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New Slit-Limpets (Scissurellacea and Fissurellacea) from Hydrothermal Vents. Part 1. Systematic Descriptions and Comparisons Based on Shell and Radular Characters

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Natural History Museum of Los Angeles County

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New Slit-Limpets (Scissurellacea and Fissurellacea) from Hydrothermal Vents. Part 1. Systematic Descriptions and Comparisons Based on Shell and Radular Characters

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ABSTRACT. Six new species of slit-limpets endemic to the deep-sea hydrothermal-vent habitat have similar shells and similar external anatomy, but are placed in two families in separate superfamilies: Scissurellacea and Fissurellacea.

Taxonomic innovations for Scissurellacea (raised from family level by Haszprunar [1989]) include the recognition of four subfamilies in Scissurellidae: new subfamily Temnocinclinae with two new genera having open slits: *Temnocinclis,* monotypic for *T. euripes* new species from the Juan de Fuca Ridge, and *Temnozaga,* monotypic for *T. parilis* from 21°N on the East Pacific Rise; new subfamily Sutilizoninae: *Sutilizona* new genus with a closed slit, monotypic for *S. theca* from 12°N on the East Pacific Rise. Non-hydrothermal-vent scissurellids are retained in the new subfamily Anatominae and the typical subfamily Scissurellinae. Subfamilies are defined on the basis of shared protoconch, radular, and gill characters.

Taxonomic innovations for Fissurellacea are the new family Clypeosectidae with two new genera: *Clypeosectus* with an open slit, and *Pseudorimula* with a closed slit and a unique, tripartite shell muscle. *Clypeosectus* has two new species, type species *C. delectus* from the Galapagos Rift and the East Pacific Rise at 13°N and 21°N, and *C. curvus* from the Juan de Fuca Ridge and the Explorer Ridge. *Pseudorimula* is monotypic for *P. marianae* new species from the Mariana Back-Arc Basin vents.

Study of anatomy by Haszprunar (1989) confirms the need for the new higher taxa, which are based on anatomical characters as well as shell and radular characters. As in all other scissurellids, there are no reproductive specializations in the new vent-associated scissurellid limpets. Clypeosectids have such fissurellacean characters as a reduced left kidney and anal gland, but differ in having a unique radula and a pedal gland, and lacking muscle hooks and pits on the early teleoconch; they further differ in being specialized for internal fertilization.

The new genera of both superfamilies lack the enlarged outermost lateral teeth that characterize the non-vent associated genera. This is interpreted as a convergent loss possibly due to a more easily processed food source of bacterial films in the hydrothermal-vent habitat.

As previously hypothesized for other hydrothermal-vent limpets, these groups may have entered the hydrothermal-vent habitat in the early Mesozoic, at the same time their superfamilies appeared and diversified in shallow water.

INTRODUCTION

The recently discovered hydrothermal-vent community has produced a number of unusual new mollusks, among which gastropods of limpet form are exceptionally well represented. At latest summary (McLean, 1988b), seven superfamilies (four endemic) and eight families (seven endemic) were represented by 27 species.

Radulae characteristic of some of the hydrothermal-vent limpet groups have been illustrated (Hickman, 1983) prior to their formal descriptions. Except for the slit-limpets, brief preliminary notes on external features of the new groups of hydrothermal-vent limpets have been given by McLean (1985). Protoconchs and immature shells of many of the limpets, including two species of slit-limpets, have also been illustrated (Turner et al., 1985), although not identified to family or species.

To date, five new families of limpets from hydrothermal vents have been described: Neomphalidae in the new superfamily Neomphalacea (McLean, 1981), anatomy by Fretter et al. (1981); Pyropeltidae in the existing superfamily Lepetellacea (McLean and Haszprunar, 1987); Lepetodrilidae and Gorgoleptidae in the new superfamily Lepetodrilacea (McLean, 1988a), anatomy by Fretter (1988); and Peltospiridae in the new superfamily Peltospiracea (McLean, 1989), anatomy by Fretter (1989).

Slit-limpets from the hydrothermal-vent community were first noted by Turner (1980), who illustrated a shell of the species from the Galapagos Rift that is here described as *Clypeosectus delectus.* Other illustrations of shells of slit-limpets from the Galapagos Rift and from the East Pacific Rise at 21°N have been given by Lutz et al. (1984), Turner and Lutz (1984), and Turner et al. (1985), who also included a species from 21°N identified as an "unnamed *Rimula*(?)," which is here described as *Temnozaga parilis.*

The caption to Turner's (1980) first figure of a slit-limpet (the species here described as *Clypeosectus delectus*) stated that "it is probably a living representative of a genus known in the fossil record from the Upper Jurassic to the Eocene." That allocation surely alluded to *Loxotoma* Fischer, 1885, a fissurellid that had a markedly asymmetrical slit (see Knight et al., 1960, fig. 141-7). On shell characters, however, the slit-limpets lack the pits that characterize the early teleoconch sculpture of all fissurellids (e.g., see Bandel, 1982, pl. 11, fig. 11). Hickman (1983) figured the radula of the same species from the Galapagos Rift, noting that it is unlike that of fissurellids, and concluded that the species is but "questionably allied to the Fissurellidae."

Although shells of the six species described here may suggest (except for the lack of pits) that these are fissurellid limpets, the first impression derived from the external morphology suggests that all are scissurellids, because all have a large anterior pedal gland (which is lacking in fissurellids) and all have relatively few epipodial tentacles (as in scissurellids, not fissurellids). In view of the unique radula previously figured by Hickman (1983), a study of the internal anatomy was necessary to establish relationships. Anatomy of these species is treated by Haszprunar (1989) in Part 2. His investigation of anatomy has indicated that a new family related to Fissurellidae should be erected for three species in two genera having the bizarre radular type originally figured by Hickman, and that limpets of the family Scissurellidae are also present in the hydrothermal-

vent community. The new scissurellids, however, have modified scissurellid radulae.

MATERIALS AND METHODS

Slit-limpets were found when the deep-sea hydrothermal-vent biological community was discovered in 1979 along the Galapagos Rift by the Woods Hole submersible *Alvin* (Corliss et al., 1979; Hessler and Smithey, 1983). In 1979, slit-limpets were again collected by the *Alvin* at the Galapagos Rift and at the East Pacific Rise at 21°N (Spiess et al., 1980; Hessler et al., 1985). In 1982, the limpets were collected at 13°N on the East Pacific Rise by a French expedition using the submersible *Cyana* (Desbruyeres et al., 1982; Desbruyeres and Laubier, 1983). Two additional species described here were first collected in 1983 with the submersible *Pisces IV* on the Juan de Fuca Ridge by a Canadian expedition (Chase et al., 1985; Tunnicliffe et al., 1985). Jones et al. (1985) give station data for all dives made by these submersibles through 1985.

Yet another species was discovered with the *Alvin* in 1987 at the Mariana Back-Arc Basin vents in the western Pacific (Hessler et al., 1988). The most recently discovered species was collected with the *Alvin* in March, 1988, on the East Pacific Rise at 12°N.

Hydrothermal-vent sites investigated by the *Alvin* that have not yielded slit-limpets are the Guaymas Basin, first visited in 1982, and the Florida Escarpment, first visited in 1984.

Mollusks were collected as part of the sampling program on most dives made by submersibles at hydrothermal-vent sites (for details of collecting procedures see Turner et al., 1985). Many of the limpets were collected along with samples of vestimentiferan tube worms by the mechanical arms of the submersibles. Specimens were dead on reaching the surface and were originally fixed for 24 hours in 5% seawater formalin buffered with sodium borate, washed in freshwater, and transferred to 70% ethanol.

Unlike all other newly described limpet groups from hydrothermal vents, none of the slit-limpets was abundant. For most species the number available was barely sufficient for description and, in some cases, not enough to provide specimens of both sexes for sectioning. Station data and numbers of specimens for dives yielding slit-limpets are summarized in Table 1. Measurements and disposition of all examined specimens are given in Table 2.

Except for Figures 4B,C and 9A–F, which have previously been published by Turner et al. (1985), and Figure 11A, previously published by Hickman (1983), the illustrations in this paper result from photographic and SEM work at the Natural History Museum of Los Angeles County.

Type material is placed in the Natural History Museum of Los Angeles County (LACM), the Museum of Comparative Zoology, Harvard University, Cambridge (MCZ), the Museum National d'Histoire Naturelle, Paris (NMNH), and the National Museum of Natural History, Washington, D.C. (USNM).

SYSTEMATICS

Order ARCHAEOGASTROPODA Thiele, 1925

Suborder VETIGASTROPODA Salvini-Plawen, 1980

Recent authors (Salvini-Plawen, 1980; Salvini-Plawen and Haszprunar, 1987; Haszprunar, 1988a, 1988b; Hickman, 1988) have discussed the problems inherent in the archaeogastropod concept, pointing out that the order Archaeogastropoda, as traditionally constituted (Thiele, 1925; Knight et al., 1960), represents a grade. Although Hickman (1988) has redefined and limited Archaeogastropoda to cover those superfamilies now treated by Salvini-Plawen and Haszprunar (1987) as the suborder Vetigastropoda (in so doing making Vetigastropoda a synonym of Archaeogastropoda), I have elected to follow Haszprunar (1988a, 1988b) in a classification scheme that allows Archaeogastropoda as an "orthophyletic grade" and Vetigastropoda as a clade.

