

# The Xiphostylidae Haeckel and Parvivaccidae, n. fam., (Radiolaria) from the North American Jurassic

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**ABSTRACT:** This report deals with the Parvivaccidae, n. fam. and a revision of the Xiphostylidae Haeckel. Both of these spumellarian families are unique in that they possess cortical shells consisting of two distinct fused layers of latticed meshwork. Three new genera and twenty-nine new species are described from the Xiphostylidae Haeckel. Emended definitions are presented for *Triactoma* Ruest, *Tripocyclia* Haeckel, and *Xiphostylus* Haeckel. Two new genera and two new species are described under the Parvivaccidae. Only Jurassic xiphostylid and parvivaccid taxa are figured herein. Range, occurrence, and relative abundance of the more important taxa are shown in the text-figures.

## INTRODUCTION

In 1887 Haeckel presented a classification of the Radiolaria based largely on test shape and symmetry rather than on test structure. Unfortunately, Haeckel's massive monographic study had a profound influence on the classification of Radiolaria not only in Haeckel's day, but also for nearly a century later (e.g., Campbell 1954; Orlov et al. 1959).

Riedel (1971) was the first worker who dared to suggest that Haeckel's classification was artificial and obscured phylogenetic relationships. Moreover, Riedel suggested that radiolarian specialists abandon Haeckel's classification and attempt to build classificatory models that are based on morphological features that have phylogenetic significance. Subsequently, studies by Pessagno (1973, 1979), Baumgartner (1980a), Pessagno and Whalen (1982), and Pessagno, Whalen, and Yeh (1986) have stressed test structure in the classification of the Radiolaria. We believe that a better understanding of test construction – particularly test ultrastructure – will lead to the development of a more phylogenetic classification of the Radiolaria at superspecific levels.

The present report focuses on two radiolarian families: (1) the Xiphostylidae Haeckel (emend. herein) and (2) the Parvivaccidae, n. fam. Furthermore, it stresses the importance of radiolarian test ultrastructure in developing a meaningful classification. This report should not be regarded, however, as a comprehensive analysis of all xiphostylid and parvivaccid generic and species level taxa. Numerous new species and even new genera remain to be

described in these two families. Hopefully, the present report offers a classificatory framework for future studies of xiphostylid and parvivaccid taxa.

## XIPHOSTYLID AND PARVIVACCID TEST ULTRASTRUCTURE

Both the Xiphostylidae and the Parvivaccidae share similar test wall structure and ultrastructure. Namely, both family groups possess cortical shells comprised of two fused latticed layers: (1) a thin inner latticed layer and (2) a thicker outer latticed layer each consisting of symmetrical polygonal pore frames. The juncture between the inner and outer latticed layers is referred to herein as the primary lamella (pl. 1, figs. 1, 2, 4-11, 13; pl. 9, fig. 23).

We suggest that the inner latticed layer and the outer latticed layer were formed by the secretion of bundles of thin lamellae of microgranular silica. Moreover, we suggest that the inner latticed layer served as a template for the secretion of the outer latticed layer. The possible function of the outer latticed layer is discussed under Systematic Paleontology (see Xiphostylidae below).

In spite of similarities in the wall structure of the cortical shell, the Xiphostylidae differ from the Parvivaccidae by possessing secondary spines and by totally lacking a medullary shell and primary radial beams. The Parvivaccidae possess a single medullary shell which is connected to the cortical shell both by secondary and primary radial beams. The parvivaccid cortical shell also possesses primary spines which connect directly to the primary radial beams.

## PHYLOGENETIC MODELS FOR THE XIPHOSTYLIDAE AND PARVIVACCIDAE

### Xiphostylidae

Based on the morphology of generic-level taxa as well as their first occurrence, the following tentative phylogenetic model is advanced for the Xiphostylidae:

*Event 1:* *Archaeocenosphaera*, n. gen., the simplest member of the Xiphostylidae, gave rise to *Triactoma* Ruest and *Xiphostylus* Haeckel during late Pliensbachian times. *Archaeocenosphaera* gave rise to *Triactoma* (*Archaeocenosphaera* sp. to *Triactoma* sp.) through the acquisition of three more or less equidistant spines situated in the same plane. The cortical shell of *Triactoma* remained spherical like that of *Archaeocenosphaera*. *Archaeocenosphaera* also gave rise to *Xiphostylus* (*Archaeocenosphaera* sp. to *Xiphostylus* sp.) through the acquisition of two opposed secondary spines with cortical buttresses and a spherical to compressed cortical shell. The latter scenario is reinforced by the fact that late Pliensbachian specimens of *Xiphostylus* tend to have spherical cortical shells (see *Xiphostylus* sp. F and X. sp. G herein and X. sp. A of Yeh 1987, p. 114, pl. 3, fig. 15).

*Event 2:* *Triactoma* Ruest gave rise to *Tripocyclia* Haeckel (*Triactoma* sp. to *Tripocyclia* sp.) through the acquisition of three secondary spines with cortical buttresses and a cortical shell that may either be spherical or ellipsoidal in cross-section and circular to subtriangular in outline (viewed at right angles to plane of spines). This event seems to have occurred during the Aalenian or early Bajocian.

*Event 3:* *Triactoma* gave rise to *Zanola*, n. gen., (*Triactoma* sp. to *Zanola* sp.) through the acquisition of three asymmetrically placed spines of variable length and a test which is both subelliptical to circular in outline when viewed at right angles to the plane of the three spines and in cross-section. This event occurred during the Kimmeridgian (Callovian? Oxfordian?).

*Event 4:* *Tripocyclia* Haeckel gave rise to *Neotripocyclia*, n. gen., (*Tripocyclia* sp. to *Neotripocyclia* sp.) during the Oxfordian through the acquisition of a test which is cylindrical in cross-section and the shift of the three secondary spines to an asymmetrical position. This scenario is supported by the fact that many species of *Tripocyclia* possess cortical shells which are markedly elliptical in cross-section. Moreover, species assignable to both genera possess cortical buttresses.

### Parvivaccidae

It is conceivable that *Lanubus* evolved from the pantaneliid genus *Gorgansium* Pessagno and Blome through the loss of one primary spine and the retention of the two adjacent, asymmetrically placed primary spines (*Gorgansium* sp. to *Lanubus* sp.). This maneuver would also require the development of a two latticed layered cortical shell. However, it should be noted that this hypothesis is also supported by the fact that the two adjacent primary spines of *Lanubus* are invariably subequal in length just

like those of *Gorgansium*. Based on our present body of biostratigraphic data, this evolutionary event occurred during Middle Jurassic (early Bajocian) times.

It is likely that *Lanubus* gave rise to *Parvivacca* (*Lanubus* sp. to *Parvivacca* sp.) by Oxfordian times through the development of two opposed flattened surfaces, planar sides and the loss of the outer layer of latticed meshwork on all but the two opposed flattened surfaces.

## BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

The biostratigraphic and chronostratigraphic assignment of radiolarian-bearing samples cited in this report for the most part follows that presented for the Jurassic by Pessagno et al. (1987b). The reader is referred to the latter report for the formal definition of all radiolarian zonal units, their approximate correlation with European ammonite standard zones, and their chronostratigraphic assignment. Portions of the radiolarian zonation presented for the Jurassic by Pessagno et al. (ibid.) are shown in Text-figures 1, 2, and 3 herein.

It should be noted that Pessagno et al. (ibid.) utilized the first occurrence of *Mirifusus* Pessagno to mark the base of their Zone 2. Very well-preserved North American radiolarian faunas which are well-constrained by ammonite biostratigraphy prevent us from accepting a prelate middle Callovian date for the first occurrence of *Mirifusus*. This view is obviously in clear conflict with the opinion of Baumgartner (1986) who placed the *Mirifusus* first occurrence event in the Bathonian.

New biostratigraphic and geochronometric data from the Smith River subterranean (Klamath Mts., N.W. Calif.; see Stratigraphic Summary below) support an Oxfordian age for the *Mirifusus* first occurrence event (Pessagno and Blome 1989; in press). Along the Middle Fork of the Smith River at Harper's (1983) loc. 1, *Mirifusus* first appears in volcanopelagic strata 17.6 m (58.0 f; sample JO-34 herein) above the contact with the Josephine ophiolite (JO). As indicated in Text-figure 4, below this horizon the radiolarian assemblage is characterized by lacking *Mirifusus* and by containing *Xiphostylus* Haeckel. However, above this horizon (i.e., from 17.6 m to 91.4 m), a zone of concurrence exists between *Mirifusus* and *Xiphostylus* (see Text-fig. 4). It is also important to note that the JO in the Smith River subterranean has been dated by Miller and Saleeby (1987) and Saleeby (1987) at  $162 \pm 1$  m.y. (concordant U/Pb date on zircon from plagiogranite).

