Bellascintilla parmaleeana New Genus and Species from the Tropical Eastern Pacific, with a Review of the Other, Ventrally Notched Galeommatid Genera (Bivalvia: Galeommatacea)

C. Clifton Coney
Los Angeles County Museum of Natural History
900 Exposition Boulevard
Los Angeles, CA 90007, USA

ABSTRACT

Bellascintilla parmaleeana, new genus and species, is described from the tropical eastern Pacific. It differs from *Divariscintilla maoria* Powell, 1932, in the morphology of the cardinal teeth, as well as the internal crenulation of the ventral margin of the valves, prominent exterior radiating sulcus, sculpture of commarginal striae, and in shell ultrastructure.

Four other ventrally notched galeommatids are redescribed on the basis of shell characters and shell ultrastructure: *Vasconiella jeffreysiana* (Fischer, 1873), from the northeastern Atlantic, *Divariscintilla maoria* Powell, 1932, from New Zealand, *Tryphomyax lepidoformis* Olsson, 1961, and *T. mexicanus* (Berry, 1959) from the tropical eastern Pacific. The general shell characters of the latter two species indicate these to be more closely allied with *Galeomma*.

Divariscintilla yoyo Mikkelsen and Bieler, 1989, and *D. troglodytes* Mikkelsen and Bieler, 1989, lack a ventral notch and are reassigned to the genus *Phlyctaenachlamys* Popham, 1939, based on shared characters of internal shell and morphology of shell, hinge, ligament, mantle, and ctenidia; however, the "flower-like organ" has not been reported in *Phlyctaenachlamys*.

Key words: ventrally notched galeommatids; systematics; anatomy; shell ultrastructure; *Phlyctaenachlamys*.

INTRODUCTION

Galeommatid bivalves are small and easily overlooked, particularly because the living animals are often commensal with other kinds of animals, such as living attached to the walls of stomatopod burrows. Stomatopod burrows have not been adequately sampled for associated species of Mollusca. Galeommatid shells, however, are reasonably well represented in museum collections and have morphological characters that enable the definition of genera and species based on shell characters alone. One group of galeommatids has the shell ventrally notched in one or both valves. Until now the number of species known with this feature is four, and a total of three generic taxa have been introduced to accommodate them.

The objective here is to describe a new monotypic genus and species that is broadly distributed throughout the Panamic Province. This necessitated comparison with other ventrally notched galeommatids from the same faunal region and other regions of the world. The total number of taxa is sufficiently small to enable a full review of all species.

I have included descriptions of shell ultrastructure in addition to the conventional shell characters, providing an additional character set. The information derived from shell ultrastructure provides finer distinctions in support of the classification adopted here.

MATERIALS AND METHODS

Specimens of *Vasconiella jeffreysiana, Divariscintilla maoria, Tryphomyax lepidoformis, T. mexicanus* and of *Bellascintilla parmaleeana* (LACM paratypes 2447 and 2448), were mounted on stubs, gold coated and examined with a Cambridge 360 scanning electron microscope (SEM) set at 20 kilovolts and a working distance of 10 mm. The holotype of *B. parmaleeana* (LACM 2446) was examined uncoated with SEM set at 2 kilovolts and a working distance of 6 mm.

Only a single valve of each genus was examined for shell ultrastructure because the ventrally notched galeommatid species are rare and few specimens are available for study. Examination of shell ultrastructure was conducted on adult valves that were broken radially from hinge line to ventral edge. It was generally possible to follow each of the shell layers described from umbo to ventral margin. Individual shell layers were observed at magnifications of 5,000 × and 10,000 ×. Photomicrographs were made in the central region of the shell that contained all the shell layers. Measurements of shell thickness were made in the central region of the shell,

Table 1. Comparison of shell characters of *Vasconiella, Divariscintilla, Tryphomyax,* and *Bellascintilla.*

Character	*Vasconiella*	*Divariscintilla*	*Tryphomyax*	*Bellascintilla*
Ventral notch	present on right valve	present on both valves	present on both valves	present on both valves
Valve congruence	greatly inequivalve	equivalve	equivalve	slightly inequivalve
Exterior sculpture	right smooth, left with commarginal striae	smooth	cancellate	commarginal striae
Mid-valve sculpture	two radiating ribs fused by suture	radiating rib	radiating rib bound by sulci	two radiating ribs fused by suture
Interior sculpture	fine riblets on margin	minutely granulate	radiating ribs	crenulate margin
Position of beak & cardinals	central	anterior	central	anterior
Cardinals type	tubercular	tubercular	tubercular	cuniform
no. left	2	0	2	2
no. right	1	1	1–2*	2
Laterals				
no. left	1	1	1	1
no. right	1	0	1–2*	2
Adductor	unknown	unknown	unknown	isomyarian
Ligament	unknown	amphidetic	resilium	resilium

* Reflects a species level differentiation.

using a vertical point-to-point feature. Characterization of individual layers of shell ultrastructure follows standards defined by Carter and Clark (1985). Shell dimensions were measured using a Zeiss zoom stereomicroscope with optical reticle.

For consistency, revised descriptions are given for each species.

The following institutional abbreviations are used: ANSP, Academy of Natural Sciences of Philadelphia; CAS, California Academy of Science; LACM, Los Angeles County Museum of Natural History; NMNZ, National Museum of New Zealand; SDNHM, San Diego Natural History Museum; SMNH, Swedish Museum of Natural History; USNM, National Museum of Natural History.

SYSTEMATICS

Bivalvia Linnaeus, 1758
Heterodonta Neumayr, 1884
Veneroida H. & A. Adams, 1856
Galeommatacea Gray, 1840
Galeommatidae Gray, 1840
[= Galeomatidae Nordsieck, 1969]
[= Vasconiellidae Scarlato and Starobogatov, 1979]

Chavan (1969) treated the family Galeommatidae without subfamilial division, recognizing 24 genera (five of these questionably, with four others pronounced *genera dubia*), and 10 subgenera. Of these, only three genera possess a ventral notch at mid-valve position in one, or more commonly, both valves.

The new species described herein differs at the generic level. Its description follows the review of other ventrally notched galeommatids: *Vasconiella jeffreysiana* (P. Fischer, 1873), *Divariscintilla maoria* Powell, 1932, *Tryphomyax lepidoformis* Olsson, 1961, and *T. mexicanus* (Berry, 1959).

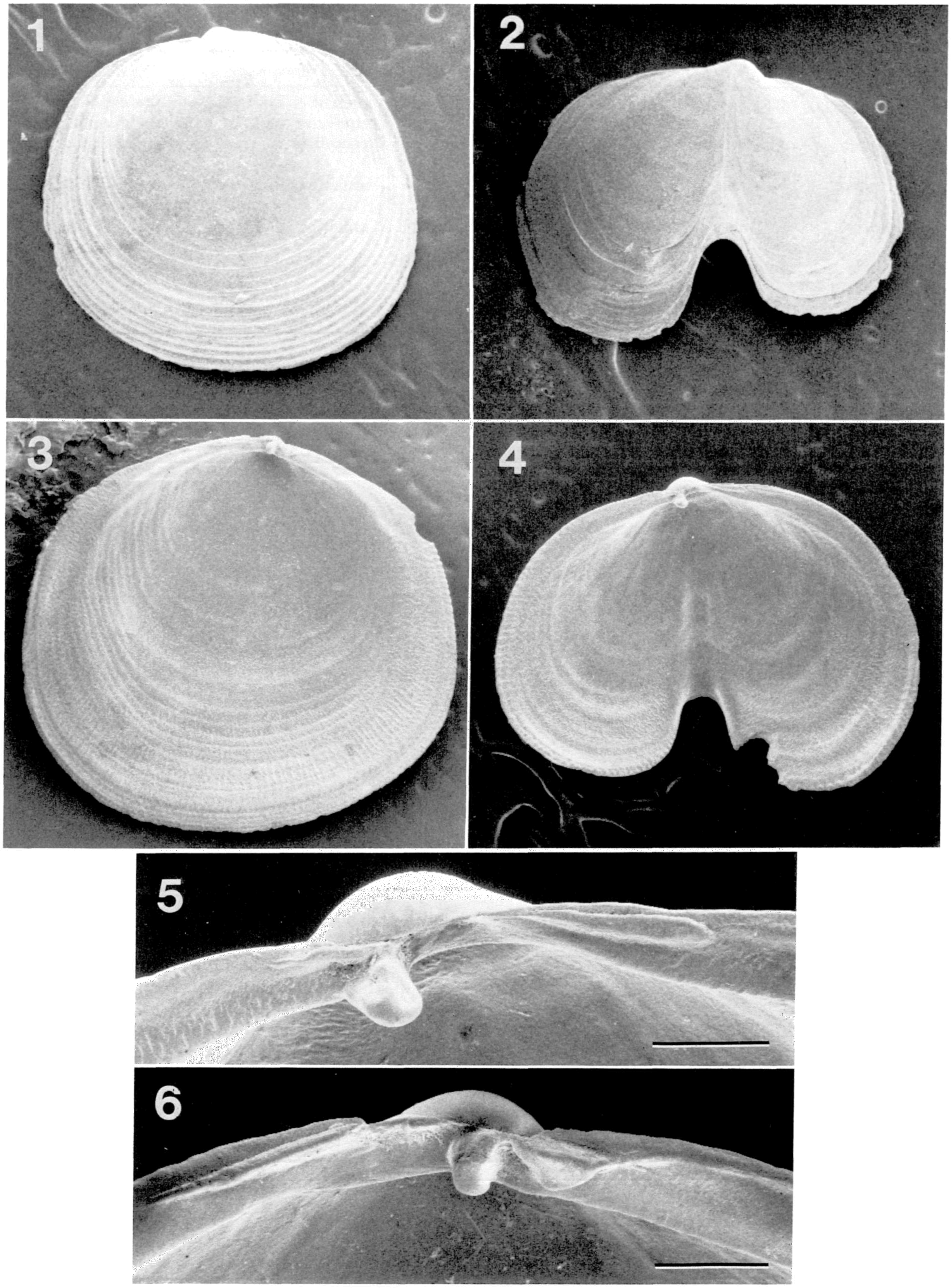
Key to the ventrally notched Galeommatidae:
(See table 1 for additional details)