Superfamily SCISSURELLACEA Gray, 1847

Justification for the removal of Scissurellidae from the Pleurotomariacea and elevation to superfamilial status is given by Haszprunar in (1989). As the superfamily contains but a single living family, the diagnosis that follows serves for that of the superfamily and family.

Family SCISSURELLIDAE Gray, 1847

DESCRIPTION. Coiled or limpetlike, interior nacre lacking, with shell slit, two shell muscles, and operculum. Protoconch finely reticulate (sometimes finely pitted), or with strong collabral ridges. Eyes (if present) with closed vesicles. Operculum retained in all genera. Rachidian tooth broad, base of shaft with lateral projections; overhanging cusp broad with one main denticle and smaller lateral denticles; lateral teeth narrow, cusps with several sharp denticles, shafts with laterally directed elbow; enlarged outer lateral present or absent; marginal teeth numerous.

REMARKS. Herbert (1986) has reviewed the systematics of Scissurellidae and discussed the shell and protoconch characters upon which the relatively few genera in the family have been based. Two groups were apparent, based on protoconch sculpture. The genera *Anatoma* Woodward, 1859, and *Sukashitrochus* Habe and Kosuge, 1964, have a finely reticulate protoconch, whereas the genera *Scissurella* d'Orbigny, 1824, and *Sinezona* Finlay, 1927, have strong collabral sculpture on the protoconch (Fig. 6C; see also Batten, 1975; Yaron, 1980; Bandel, 1982; Herbert, 1986). Here I add *Incisura* Hedley, 1904, to those with strong collabral sculpture (Fig. 6E). All of these genera have a basic radular plan in common: a broad, multicuspid rachidian tooth, three lateral teeth of similar morphology, and an enlarged outer lateral tooth with numerous cusps (Figs. 6F,G).

The three new scissurellid genera from the hydrothermal-vent habitat (*Temnocinclis*, *Temnozaga*, and *Sutilizona*) do not have the collabral sculpture on the protoconch and share certain features

Table 1. Station data and number of specimens from dives yielding slit-limpets.

Dive	Depth (m)	Position	Date	Number
		Temnocinclis euripes		
		Alvin dives, Endeavour Segment, Juan de Fuca Ridge		
1447	2213	47°57.0′N, 129°06.0′W	03 Sep 1984	2
1452	2208	47°57.0′N, 129°0.60′W	07 Sep 1984	2
		Pisces IV dive, Axial Seamount, Mid-Juan de Fuca Ridge		
1726	1575	45°59.5′N, 130°03.5′W	27 Jul 1986	4
		Alvin dive, Southern Juan de Fuca Ridge		
1463	2250	44°39.2′N, 130°22.0′W	24 Oct 1984	3
		Temnozaga parilis		
		Alvin dives, East Pacific Rise at 21°N		
1226	2616	20°50.0′N, 109°06.0′W	10 May 1982	1
1229	2615	20°50.0′N, 109°06.0′W	14 May 1982	1
		Sutilizona theca		
		Alvin dive, East Pacific Rise at 12°N		
2003	2715	11°46.0′N, 103°47.0′W	25 Mar 1988	3
		Clypeosectus delectus		
		Alvin dives, Galapagos Rift		
733	2496	00°47.3′N, 86°07.8′W	16 Mar 1977	1
880	2493	00°47.6′N, 86°06.4′W	21 Jan 1979	1 + 1 juv.
884	2482	00°48.1′N, 86°07.0′W	25 Jan 1979	8 juv.
890	2447	00°48.9′N, 86°13.3′W	15 Feb 1979	1
895	2482	00°47.9′N, 86°09.3′W	20 Feb 1979	2 + 1 juv.
896	2460	00°48.2′N, 86°13.6′W	21 Feb 1979	3 juv.
984	2451	00°48.0′N, 86°13.0′W	01 Dec 1979	3
989	2482	00°48.0′N, 86°09.0′W	06 Dec 1979	1
991	2490	00°48.0′N, 86°09.0′W	08 Dec 1979	1
		Cyana dive, East Pacific Rise at 13°N		
82-36	2633	12°48.6′N, 103°56.7′W	13 Mar 1982	4
		Alvin dives, East Pacific Rise at 21°N		
1221	2618	20°50.0′N, 109°06.0′W	04 May 1982	2
1222	2614	20°50.0′N, 109°06.0′W	06 May 1982	1
1223	2616	20°50.0′N, 109°06.0′W	07 May 1982	1
1226	2616	20°50.0′N, 109°06.0′W	10 May 1982	10 + 8 juv.
		Clypeosectus curvus		
		Pisces IV dive, Explorer Ridge		
1494	1818	49°45.6′N, 130°16.1′W	01 Jul 1984	1
		Alvin dive, Endeavour Segment, Juan de Fuca Ridge		
1447	2213	47°57.0′N, 129°06.0′W	03 Sep 1984	1
		Pisces IV dives, Axial Seamount, Mid-Juan de Fuca Ridge		
1729	1575	45°59.5′N, 130°03.5′W	30 Jul 1986	1
1730	1575	45°59.5′N, 130°03.5′W	31 Jul 1986	5
1733	1575	45°59.5′N, 130°03.5′W	03 Aug 1986	2
		Pseudorimula marianae		
		Alvin dives, Mariana Back-Arc Basin		
1836	3660	18°10.95′N, 144°43.2′E	27 Apr 1987	4
1843	3640	18°12.6′N, 144°42.4′E	04 May 1987	1

of the external anatomy (monopectinate ctenidia, loss of eyes, cephalic tentacles lacking micropapillae). Additionally, they have a radular distinction in common: all lack the enlarged fourth lateral tooth. However, *Sutilizona* stands apart from *Temnocinclis* and *Temnozaga* in radular and protoconch characters. Because a number of shared characters can now be limited to groups of genera in Scissurellidae, it is necessary to recognize four groups at the subfamily level:

1. Anatominae, new subfamily for *Anatoma* and *Sukasitrochus*. Shell coiled, protoconch finely reticulate, radula with enlarged fourth lateral tooth, ctenidia bipectinate.

2. Scissurellinae, typical subfamily for *Scissurella, Sinezona,* and *Incisura*. Shell coiled or of limpet form, protoconch with strong axial ribs, radula with enlarged fourth lateral tooth, ctenidia bipectinate.

3. Temnocinclinae, new subfamily for the new genera *Temnocinclis* and *Temnozaga*. Shell of limpet form, protoconch finely reticulate, radula lacking enlarged fourth lateral tooth, ctenidia monopectinate.

4. Sutilizoninae, new subfamily for new genus *Sutilizona*. Shell of markedly asymmetrical limpet form, protoconch reticulate with deep pits, radula lacking enlarged fourth lateral tooth, marginal teeth similar to lateral teeth, ctenidia monopectinate.

The two new subfamilies (Temnocinclinae and Sutilizoninae) restricted to the hydrothermal-vent community are treated below in greater detail.

Waren and Bouchet (1989) illustrated a fragmentary specimen from *Alvin* dive 1214, East Pacific Rise near 21°N, identified as *Sinezona* sp., representing a scissurellid genus from shallow water. That record needs further confirmation before a species of *Sinezona* can be admitted to the hydrothermal-vent fauna.

TEMNOCINCLINAE new subfamily

TYPE GENUS. *Temnocinclis* new genus.

DESCRIPTION. Shell of limpet form, nearly symmetrical; slit remaining open at maturity, slit-borders with interlocking projections; protoconch finely reticulate, lacking collabral ridges. Radula lacking enlarged fourth lateral tooth. Ctenidia monopectinate, of equal size and position; cephalic tentacles non-papillate, eyes lacking.

For anatomical characters see Haszprunar (1989).

REMARKS. Two new genera (*Temnocinclis* and *Temnozaga*) known only from the hydrothermal-vent habitat share the above characters. Both genera are monotypic. The two species are unusually large-sized members of the family. Unique characters of this subfamily are the finely reticulate protoconch and the interlocking edges of the slit-borders, particularly near the anterior tip. The monopectinate ctenidia, the lack of eyes, and the lack of sensory papillae on the cephalic and epipodial tentacles are shared with the new subfamily Sutilizoninae.

Investigation by Haszprunar (1989) shows that the internal anatomy of Temnocinclinae closely corresponds to that of shallow-water Scissurellidae, with no reproductive specializations, making this and the Sutilizoninae the only groups of hydrothermal-vent limpets not requiring the erection of a new family.