The placement of the Zone 2 – Superzone 1 boundary in the middle Oxfordian is somewhat arbitrary; it could just as easily be placed in the lower Oxfordian. Nevertheless, in that the upper part of Subzone 2 gamma occurs in strata (Galice s.l.) which also contain *Buchia concentrica* (Sowerby) at nearby localities in the Smith River Subterranean, it is likely that at least part of the new biozone is assignable to the middle Oxfordian. (Range of *Buchia concentrica* in North America = middle Oxfordian to upper Kimmeridgian s.g.; see Imlay 1980; Pessagno, Blome, and Longoria 1984.)



RANGE ZONES OF SELECTED TAXA	LOWER JURASSIC					MIDDLE JURASSIC					
	Pliensbachian		Toarcian		Aalen.	Bajocian				Bathonian	
	lower	upper	lower	upper	X	lower		upper	X		
	X				SUPERZONE 1 (PART)						
	Zone 02	Zone 01		Zone 1A		Zone 1B	Zone 1C	Zone 1D	Zone 1E	Zone 1F	
	X	Sz. 01A	Sz. 01B	Sz. 1A2	Subzone 1A1	X					
<i>Triactoma</i> spp.											
<i>Tripocyclia brooksi</i> , n. sp.											
<i>Tripocyclia smithi</i> , n. sp.											
<i>Tripocyclia southforkensis</i> , n. sp.											
<i>Tripocyclia wickiupensis</i> , n. sp.											
<i>Tripocyclia</i> spp.											
<i>Xiphostylus fragilis</i> , n. sp.											
<i>Xiphostylus halli</i> , n. sp.											
<i>Xiphostylus logdellensis</i> , n. sp.											
<i>Xiphostylus sinuosus</i> , n. sp.											
<i>Xiphostylus superbus</i> , n. sp.											
<i>Xiphostylus vallieri</i> , n. sp.											
<i>Xiphostylus whalenae</i> , n. sp.											
<i>Xiphostylus</i> spp.											
<i>Lanubus dickinsoni</i> , n. sp.											
<i>Lanubus holdsworthi</i> , n. sp.											
<i>Lanubus purus</i> , n. sp.											
<i>Lanubus</i> spp.											

TEXT-FIGURE 1

Range zones of selected Lower Jurassic (Pliensbachian) to Middle Jurassic (Bathonian) xiphostylid and parvivaccid taxa. Zonal terminology after Pessagno et al. (1987b). Zonal units not defined by taxa listed here.

#### Definition of Subzone 2 gamma, new subzone

**Top:** Defined by last occurrence of primary marker taxon *Xiphostylus* Haeckel.

**Base:** Defined by first occurrence of primary marker taxon *Mirifusus* Pessagno. (Forms with three rows of pores between circumferential ridges).

**Corporeal taxa:** *Acanthocircus suboblongus* (Yao) and *Tetraditryma praeplena* Baumgartner make their final appearance within the upper part of Subzone 2 gamma.

**Type of zone:** Concurrent range zone sensu ISSC International Stratigraphic Guide (International Subcommission on Stratigraphic Classification, 1976, pp. 55-56).

**Occurrence:** A similar zone of concurrence between *Mirifusus* and *Xiphostylus* occurs in the upper part of the *Unuma echinatus* Zone of Japan (Mizutani and Koike 1982, table 1, p. 122). Moreover, it is important to note that both Subzone 2 gamma and its equivalent in Japan contain *Acanthocircus suboblongus* (Yao) and

*Tetraditryma praeplena* Baumgartner; both of these taxa occur in the upper part of underlying Superzone 1 and have been recognized in upper Superzone 1 strata in Yugoslavia (Gorican 1987). *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) has not been observed in Subzone 2 gamma strata in North America or at the top of the *Unuma echinatus* Zone (= top of *Tricolocapsa plicarum* Zone, Matsuoka and Yao 1986) in Japan. In North America *E. ptyctum* is present in the lower part of Subzone 2 beta (see emended definition below). To date, *E. ptyctum* has not been observed in association with either *A. suboblongus* or *T. praeplena* in either the North American or Japanese radiolarian assemblage (Pessagno and Mizutani, in press).

#### Emended definition of Subzone 2 beta

**Top:** Immediately below first occurrence of primary taxon *Parvicingula* s.s. No secondary marker taxa selected.

**Base:** Immediately above final occurrence of primary marker taxon *Xiphostylus* Haeckel. No secondary marker taxa selected.

CHRONOSTRATIGRAPHIC UNITS			BIOSTRATIGRAPHIC UNITS		PRIMARY MARKER TAXA <i>Taxa used to define a given biostratigraphic unit (i.e., Subzone, Zone, Superzone).</i>	
UPPER JURASSIC	TITHONIAN	UPPER	ZONE 4	SUBZONE 4 ALPHA	<div><div></div><div><i>Ristola altissima</i></div><div><i>Ristola procera</i></div></div>	
				SUBZONE 4 BETA	<div><div><i>Vallupus hopsoni</i></div><div><i>Perispyridium</i></div><div><i>Acanth. dicranocanthos</i></div></div>	
		LOWER		SUBZONE 3 ALPHA	<div><div></div><div><i>Napora burckhardti</i></div></div>	
				SUBZONE 3 BETA	<div><div><i>Mirifusus baileyi</i></div><div><i>Mirifusus guadalupensis</i></div></div>	
	KIMMERIDGIAN	UPPER	ZONE 2	SUBZONE 2 ALPHA	<div><div></div><div><i>Parvicingula s.s.</i></div></div>	
		LOWER		SUBZONE 2 BETA	No Primary Marker taxa utilized at present.	
	OXFORDIAN	UPPER		SUBZONE 2 GAMMA	<div><div><i>Xiphostylus spp.</i></div><div><i>Mirifusus spp.</i></div></div>	
		MIDDLE		SUPERZONE 1 (Part)		↓ = First Occurrence.
		LOWER				↑ = Last Occurrence.

TEXT-FIGURE 2

Revised zonation for the Upper Jurassic. The revised zonation shown here differs from that of Pessagno et al. (1987b) by including a new subzone, Subzone 2 gamma, within Zone 2. Moreover, the definition of Subzone 2 beta has been emended. See Biostratigraphy and Chronostratigraphy in text.

RANGE ZONES OF SELECTED TAXA	UPPER JURASSIC							
	Oxfordian (part)			Kimmeridgian		Tithonian		
	lo.	middle	upper	lower	upper	lower	upper	
	Superzone 1 Part (unsubdivided)	Not Subdivided into Superzones.						
		Zone 2			Zone 3		Zone 4	
		Subzone 2 gamma	Subzone 2 beta	Sz. 2 alpha	Subzone 3 beta	Subzone 3 alpha	Subzone 4 beta	Subzone 4 alpha
<i>Neotripocyclia harperi</i> , n. sp.		—						
<i>Triactoma blakei</i>				—	—			
<i>Triactoma hidalgoensis</i> , n. sp.			? —					
<i>T. sp. aff. T. hidalgoensis</i> , n. sp.				—				
<i>Triactoma kellumi</i> , n. sp. (1)						? —		
<i>Triactoma mexicana</i> , n. sp.							— ?	
<i>Triactoma paramexicana</i> , n. sp.							— ?	
<i>Triactoma(?) prolongata</i> , n. sp.							—	
<i>Tripocyclia amajacensis</i> , n. sp. (1)					— ?			
<i>Tripocyclia foremanae</i> , n. sp.							—	
<i>Tripocyclia frequens</i> , n. sp.							—	
<i>Tripocyclia jonesi</i>				—	—		—	
<i>Tripocyclia notabilis</i> , n. sp.							—	
<i>Tripocyclia saleebii</i> , n. sp.		? —					—	
<i>Tripocyclia spinosa</i> , n. sp.							—	
<i>T. sp. cf. T. spinosa</i> , n. sp.							—	
<i>Xiphostylus gasquetensis</i> , n. sp.	? —	—						
<i>Xiphostylus</i> spp.	—	—						
<i>Lanubus</i> spp.	—	—	—	—	—	—	— ?	
<i>Parvivacca blomei</i> , n. sp.							—	
<i>Parvivacca simplex</i> , n. sp.							—	
<i>Parvivacca</i> spp.		—	—	—	—	—	—	?

TEXT-FIGURE 3

Range zones of selected Upper Jurassic (Oxfordian to Tithonian) xiphostylid and parvivaccid taxa. Zonal terminology emended from that of Pessagno et al. (1987b). Zonal units not defined by taxa listed here. See text-figures 2, 4. Note: (1) = upper or lower limit of range zone not fully established.

**Corporeal taxa:** *Praeconocaryomma immodica* Pessagno and Poisson makes its final appearance in the lower part of this subzone. *Hsuum cuestaense* Pessagno and *Eucyrtidiellum ptyctum* (Riedel and Sanfilippo) first appear at or near the base of Subzone 2 beta.

**Type of zone:** Interval zone sensu ISSC International Stratigraphic Guide (International Subcommission on Stratigraphic Classification, 1976, pp. 60-61).