1. Shell ventrally notched at mid-valve length in right valve only, left valve orbicular in profile .... *Vasconiella*
   Both valves ventrally notched at mid-valve length 2
2. Shell exterior smooth, unsculptured, with single, small mid-valve rib; ventral notch broad and shallow .... *Divariscintilla*
   Shell exterior sculptured, mid-valve rib prominent, ventral notch narrow and deep 3
3. Shell exterior sculptured with riblets and commarginal striae giving the exterior a cancellate appearance, mid-valve rib bordered on either side by minute sulci .... *Tryphomyax*
   Shell exterior sculptured with fine commarginal striae only, mid-valve rib composed of two ribs fused together by a medial suture ... *Bellascintilla*

Vasconiella Dall, 1899

Type species by original designation: *Hindsia jeffreysiana* P. Fischer, 1873. The genus is monotypic.

Diagnosis: Highly inequivalve with left valve larger than right valve. Shell ventrally notched at mid-valve length in right valve only, left valve orbicular in profile. Two ribs, fused by a suture, ascend from mid-valve notch of right valve and rise to middle of central slope, left valve without such sculpture. Cardinal teeth tubercular,



Figures 1–6. *Vasconiella jeffreysiana* (P. Fischer, 1873). SMNH uncataloged. Sagres, Algarve Prov., Portugal, 17–33 m. **1.** Exterior of left valve, length 3.4 mm, Pontal dos Corvos, 17–22 m. **2–6.** Ponta dos Caminos, 23–33 m, sand. **2.** Exterior of right valve, length 3.5 mm. **3.** Interior of left valve, length 4.0 mm. **4.** Interior of right valve, length 3.8 mm. **5.** Hinge of right valve, scale bar = 200 μm. **6.** Hinge of left valve, scale bar = 200 μm.

one in right valve, two in left valve. One posterior lateral tooth present in each valve.

Remarks: The type species of *Vasconiella* was originally described in the genus *Hindsia* Deshayes, 1858, not H. and A. Adams, 1853, in which the type species has a geologic range of Paleocene to Upper Eocene. *Hindsia* was replaced by *Hindsiella* Stoliczka, 1871, and assigned to the Sportellidae by Dall (1899:876). The genus *Vasconia* Fischer, 1873, was another unnecessary new name for *Hindsia*; Fischer (1887) corrected this error. Dall (1899:875) was the first to recognize the need for generic separation of "*Vasconia*" *jeffreysiana*; the name *Vasconiella* was proposed in a provisional classification scheme without discussion.

Vasconiella jeffreysiana (P. Fischer, 1873)
(figures 1–6, 31, 35)

Hindsia jeffreysiana P. Fischer, 1873:83, pl. 2, fig. 8; 1887: 1032–1033, fig. 776a,b.
Scintilla crispata P. Fischer, 1873:83, pl. 2, fig. 7; P. Fischer, 1874:220; P. Fischer, 1878:178; Hildago, 1917:631; Aartsen, 1982:125.
Vasconia jeffreysiana; P. Fischer, 1874; de Folin and Perier, 1878:351; P. Fischer, 1878:178; Hildago, 1917:727.
Lepton lepisma Monterosato, 1878:314; Warén, 1980:46; Aartsen, 1975:467; 1982:125.
Vasconiella jeffreysiana; Dall, 1898:875; Pasteur-Humbert, 1962:53, pl. 19, fig. 75; Montero Aguera, 1971:58; Kisch, 1958:21–24, fig. 1, pl. 3; Nordsieck, 1969:91, pl. 14, fig. 51.30; Chavan, 1969:537, figs. 35–7a,b; Aartsen, 1975:466–467; 1982:125; Bruggeman-Nannenga, 1975:14; Dekker, 1975:466; Mienis, 1975:441; 1976:522; Verduin, 1975:422; Bouchet, Danrigal, and Huyghens, 1978:126, pl. 5, fig. 17; Montero Aguera, 1971:58–59; Cornet, 1982:36–43, figs. 2–5; Mikkelsen and Bieler, 1989:189.
Solecardia (*Scintillorbis*) *crispata*; Montero Aguera, 1971:223–224.

Material examined: SMNH uncataloged, Pontal dos Corvos, Sagres, Algarve Prov., Portugal (37°01.3'N, 08°58.3'W), 17–22 m, base of cliff, May 1988, one left valve. SMNH uncataloged, Ponta dos Caminos, Sagres, Algarve Prov., Portugal (37°02'N, 08°52'W), 23–33 m, sand, May 1988, five right valves, one left valve. SMNH uncataloged, Sagres Harbor, Algarve Prov., Portugal (37°00.6'N, 08°55.6'W), 9–15 m, May 1988, one left valve. SMNH uncataloged, Baía Baleeira, Sagres, Algarve Prov., Portugal (37°00.7'N, 08°55.0'W), 12–17 m, sand, May 1988, one right valve.

Description: Right and left valves highly disparate, inequivalve by virtue of deep notch in ventral shell margin of right valve; ventral shell margin of left valve subcircular. Right valve attaining 4.2 mm in length and 3.0 mm in height; left valve larger, attaining 5.4 mm in length and 4.6 mm in height. Exterior of right valve smooth except for growth rings and two ribs joined together by suture radiating from umbo, becoming more raised where joining notch of ventral shell margin. Interior of right valve with corresponding sulcus radiating of ventral shell margin. Left valve subcircular in outline. Exterior surface smooth, with many evenly spaced commarginal striae on shell exterior from middle of valve to valve margin. Fine radiating riblets faintly impressed on ventral margin of interior of right valve, strongly impressed on ventral margin of interior of left valve. One tubercular cardinal tooth and one short posterior lateral tooth in right valve; two cardinal teeth in left valve, anterior cardinal wedge-shaped, posterior cardinal tubercular; one short posterior lateral tooth.

Shell ultrastructure (figure 35): Shell thickness of specimen studied 35 μm, consisting of five distinct layers. Exterior layer of thin, blocky simple prismatic structure, underlain by layer of fine-grained homogeneous structure; median and thickest layer of crossed-lamellar structure, underlain by fine-grained homogeneous structure; innermost layer of thin blocky simple prismatic structure.

Distribution: Bay of Biscay and Mediterranean Sea (Franc, 1960) to Morocco (Pasteur-Humbert, 1962), north to Plage de l'Aber, Kerfany les Pins and Quiberon on the French Atlantic coast (Aartsen, 1982).

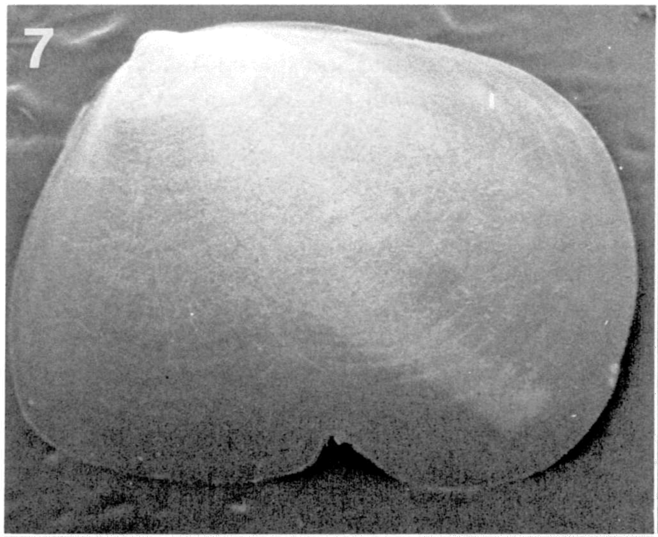
Remarks: The notched right valve of *Vasconiella jeffreysiana* was described by P. Fischer (1873) as *Hindsia jeffreysiana* while the unnotched left valve also was described by P. Fischer (1873) as *Scintilla crispata*. Kisch (1958) reported the discovery of to disparate valves joined together in a single specimen; however, he did not associate the name *S. crispata* with the left valve and described and illustrated the left valve as if for the first time. Cornet (1982), in a partial synonymy of *Vasconiella jeffreysiana*, was first to recognize and associate the left valve with the original description of *S. crispata*.