The limpet form in Scissurellidae is also known in *Incisura lytteltonensis* (E.A. Smith, 1894) (Figs. 6B,E,G), a species common in the intertidal zone in New Zealand. *Incisura* has a maximum length of 1.3 mm, which is about one-third the length of *Temnocinclis* and *Temnozaga*. *Incisura* continues to be erroneously assigned to Fissurellidae (e.g., by Powell, 1979:37, who had missed Bourne's (1910) study of the anatomy and radula). *Incisura* has an axially ridged protoconch (Fig. 6E) like that of *Sinezona* (Fig. 6C) and *Scissurella*. It lacks the sculptural elements of the teleoconch of other scissurellids and the slit-borders are not raised; it has an extremely short slit and selenizone (Fig. 6B). However, as in *Temnocinclis*, there is a reduction in the epipodial tentacles, compared to those of other scissurellids.

The extremely long slits of both *Temnocinclis* and *Temnozaga* are very different from the short slit of *Incisura* and appear to represent structural liabilities in the shell; yet, some stability and rigidity may result from the interlocking projections along the slit-borders (Figs. 1G, 2B).

The radula of temnocincline genera (Figs. 5A–D) agrees with that of other scissurellid genera in having little asymmetry between the left and right sides of the radular ribbon. Temnocincline genera lack the enlarged outer lateral tooth of other scissurellid genera, but the morphology of the rachidian and inner lateral teeth is clearly comparable to the condition in other scissurellid genera.

KEY TO GENERA

Apical whorl overhanging posterior end of shell . . . . . *Temnocinclis*

Apical whorl not overhanging shell posterior . . . . . *Temnozaga*

Temnocinclis new genus

TYPE SPECIES. *Temnocinclis euripes* new species.

DESCRIPTION. Shell elongate, relatively high; apical whorl posterior to apertural margin, not raised above it. Protoconch sculpture unknown (all specimens heavily coated with mineral deposits). Sculpture sharply clathrate; slit-borders raised, with interlocking projections in contact at anterior end. Broad band of periostracum stretched posteriorly across excavated columellar region of shell.

External Anatomy. Cephalic tentacles and ctenidia as diagnosed for subfamily. Three posterior pairs of epipodial tentacles; operculum small, multispiral, early volutions with raised edges.

Radula. Rachidian tooth broad, multicuspid; lat-

Table 2. Dive numbers, figure numbers, museum catalog numbers of holotypes and paratypes, dimensions, and condition of slit-limpet specimens. Except where indicated as dry, most specimens are maintained in alcohol because shells are decalcified at the margins. Dimensions are given in the order: length, width, and height.

Dive	Figure	Museum no.	Dimensions (mm)	Condition
		Temnocinclis euripes		
1447a	—	USNM 859962	2.9 × 2.0 × 1.6	Shell decalcified at margin, body intact
1447b	1E,F	LACM 2351	— — —	Shell fragmented, body sectioned (female)
1452	5A,B	USNM 859963	3.7 × 2.3 × 1.6	Shell decalcified at margin, radula used
1726a	1A–C	USNM 859964	3.8 × 2.4 × 1.5	Holotype, shell dry, body sectioned (male)
1726b	1G,H	LACM 2352a	4.0 × 2.7 × 1.8	Shell decalcified at margin, body intact
1726c	4A	LACM 2352b	2.5 × 1.6 × —	Shell dry, scanned, body intact
1726d	—	USNM 859965	1.8 × 1.3 × 0.7	Shell decalcified at margin, body intact
1463a	1D	LACM 2353a	3.8 × 2.4 × 1.7	Shell decalcified at margin, body intact
1463b	—	LACM 2353b	— — —	Shell crushed, body intact
1463c	—	MCZ 297060	3.8 × 2.5 × 1.7	Shell decalcified at margin, body intact
		Temnozaga parilis		
1226	2A–F, 4B,C	USNM 859966	4.1 × 3.0 × 1.7	Holotype, Turner et al., 1985, fig. 11
1229	2G,H, 5C,D	LACM 2354	— — —	Shell missing, radula used, operculum intact
		Sutilizona theca		
2003a	4D–F,3C	USNM 859967	1.3 × 0.9 × 0.5	Holotype, shell scanned, body sectioned
2003b	3A,B	LACM 2355a	1.3 × 0.9 × 0.5	Shell broken, body sectioned
2003c	E,F	LACM 2355b	— — —	Shell in fragments, radula used
		Clypeosectus delectus		
—	9A–C	— —	1.9 × 1.4 —	Turner et al., 1985, fig. 9
733	11A	— —	— — —	Hickman, 1983, fig. 5, radula
880a	—	LACM 2356a	— — —	Shell broken (ca. 3 mm), no body
880b	—	LACM 2356b	— — —	1 decalcified juvenile under 1 mm
884	—	USNM 859968	— — —	8 decalcified juveniles under 1 mm
890	—	USNM 859969	1.8 × 1.3 × 0.4	Shell decalcified at margin, body intact
895a	—	MCZ 297601	4.2 × — × 1.0	Shell sides broken, margin decalcified, body intact
895b	—	LACM 2357a	4.6 × — × 1.5	Shell sides broken, margin decalcified, body intact
895c	—	LACM 2357b	— — —	1 decalcified juvenile under 1 mm
896	—	MCZ 297062	— — —	3 decalcified juveniles under 1 mm
984a	7A–E	USNM859970	5.2 × 3.7 × 1.2	Holotype, shell dry, body sectioned (female)
984b	—	USNM 859971	4.5 × — × —	Shell sides and apex broken, body intact
984c	11B	LACM 2358	4.0 × 3.0 × 1.3	Shell broken, radula used
989	—	LACM 2359	— — —	Shell only, broken
991	7F–H	LACM 2360	4.5 × 3.0 × 1.0	Shell margin decalcified, body intact
82-36a	8A–D, 11C–E	MNHN —	3.2 × 2.3 × 1.2	Shell dry (4 separate bodies, radula used)
82-36b	—	MNHN —	— — —	Shell dry, anterior end broken
82-36c	—	MNHN —	— — —	Shell fragmented, dry
1221a	8E–H	LACM 2361a	3.9 × 2.7 × 0.8	Shell intact, body intact
1221b	—	LACM 2361b	1.8 × 1.3 × 0.6	Shell intact, body intact
1222	—	USNM 859972	1.6 × 1.2 × 0.6	Shell intact, body intact
1223	—	USNM 859973	— — —	Juvenile, shell decalcified
1226a	9D–F	— —	0.9 × 0.7 × —	Turner et al., 1985, fig. 10
1226b	—	LACM 2362a	3.6 × 2.8 × 1.1	Shell and body intact
1226c	—	LACM 2362b	— — —	Shell and body crushed, ca. 4 mm long
1226d	—	LACM 2362c	2.5 × 1.9 × 0.7	Shell decalcified, body intact
1226e	—	LACM 2362d	— — —	2 small crushed, 2 decalcified juveniles under 1 mm
1226f	—	USNM 859974a	3.2 × 2.2 × 1.1	Intact, partially decalcified at margin
1226g	—	USNM 859974b	2.6 × 2.0 × 1.0	Intact, partially decalcified at margin
1226h	—	USNM 859974c	2.5 × 1.8 × 0.8	Intact, partially decalcified at margin
1226i	—	USNM 859974d	1.8 × 1.3 × 0.5	Intact, partially decalcified at margin
1226j	—	USNM 859974e	1.7 × 1.2 × 0.5	Intact, partially decalcified at margin
1226k	—	MCZ 297063a	3.1 × 2.3 × 0.9	Intact, partially decalcified at margin
1226l	—	MCZ 297063b	2.3 × 1.5 × 0.7	Intact, partially decalcified at margin
1226m	—	MCZ 297063c	2.0 × 2.6 × 0.6	Intact, partially decalcified at margin

Table 2. Continued.

Dive	Figure	Museum no.	Dimensions (mm)	Condition
1226n	—	MCZ 297063d	1.6 × 1.1 × 0.4	Intact, partially decalcified at margin
1226o	—	MCZ 297063e	1.3 × 1.0 × 0.3	Intact, partially decalcified at margin
		Clypeosectus curvus		
1494	—	USNM 859975	4.1 × 3.2 × 1.8	Shell chipped, body used for radular attempt
1447	10G, 11F	LACM 2363	2.4 — —	Shell fragmented, body used for radula
1729	—	MCZ 297064	4.8 × 3.7 × 2.0	Shell only, chipped near slit
1730a	10A-F	USNM 859976	4.6 × 4.0 × 2.0	Holotype, shell dry, body intact
1730b	10H	LACM 2364a	4.0 × 3.5 × 2.0	Shell dry, body sectioned (female)
1730c	—	LACM 2364b	4.4 × 3.8 × 2.0	Shell dry, chipped, body sectioned (male)
1730d	—	LACM 2364c	— — —	Shell fragments, radular attempt
1730e	—	LACM 2364d	3.4 × 2.4 × 1.6	Shell only, edges chipped
1733	—	LACM 2365	2.3 × 1.9 × 0.6	Shell margin decalcified, body intact
		Pseudorimula marianae		
1836a	12A-E, 13C,D	USNM 859977	6.4 × 5.2 × 2.4	Holotype, shell dry, radula used, body sectioned (female)
1836b	12F	LACM 2366a	8.6 × 7.1 × 3.3	Shell dry, edges broken, body sectioned (male)
1836c	—	USNM 859978	6.1 × 4.9 × 2.5	Shell dry, body intact
1836d	12G,H	LACM 2366b	4.1 × 3.1 × 1.7	Shell in good condition, body intact
1843	13A,B	LACM 2367	2.7 × 2.0 × 0.8	Shell scanned, body intact

eral teeth three pairs, each with four denticles; basal part of shafts of laterals and inner marginal teeth fading into basal membrane of ribbon.