**Occurrence:** Pessagno, Blome, and Longoria (1984, p. 12) noted that *Mirifusus* Pessagno first appeared 4.5 m (15 f) above the base of the Coast Range ophiolite (Santa Barbara Co., Calif.). As a result they tentatively assigned strata below this horizon and above the contact with the Coast Range ophiolite (CRO) to the upper part of Superzone 1. This interpretation is no longer justifiable.

Evidence from east-central Mexico suggests that *Mirifusus* is a stenobathic abyssal taxon. The absence of *Mirifusus* in the lower 4.5 m of the Point Sal succession may be due to the elevation of the sea floor to shallower abyssal or bathyal depths at the site of an oceanic spreading center. We assign the lower 4.4 m of the volcanopelagic succession to Subzone 2 beta herein. Although this interval lacks *Mirifusus*, it contains *Eucyrtidiellum ptyctum* in samples collected 0.9 m (3.0 f) above the contact with the CRO. Moreover, it lacks *Xiphostylus*, *Acanthocircus suboblongus* (Yao) and *Tetraditryma praeplena* which are present in Subzone 2 gamma strata above the Josephine ophiolite and in the upper part of the *Unuma echinatus* Zone in Japan. *Mirifusus* occurs in the volcanopelagic succession 4.7 m (15.5 f) above the contact with the Stanley Mountain (Alamo Creek, San Luis Obispo

Co.) remnant of the CRO. The presence of *Eucyrtidiellum prytum* at 3.8 m (9.4 f) above the contact with CRO at this locality suggests that Subzone 2 beta extends downwards to this horizon. No Radiolaria have been recovered to date from below 3.8 m in the Stanley Mountain section. Future sampling should determine whether this lowermost interval is assignable to Subzone 2 beta or to Subzone 2 gamma.

In the Taman Formation of east-central Mexico all samples previously assigned by Pessagno, Blome, and Longoria (1984) and Pessagno et al. (1987a) to Superzone 1 (see MX-82-3, MX-82-6 herein) are reassigned to Subzone 2 beta. Although these lower Kimmeridgian s.g. samples lack *Mirifusus*, its absence is likely due to the depth of Taman basin of deposition. *Xiphostylus* (primary marker taxon, top of Subzone 2 gamma) appears to be absent in the lower Kimmeridgian Taman samples that we have analyzed to date. As a result, we tentatively place the Subzone 2 gamma – Subzone 2 beta boundary at the base of the Kimmeridgian.

### STRATIGRAPHIC SUMMARY

Only lithostratigraphic units from which radiolarian taxa cited in Systematic Paleontology and in the plate descriptions are discussed in the summary to follow. A more complete discussion of most of these lithostratigraphic units was presented by Pessagno et al. (1986, 1987a).

#### **Wrangellia terrane, Queen Charlotte Islands, British Columbia**

**Kunga Group (= Kunga Formation, Southerland Brown 1968; Pessagno, Whalen, and Yeh 1986; Pessagno et al. 1987b)**

At its type locality on Kunga Island the Kunga Group (Southerland Brown and Jeffrey 1960; Southerland Brown 1968; Cameron and Tipper 1985) consists of a 947 m (3106 f) succession of siliceous mudstone ("argillite"), limestone, and sandstone. The Kunga Group rests conformably(?) on the Karmutsen Group (Ladinian to Karnian) and either conformably beneath the Maude Group (Pliensbachian to Toarcian) or unconformably beneath the Yakoun Group (Middle Jurassic).

Southerland Brown (1968, p. 51) divided what he termed the "Kunga Formation" into three informal members: (1) a lower, massive gray limestone member (Upper Triassic, Karnian); (2) a middle, thin-bedded black limestone member (upper lower Karnian to upper Norian); and (3) an upper, thin-bedded black argillite member (Hettangian to upper Sinemurian; see below). More recently, Cameron and Tipper (1985) elevated the Kunga Formation to group status. Moreover, they formally proposed the name Sandilands Formation for Southerland Brown's upper black argillite member. No formal names were introduced by these workers for Southerland Brown's two other informal lithostratigraphic units.

The biostratigraphy and chronostratigraphy of Southerland Brown's informal member units were discussed by Pessagno, Whalen, and Yeh (1986). The only two samples noted from the Kunga Group in this report were collected

from the Sandilands Formation (= the upper, thin-bedded black argillite member). Hence, we only summarize the characteristics of this unit below.

#### **Sandilands Formation**

The Sandilands Formation is characterized by thin, often rhythmically bedded black siliceous mudstone ("argillite") which superficially resembles ribbon chert. It includes minor amounts of black, thin-bedded micritic limestone, gray bioclastic limestone, dark-gray to greenish gray lithic sandstone, and thin-bedded black calcareous shale.

Cameron and Tipper (1985) indicated that the Sandilands Formation is assignable to the lower and upper Sinemurian (upper Hettangian?) on the basis of their analysis of the megafossil assemblage. At Kunga Island, Pessagno, Whalen, and Yeh (1986, p. 13) and Pessagno et al. (1987b, p. 15) noted the presence of Zone 05 Radiolaria in the lower 56 m (184 f) of the Sandilands Formation below the first occurrence of definite Sinemurian arietitid ammonites and above the last occurrence of *Monotis subcircularis* Gabb. They indicated that the Zone 05 radiolarian assemblage from this interval contained faunal elements such as *Canoptum merum* Pessagno and Whalen that also occur in the Hettangian portion of the Graylock Formation of east-central Oregon.

#### **Maude Group**

The Maude "Formation" (MacKenzie 1916) was recently elevated to group status by Cameron and Tipper (1985). In general, the Maude Group includes dark-gray to black shale, siliceous mudstone ("argillite"), limestone siltstone and lithic sandstone. Bedded limestone and limestone nodules (black micrites) with abundant Radiolaria are common to abundant throughout much of the unit. The Maude Group conformably overlies the Kunga Group and rests unconformably beneath the Yakoun Group (Middle Jurassic). Studies by Cameron and Tipper (ibid.) indicate that the Maude Group ranges from lower Pliensbachian at its base to Aalenian at its top. The single sample noted in this report (Loc. QC-622) was collected from the upper Pliensbachian portion of the Maude Group.

#### **Blue Mountains Province, Izee terrane, east-central Oregon (John Day Inlier)**

In previous reports (e. g., Pessagno et al. 1986) the Snowshoe Formation and other associated lithostratigraphic units (e. g., Nicely Formation) were included in the Mesozoic clastic terrane of Dickinson (1979). In this report we use the more formalized terrane nomenclature of Silberling et al. (1984, 1986) and include such lithostratigraphic units in the Izee terrane.

#### **Nicely Formation**

The Nicely Formation (Lupher 1941; Dickinson and Vigrass 1965; Imlay 1968) consists of 23 m to 91 m (75-300 f) of reddish-weathering, dark-gray silty mudstone and shale with common dark-gray to black micritic limestone nodules bearing common ammonites



and abundant Radiolaria. In the Izee terrane the Nicely Formation is best exposed at Morgan Mountain west of Izee. Here, it reaches its maximum thickness of 91 m (300 f). The upper half of the Nicely at Morgan Mountain is characterized by having shale and mudstone interbedded with occasional layers of Hyde-like bluish gray volcanic wacke which often reaches 1 m in thickness.

The Nicely Formation conformably overlies the Suplee Formation (Sinemurian?; lower Pliensbachian?; upper Pliensbachian) and beneath the Hyde Formation (see below).

Investigations by Imlay (1968, pp. C8-C9) indicate that the Nicely Formation is correlative with the *Amaltheus margaritatus* and *Pleuroceras spinatum* Standard Zones of the upper Pliensbachian. At Morgan Mountain both Imlay's ammonite faunas and all of our radiolarian faunas come from the lower half of the Nicely. No ammonites or Radiolaria have been recovered to date from the upper half of the unit at this locality. Radiolaria recovered from the lower half of the Nicely Formation at Morgan Mountain are assignable to Zone 01, Subzone 01A (upper Pliensbachian).

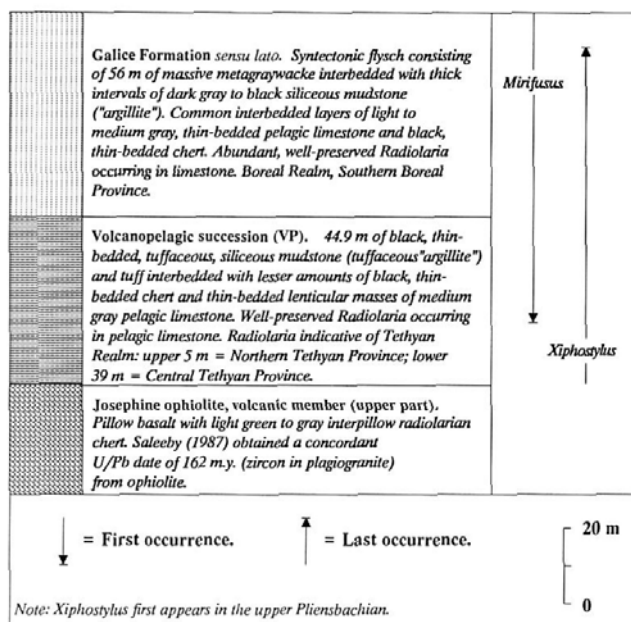
#### Hyde Formation

The Hyde Formation (Lupher 1941; Dickinson and Vigrass 1965) includes 305 m to 366 m (1000-1200 f) of massive, blue-gray volcanic wacke and andesitic tuff. Thinner beds of dark-gray tuffaceous mudstone with dark-gray to black micritic limestone nodules occur at some localities near the base of the formation.