Cornet (1982) illustrated the hinge of both left and right valves and provided additional description of the hinge and exterior "deposit", but stated in error that "there are no true lateral teeth." Scanning electron photomicrographs of the hinge clearly show the presence of a short posterior lateral tooth in the right valve (figure 5), and a short posterior lateral tooth in the left valve (figure 6). The single cardinal tooth of the right valve fits beneath the two cardinal teeth of the left valve, and the lateral tooth of the left valve fits beneath the lateral tooth of the right valve, forming a very effective fulcrum and counterlocking hinge. SEM views of the mid-valve ridge (figure 31) show it to be two ridges fused together by a radial suture.

The anatomy of *Vasconiella jeffreysiana* was described in detail by Cornet (1982). No positive evidence for commensial association with stomatopods has been documented; however, Cornet (1982) noted that the distribution of *Vasconiella jeffreysiana* was congruent with that of *Lysiosquilla eusebia* (Risso, 1816).

Divariscintilla Powell, 1932

Type species by original designation: *Divariscintilla maoria* Powell, 1932. The genus is monotypic.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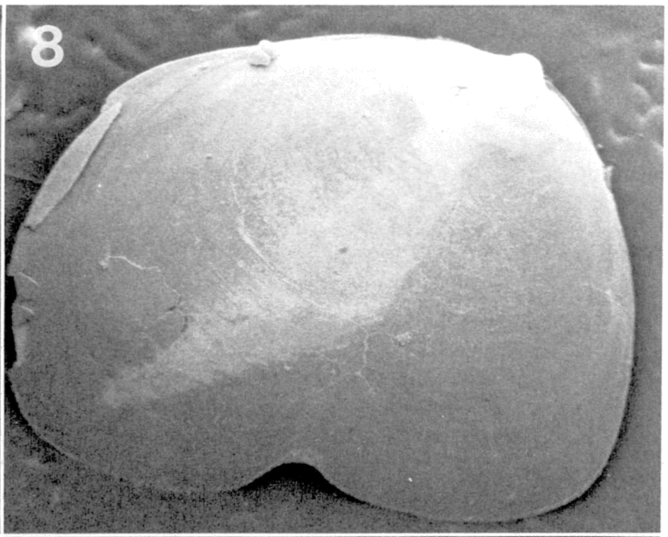
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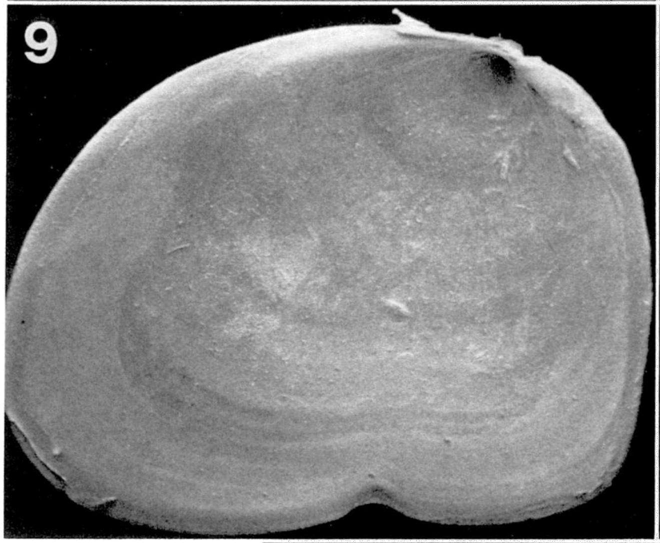
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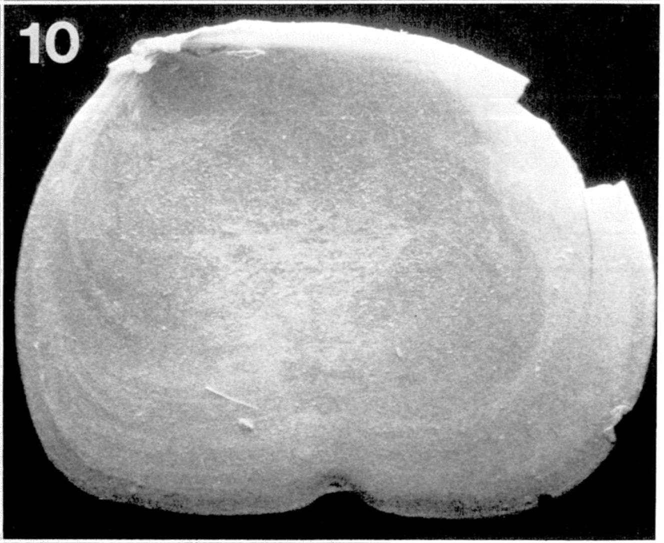
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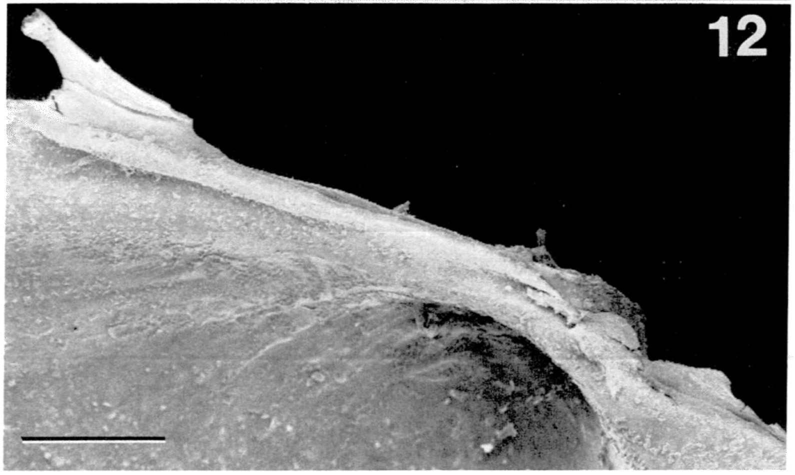
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Diagnosis: Both valves ventrally notched at mid-valve length, ventral notch broad and shallow. Shell exterior smooth, unsculptured, with single, small mid-valve rib beginning at mid-valve notch and ending on central slope. Two tubercular cardinal teeth in right valve, left valve without teeth.

Divariscintilla maoria Powell, 1932
(figures 7–12, 32, 36)

Divariscintilla maoria Powell, 1932:66–67, pl. 6, fig. 1 [holotype, Auckland Museum]; 1962:122; Judd, 1971:343–353, figs. 1–7; Morton, 1975:365, 368; 1976:32; Mikkelsen and Bieler, 1989:175–195.

Vasconiella (*Divariscintilla*) *maoria*; Chavan, 1969:537; Powell, 1976:126.

Material examined: NMNZ M.21965, Cheltenham Beach, Auckland, New Zealand, from *Lysiosquilla spinosa* burrows, one left valve, one right valve, and two specimens with paired valves.

Description: Shell equivalve, inequilateral. The second largest of the ventrally notched galeommatids with both valves attaining 6.0 mm in length and 4.9 mm in height. Anterior end shorter than posterior as defined by notch on mid-ventral margin. Fine, week rib radiating from umbo to ventral notch in both valves, otherwise shell exterior with commarginal growth lines divaricating at radiating rib. Interior of valves minutely granulate, shell margin smooth; weak interior sulcus radiating from beak cavity to ventral notch and corresponding to external radiating rib. Ligament amphidetic, mostly posterior to beak supported by nymphs. Hinge of right valve with one tubercular cardinal tooth, anterior to large resilium (figure 11). Left valve lacking cardinal teeth, narrow horizontal resilifer under posterior side of beak; lateral tooth posterior to beak, terminating at terminus of nymph.

Shell ultrastructure (figure 36): Shell thickness of specimen examined 25 μm. Shell consisting of three distinct layers. Exterior shell layer of fine grained homogeneous structure; median and thickest layer consisting of intersected crossed platy structure; interior shell layer of irregular simple prismatic structure.

Distribution: Scattered shells have been found throughout New Zealand (Judd, 1971).

Remarks: Powell's (1932) description, although detailed, lacks mention of the following features. The ligament is described as being amphidetic without mention of a nymph. The ligament is primarily posterior to the beak where it is supported by a nymph (figure 12), yet the ligament does pass between the beaks, terminating slightly anterior to them where it is supported by a small nymph. Additionally, no mention is made of the lateral tooth of the left valve, the granular interior shell surface, or the weak external rib that radiates from umbo to ventral notch (figure 32), with a corresponding sulcus on interior of valves.

Judd (1971) documented the anatomy, behavior, and commensal relationship of *Divariscintilla maoria* with stomatopods.

Tryphomyax Olsson, 1961

Type species: *Tryphomyax lepidoformis* Olsson, 1961 by original designation. The genus *Tryphomyax* presently contains two species: *T. lepidoformis* Olsson, 1961, and *T. mexicanus* (Berry, 1959).