REMARKS. This genus is based on a single, previously unfigured species from the hydrothermal vents of the Juan de Fuca Ridge.

ETYMOLOGY. The generic name is a Greek compound of *temno,* to cut, and *kinklis,* lattice, suggested by the sculpture and deeply cut slit. Gender: feminine.

Temnocinclis euripes new species

Figures 1A–H, 4A, 5A,B

Split limpet; Tunnicliffe, 1988:353.

DIAGNOSIS. Shell asymmetical, apical whorl projecting posteriorly, sculpture clathrate.

DESCRIPTION. Shell (Figs. 1A–C,G,H, 4A) large for family (maximum length 4.0 mm), thin; periostracum thick, light brown; outline of aperture elongate oval, anterior broader than posterior, margin of aperture in same plane; apical whorl (first whorl of teleoconch) projecting posteriorly. Profile relatively high; height of holotype 0.39 times length. Protoconch diameter 250 μm, surface sculpture unknown (all specimens coated, Fig. 4A). First whorl of teleoconch rounded, descending below protoconch; sculpture weak, both axial and spiral. Slit arising at position of three-fourths growth of first teleoconch whorl, at which stage aperture expands to produce limpet form through one-half whorl of additional rotation. Slit open more than half length of shell in dorsal view, dividing shell into nearly equal areas, its position only slightly deflected to right in dorsal view. Slit-borders sharply raised, edges enveloped by periostracum; left and right sides of shell with interlocking projections along anterior termination of slit (Fig. 1G). Selenizone depressed below slit-borders, filled with fine lamellar additions. Sculpture of sharply raised axial ribs and spiral cords, forming laterally stretched beads at intersections. Additional spiral cords arising in interspaces, assuming equal prominence so that overall number of beaded intersections increases with growth while strength of beading remains the same. Apertural lip thin anteriorly, posteriorly forming broad, depressed shelf in position corresponding to columella. Periostracum stretched across depression of posterior shelf (Figs. 1B,H). Muscle scar barely detectable, its terminations rounded, extending anteriorly to position equal to greatest breadth of shell. Shell interior highly transparent, revealing exterior clathrate sculpture except near margin, where surface is somewhat opaque. Slit-border and previous positions of septum not marked by heavy deposition of interior callus.

External Anatomy (Figs. 1D–F,H). Cephalic tentacles non-papillate, thick, short (contracted condition); three posterior pairs of non-papillate epipodial tentacles. Shell muscle horseshoe-shaped, solid, muscle terminations rounded. Two monopectinate ctenidia, left slightly larger than right. Foot with double anterior edge marking opening of pedal gland; operculum attached to metapodium, multispiral with early volutions raised (Figs. 1F,H).

Internal anatomy is described by Haszprunar, (1989).

Radula (Figs. 5A,B). Radular ribbon nearly symmetrical. Rachidian tooth broad, with strong lateral

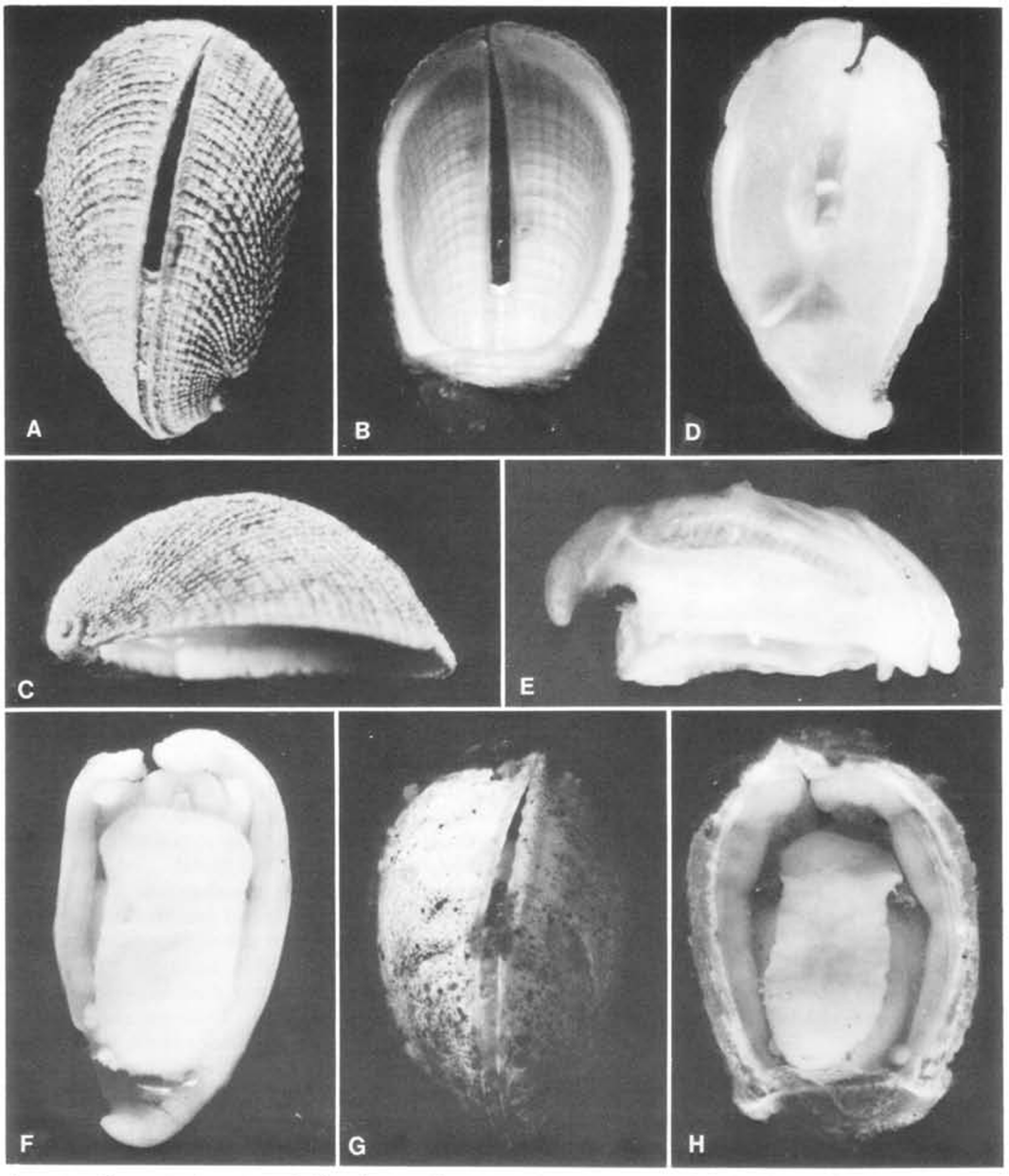

Figure 1. *Temnocinclis euripes,* shell and external anatomy. Anterior at top in dorsal and ventral views. **A–C.** USNM 859964, holotype. Axial Seamount, Juan de Fuca Ridge, *Pisces IV* dive 1726. Length 3.8 mm. **A.** Exterior view. **B.** Interior, showing band of periostracum across posterior margin. **C.** Right side. **D.** LACM 2353a, body of paratype, dorsal view. Southern Juan de Fuca Ridge, *Alvin* dive 1463. Length 3.4 mm. **E,F.** LACM 2351, body of paratype, prior to sectioning. Endeavour Segment, Juan de Fuca Ridge, *Alvin* dive 1447. **E.** Right side showing monopectinate right ctenidium. **F.** Ventral view, showing operculum attached to metapodium. **G,H.** LACM 2352a, paratype with attached body, showing less pronounced sculpture and decalcification at margin. Axial Seamount, Juan de Fuca Ridge, *Alvin* dive 1726. Length 4.0 mm. **G.** Dorsal view. **H.** Ventral view, showing attached operculum.

projections, overhanging edge with sharp pointed central cusp, flanked by five to six pairs of smaller pointed cusps. Three pairs of lateral teeth with similar morphology, overhanging cusps with four sharp denticles, decreasing in size from large innermost cusp; shafts of laterals with elbows corresponding to lateral projections of rachidian; shafts below elbow fading into basal membrane of ribbon. Enlarged outer lateral and lateromarginal plate lacking. Marginal teeth numerous, cusps of similar size and with four pointed denticles like those of laterals; shafts of innermost marginals short, fading

into basal membrane in manner like that of laterals; shafts of outer marginals long, not clearly separated at base from those of adjacent marginals.

DIMENSIONS. Length 3.8, width 2.4, height 1.5 mm (holotype).

TYPE LOCALITY. Hydrothermal vents of Axial Seamount, Juan de Fuca Ridge off Washington (45°59.5'N, 130°03.5'W), 1575 m.