The Hyde Formation rests conformably both above the Nicely Formation and below the Warm Springs Member of the Snowshoe Formation. Megafossils including sparse fragments of ammonites and land plants occur in the Hyde Formation at some horizons. Well-preserved Radiolaria assignable to Zone 01, Subzone 01B have been recovered from the lower part of the Hyde Formation (Yeh 1987). The age of the Hyde can only be established by superposition. That is, it overlies Nicely strata containing upper Pliensbachian ammonites and underlies Snowshoe strata containing middle/upper Toarcian ammonites. Pessagno et al. (1986, pp. 14-15) indicated that most of the Hyde is probably lower Toarcian; nevertheless, it may include upper Pliensbachian strata at its base and middle Toarcian strata at its top. More detailed studies of both the Radiolaria and ammonites are needed to determine the chronostratigraphic position of this unit.

#### Snowshoe Formation

In its type area near Izee, the Snowshoe Formation (Lupher 1941; Dickinson and Vigrass 1965) includes approximately 838 m (2750 ft) of dark-gray to black mudstone and shale interbedded with volcanoclastic siltstone, sandstone, and conglomerate. Micritic, dark-gray to black limestone nodules and thin-bedded micritic limestone often containing abundant, extremely well-preserved Radiolaria occur in the mudstones and shales. Whereas the finer-grained clastics (i. e., mudstone and shale) tend to be hemipelagic



TEXT-FIGURE 4

Measured section of strata occurring above the Josephine ophiolite at Harper (1983) Locality 1: Middle Fork of Smith River, northwestern California, Western Klamath terrane, Smith River subterrane. Note that Saleeby (1987) obtained a concordant U/Pb date of  $162 \pm 1$  Ma (zircon from plagiogranite) from ophiolite. Note also that a zone of concurrence exists between *Xiphostylus* Haeckel s.s. and *Mirifusus* Pessagno. This zone of concurrence is referred to as Subzone 2 gamma herein. See Biostratigraphy and Chronostratigraphy herein and Text-figure 2.

strata, the coarser grained clastics (e. g., siltstone, sandstone, and conglomerate) are turbidites.

Dickinson and Vigrass (1965) informally subdivided the Snowshoe Formation into a lower member, a middle member, and an upper member in the Izee area. Subsequently, Smith (1980, pp. 1603-1608) applied the names "Warm Springs Member", "Schoolhouse Member", and "South Fork Member" to these same units (see descriptions below). Both to the east and west of the type area of the Snowshoe Formation near Izee, the Schoolhouse Member interfingers with the Silvies Member and the Basey Member respectively (Dickinson and Vigrass 1965; Imlay 1973, 1980).

The Snowshoe Formation rests conformably on the Hyde Formation and either conformably (e. g., near Izee) or unconformably beneath the Trowbridge Formation. Radiolarian and ammonite biostratigraphic data from the eastern part of the Izee terrane indicate that the Snowshoe Formation ranges in age from middle Toarcian at its base to late Bathonian at its top (Imlay 1981; Pessagno et al. 1986).

### **Warm Springs Member**

In the eastern part of the Izee terrane in the type area of the Snowshoe Formation, the Warm Springs Member (Lupher 1941; Dickinson and Vigrass 1965; Smith 1980) includes 140 to 200 m (459 to 656 ft) of reddish-brown weathering, black to dark gray mudstone, fissile shale, and siltstone. Common to abundant micritic, dark-gray limestone nodules and lenticular masses of micritic to silty limestone are characteristic of the Warm Springs Member in the eastern part of the Izee terrane. Moreover, the limestone nodules contain abundant Radiolaria which are often silicified and well-preserved.

In the area near Izee the Warm Springs Member conformably overlies the massive volcanic wacke of the Hyde Formation. The contact may be either sharp or gradational. Near Izee the Warm Springs Member is overlain by the Schoolhouse Member. However, farther to the east along the Flagtail Lookout road (USGS Izee Quad. 15': T16S; R29E; Sec. 19; NFS Road 014, 1.69 mi north of juncture between NFS 014 with Grant Co. Road 63) the Warm Springs Member is conformably overlain by the massive turbiditic volcanoclastic conglomerate and volcanic wacke of the Silvies Member. Farther to the south near the juncture of Hog Creek and Little Snowshoe Creek, a reverse fault separates the two units (e. g., near OR-705; See Locality Descriptions herein).

Ammonite and radiolarian biostratigraphic data indicate that the Warm Springs Member ranges in age from middle Toarcian at its base to late early Bajocian at its top (Zone 01, upper part of Subzone 01B to Superzone 1, middle part of Zone C. See Pessagno et al. 1986, 1987b; text-fig. 1 herein).

### **Schoolhouse Member**

The Schoolhouse Member (Smith 1980) consists of 300 m (984 ft) of laminated, gray, green, and rarely buff colored siltstone and sandstone (volcanic wacke) that alternates with thin layers of mudstone and shale similar to those of the Warm Springs Member. The laminated nature of the siltstone and sandstone is particularly characteristic of this unit. Laminae range in thickness from 1 mm to 1 cm (Smith 1980, p. 1605). The Schoolhouse Member conformably overlies the Warm Springs Member and conformably underlies the South Fork Member near Izee. Farther to the east at Bunton Hollow (USGS Izee Quad., 15': T17S; R28E; Sec. 1) the Schoolhouse Member interfingers with the Silvies Member.

The Schoolhouse Member contains a lower to upper Bajocian ammonite assemblage (Imlay 1973, 1980; Smith 1980). See Pessagno et al. (1986, 1987b) for further discussion.

### **Silvies Member**

The Silvies Member (Dickinson and Vigrass 1965) crops out in the eastern part of the Izee terrane from Bunton Hollow (see above) to Seneca. Dickinson and Vigrass (ibid. pp. 45, 49-51) indicated that, at least in its type area near the headwaters of the Silvies River (USGS Logdell

Quad. 15': T16S; R29E; juncture of sects. 21, 22, 27, and 28), the Silvies Member is 457 m (1500 ft) thick.

The Silvies consists of massively-bedded volcanoclastic conglomerate and interbedded volcanoclastic wacke. In addition to the largely andesitic clasts that characterize the Silvies conglomerate, the conglomerate also contains clasts of micritic, dark-gray, thin-bedded limestone, limestone nodules, and black radiolarian chert. Limestone clasts are more prevalent in the Silvies Member at localities adjacent to and south of Seneca (USGS Seneca Quad. 15': T15S; R31E; sects. 2 and 3).

The Silvies Member rests conformably above the Warm Springs Member and beneath the South Fork Member in the western portion of its outcrop area. Farther to the east at Seneca, it appears to rest conformably above and below yet unnamed members of the Snowshoe Formation.

In the western part of its outcrop area, the Silvies is assignable to the lower part of the upper Bajocian (Superzone 1, upper part of Zone 1C to lower part of Zone 1D of Pessagno et al. 1987b). However in the Seneca area to the east, the Silvies is assignable to the upper part of the upper Bajocian (Superzone 1, Zone 1E of Pessagno et al. 1987b; see text-fig. 1 herein). It would appear, therefore, that the Silvies Member is time transgressive from west to east.

### **South Fork Member**

The South Fork Member (Smith 1980, p. 1605) includes over 500 m (1640 ft) of dark-gray to black shale and mudstone frequently interbedded with massive beds of dark-gray, partly volcanoclastic graywacke which rests conformably on the Schoolhouse Member or Silvies Member, and either conformably or unconformably beneath the Trowbridge Formation (See Imlay 1980, 1981; Smith 1980; Pessagno et al. 1986).

The lower part of the South Fork Member is assignable to the lower upper Bajocian whereas the upper part of the unit is assignable to the upper Bathonian at its type area near Izee (Superzone 1, Zone 1D to Zone 1F; Imlay 1981; Pessagno et al. 1987b; see text-fig. 1 herein).

### **California Coast Ranges**

The origin and age of the Coast Range ophiolite and its cover of sedimentary strata has been discussed in detail by Hopson et al. (1981) and subsequently by Pessagno et al. (1984, 1986). In sections that have not been dismembered structurally, the Coast Range ophiolite is overlain at most localities by a volcanopelagic succession consisting of green to black tuffaceous chert, tuff breccia, and occasional lenses, beds, or nodules of light gray, micritic pelagic limestone. Moderately well-preserved Radiolaria occur in the chert whereas well-preserved Radiolaria occur in the pelagic limestone. The volcanopelagic succession is in turn conformably overlain (in most cases) by the flysch of the Great Valley Supergroup.