Diagnosis: Shell quadrate or subovate with a prominent radial mid-valve rib from mid-valve notch to umbo bound on either side by minute sulci. Cancellate sculpture of exterior produced by radial riblets and commarginal striae. One or two tubercular cardinal teeth in right valve, two in left valve. One or two lateral teeth in right valve, one lateral tooth in left valve.

Tryphomyax lepidoformis Olsson, 1961
(figures 13–16, 33)

Tryphomyax lepidoformis Olsson, 1961:240–241, pl. 36, figs. 4, 4a [holotype, ANSP 218922]; Keen, 1971:133–135, fig. 308; Bernard, 1983:30.

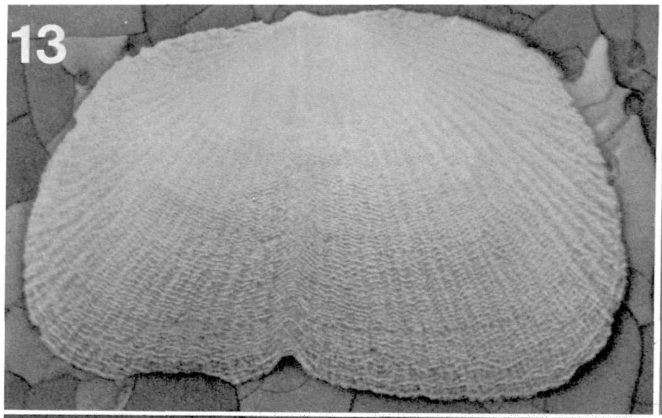
Tryphomyax lepidoformis laevis Olsson, 1961:241, pl. 36, figs. 7, 7b [holotype, ANSP 218923].

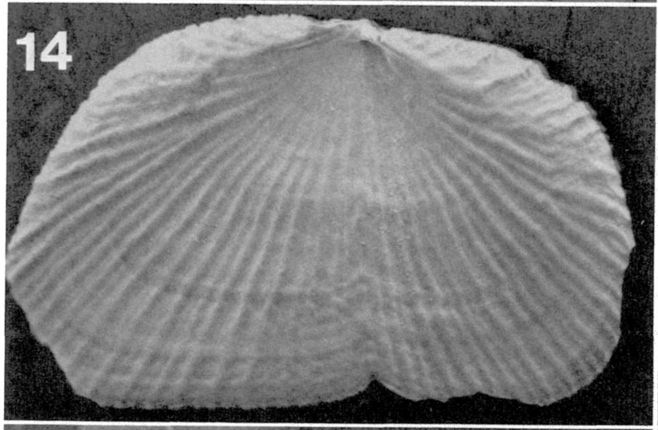
Material examined: LACM 77-144.4, Punta Chame, Golfo de Panama, Panama (08°41′N, 79°39′W), shallow dredging, two left valves. LACM 62-22.1, Bahía Cholla, W of Puerto Peñasco, Sonora, Mexico (31°19.6′N, 113°37.7′W), intertidal screenings, one right valve.

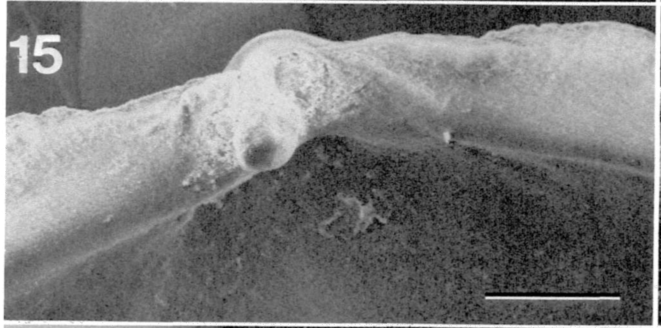
Description: Shell equivalve, inequilateral. Outline of shell rectangular. Anterior of valves shorter than posterior as defined by notch on mid-ventral valve margin. Wide, pronounced rib radiating from umbo to ventral notch in both valves (figure 33). Exterior of valves with regularly spaced riblets radiating from umbo and densely covered with thin, closely spaced commarginal multicostae. Interior of valves with regularly spaced, pronounced ribs radiating from umbo cavity, becoming slightly divaricated anteriorly; weak interior sulcus radiating from beak cavity to ventral notch and corresponding to external radiating rib. Ligament internal. Hinge of right valve with one large tubercular cardinal tooth and a smaller lamellar cardinal tooth anterior and dorsal to larger tooth; two very short lateral teeth located posterior to cardinal teeth; ventral lateral tooth descend-

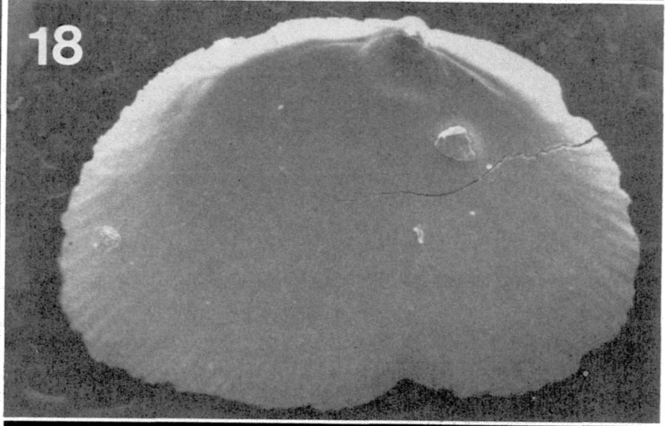
←

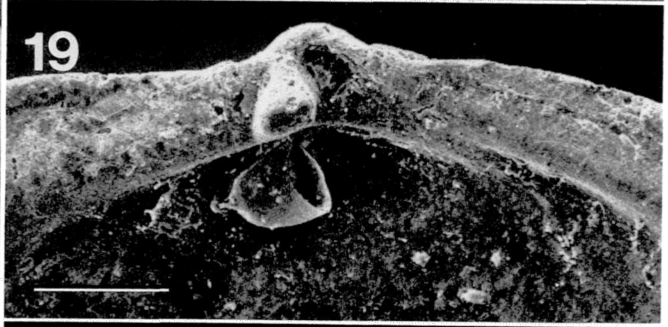
Figures 7–12. *Divariscintilla maoria* Powell, 1932. NMNZ M.21965. Cheltenham Beach, Auckland, New Zealand, from *Lysiosquilla spinosa* burrows. **7.** Exterior of left valve, length 6.1 mm. **8.** Exterior of right valve, length 6.0 mm. **9.** Interior of left valve, length 5.0 mm. **10.** Interior of right valve, length 5.0 mm. **11.** Hinge of right valve, scale bar = 500 μm. **12.** Hinge of left valve, scale bar = 200 μm.

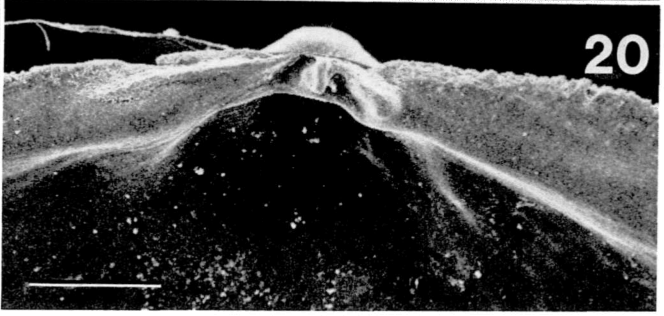












Figures 13–16. *Tryphomyax lepidoformis* Olsson, 1961. **13–14, 16.** LACM 77-144.4, Punta Chame, Golfo de Panama, Panama. **13.** Exterior of left valve, length 5.4 mm. **14.** Interior of left valve, length 5.4 mm. **15.** LACM 62-22.1, Bahía Cholla, Sonora, Mexico. Hinge of right valve, scale bar = 200 μm. **16.** Hinge of left valve, scale bar = 200 μm.

Figures 17–20. *Tryphomyax mexicanus* (Berry, 1959). **17.** LACM 65-82.1, N end Isla Ceralvo, Gulf of California, Baja California Sur, Mexico, left valve exterior, length 5.7 mm. **18, 20.** LACM 71-22.1, S of Punta Arena, Gulf of California, Baja California Sur, Mexico. **18.** Interior of left valve, length 2.9 mm. **19.** LACM 66-21.3, from off Punta Arena, Gulf of California, Baja California Sur, hinge of right valve, scale bar = 200 μm. **20.** Hinge of left valve, scale bar = 200 μm.

ing sharply from beak, dorsal lateral tooth approximately parallel to hinge margin; obscure resilifer posterior to tubercular cardinal tooth. Left valve with two cardinal teeth, anterior cardinal tooth tubercular, separated from posterior cardinal tooth by curved fossa; posterior cardinal tooth C-shaped, curved anteriorly; posterior lateral tooth descending sharply from beak, separated from posterior cardinal tooth by resilifer forming triangular fossa with apex reaching beak.

Distribution: A single valve is reported here from the head of the Gulf of California. This may have been due to a labeling error, as all other records are from Panama.

Remarks: This species is one of the rarest bivalves in the Eastern Pacific. It was reported by Olsson (1961) to occur in association with "worm tubes". Anatomy, behavior, and reproduction are unknown.