TYPE MATERIAL. Holotype and three paratypes from *Pisces IV* dive 1726, 27 July 1986. Holotype, USNM 859964 (Figs. 1A–C). Paratypes from this dive and other dives from the Endeavour Segment, Juan de Fuca Ridge, and other sites on the southern Juan de Fuca Ridge are distributed as indicated in Tables 1 and 2.

The holotype shell is the only specimen in good condition; it is preserved dry and the body has been sectioned. All specimens except the holotype exhibit some decalcification at the margin. No juvenile specimens smaller than a length of 1.8 mm are known.

DISTRIBUTION. Hydrothermal-vent community at Juan de Fuca Ridge, from northern Endeavour Segment (47°57.0'N) to southern section (44°39.2'N).

REMARKS. Sculpture ranges from sharply clathrate (holotype, Figs. 1A,C) to very weak (Fig. 1G). Of the present material, the holotype has the best-developed sculpture.

ETYMOLOGY. The specific name of the type species, from Greek *euripos*, means strait, or channel, referring to the slit.

Temnozaga new genus

TYPE SPECIES. *Temnozaga parilis* new species.

DESCRIPTION. Shell elongate, relatively high; apical whorl close to apertural margin. Protoconch sculpture smooth with fine reticulations. Sculpture predominantly radial, concentric sculpture of raised lamellae. Slit-borders raised, with interlocking projections in contact at anterior end. Columella with angular posterior ridge.

External Anatomy. Cephalic tentacles and ctenidia as diagnosed for subfamily. Four posterior pairs of epipodial tentacles. Operculum small, multispiral, edges of early volutions raised. Ctenidia monopectinate.

Radula. Rachidian broad, overhanging tip narrow, with three main cusps, three pairs of lateral teeth, each with four denticles; basal part of shafts of laterals and inner marginals fading into basal membrane of ribbon.

REMARKS. This genus is based on a single, previously figured species from hydrothermal vents at 21°N on the East Pacific Rise.

Temnozaga and *Temnocinclis* share a number of features, including relatively large size for the family, the interlocking projections of the shell edge along the anterior contact, and similar opercular morphology. There are, however, two major differences: the position of the apex, posterior to the shell margin in *Temnocinclis,* but not in *Temnozaga,* and, of more importance, the excavated posterior rim in *Temnocinclis,* over which the periostracum extends. There is no comparable structure in *Temnozaga,* which has a smooth posterior rim. There are also major differences in the radula: the rachidian and lateral teeth of *Temnocinclis* have more secondary cusps than those of *Temnozaga, Temnozaga* has a much narrower overhanging cusp on the rachidian tooth, and the innermost marginal teeth of *Temnozaga* have longer shafts than those of *Temnocinclis.*

ETYMOLOGY. The generic name is a Greek compound of *temno,* to cut, and part of zig-zag, with reference to the deeply cut slit and the interlocking projections of the shell along the slit margin anteriorly. Gender: neuter.

Temnozaga parilis new species

Figures 2A–H, 4B,C, 5C,D

Unnamed *Rimula*(?); Turner, Lutz, and Jablonski, 1985, figs. 11a–c (juvenile shell and protoconch).

DIAGNOSIS. Shell nearly symmetrical, apical whorl not projecting.

DESCRIPTION. Shell (Figs. 2A–C, 4B,C) relatively large for family (maximum length 4.0 mm); periostracum thick; outline of aperture elongate-oval, broader anteriorly. Margin of aperture nearly in same plane, sides raised slightly relative to ends. Highest elevation of shell at half its length. Profile moderately high, height of holotype 0.41 times length. Apical whorl nine-tenths shell length from anterior end, deflected to right. Protoconch diameter 170 μm; protoconch surface smooth; first teleconch whorl smooth, rounded, slightly descending below level of protoconch, slit arising three protoconch diameters away at position of one-half whorl of growth in first teleoconch whorl, at which stage expansion of aperture produces limpet form through one-half whorl of additional rotation. Slit open nearly three-fourths length of shell in dorsal view, not deflected to right. Slit-borders sharply raised, bearing alternating, interlocking projections in contact anteriorly. Selenizone depressed below slit-border, additions to selenizone slightly curved, projecting farther anteriorly on left side. Sculpture of about 30 strong primary ribs with one to three secondary and tertiary ribs arising in interspaces. Concentric sculpture of fine growth lines, raised into sharp lamellar scales on crossing primary radial ribs. Shell margin finely crenulated by ribs. Apertural lip thin anteriorly, forming angulate ridge posteriorly in position corresponding to columella. Shell interior opaque white, muscle scar barely detectable, its terminations rounded. Slit bordered by slightly raised callus deposition.

External Anatomy (Figs. 2D–H). Body nearly bilaterally symmetrical; cephalic tentacles thick, tapered, short (contracted condition); four posterior pairs of epipodial tentacles (strongly contracted),

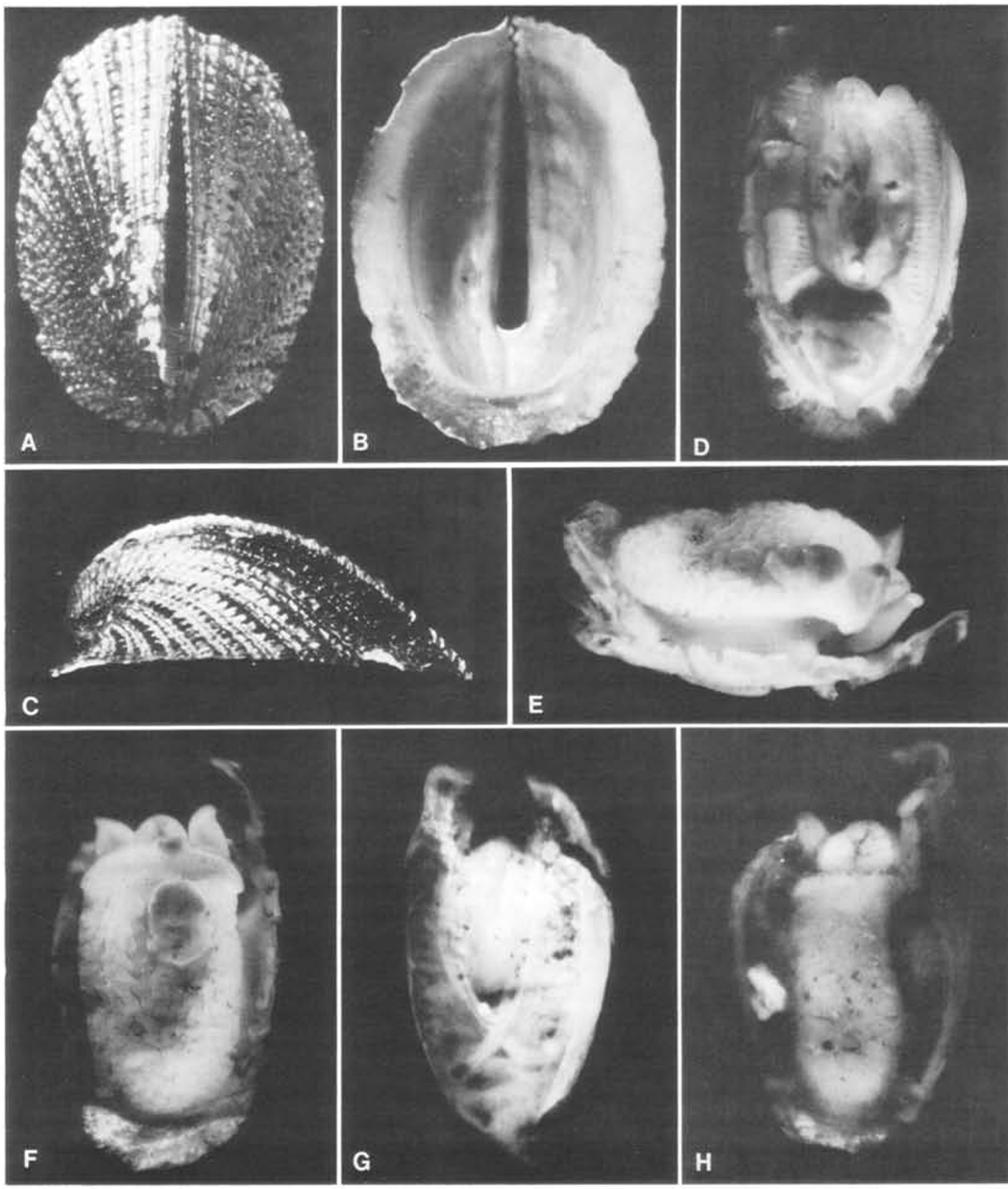

Figure 2. *Temnozaga parilis*, shell and external anatomy. East Pacific Rise at 21°N. Anterior at top in dorsal and ventral views. **A–C.** USNM 859966, holotype shell, photographed subsequent to gold coating for scanning and loss of pieces of periostracum. *Alvin* dive 1226. Length 4.0 mm. **A.** Exterior view. **B.** Interior view. **C.** Right side. **D–F.** Body of holotype prior to sectioning, mantle skirt torn away anteriorly. Length 2.5 mm. **D.** Dorsal view, showing paired monopectinate ctenidia by transparency through mantle skirt. **E.** Left side, showing folded operculum. **F.** Ventral view, showing inner side of iridescent operculum. **G,H.** LACM 2354, body of paratype (shell lost), prior to extraction of radula. *Alvin* dive 1229. Length 1.0 mm. **G.** Dorsal view, showing paired monopectinate ctenidia by transparency through mantle skirt. **H.** Ventral view, showing operculum and paired epipodial tentacles at posterior end of foot.

decreasing in size posteriorly, all tentacles non-papillate. Shell muscle horseshoe-shaped, of similar width throughout; muscle terminations rounded. Two monopectinate ctenidia of equal size, 27 leaflets visible on left ctenidium (right ctenidium damaged). Foot with double anterior edge marking opening of pedal gland. Operculum 1.3 mm in diameter, at least six volutions, edges of early volutions raised (Figs. 2E,F).