Recent studies by Pessagno et al. (1984, 1986, 1987b) indicated that the volcanopelagic succession ranges in age from Oxfordian(?); Kimmeridgian (*sensu gallico*) to upper

Tithonian (Zone 2, Subzone 2 beta to Zone 4, Subzone 4 alpha; see Pessagno et al. 1987b and text-figs. 2, 3 herein).

**Klamath Mountains, Western Klamath terrane, Smith River subterrane of Blake et al. (1985): Strata overlying Josephine ophiolite**

In the Smith River subterrane, the Josephine ophiolite (Harper 1983, 1984) is conformably(?) overlain by 44.8 m (147 ft) of volcanopelagic strata and in turn by 56.0 m (184 ft) of flysch at Harper (1983) Loc. 1 along the Middle Fork of the Smith River (USGS Gasquet Quad. 15°: T17N; R2E; eastern edge of sec. 16; northwestern California). The volcanopelagic succession (VP) consists of black, thin-bedded tuffaceous mudstone ("argillite") and tuff interbedded with lesser amounts of black, thin-bedded chert and thin-bedded lenticular masses of medium gray pelagic limestone (text-fig. 4). The flysch succession consists of massive metagraywacke interbedded with thick intervals of dark gray to black siliceous mudstone ("argillite"), together with common interbedded layers of light to medium gray, thin-bedded pelagic limestone and black, thin-bedded chert. Harper (ibid.) included both the volcanopelagic strata and the overlying flysch succession within the Galice Formation. However, Pessagno and Blome (1989; in press) restrict the Galice Formation (= their Galice Formation s.l. to the flysch succession (text-fig. 4 herein). No valid formal lithostratigraphic name has been applied to the volcanopelagic succession (VP) in this area.

Saleeby et al. (1982) originally obtained a U/Pb date of 157 Ma. from zircon in plagiogranite within the Josephine ophiolite. However, recent changes in technique for the analysis of zircon in U/Pb geochronometry have resulted in a new date of  $162 \pm 1$  Ma for the Josephine ophiolite along the Middle Fork of the Smith River (Saleeby 1987; see also Miller and Saleeby 1987).

As noted by Pessagno et al. (1986, pp. 17-18), Saleeby (1984) also obtained a date of  $157 \pm 1.5$  Ma (on zircon) from dacitic tuff breccia in the upper several hundred meters of the Rogue Formation. According to Saleeby (personal communication, 1987), this date is still valid. Pessagno et al. (1986) used the 157 Ma date from the Rogue to determine that the *Buchia* and ammonite-bearing middle Oxfordian strata of the Galice Formation are younger than 157 Ma. Moreover, Pessagno et al. (ibid. p. 18) indicated that the composite biostratigraphic, chronostratigraphic, and geochronometric data from the Rogue and Galice formations (Western Klamath terrane, Rogue River subterrane; Blake et al. 1985) demonstrated that the 156 Ma age for the Oxfordian - Kimmeridgian boundary advocated by Kent and Gradstein (1985) is too old. They stated that - "Westermann (1984) used what he termed the 'scaled equal subzone method' to calculate the relative duration of the Jurassic ammonite zones. He concluded that the middle Oxfordian represented 1.7 m.y. and that the upper Oxfordian represented 2.6 m.y. If the Oxfordian - Kimmeridgian boundary is placed at 156 Ma as suggested by Kent and Gradstein, more than one third of Oxfordian time would be crowded into less than 1 million years." Pessagno et al. (1986) and Pessagno and Blome

(1989; in press) now place the Oxfordian - Kimmeridgian boundary at 154 Ma and tentatively place the Oxfordian - Callovian boundary at 161 Ma. Moreover, they present evidence for placing the Kimmeridgian (sensu gallico) - Tithonian boundary at 150 Ma (see also Pessagno et al. 1986, p. 17; Pessagno et al., 1987b, p. 7).

The presence of *Buchia concentrica* (Sowerby) in the Galice s.l. at nearby localities (e.g., Shelly Creek; see Harper 1983) suggests that these strata are no older than middle Oxfordian. The Galice Formation s.l. and the Galice Formation s.s. are genetically related to syntectonic flysch lithostratigraphic units in the Foothills terrane (Sierra Nevada; i.e., the Monte del Oro and Mariposa formations). The Galice Formation s.s., the Monte del Oro Formation, and Mariposa Formation all contain *Buchia concentrica* in association with middle Oxfordian ammonites such as *Dichotomosphinctes* at their base. It would appear, therefore, from an analysis of the biostratigraphic, chronostratigraphic, and geochronometric data that all of the strata overlying the Josephine ophiolite along the Middle Fork of the Smith River at Harper's (1983) Loc. 1 are Oxfordian (late Callovian?) in age.

**Huayacocotla segment of the Sierra Madre Oriental, east-central Mexico (Longoria 1984)**

The stratigraphy of this area, particularly the Taman-Tamazunchale area was discussed in detail by Pessagno et al. (1987a). Only a brief synopsis of the stratigraphy is given below.

**Taman Formation**

The Taman Formation (Heim 1926, 1940; Cantú Chapa 1969, 1971) is typically exposed adjacent to the village of Taman (San Luis Potosí) along the Río Moctezuma (see Pessagno et al. 1987a, figs. 1-2, pp. 4-5). Pessagno et al. (1987a) divided the Taman Formation into two informal member units: (1) a lower member unit consisting of medium- to thick-bedded, dark gray to black micritic limestone with thin black shale interbeds and (2) an upper member consisting of thin-bedded dark gray to black micritic limestone with thick interbeds of black shale, siltstone, and tuff. Minor small, lenticular masses of black chert are present in the upper half of the upper member. Limestone nodules ranging in size from 7.6 cm (3 in) to 0.9 m (3 ft) in diameter are common in the upper half of the lower member and throughout all of the upper member. Radiolaria are abundant in both the thin-bedded micritic limestone and limestone nodules. When well-preserved, they are either silicified or pyritized.

The Taman Formation ranges in thickness regionally from 200 m (656 ft) to 500 m (1640 ft; Erben 1956). However, since some workers (e. g., Cantú Chapa 1971) included all of the upper member of the Taman Formation in the overlying Pimienta Formation, these estimates of thickness are most likely inaccurate. Measured sections of the Taman Formation in the Taman-Tamazunchale area will be presented by Longoria and Pessagno (in prep.) at a later date.



The Taman Formation conformably overlies the "Santiago Formation" in its type area and at most other localities (e.g., Huauchinango area, Puebla); in its type area, it is overlain conformably by the Pimienta Formation (sensu Pessagno et al. 1987a). In the Taman-Tamazunchale area, all but the uppermost 6 m (20 ft) of the lower member are assignable to the lower Kimmeridgian, upper Kimmeridgian, and lower Tithonian (Zone 2, Subzone 2 beta to Zone 3; see Pessagno et al. 1987a; pp. 194-198 herein). The upper 6 m of the lower member and all but the uppermost part of the upper member are assignable to the upper Tithonian (Zone 4, Subzone 4 beta; see Pessagno et al. 1987a). Farther to the south near Huauchinango, Puebla (Loc. MX-84-38; see Locality Descriptions herein), upper Tithonian Radiolaria assignable to Zone 4, Subzone 4 alpha were recovered from the upper member.

# SYSTEMATIC PALEONTOLOGY

In the following descriptions, the designation USNM refers to the deposition of primary types at the U. S. National Museum, Washington, D. C. All new taxa are attributed to Pessagno and Yang.

Order POLYCYSTIDA Ehrenberg 1838

Suborder SPUMELLARIINA Ehrenberg 1838

Superfamily LIOSPHERACEA Haeckel 1881; emended Pessagno and Blome 1984.

Subsuperfamily LIOSPHERILAE Haeckel 1881

Family XIPHOSTYLIDAE Haeckel 1881 (nomen correctum), **emend.** herein.

Type genus: *Xiphostylus* Haeckel 1881, **emend.** herein.

**Emended definition:** Tests with cortical shell only, lacking primary radial beams or internal spicules. Cortical shell variable in shape with symmetrical polygonal pore frames. Wall of cortical shell consisting of two fused layers of latticed meshwork: (1) a thin inner layer with flattened, polygonal, symmetrical pore frames and (2) a thick to very thick outer latticed layer with symmetrical polygonal pore frames (e.g., *Triactoma* Ruest, *Tripocyclia* Haeckel, *Xiphostylus* Haeckel; pl. 1, figs. 2, 8). Junction between inner and outer latticed layers referred to herein as the primary lamella (See pl. 1, fig. 6). Cortical shell lacking secondary spines (e.g., *Archaeocenosphaera*, n. gen.), with two or more symmetrically arranged secondary spines (e.g., *Xiphostylus*, *Triactoma*, *Tripocyclia*), or with three asymmetrically arranged secondary spines (e.g., *Zanola*, n. gen.; *Neotripocyclia*, n. gen.). Secondary spines predominantly triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges. Secondary spines with (e.g., *Tripocyclia*, *Xiphostylus*) or without (e.g., *Triactoma*) cortical buttresses.