Although Bernard (1983) listed *Tryphomyax lepidoformis* Olsson as a synonym of *T. mexicanus* (Berry), both taxa are recognized here as distinct species. Comparisons with *T. mexicanus* are given below.

Tryphomyax mexicanus (Berry, 1959)
(figures 17–20, 37)

Galeomma mexicanus Berry, 1959:108–109 [holotype, CAS 043981, paratype, SDNHM 42813]; Hertz, 1984:18, fig. 35.

Tryphomyax mexicanus: Keen, 1971:135, fig. 308; Bernard, 1983:30.

Material examined: LACM 69-21.4, W side Isla Miramar, S of Puertecitos, Gulf of California, Baja California, Mexico (30°04.8′N, 114°33.0′W), 15–26 m, sand, one left valve. LACM 69-22.3, W of Isla San Luis, S of Puertecitos, Gulf of California, Baja California, Mexico (29°57.80′N, 114°28.0′W), 26 m, sand, right valve (broken for shell ultrastructure after measurement). LACM 85-21.1, Juncalito, Gulf of California, Baja California Sur, Mexico (25°53′N, 111°20.5′W), beach drift, one right valve, one left valve. LACM 65-82.1, off N end Isla Ceralvo, Gulf of California, Baja California Sur, Mexico (24°23′N, 109°55.5′W), 9 m, one left valve. LACM 66-21.3, off Punta Arena, Gulf of California, Baja California Sur, Mexico (23°32′N, 109°28′W), 18–37 m, sand, one right valve. LACM 71-22.1, Los Tezos Ranch, 1.5 mile S of Punta Arena, Gulf of California, Baja California Sur, Mexico (23°31′N, 109°00′W), 9 m, one left valve.

Description: Shell equivalve, inequilateral. Largest of the ventrally notched galeommatids with valves reaching 6.4 mm in length and 4.0 mm in height. Outline of shell oblong and rounded, not rectangular. Anterior of valves shorter than posterior as defined by notch on mid-ventral valve margin. A weak rib radiating from umbo to ventral notch in both valves. Exterior of valves with irregularly spaced riblets radiating from the central slope to the ventral margin; densely covered with thin, closely spaced commarginal multicostae. Interior of valves smooth, except ventral margin, which is crenulate with small radiating riblets. Hinge of right valve with one large tubercular tooth, and posterior fossa for resilifer, both located under beak; one large lateral tooth posterior to resilifer. Left valve with two cardinal teeth, posterior cardinal tooth tubercular, arising from directly under the beak; anterior cardinal tooth lamelliform, descending at an angle from beak. Lateral tooth of left valve horizontal and parallel to dorsal hinge line.

Shell ultrastructure (figure 37): Shell thickness of specimen examined 59 μm, with a single distinct layer, consisting of very fine complex crossed-lamellar structure.

Distribution: Throughout the Gulf of California. Previously reported only from the head of the Gulf of California (Berry, 1959; Keen, 1971). The distribution is here extended south to Punta Arena, Gulf of California, Baja California Sur, Mexico. The more extensive distribution cited by Bernard (1983) from the head of the Gulf of California to Panama was a result of his synonomy of *T. lepidoformis* with *T. mexicanus*.

Remarks: This species differs from *T. lepidoformis* in profile, being rounded rather than rectangular, in both external and internal shell sculpture, and in having a different hinge structure. The posterior lateral teeth in the right valves are different in both number and relative size, *T. mexicanus* having a single large posterior lateral (figure 19 truncates prior to posterior terminus of lateral tooth due to accidental shell breakage) whereas *T. lepidoformis* has two small short posterior lateral teeth in the right valve. The primary distribution is more northern than that of *T. lepidoformis*, the records limited to the Gulf of California. Anatomy, ecology, behavior, and reproduction are unknown.

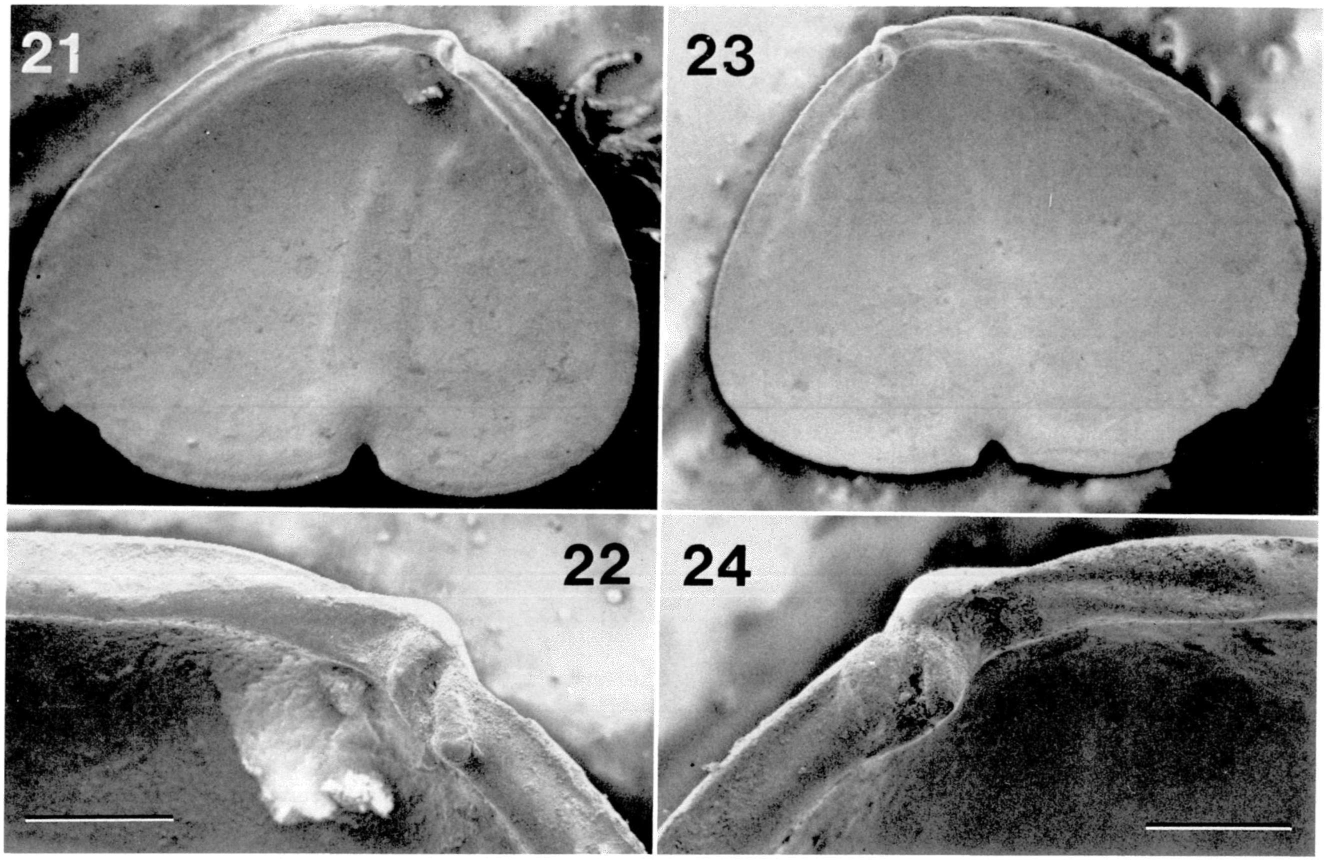
Bellascintilla new genus

Type species, here designated: *Bellascintilla parmaleeana* new species. The genus is monotypic.

Diagnosis: Shell subtriangular in outline with beaks anterior. Two distinct ribs fused together by medial suture arising from mid-valve notch, terminating abruptly on umbo. Shell sculptured with fine commarginal striae that ascends towards mid-valve ribs. Cardinal teeth cuneiform, two in each valve. One posterior lateral tooth in left valve, two posterior lateral teeth in right valve. Resilifer between cardinal teeth and lateral teeth.

Etymology: The name is a Latin compound derived from *scintilla*, spark, and *bella*, beautiful.

Remarks: The smallest of the ventrally notched galeommatids, the shell attaining 4.5 mm in length and 3.5 mm in height. *Bellascintilla* (figure 38) differs from *Divariscintilla* (figure 36) in shell ultrastructure (thickest layer of crossed lamellar structure underlain by fine grained homogeneous structure rather than thickest layer of intersected crossed platy structure underlain by irregular simple prismatic structure as in *Divariscintilla*), being more like that of *Vasconiella* (figure 36); in exterior shell



Figures 21–24. *Bellascintilla parmaleeana* new species. Holotype, LACM 2446, off Bahía Herradura, Puntarenas Province, Costa Rica. **21.** Interior of left valve, length 3.2 mm. **22.** Hinge of left valve, scale bar = 200 μm. **23.** Interior of right valve, length 3.1 mm. **24.** Hinge of right valve, scale bar = 200 μm.

sculpture (fine commarginal striae, with small undulating ribs along posterior dorsal margin and ventral margin internally crenulate rather than essentially smooth, featureless sculpture as in *Divariscintilla*); in form and number of the mid-valve ribs (two fused together by suture rather than a single small rib as in *Divariscintilla*); and in the hinge teeth (cuniform rather than tuberculiform). Based on similarity of shell ultrastructure, and the formation of the mid-valve ridge, *Bellascintilla* also requires comparison to *Vasconiella*. These genera differ in left valve profile (triangular and ventrally notched rather than suborbicular and lacking a ventral notch as in *Vasconiella*), and in the morphology of their hinge teeth (cuneiform rather than tuberculiform). *Tryphomyax* and *Bellascintilla* do not share any of the features studied here other than the presence of a ventral notch.