Radula (Figs. 5C,D). Radular ribbon slightly asymmetrical. Rachidian tooth broad, its basal area expanded, neck of overhanging tip narrow, with

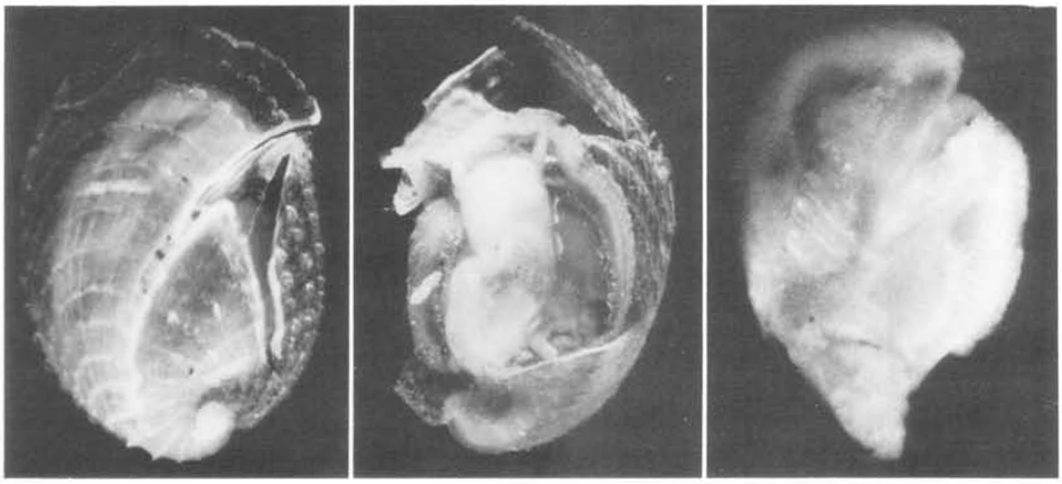

Figure 3. *Sutilizona theca*, shell and external anatomy. East Pacific Rise at 12°N. Anterior at top in dorsal and ventral views. **A,B.** LACM 2355a, paratype with body attached, prior to sectioning. *Alvin* dive 2003. Length 1.3 mm. **A.** Dorsal view. **B.** Ventral view. **C.** USNM 859966, holotype body prior to sectioning, showing monopectinate ctenidia by transparency, the left larger than the right. *Alvin* dive 2003. Length 1.2 mm.

sharp pointed central cusp, flanked by one relatively large cusp on either side, sometimes with smaller cusps between. Three pairs of similar lateral teeth, overhanging edge with one major cusp and one or two minor cusps; shafts of laterals with elbows corresponding to basal projections of rachidian; shafts below elbow fading into basal membrane of ribbon. Enlarged outer lateral and lateromarginal plate lacking. Marginal teeth numerous, cusps of similar size and with denticles like those of laterals, shafts with strong indentation near tip; shafts of all marginals long, those of outermost marginals not clearly separated from those of adjacent marginals.

DIMENSIONS. Length 4.1, width 3.0, height 1.7 mm (holotype).

TYPE LOCALITY. East Pacific Rise at 21°N (20°50.0′N, 109°06.0′W), 2616 m.

TYPE MATERIAL. Holotype from *Alvin* dive 1226, 10 May 1982. Holotype, USNM 859966. The shell had been coated with gold for SEM by R. Lutz (Figs. 4B,C) prior to photography (Figs. 2A–C), which accounts for its present metallic appearance. The holotype body (Figs. 2D–F) has been sectioned by Haszprunar; the operculum remains intact. Paratype (LACM 2354, Figs. 2G,H) from *Alvin* dive 1229, single body 1.0 mm long of which the anterior end was used for the radular preparation; the posterior part of the body with operculum attached remains.

DISTRIBUTION. Hydrothermal-vent habitat of East Pacific Rise at 21°N.

REMARKS. The imbricate sculpture on the radial ribs resembles that of the clypeosectid *Pseudorimula marianae* new species, but that represents convergence in shell characters between two families in different superfamilies. Differences from *Temnocinclis euripes* are treated above.

ETYMOLOGY. The specific name is Latin for equal, denoting the symmetry of the teleoconch shell.

SUTILIZONINAE new subfamily

TYPE GENUS. *Sutilizona* new genus.

DESCRIPTION. Shell of strongly asymmetrical limpet form, retaining a coiled portion; slit closed (fused) at maturity. Protoconch reticulate with deep pits. Radula lacking enlarged fourth lateral tooth, marginal teeth similar to lateral teeth. Ctenidia monopectinate, of unequal shape and position; cephalic and epipodial tentacles non-papillate, eyes lacking.

For anatomical characters see Haszprunar (1989).

REMARKS. Although the new genus *Sutilizona* has monopectinate ctenidia, as do both genera of the new subfamily Temnocinclinae, additional characters of the protoconch and radula are unique to it, and are not represented in any other genus of Scissurellidae. Haszprunar (1989) finds further justification for separating this genus at the subfamily level.

In shell characters *Sutilizona* is unlike *Temnocinclis* and *Temnozaga* in having no posterior ridge for muscle insertion on the shell interior, in retaining a posterior coiled portion visible on the interior side, and in having the slit sealed anteriorly in mature specimens. The anteriorly sealed slit is a character shared with the shallow-water scissurellid genera *Sinezona* (subfamily Scissurellinae) and *Sukashitrochus* (subfamily Anatominae), each of which is assigned to a different subfamily on the basis of radular and protoconch characters.

The radula of *Sutilizona* is more similar to that of *Temnozaga* than to *Temnocinclis* in having a

