John Taylor (NHMUK) for his feedback and assistance with my research. I thank Dr. Eugene Coan for his edits and knowledgeable feedback. I appreciate Ellen Strong for providing images of the lectotype of *Phacoides (Bellucina) amiantus*, and Linda Ward and Paul Greenhall (USNM) for their assistance. I also thank Eric Hochberg and Patricia Sadeghian for their support, and Daniel Geiger (SBMNH) for taking images on the scanning electron microscope. I thank Charlene G. Garfinkle and Jeffrey B. Garfinkle for their support towards another paper and always. Open access to this paper was supported by the Encyclopedia of Life (EOL) Open Access Support Project (EOASP).

**References**

Barnes PAG, Hickman CS (1999) Lucinid bivalves and marine angiosperms: a search for causal relationships. In: Walker DI, Wells PE (Eds) The Seagrass Flora and Fauna of Rottnest Island, Western Australia. Western Australian Museum, Perth, 215–238.
Bouchet P, Cosel R (2004) The world’s largest Lucinid is an undescribed species from Taiwan (Mollusca: Bivalvia). Zoological Studies 43: 704–711.

Bretsky S (1976) Evolution and Classification of the Lucinidae (Mollusca: Bivalvia). Palaeontographica Americana 50: 219–321.

Britton JC Jr (1972) Two New Species and a New Subgenus of Lucinidae (Mollusca: Bivalvia), with Notes on Certain Aspects of Lucinid Phylogeny. Smithsonian Contributions to Zoology 129: 1–19. doi: 10.5479/si.00810282.129

Boss K, Rosewater J, Ruhoff F (1968) The zoological taxa of William Healey Dall. United States Nation Museum, Bulletin 287, 427 pp.

Coan E, Valentich-Scott P (2012) Bivalve Seashells of Tropical West America, Marine Bivalve Mollusks from Baja California to Northern Perú. Santa Barbara Museum of Natural History Monographs 6, Studies in Biodiversity 4, Santa Barbara, 1258 pp.

Cosel R (2006) Taxonomy of tropical West African bivalves. VI. Remarks on Lucinidae (Mollusca, Bivalvia) with description of six new genera and eight new species. Zootaxa 26.

Dall W (1901) Synopsis of the Lucinacea and of the American species. Proceedings of the United States National Museum 23: 779–833. doi: 10.5479/si.00963801.23-1237.779

Dall W (1901–3) Contributions to the Tertiary fauna of Florida, with especial reference to the silex beds of Tampa and the Pliocene beds of the Caloosahatchie River, including in many cases a complete revision of the generic groups treated of and their American species. Part VI. Concluding work, Wagner Free Institute of Science of Philadelphia, Transactions 3(6): 1219–1654.

d’Orbigny A (1834–1847) Voyage dans l’Amérique Méridionale ... exécuté pendant les années 1826 ... 1833, .... 5(3): Mollusques: xliii + 758, 85 pls. [in Atlas]: Paris (Bertrand) & Strasbourg (Levrault) [concerning: J. E. Gray (1855), Keen (1966d), Sherborn & Griffin (1934), Sherborn & Woodward (1901), Browning & Monroe (1991)]: Pp. 1–48, 73–128, pl. 1, 2, 9–13, 15, 16, 56, 1834 [pls. 1, 2: 14 Nov.]; pp. 49–72, 129–176, pl. 3, 8, 17–23, 25, 55, 1835 [pls. 18, 19, 22: 13 March; pl. 4: 18 May; pl. 3: 1 June; pp. 49–72: 23 Nov.]; pp. 177–184, pls. 14, 24, 26–28, 30–32, 34, 35, 37, 58, 1836; pls. 33, 36, 1836?: pp. 185–376, pl. 29, 38–52, 57, 1837 [pls. 38, 41: 19 June]; pl. 54, 59–66, 68, 69, 1839; pl. 377–424, pls. 53, 67, 70, 71, 1840; pp. 425–488, pl. 72–76, 80, 1841; pls. 83, 85, 1842; pl. 84, 1842?: pp. 529–600, 1845; pp. 489–528, 601–728, 1846; pl. 729–758, 1847?: pl. 77–79, 81, 82, 1847.

Glover E, Taylor J (2007) Diversity of chemosymbiotic bivalves on coral reefs: Lucinidae (Mollusca, Bivalvia) of New Caledonia and Lifou. Zootaxa 29: 109–181.

Hedley C (1901) Mollusca from the Hope Islands, North Queensland. Proceedings of the Linnean Society of New South Wales 34: 420–466.

Hickman C (1994) The Genus Parvilucina in the Eastern Pacific: Making Evolutionary Sense of Chemosymbiotic Species Complex. The Veliger 37 (1): 43–61.

Keen A (1971) Sea Shells of Tropical West America: Marine Mollusks from Baja California to Peru. Stanford University, Stanford, California, 1064 pp.

Mikkelsen P, Bieler R (2007) Seashells of Southern Florida: Living Marine Mollusks of the Florida Keys and Adjacent Regions. Princeton University Press, New Jersey, 236 pp.
Olsson A (1961) Mollusks of the tropical eastern Pacific particularly from the southern half of the Panamic-Pacific faunal province (Panama to Peru). Paleontological Research Institute, Ithaca, New York, 574 pp. doi: 10.5962/bhl.title.6853

Philippi RA (1846) [Monograph of] Ostrea. Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien 2 (2): 81–82.

Roeselers G, Newton LG (2012) On the evolutionary ecology of symbioses between chemosynthetic bacteria and bivalves. Applied Microbiology and Biotechnology 94: 1–10. doi: 10.1007/s00253-011-3819-9

Sacco F (1901) I molluschi dei terreni terziarii del Piemonte e della Liguria. Parte 29. Clausen, Torino, 216 pp.

Taylor J, Glover E (2000) Functional anatomy, chemosymbiosis and evolution of the Lucinidae. Geological Society of London, Special Publications 177, London, 207–225.

Taylor J, Glover E (2006) Lucinidae (Bivalvia) - the most diverse group of chemosymbiotic mollusks. Zoological Journal of the Linnean Society 148: 421–438. doi: 10.1111/j.1096-3642.2006.00261.x

Taylor J, Glover E (2009) New lucinid bivalves from hydrocarbon seeps of the Western Atlantic (Mollusca: Bivalvia: Lucinidae). Steenstrupia 30 (2): 111–124.

Taylor J, Glover E, Smith L, Dyal P, Williams S (2011) Molecular phylogeny and classification of the chemosymbiotic bivalve family Lucinidae (Mollusca: Bivalvia). Zoological Journal of the Linnean Society 163: 15–49.

Tunnell J Jr, Andrews J, Barrera N, Moretzsohn F (2010) Encyclopedia of Texas Seashells, identification, ecology, distribution, and history. Texas A&M University Press, Texas, 343 pp.

Tuomey M, Holmes FS (1857) Pleiocene Fossils of South-Carolina containing descriptions and figures of the Polyparia, Echinodermata and Mollusca. Russell & Jones, Charleston, South Carolina, 152 pp.