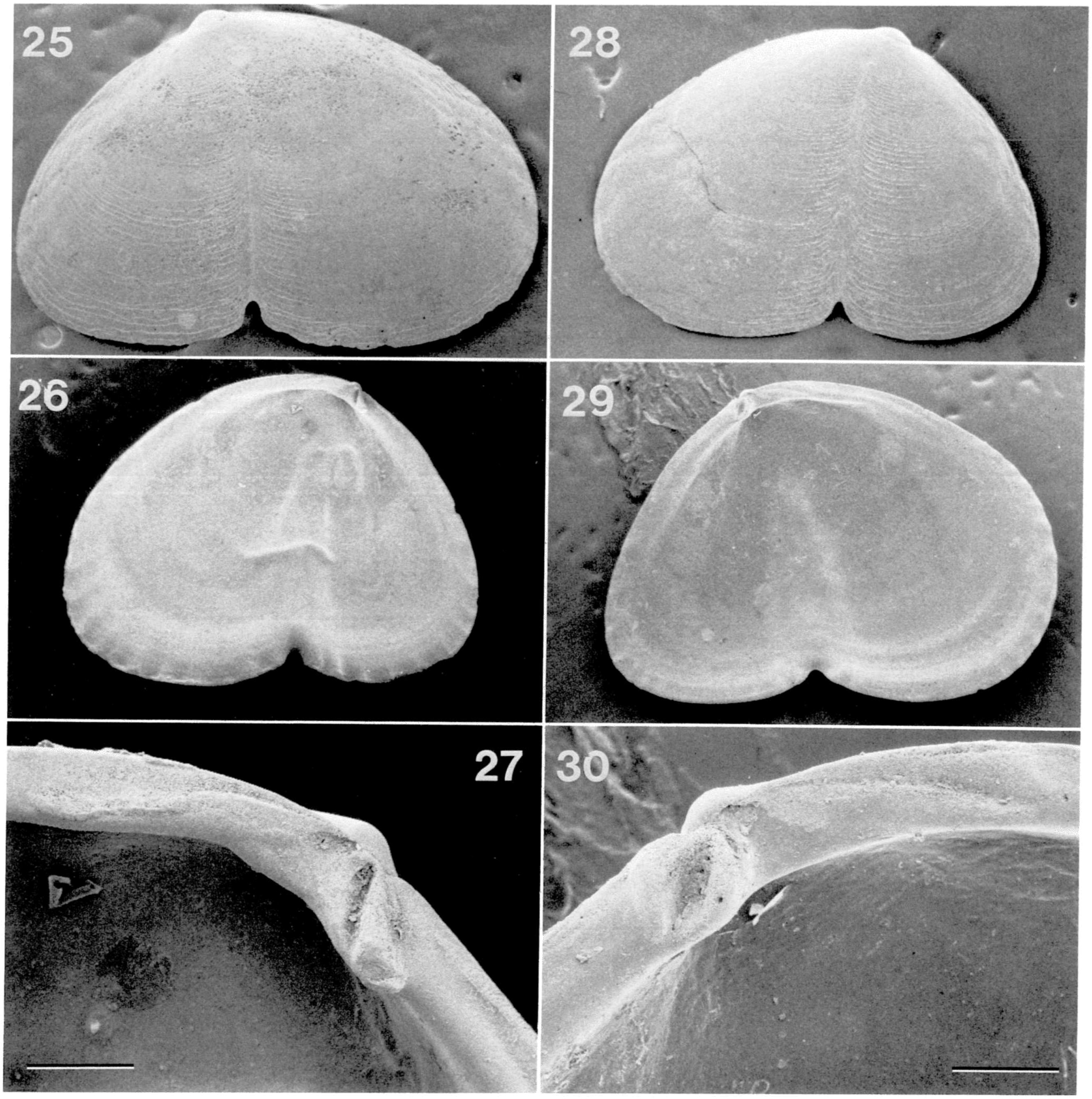
The discovery of a new species that shares with the type species of *Divariscintilla* the presence of a notch in the ventral margin of both valves initially suggested that *Divariscintilla* includes species possessing this specific character. Comparison of shell ultrastructure characters, and the formation of the mid-valve ridge, reveal that *Bellascintilla* is more closely related to *Vasconiella* than to *Divariscintilla*, despite the initial similarity of shell form between *Bellascintilla* and *Divariscintilla*. The hinge teeth of *Bellascintilla* are cuniform rather than tuberculiform as in *Vasconiella*, *Divariscintilla* and *Tryphomyax* suggesting that possession of a notch in the ventral valve margin could be convergent, or that the cuneiform teeth of *Bellascintilla* evolved from tuberculiform teeth of its ancestor.

Bellascintilla parmaleeana new species
(figures 21–30, 34, 38)

Type locality: Off Bahía Herradura, Puntarenas Province, Costa Rica (9°38.8′N, 84°40.8′W), 37 m (R/V SEARCHER station 451; LACM station 72-54).

Type material: Holotype: LACM 2446; articulating pair of valves, left valve length 3.2 mm (figures 21–22), right valve length 3.1 mm (figures 23–24), height both valves 2.4 mm.

LACM 2447, five paratypes, Isla del Cano, Puntarenas Province, Costa Rica (8°44.0′N, 83°52.5′W), 12 m, sand, R/V SEARCHER (LACM station 72-64): specimen *a*, left valve, length 3.6 mm, height 2.6 mm (figure 25); specimen *b*, left valve, length 4.1 mm, height 3.4 mm (figures 26–27); specimen *c*, right valve, length 3.1 mm, height 2.4 mm (figures 28, 34); specimen *d*, right valve length 3.4 mm, height 2.5 mm; specimen *e*, right valve length 3.5 mm, height 2.9 mm.