**Remarks:** Haeckel (1881, pp. 449-450; 1887, p. 122) treated the Xiphostylidae as a subfamily of his "Stylosphaerida" and included only forms with a single latticed [cortical] shell and opposed [secondary] spines. With the possible exception of *Saturnalis* Haeckel, only Cenozoic taxa were included by Haeckel in his subfamily "Xiphostylida".

*Xiphostylus* was originally described by Haeckel (1881, p. 450) without the inclusion of nominal species. The next use of the name *Xiphostylus* was by Ruest (1885) who included one species, the Jurassic species *X. attenuatus*, under *Xiphostylus*. Subsequently, Haeckel (1887) included fifteen Cenozoic species in *Xiphostylus*. Unfortunately, Campbell (1954, p. D54) selected (subsequent designation) *X. attenuatus* Ruest (1885) as the type species of *Xiphostylus*. Campbell's curious subsequent designation of *X. attenuatus* completely altered and confused Haeckel's original concept of both his "Xiphostylida" and his genus *Xiphostylus*. *X. attenuatus* was described by Ruest from the upper Lias or lower Dogger of Germany. In North America *Xiphostylus* (sensu type species) ranges from the Lower Jurassic (upper Pliensbachian) to the Upper Jurassic (Oxfordian). North American species of *Xiphostylus* display polar spines and two layers of latticed meshwork as described in the emended definition above.

Campbell (1954) largely followed Haeckel's classification of the "Xiphostylida". However, he further confused Haeckel's concept of the "Xiphostylida" by selecting (subsequent designation) *Xiphosphaera tredecimporata* Ruest as the type species for *Xiphosphaera* Haeckel (1881) and by including *Stigmatosphaerostylus* Ruest (1892) in Haeckel's subfamily. *X. tredecimporata* Haeckel is a Jurassic species with large, symmetrical, polygonal pore frames on its cortical shell. It most closely resembles species of *Pantanellium* Pessagno (1977a). However, its internal structure is unknown. This species is declared a nomen dubium herein. Fortunately, Campbell's subsequent designation of *X. tredecimporata* as the type species of *Xiphosphaera* represents a junior subsequent designation. Frizzell and Middour (1951, p. 13) previously selected *Xiphosphaera gaea* Haeckel 1887 as the type species of *Xiphosphaera*.

*Stigmatosphaerostylus* Ruest is a Paleozoic taxon displaying internal spicular structure and should be assigned to the Entactiniidae Riedel. Except for the type genus, *Xiphostylus*, all other genera and subgenera listed by Campbell under the "Xiphostylinae Haeckel" are excluded from the Xiphostylidae herein. There is no direct phylogenetic link between *Xiphostylus*, which became extinct in the Late Jurassic (Oxfordian) and these largely Cenozoic taxa (e.g., *Xiphosphaera* Haeckel 1881, *Xiphostyletta* Haeckel 1887, *Xiphosphaerella* Haeckel 1887). In addition, in so far as can be determined, such taxa do not display the same sort of test wall structure characteristic of *Xiphostylus* and other members of the Xiphostylidae. *Xiphosphaera* Haeckel, though similar to *Xiphostylus* in gross morphology, lacks the cortical buttresses characteristic of the latter taxon.

The emended definition presented for the Xiphostylidae stresses the construction of the test wall rather than test symmetry or the disposition of spines. These latter characteristics are stressed at lower taxonomic levels.

It is suggested that the two fused latticed layers forming the xiphostylid cortical shell each consist of a series of lamellae of microgranular silica. The thin inner latticed



layer is believed to have served as a template for the secretion of the outer latticed layer. The deposition of the silica in the form of microgranules has been documented by Anderson (1983) and Cachon and Cachon (1972). However, evidence for the deposition of microgranular silica in a lamellar mode has thus far only been observed with the Nassellariina (Anderson 1983, pp. 140-142; see also Pessagno and Whalen 1982).

The extremely thick nature of the outer latticed layer of some xiphostylid taxa (e.g., *Triactoma* Ruest, *Tripocyclia* Haeckel) is analogous to the calcite crust of Cenozoic planktonic foraminifera (Bé and Ericson 1963). Among Cenozoic planktonic foraminifera (e.g., *Globorotalia truncatulinoides* (d'Orbigny), the calcite crust is absent in the earlier ontogenetic stages (epipelagic individuals). However, it is present in later ontogenetic stages (mesopelagic individuals). It is probable that the outer latticed layer of the xiphostylid test likewise developed at a later stage of ontogenetic development. As in the case of the calcite crust of planktonic foraminifera, it may have served as a ballast mechanism which allowed the organism to float at greater depths in the water column.

The Xiphostylidae differ from the Pantanelliidae Pessagno by lacking a medullary shell, primary spines, primary radial beams, and by possessing a cortical shell with two fused latticed layers. The genera included herein in the Xiphostylidae are differentiated by the presence or absence of secondary spines, by the number and arrangement of secondary spines when present, by the presence or absence of "cortical buttresses" (see pl. 1, figs. 3, 4; pl. 5, fig. 14), and by the symmetry and structure of the cortical shell.

**Range:** Mesozoic: Triassic to Cretaceous.

**Occurrence:** World-wide in the Tethyan Realm and the southern part of the Boreal Realm (sensu Pessagno and Blome, 1986; Pessagno et al. 1986, 1987a).

**Genus** *Archaeocenosphaera* Pessagno and Yang, n. gen.

**Type species:** *Archaeocenosphaera ruesti* Pessagno and Yang, n. sp.

**Description:** Cortical shell spherical, lacking spines, consisting of two fused latticed layers (pl. 1, fig. 9). Latticed layers comprised of symmetrical polygonal pore frames. Outer latticed layer often quite thick.

**Remarks:** *Archaeocenosphaera*, n. gen., differs from *Cenosphaera* Ehrenberg (1854; type sp. = *Cenosphaera plutonis* Ehrenberg; subsequent designation: Campbell 1954, p. D48) by having a thick cortical shell with two fused latticed layers and by usually having symmetrical polygonal pore frames. *Archaeocenosphaera* differs from *Triactoma* Ruest (1885) by lacking three secondary spines. Both genera possess spherical cortical shells with two fused latticed layers. Hence, it is likely that both genera are closely related.

No attempt is made to describe the numerous morphotypes of *Archaeocenosphaera* that occur in Mesozoic strata.

Many of these forms are difficult to speciate and are of no great biostratigraphic value. It should be noted that *Cenosphaera boria* Pessagno (1977b), described from the Lower Cretaceous portion of the Great Valley Supergroup (California Coast Ranges) should be assigned to *Archaeocenosphaera*.

We note also that in many parts of the Jurassic succession of North America (e.g., Maude Formation, Queen Charlotte Islands, B. C.) "floods" of *Archaeocenosphaera* sp. occur at given stratigraphic intervals. This phenomenon is often accompanied by a drop in both the abundance and diversity of other radiolarian taxa and is, at present, inexplicable.

**Etymology:** Archaeo- (Gr. suffix, from Archaos = ancient) + *Cenosphaera*.

**Range:** Paleozoic?; Triassic to Cretaceous so far as is known.

**Occurrence:** Tethyan and Boreal Realms.

***Archaeocenosphaera laseekensis*** Pessagno and Yang, n. sp.

Plate 2, figures 18, 21, 22, 25.

**Description:** Cortical shell large, spherical with thin outer latticed layer comprised of numerous small, thin-walled, symmetrical, hexagonal pore frames and occasional pentagonal pore frames; all pore frames weakly nodose.

**Remarks:** *Archaeocenosphaera laseekensis*, n. sp., differs from *A. ruesti*, n. sp., by having a considerably thinner outer latticed layer and by having smaller, more numerous, less massive and less nodose pore frames.

**Etymology:** This species is named for Laseek Bay near its type locality (Kunga Islands, Queen Charlotte Islands, B. C.).

**Measurements:** (μm) Holotype + ten paratypes:

	Diameter
Holotype	185.4
Mean	179.2
SD	17.7
Max.	220.2
Min.	150.6

Type locality: QC-543. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424134. Paratypes = USNM 424135 and Pessagno Collection.

**Range and Occurrence:** Zone 05; Hettangian. See Pessagno et al. (1987b). Kunga Formation, Queen Charlotte Islands, B. C.; Wrangellia terrane; Tethyan Realm. See Pessagno et al. (1986) and Text-figure 7 herein.

***Archaeocenosphaera ruesti*** Pessagno and Yang, n. sp.

Plate 1, figure 9; plate 9, figure 23.

**Description:** Cortical shell spherical with very thick outer latticed layer. Outer latticed layer comprised of massive, thick-walled pentagonal and hexagonal pore frames with well developed nodes at their vertices.

**Remarks:** *Archaeocenosphaera ruesti*, n. sp., is compared to *A. laseekensis*, n. sp., under the latter species.

**Etymology:** This species is named for Dr. David Ruest in honor of his pioneering contributions to the study of Mesozoic Radiolaria in the late 1800's.