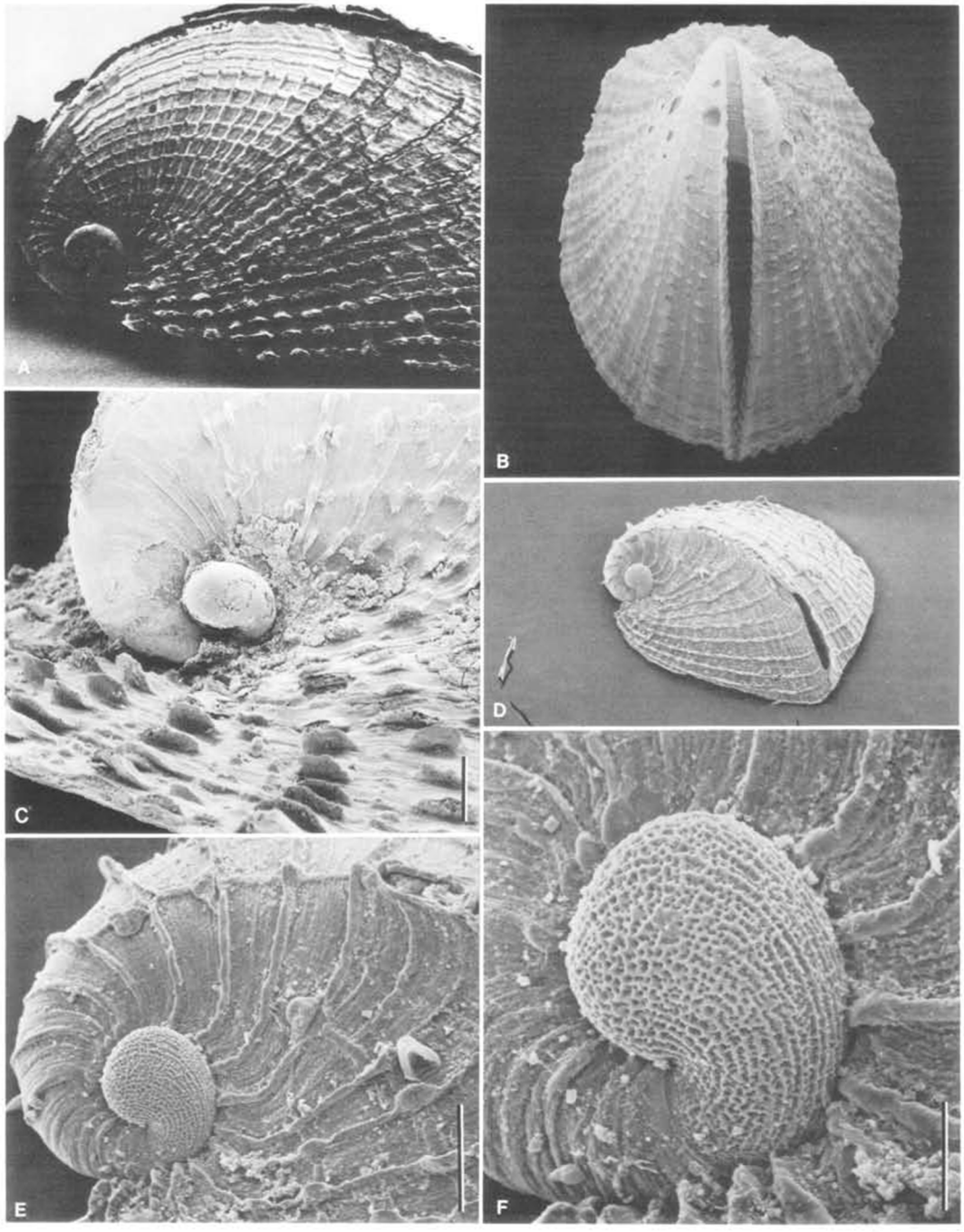

Figure 4. SEM views of early sculpture and protoconchs of scissurellids from hydrothermal vents. **A.** *Temnocinclis euripes*. LACM 2352b, right lateral view of paratype, in which surface of protoconch has exfoliated. Axial Seamount, Juan de Fuca Ridge, *Pisces IV* dive 1726. Length 2.7 mm. **B,C.** *Temnozaga parilis*. USNM 859966, holotype shell (after Turner et al., 1985, figs. 11a,b). East Pacific Rise at 21°N, *Alvin* dive 1226. Length 4.0 mm. **B.** Exterior view, anterior at bottom. **C.** Enlarged view of apical area showing lamellar sculpture and eroded protoconch. Scale bar = 100 μm. **D–F.** *Sutilizona theca*. USNM 859967, holotype shell. East Pacific Rise at 13°N, *Alvin* dive 2003. Length 1.3 mm (anterior end broken). **D.** Oblique view of entire shell from left side (anterior end broken to left of foramen). Scale bar = 400 μm. **E.** Protoconch and early teleoconch sculpture. Scale bar = 100 μm. **F.** Enlarged view of protoconch showing pits. Scale bar = 40 μm.

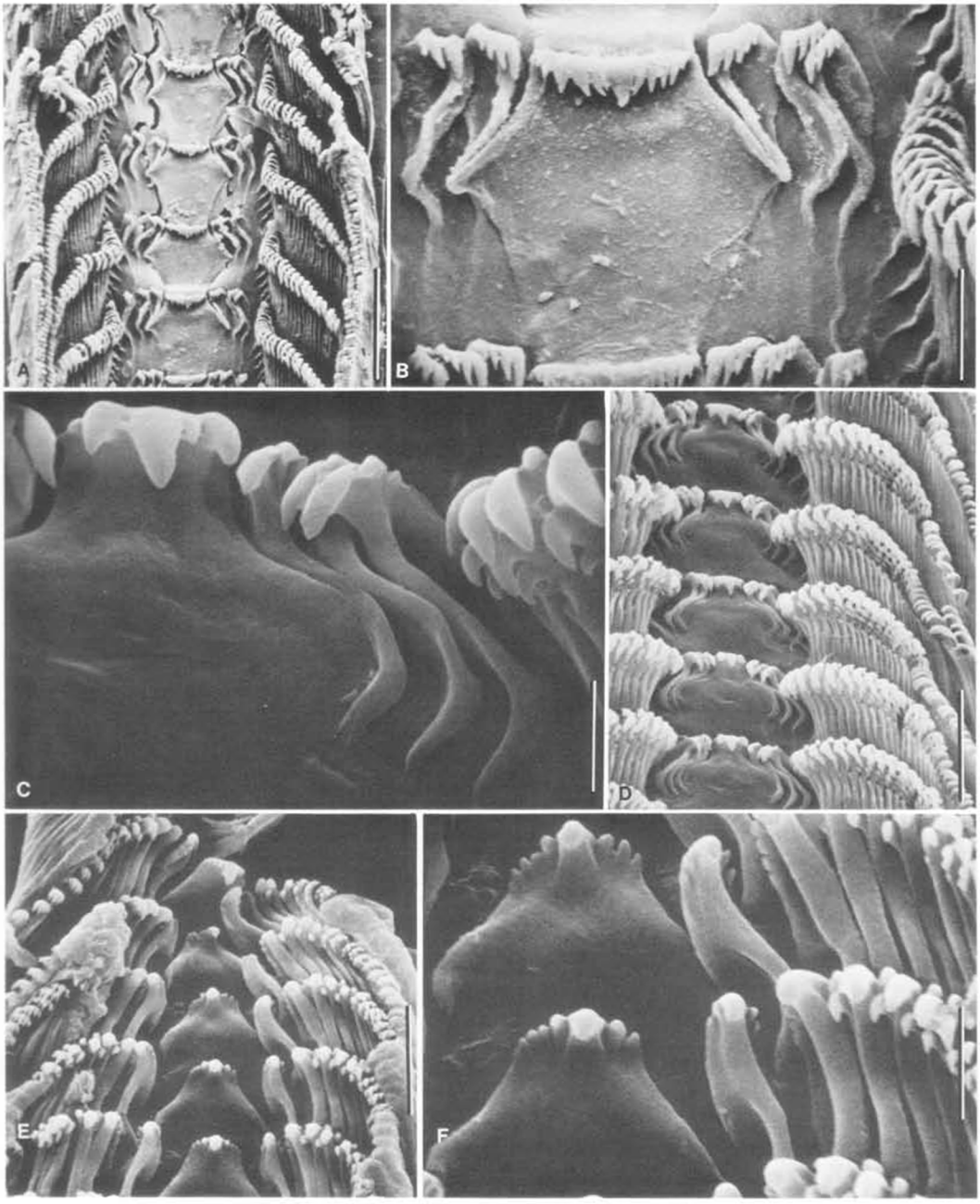

Figure 5. SEM views of radulae of hydrothermal-vent scissurellids. **A,B.** *Temnocinclis euripes.* USNM 859963. Endeavour Segment, Juan de Fuca Ridge, *Alvin* dive 1452. **A.** Full width of radular ribbon. Scale bar = 40 μm. **B.** Rachidian, three pairs of laterals, and inner marginals. Scale bar = 10 μm. **C,D.** *Temnozaga parilis.* LACM 2354. East Pacific Rise at 21°N, *Alvin* dive 1229. **C.** Rachidian, laterals, and tips of inner marginals. Scale bar = 4 μm. **D.** Half width of ribbon. Scale bar = 20 μm. **E,F.** *Sutilizona theca.* LACM 2355b. East Pacific Rise at 13°N, *Alvin* dive 2003. **E.** Full width of ribbon. Scale bar = 10 μm. **F.** Rachidian, laterals, and inner marginals. Scale bar = 4 μm.

narrower overhanging cusp and relatively few secondary cusps on the rachidian and lateral teeth. It differs primarily in the lack of morphological distinction between lateral and marginal teeth, making it unclear whether there are two or three pairs of lateral teeth. Marginal teeth of *Temnozaga* (Fig. 5C) may be distinguished from lateral teeth in having a significant indentation high on the shaft, but there is no indentation on the marginals of *Sutilizona*.