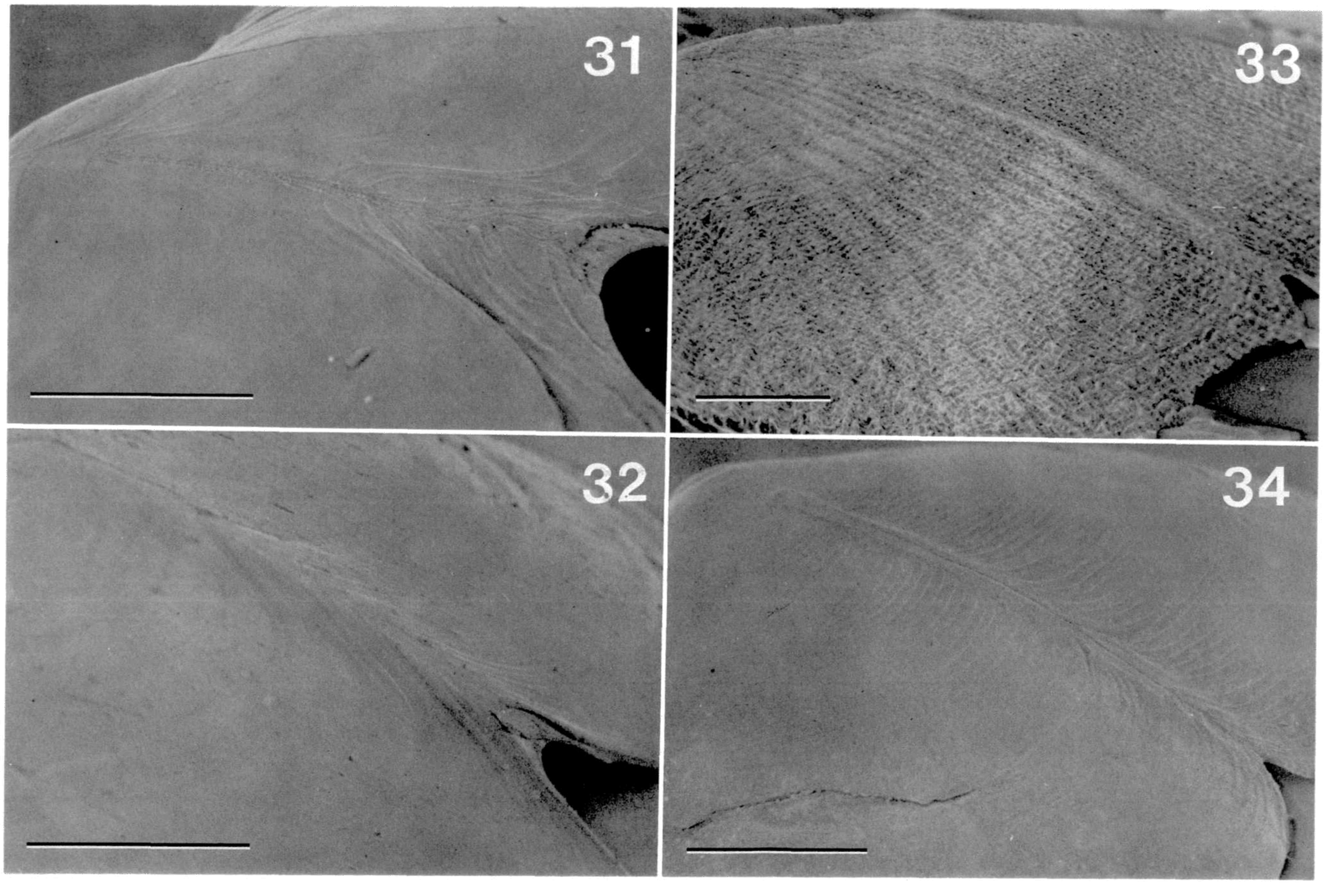


Figures 25–30. *Bellascintilla parmaleeana* new species. Paratypes, **25–28.** LACM 2447, Isla del Cano, Puntarenas Province, Costa Rica. **25.** Specimen *a*, exterior of left valve, length 3.6 mm. **26.** Specimen *b*, interior left valve, length 4.1 mm. **27.** Specimen *b*, hinge of left valve, scale bar = 200 μm. **28.** Specimen *c*, exterior of right valve, length 3.1 mm. **29–30.** LACM 2448, off Rancho El Tule and Rancho Palmilla, Gulf of California, Baja California Sur, Mexico. **29.** Interior of right valve, length 4.5 mm. **30.** Hinge of right valve, scale bar = 200 μm.

LACM 2448, paratype, between Rancho El Tule and Rancho Palmilla, Gulf of California, Baja California Sur, Mexico (22°58′N, 109°48′W), 18–37 m, sand (LACM station 66-17), right valve, length 4.5 mm, height 3.5 mm (figures 29–30).

LACM 2449, paratype, Playa Nancite, N side Golfo de Papaguayo, Parque Nacional Santa Rosa, Guanacaste Province, Costa Rica (10°48′N, 85°42′W), beach drift (LACM station 86-26), left valve, length 3.1 mm, height 2.5 mm.

LACM 2450, seven paratypes, Punta Chame, Golfo de Panama, Panama (08°41′N, 79°39′W), shallow dredging (LACM station 77-144), specimen *a*, right valve, length 4.2 mm, height 3.3 mm; specimen *b*, right valve, length 3.4 mm, height 2.7 mm; specimen *c*, right valve, length 3.5 mm, height 2.6 mm; specimen *d*, right valve, length



Figures 31–34. Comparison of mid-valve ribs. **31.** *Vasconiella jeffreysiana*, SMNH uncataloged, scale bar = 500 μm. **32.** *Divariscintilla maoria*, NMNZ M.21965, scale bar = 500 μm. **33.** *Tryphomyax lepidoformis*, LACM 77-144.4, scale bar = 500 μm. **34.** *Bellascintilla parmaleeana* new species, paratype, LACM 2447, specimen *c*, scale bar = 500 μm.

3.3 mm, height 2.7 mm; specimen *e*, right valve, length 2.9 mm, height 2.3 mm; specimen *f*, left valve, length 4.1 mm, height 3.1 mm; specimen *g*, left valve, length 3.5 mm, height 2.9 mm.

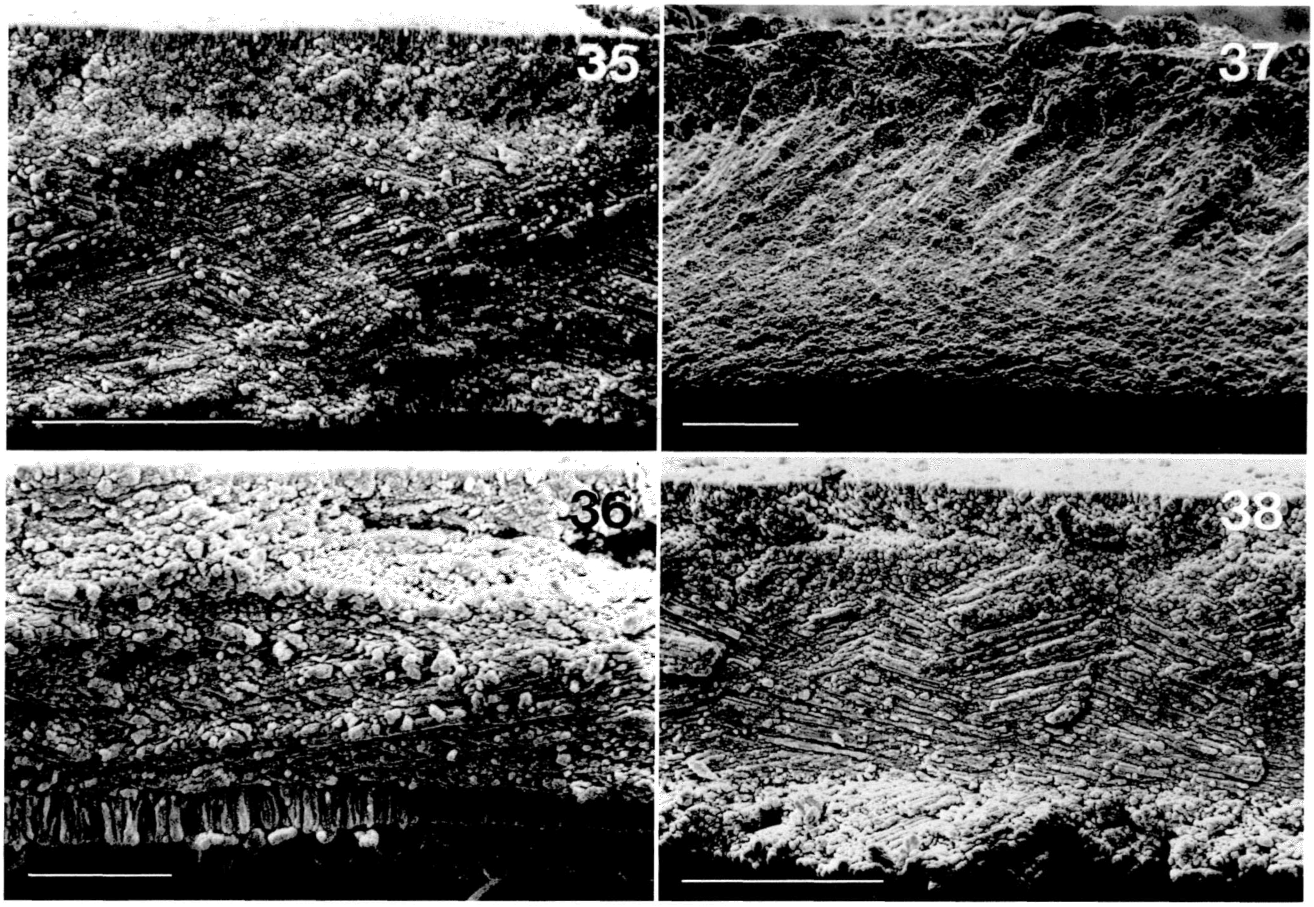
LACM 2451, paratype, N side Isla Salango, Manabi Province, Ecuador (01°35.5′S, 80°53.4′W), 6–12 m, under rocks and coral (LACM station 80-65), left valve, length 2.8 mm, height 2.1 mm.

USNM 859410, paratype from type locality, right valve, length 2.7 mm, height 2.0 mm.

Description: Shell inequivalve, inequilateral, very small (to 4.5 mm). Ligament an internal resilium. Left valve slightly longer than right valve. Left valve with two cuneiform cardinal teeth, posterior cardinal low, apex directly under beak, anterior cardinal with apex anterior to beak, widening as it descends, two cardinal teeth separated by narrowly radiating fossa. Resilifer separating cardinal teeth from posterior lateral teeth in both valves. Left valve with single downward curving lateral tooth. Right valve with two radiating cuneiform cardinal teeth, apices fused immediately below beak, widening as they descend. Teeth separated by deep fossa that widens as it descends. Two posterior lateral teeth in right valve posterior to resilium and cardinal teeth. Posterior and anterior adductor muscle scars equal in size, posterior adductor muscle scar located higher in valves than anterior adductor scar. Ventral margin of shell in both valves internally crenulate. Mid-ventral notch pronounced giving rise to a raised triangular fold that ascends dorsally to umbo. This interior, raised triangular fold corresponds externally to two ribs joined together by suture that arises from mid-ventral notch on ventral margin of exterior shell valve and ascends towards umbo. The fold truncates abruptly within 0.3 to 0.5 mm of umbo. Exterior sculpture of both valves with fine commarginal striae. Small undulating ribs radiating along posterior dorsal margin of shell, less developed along anterior shell margin.

Shell ultrastructure (figure 38): Shell thickness of specimen examined 37 μm, consisting of four distinct layers. Exterior layer of very thin, blocky, simple prismatic structure, underlain by layer of fine grained homogeneous structure; median, thickest layer consisting of crossed lamellar structure, underlain by layer of fine grained homogeneous structure.