**Measurements:** ( $\mu\text{m}$ ) Holotype + eleven paratypes:

	Diameter
Holotype	208.6
Mean	197.5
SD	9.3
Max.	208.6
Min.	185.4

Type locality: MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424136. Paratypes = USNM 424137 and Pessagno Collection.

**Range and Occurrence:** Zone 4, Subzone 4 beta; upper Tithonian so far as known. See Pessagno et al. (1987a, b) and Text-figure 2 herein. Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figure 10 herein.

Genus *Neotripocyclia* Pessagno and Yang, n. gen.

Type species: *Neotripocyclia harperi* Pessagno and Yang, n. sp.

**Description:** Cortical shell circular to subcircular in outline, cylindrical in cross-section with its long axis at right angles to plane of three asymmetrically arranged, equal length spines. Spines predominantly triradiate in axial section; two adjacent spines often arranged at right angles to third. Cortical buttresses (for definition see *Xiphostylus* below) present, but often not prominent.

**Remarks:** *Neotripocyclia*, n. gen., differs from *Tripocyclia* Haeckel by having a well-developed cylindrical cortical shell and three asymmetrically placed spines. Like *Tripocyclia*, it possesses cortical buttresses. *Neotripocyclia* differs from *Triactoma* Ruest by possessing a cylindrical cortical shell, asymmetrically placed spines, and cortical buttresses.

Many species of *Tripocyclia* (e.g., *T. jonesi* Pessagno) display cortical shells which are elongate at right angles to the plane of their spines. It is believed, therefore, that *Tripocyclia* sp. gave rise to *Neotripocyclia* sp. by the development of a cylindrical cortical shell and asymmetrically placed spines.

We include *Triactoma echiodes* Foreman (1973, p. 260, pl. 3, fig. 1; pl. 16, fig. 21) under *Neotripocyclia*. This form,

as well as the form figured by Foreman as *Triactoma* sp. cf. *T. echiodes* (pl. 3, figs. 2-3), display cylindrical cortical shells and asymmetrically arranged spines. Foreman's holotype of *T. echiodes* (pl. 3, fig. 1) displays two opposed spines which are situated along an axis at right angles to the third spine.

The specimen figured by Aita (1987, pl. 12, fig. 9; loc. Sta. 6) as "*Triactoma* cf. *echioides*" from the Santa Ana section of Sicily is also assigned to *Neotripocyclia*. This specimen differs from *Neotripocyclia harperi* by having top and bottom surfaces (parallel to plane of spines) that are considerably more planiform in character; by having three secondary spines which are shorter, broader, and structurally different; and by having larger, less numerous pore frames. It should be noted also that we assign Aita's loc. Sta. 6 to the uppermost Kimmeridgian or lowermost Tithonian (See discussion under *Triactoma* sp. aff. *T. hidalgoensis*, n. sp. below).

**Range:** Zone 2, Subzone 2 beta to Zone 5, Subzone 5C; Upper Jurassic (Middle Oxfordian) to Lower Cretaceous (upper Valanginian/lower Hauterivian). The association of *Neotripocyclia echiodes* (Foreman) at numerous DSDP sites (e. g., See Foreman 1973; Baumgartner 1984) with *Cecrops* Pessagno (1977b) suggests that the former genus ranges at least as high as the upper Valanginian or lower Hauterivian. Moreover, in North America, we have not observed *Neotripocyclia* in Tethyan or Boreal Middle Jurassic and Early Jurassic (middle Callovian to late Pliensbachian) strata whose age is well-constrained by ammonite biostratigraphy. See Pessagno et al. (1987b).

**Occurrence:** Tethyan Realm (Central Tethyan Province) to Boreal Realm (Southern Boreal Province) sensu Pessagno et al. (1986, 1987a). To date, we have no record of *Neotripocyclia* from Northern Tethyan strata.

*Neotripocyclia harperi* Pessagno and Yang, n. sp.

Plate 6, figures 9, 14, 11, 17-20, 26-27; plate 7, figure 22.

**Description:** Cylindrical cortical shell well-developed with thick outer latticed layer consisting of a mixture of small, slightly nodose pentagonal and hexagonal pore frames; hexagonal pore frames more numerous and somewhat larger. Three long, slender, sharply pointed, asymmetrically arranged secondary spines situated in same plane and often equal in length to diameter of cortical shell (in plane of spines). Proximal two thirds of each secondary spine triradiate in axial section with three narrow longitudinal ridges alternating with three narrow, subparallel longitudinal grooves. Longitudinal grooves gradually decreasing in width and closing off before spinal tip. Distal one third (spinal tip) of each spine circular in axial section lacking longitudinal ridges and grooves. Cortical buttresses not prominent.

**Remarks:** *Neotripocyclia harperi*, n. sp., differs from *Neotripocyclia echiodes* (Foreman) by having longer, more slender and sharply pointed secondary spines. Whereas the spines of *N. echiodes* are triradiate in axial section throughout, those of *N. harperi* possess spinal tips which are circular in axial section. In addition, the

holotype (Foreman 1973, pl. 3, fig. 1) displays two spines which are opposed and aligned along the same axis. In terms of spinal symmetry, *N. harperi* more closely resembles *N. sp. cf. N. echiodes* (Foreman 1973; pl. 3, figs. 2-3).

**Etymology:** This species is named for Dr. Gregory D. Harper (State University of N. Y., Albany) in honor of his contributions to the study of the Josephine ophiolite (Smith River subterrane, Klamath Mountains, northwestern California).

**Measurements:** ( $\mu\text{m}$ ) Holotype + seven paratypes unless otherwise indicated by the number in parenthesis (e. g., 4 = only 4 specimens measured due to broken spines). xxxx = not calculated. See text-figure 5.

	DD'	D'S1	cc'	S1S2	S2S3	ht
Holotype	162.3	162.3	41.7	509.7	440.2	208.5
Mean	174.6	191.7(4)	40.8	484.2(4)	xxxx	201.2
SD	17.5	19.0(4)	3.6	20.7(4)	xxxx	21.6
Max.	197.0	208.5(4)	44.0	509.7(4)	440.0(2)	231.7
Min.	139.0	162.2(4)	34.7	451.8(4)	417.0(2)	173.2

Type locality: JO-48. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424138. Paratypes = USNM 424139 and Pessagno Collection.

**Range:** Zone 2, Subzone 2 gamma; Oxfordian. See Text-figures 2-3.

**Occurrence:** Galice Formation s.l., Western Klamath terrane, Smith River subterrane (Klamath Mts., northwestern California). Boreal Realm, Southern Boreal Province sensu Pessagno et al. (1986; 1987a). See Text-figures 3, 7.

Genus *Triactoma* Ruest 1885, **emend.** herein.

Type species: *Triactoma tithonianum* Ruest 1885, p. 289, pl. 28, fig. 5.

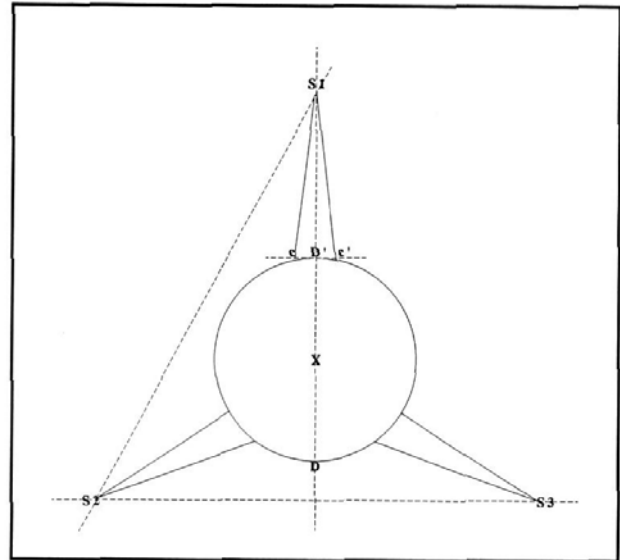
*Triactis* HAECKEL 1881, p. 457. Type species: *Triactoma tithonianum* Ruest 1885 (subsequent designation by Campbell 1954, p. D81). NOT *Triactis* KLUNZINGER 1877, p. 85 (= senior homonym of *Triactis* HAECKEL 1881).

*Triactoma* RUEST 1885, p. 289 (= objective synonym of *Triactis* Haeckel); type species: *Triactoma tithonianum* Ruest 1885.

NOT *Triactiscus* HAECKEL 1887, p. 421. Type species: *Triactiscus tripyramis* Haeckel 1887 (subsequent designation by Stelkov and Lipman in Rauser-Chernousova and Fursenko 1959, p. 443).

**Emended definition:** Cortical shell spherical with three symmetrically placed, equal length secondary spines occurring in the same plane. Spines triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges; ridges of some species occasionally developing small subsidiary grooves. Spines lacking cortical buttresses at junction with cortical shell. Outer latticed layer often very thick (pl. 1, figs. 2, 8).