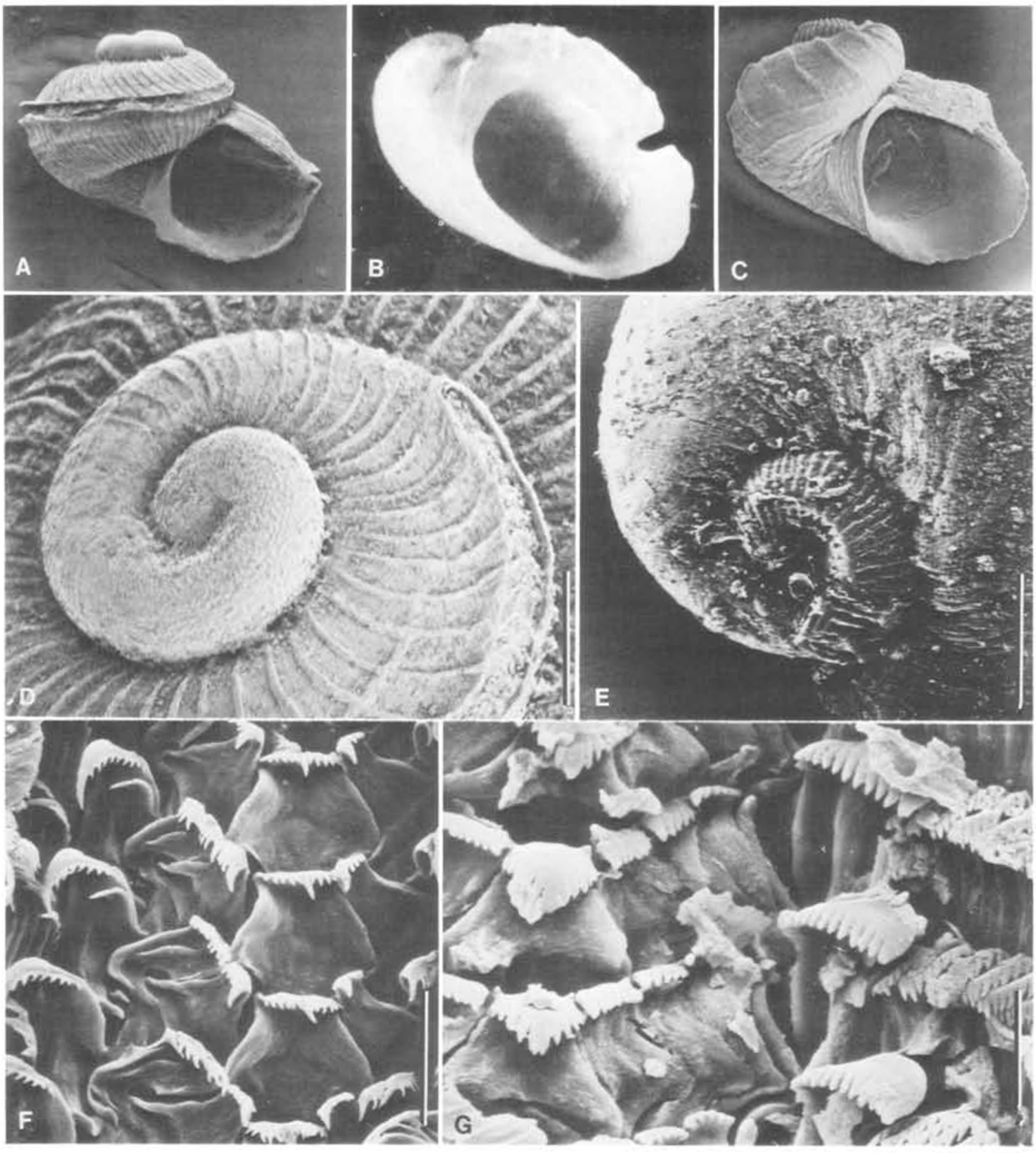

Figure 6. SEM views (except B) of shells, protoconchs, and radulae of non-hydrothermal vent scissurellids. **A.** Shell of *Anatoma lyra* (Berry, 1947). LACM 82-64. Cordell Bank, California, 50 m. Height 0.8 mm. **B.** Shell of *Incisura lytteltonensis* (E.A. Smith, 1894). LACM 47-3. Stewart Island, New Zealand. Length 1.3 mm. **C.** Shell of *Sinezona rimuloides* (Carpenter). LACM 66-57. Carmel, California. Height 0.8 mm. **D.** Protoconch of *Anatoma lyra*, showing smooth surface with irregular reticulation. Same specimen as in Figure 6A. Scale bar = 100 μm. **E.** Protoconch of *Incisura lytteltonensis*, showing strong axial ridges. Same lot as Figure 6B. Scale bar = 100 μm. **F.** Radula of *Anatoma crispata* (Fleming, 1832), showing rachidian (right center) and four pairs of laterals, the enlarged outermost (at left) with pointed tip and serrations on inner side. Scale bar = 20 μm. **G.** Radula of *Incisura lytteltonensis*, showing rachidian (at left) and four pairs of laterals, the enlarged outermost (at right) with numerous strong serrations on inner side. Scale bar = 10 μm.

Sutilizona new genus

TYPE SPECIES. *Sutilizona theca* new species.

DESCRIPTION. Shell oval and relatively low; apical whorl sharply offset to right and directly above posterior margin. Protoconch with deep pits. Sculpture predominantly concentric, radial sculpture suggested by linear alignment of raised lamellae. Slit-borders not raised, slit sealed anteriorly. Shell interior retains coiled portion at posterior.

External Anatomy. Cephalic and epipodial tentacles non-papillate, epipodial tentacles one posterior pair. Operculum small. Ctenidia monopectinate, unequal.

Radula. Rachidian tooth broad at base, overhanging tip narrow; with one prominent and two to four smaller cusps; lateral teeth at least two pairs, of similar morphology as marginal teeth.

REMARKS. This genus is based on a single species from hydrothermal vents at 12°N on the East Pacific Rise.

ETYMOLOGY. The generic name is a compound of the Latin *sutilis,* sewn together, and Latin *zona,* belt, referring to the sealed selenizone of mature specimens. Gender: feminine.

Sutilizona theca new species

Figures 3A–C, 4D–F, 5E,F

DIAGNOSIS. Slit closed at maturity, shell retaining coiled portion.

DESCRIPTION. Shell (Figs. 3A,B, 4D–F) small for family (possibly immature), maximum length 1.3 mm; periostracum thin; outline of aperture oval, broader anteriorly. Apical whorl deflected to right and overhanging posterior margin; protoconch diameter 250 μm; protoconch sculpture drawn into elongate rows with deep pits. First teleoconch whorl rounded, with strong collabral (axial) ribs; slit arising two protoconch diameters away at position of three-fourths whorl of growth in first teleoconch whorl, at which stage expansion of aperture produces limpet form. Slit sealed anteriorly at shell length of 0.9 mm, open only one-fourth length of shell in dorsal view, slit and selenizone strongly curved to right. Slit-borders not sharply raised; selenizone not depressed below slit-border. Spiral sculpture weak except for one strong rib arising at one-half whorl of growth in first teleoconch whorl and extending to slit-band. Concentric sculpture strong, producing raised lamellar scales on crossing weak radial sculpture. Apertural lip thin and fragile. Shell interior transparent, muscle scar not deeply impressed, slit and selenizone bordered by raised ridges of callus. Shell interior retaining coiled portion posteriorly.

External Anatomy (based on 1.3 and 1.1 mm bodies; Figs. 3B,C). Body asymmetrical; cephalic tentacles slender, moderately long (contracted condition); one posterior pair of epipodial tentacles. Shell muscle horseshoe-shaped, longer on left side, muscle terminations expanded inwardly. Left ctenidium monopectinate, up to seven leaflets visible through transparent mantle skirt in larger specimen, four in smaller specimen. Right gill not visible through mantle. Foot with double anterior edge marking opening of pedal gland. Operculum small, nearly transparent, diameter about 0.5 mm in larger specimen.

Internal anatomy is described by Haszprunar (1989).

Radula (Figs. 5E,F). Radular ribbon symmetrical. Rachidian tooth broad, its basal area expanded, neck of overhanging tip narrow, with sharp pointed central cusp, flanked by two to four smaller irregular cusps. Lateral teeth at least two pairs, each with large main cusp and one to two smaller cusps on each side; first lateral with depression on front surface to fit edge of rachidian; second lateral similarly shaped to fit against first lateral. Shafts of lateral teeth and marginal teeth long, their bases concealed by cusps of row below. Third and subsequent teeth in row not clearly distinguishable as either laterals or marginals.

DIMENSIONS. Length 1.1 (shell anterior broken, projected length 1.3), width 0.9, height 0.5 mm (holotype).

TYPE LOCALITY. On sulfide mounds at base of inactive chimney, East Pacific Rise near 12°N (11°46′N, 103°47′W), 2715 m.

TYPE MATERIAL. Holotype and two paratypes from *Alvin* dive 2003, 25 March 1988. Holotype, USNM 859967; two paratypes, LACM 2355 (Tables 1, 2). All specimens are in damaged condition. The holotype (Figs. 4D–F) has been coated for SEM and the body removed for sectioning. One paratype (Figs. 3A,B), initially broken, has been separated from the shell for sectioning, resulting in further breakage. The third paratype was initially so decalcified that nothing but shell fragments remain; the body was used for radular extraction.

DISTRIBUTION. Hydrothermal vents of East Pacific Rise near 12°N.

REMARKS. It is possible that the present specimens are immature, considering that their ctenidia are so poorly developed: one specimen showed seven leaflets and the other four on the left ctenidium. However, the closed slit seems to suggest that the specimens may be mature. In *Sinezona* (subfamily Scissurellinae) the slit is open during most of the growing phase and is closed only at maturity.

ETYMOLOGY. The specific name *theca* is Latin, sheath, a feminine noun in apposition referring to the coiled portion of the shell that is retained in the interior (ventral) view.

Superfamily FISSURELLACEA Fleming, 1822

CLYPEOSECTIDAE new family

TYPE GENUS. *Clypeosectus* new genus.

DESCRIPTION. Shell of limpet form with deep, asymmetrical slit or foramen; slit-borders raised, nearly in contact or sealed at anterior end. Apex deflected to right, not overhanging posterior margin. Shell lacking pits (or pores) on early teleoconch. Muscle scar without inturned hooked-process of fissurellids; anterior extension of pallial attachment scar producing false muscle scar.

External Anatomy. Eyes lacking, cephalic tentacles not papillate. Epipodial tentacles not papil-