Distribution: Rancho El Tule and Rancho Palmilla, Gulf of California, Baja California Sur, Mexico (22°58′N,



Figures 35–38. Comparison of shell ultrastructure. Exterior surface at top. SEM views taken on central slope of valves. **35.** *Vasconiella jeffreysiana*, SMNH uncataloged, scale bar = 20 μm. **36.** *Divariscintilla maoria*, NMNZ M.21965, scale bar = 10 μm. **37.** *Tryphomyax mexicanus*, LACM 69-22.3, scale bar = 20 μm. **38.** *Bellascintilla parmaleeana* new species, LACM 72-54 (from same lot as holotype), scale bar = 20 μm.

109°48′W) to Isla Salango, Manabi Province, Ecuador (01°35.5′S, 80°53.4′W).

Remarks: Known only from dead valves. This species is the smallest of the ventrally notched galeommatids. Information concerning the anatomy, reproduction, behavior and commensal association, if any, of this bivalve is not available.

Etymology: Named in honor of Dr. Paul W. Parmalee, Director of the Frank H. McClung Museum and Professor of Zooarchaeology, Emeritus, University of Tennessee, Knoxville, Tennessee, who first inspired my interest in bivalve mollusks.

DISCUSSION

The family Vasconiellidae was erected by Scarlato and Starobogatov (1979) to accommodate the ventrally notched genus *Vasconiella* Dall, 1899. Until the anatomy of more of the Galeommatidae has been studied and their relationships better understood, it seems premature to divide the Galeommatidae into subfamilies, much less additional families.

Tryphomyax shares with *Vasconiella* and *Divariscintilla* the tuberculiform cardinal teeth. However, the shell ultrastructures of these three genera exhibit major differences. Although the shell ultrastructure of *Galeomma* Turton, 1825, is unknown, the shell of *Tryphomyax* has a basic morphology suggesting affinity with *Galeomma*.

The presence of a ventral notch in the shell margin is the single shell character that genera *Vasconiella*, *Divariscintilla*, *Tryphomyax*, and *Bellascintilla* share in common. What is the purpose of the ventral notch, and does it serve the same function in all four genera? Powell (1932) believed the ventral notch to be "a true ventral byssus-sinus"; however, recent workers have demonstrated no correlation between the ventral notch and the byssus. Cornet (1982) showed that the outer and middle mantle of the right side, adjacent to the ventrally notched right valve of *Vasconiella*, formed a deep indentation whereas the inner mantle fold was straight. In *Divariscintilla* however, Judd (1971) reported that the mantle beneath the "slit" (ventral notch) was not "incised." As the structure of the mantle beneath the notch differs in these two genera, a functional similarity is regarded as unlikely. Judd (1971) demonstrated that the placement of the byssus on the foot of *Divariscintilla* was not anatomically correlated with the location of the ventral notch. He further reported that the ventral notch was completely absent from juveniles less than 2–3 mm in length, and did not develop until the shell was 3.5–4.5 mm. Cox (1969) stated that the byssus of early postlarval stages of many bivalves serves as an anchor and prevents larvae from suffocating by suspending the juveniles above the level of sediment deposition. Most bivalves lack a byssus, or it is vestigial, in the adult stage. The development of the ventral notch in *Divariscintilla* late in its life cycle may be taken as indirect evidence against the ventral notch functioning to accommodate the byssus. Other galeommatids that lack the ventral notch possess either a byssus or a byssal gland in the foot such as reported in *Phlyctaenachlamys* by Popham (1939). The function of the ventral notch in the four genera treated here remains unresolved.

Tryphomyax has the thickest shell (maximum thickness observed 59 μm), and is composed of only a single layer, which is structurally different from that of the other three ventrally notched galeommatids. *Bellascintilla* has a thinner shell (maximum thickness observed 37 μm), composed of four layers. The shell ultrastructure of *Vasconiella* is remarkably similar to that of *Bellascintilla*, but is thinner (maximum thickness observed 34 μm), and has an additional structural layer. Thus, *Vasconiella* has the most complex shell ultrastructure of the ventrally notched galeommatids studied to date. *Divariscintilla* has the thinnest shell of this group of galeommatids (maximum observed thickness 25 μm), composed of three layers that are unlike the ultrastructures of the other ventrally notched galeommatid genera. None of these genera conform to the shell ultrastructure reported by Taylor, Kennedy, and Hall (1973) for two species of *Scintilla* in terms of numbers of shell layers, or their composition. In contrast, they report finding two layers, an outer layer composed of crossed lamellar structure and an inner layer of complex crossed lamellar structure in *S. oweni* Deshayes and *S. rosea* Deshayes (Taylor *et al.*, 1973). Further investigation into the comparative shell ultrastructure of galeommataceans is warranted, both to provide characters for phylogenetic analysis as well as to examine possible variation within and between populations and environments.

In addition to a strong similarity in shell ultrastructure, *Vasconiella* and *Bellascintilla* show similarity in the formation of the mid-valve ridge, which in both genera exhibits two radiating ribs fused together with a suture between them. Prior to this study, *Vasconiella*, *Divariscintilla* and *Tryphomyax* were reported to have a single mid-valve radiating sulcus (Fischer, 1873; Olsson, 1961; Powell, 1932). Based on shell ultrastructure and the formation of the fused mid-valve ridges, *Bellascintilla* appears to be more closely related to *Vasconiella* than to either *Tryphomyax* or *Divariscintilla*, despite the differences of shell shape, hinge teeth, and zoogeography.

The hinge of *Bellascintilla* has some features in common with the family Leptonidae Gray, 1847 (*e.g.*, cuneiform cardinal teeth), and could conceivably be a primitive member of either family. It is therefore with some misgivings that I place *Bellascintilla* in the Galeommatidae. A clearer understanding of systematic relationships within the Galeommatacea will result when more information concerning the anatomy and shell ultrastructure of many of the genera becomes available. Because the definitions of the families in the Galeommatacea are not yet clarified (Ponder, 1971; Bernard, 1975), and in part because the anatomy and biology of *Bellascintilla* and *Tryphomyax* are unknown, the relationships of these four genera are subject to change as additional data becomes available.

I recognize a single species of *Divariscintilla*, the type species *D. maoria*. The two species described as *Divariscintilla yoyo* and *D. troglodytes* by Mikkelsen and Bieler (1989) are reassigned here to the genus *Phlyctaenachlamys* Popham, 1939. They share with *P. lysiosquillina* Popham, 1939, the type species of *Phlyctaenachlamys*, major conchological characters, including the unnotched ventral shell margin, hinge teeth and ligament morphology, shell ultrastructure, and anatomical characters including an internal shell, mantle morphology, and ctenidial morphology (see Mikkelsen & Bieler, 1989; Popham, 1939). As in *Phlyctaenachlamys lysiosquillina*, *P. yoyo* and *P. troglodytes* have shells that are equivalve, inequilateral, oval, flattened, and roundly elongate anteriorly. The hinge teeth and ligament are remarkably similar between the three species of *Phlyctaenachlamys*, but are quite different than those of *Divariscintilla maoria* Powell and *Bellascintilla parmaleeana*. The shell ultrastructure of *Phlyctaenachlamys lysiosquillina* is unknown. Mikkelsen and Bieler (1989) illustrate and describe the shell ultrastructure of *P. yoyo* and *P. troglodytes* as "cross-lamellar, with thin homogeneous layer on either side". This is somewhat similar to the ultrastructural arrangement of *Vasconiella* and of *Bellascintilla*, but is very different from the ultrastructural arrangement of *Divariscintilla*, and even more so from that of *Tryphomyax*. The shell of *Phlyctaenachlamys lysiosquillina* is internal (Popham, 1939), as it is in *P. yoyo* and *P. troglodytes* (Mikkelsen and Bieler, 1989). Only the anterior and posterio-dorsal margins of *Divariscintilla maoria* are covered by the mantle (Judd, 1971). The number and placement of mantle tentacles and defensive appendages is strongly similar between *P. lysiosquillina* and those of *P. yoyo* and *P. troglodytes* (see Mikkelsen & Bieler, 1989; Popham, 1939). There are two primary anterior tentacles in *P. lysiosquillina*, *P. yoyo* and *P. troglodytes* as illustrated by Popham (1939) and by Mikkelsen and Bieler (1989), although *P. troglodytes* has a second set of short anterior tentacles. *Divariscintilla maoria* has 6 to 8 large defensive appendages (Mikkelsen & Bieler, 1989) or posterior appendages (Popham, 1939), which are absent from *P. lysiosquillina*, *P. yoyo* and *P. troglodytes*. The ctenidia, usually an important source of phylogenetic information, are smooth in *Divariscintilla maoria*, but pleated in *P. lysiosquillina* (Popham, 1939) and in *P. yoyo* and *P.*

troglodytes (Mikkelsen & Bieler, 1989). The unusual "flower-like" organ of *Divariscintilla maoria* and those discovered in *P. yoyo* and *P. troglodytes* by Mikkelsen and Bieler (1989), were not reported by Popham (1939). Whether these "flower-like" organs were overlooked in *P. lysiosquillina*, or simply do not exist in this species, is unknown.

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