**Remarks:** *Triactoma* Ruest is compared to *Tripocyclia* Haeckel under the latter genus. As noted by Loeblich and Tappan (1961, pp. 224-225) and by Foreman (1973, p. 259), *Triactoma* has a confused taxonomic history. The



TEXT-FIGURE 5

System of measurement for *Neotripocyclia*, n. gen., Spines of *Neotripocyclia* may be more asymmetrically placed than shown here. For example, S2 and S3 may be almost opposed as with *N. echiodes* (Foreman) s.s. Spines labelled S1, S2, and S3 of equal length. D'D = diameter of cortical shell measured from spinal tip (e.g., S1) through X. D'S1 = length of spine (includes cortical buttress). cc' = width of spine (including cortical buttress) at juncture with cortical shell. S1S2 = distance between spinal tips of spines S1 and S2. S2S3 = distance between spinal tips of spines S2 and S3. ht (not shown in text-fig.) = height of test in edge view; ht measured from "top" surface to "bottom" surface of cylindrical cortical shell at right angles to plane of spines (see pl. 6, fig. 18).

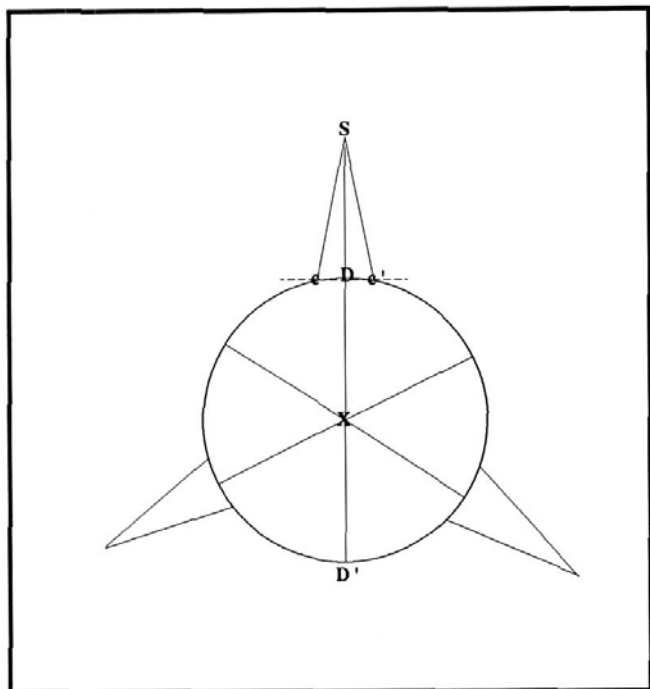
following comments are abstracted from Loeblich and Tappan's discussion:

(1) Campbell (1954, p. D81) listed *Triactoma* Ruest and *Triactiscus* Haeckel as objective synonyms of *Triactis* Haeckel.

(2) *Triactis* was proposed by Haeckel (1881, p. 457) without the citation of nominal species. Hence, any species could subsequently be selected as the type. In addition, *Triactis* Haeckel (1881) is a junior homonym of *Triactis* Klunzinger (1877).

(3) *Triactiscus* Haeckel (1887) was apparently introduced by Haeckel as a substitute name for *Triactis* Haeckel (1881) although he never mentioned the change in spelling. However, Haeckel did mention the page number in his 1881 report where *Triactis* was originally described. Haeckel (1887) described three new species under *Triactiscus*: *T. tripyramis*, *T. tricuspis*, and *T. tripodiscus*.

(4) *Triactiscus* cannot be an objective synonym of *Triactoma* as indicated by Campbell because *Triactoma tithonianum* Ruest was not included in the original list of species presented by Haeckel under *Triactiscus* (See ICZN



TEXT-FIGURE 6

Generalized system of measurement for both *Triactoma* Ruest and *Tripocyclia* Haeckel. DD' = diameter of cortical shell measured along a line from spinal tip (S) through X. DS = length of spines. Spines of *Triactoma* and *Tripocyclia* of equal length and are symmetrically placed. DS of *Tripocyclia* includes cortical buttresses. cc' = width of spinal base.

1985, art. 69). *Triactoma tithonianum* was the first of three species cited by Ruest under *Triactoma*. The subsequent designation of *Triactiscus tripyramis* Haeckel (1887) as the type species of *Triactiscus* by Strelkov and Lipman in Rauser-Chernousova and Fursenko (1959, p. 433) is the first valid citation.

(5) Both *Triactoma* Ruest (1885) and *Triactiscus* Haeckel (1887) may have been intended to be substitute names for the homonym *Triactis* Haeckel (1881). However, both genera have different type species fixed by subsequent designation.

If the emended definition presented above is adhered to, many of the species assigned to *Triactoma* by various authors should be reassigned to other genera. For example, the cortical shell of *Triactoma cellulosa* Foreman (1973) is elliptical in cross section, subcircular to triangular in the plane of the three secondary spines, and appears to possess cortical buttresses. Therefore, it is likely that this species should be assigned to *Tripocyclia* Haeckel. *Triactoma cornuta* Baumgartner (1980b) and *T. pachyderma* Ruest (1885) both possess cortical shells which are elliptical to subelliptical in cross-section, three very asymmetrically placed spines (two long, equal in length; one very short), and lack cortical buttresses. These forms are reassigned to *Zanola*, n. gen., herein. On the other hand, *Tripocyclia blakei* Pessagno (1977a) possesses a markedly

spherical cortical shell, three symmetrically placed spines, and lacks cortical buttresses. This species should be assigned to *Triactoma*.

**Range:** Lower Jurassic (upper Pliensbachian) to Cretaceous.

**Occurrence:** Tethyan and Boreal Realms.

#### *Triactoma blakei* (Pessagno)

Plate 7, figures 17, 19, 24.

*Tripocyclia blakei* Pessagno 1977a, p. 80, pl. 6, figs. 15-16. NOT *Tripocyclia blakei* Pessagno. – MIZUTANI 1981, p. 175, pl. 57, figs. 5-6.

*Triactoma blakei* (Pessagno). – FOREMAN 1973, p. 743, pl. 1, fig. 15. NOT *Triactoma blakei* (Pessagno). – BAUMGARTNER 1984, p. 789, fig. 3.

**Remarks:** The specimen figured by Mizutani (1981) as *Tripocyclia blakei* differs from Pessagno's (1977a) holotype by possessing spines which are more sharply pointed distally, by appearing to lack subsidiary grooves on the longitudinal ridges, and by having larger, less numerous pore frames. The form figured by Baumgartner (1984, pl. 10, fig. 10) possesses cortical buttresses, spines which are structurally different from those of *T. blakei*, and a test which is subelliptical in outline. This specimen is neither representative of *Triactoma blakei* nor the genus *Triactoma* Ruest. It should be reassigned to *Tripocyclia* Haeckel.

**Range:** Zone 2, Subzone 2 alpha to Zone 3, Subzone 3 beta; uppermost Kimmeridgian to lower Tithonian. See text-figures 2, 3.

**Occurrence:** Tethyan and Boreal Realms: Central Tethyan Province, Northern Tethyan Province, Southern Boreal Province (sensu Pessagno et. al. 1986; 1987a). California Coast Ranges: volcanopelagic strata above the Coast Range ophiolite at Point Sal, Cuesta Ridge, and Llanada; Franciscan Complex at Wilbur Springs (Pessagno 1977a and unpublished data). Cape Verde Basin (Foreman 1978). Greece (in sample POB 899 from Baumgartner). See text-figure 9.

#### *Triactoma hidalgoensis* Pessagno and Yang, n. sp.

Plate 1, figures 2, 8; plate 7, figures 7, 12, 14, 16, 18, 23.

**Description:** Cortical shell spherical with thick outer latticed layer (pl. 1, fig. 8). Pore frames of inner and outer latticed layers relatively large (for genus), pentagonal to hexagonal in shape (predominantly hexagonal) with nodes at vertices. Eight to ten pore frames visible on test surface along an axis aligned with longitudinal axis of a given spine. Three secondary spines pointed distally with three massive, rounded longitudinal ridges alternating with three deep longitudinal grooves. Grooves and ridges about equal in width.

**Remarks:** *Triactoma hidalgoensis*, n. sp., differs from *T. blakei* (Pessagno) by having spines which are longer, much narrower, and lack secondary grooves on the longitudinal ridges. In addition, the pore frames of *T. hidalgoensis* are larger, less numerous, and possess well-developed nodes



CHRONOSTRATIGRAPHIC  UNITS	LOWER JURASSIC				MIDDLE JURASSIC															
	Het.	upper Pliens.		lower-upper Toarcian	Aal.	lower Bajocian														
LITHOSTRATIGRAPHIC  UNITS	1	2	3	4	Snowshoe Formation Warm Springs Member															
SAMPLE LOCALITIES	QC		OR																	
	543	545	622	536J	536P	600A	589A	589H	84-8-7	84-8-8	593	580	555	594	595	705	706	709	554	516
Archaeocenosphaera laseekensis, n. sp.																				
Archaeocenosphaera spp.																				
Triactoma spp.																				
Tripocyclia wickiupensis, n. sp.																				
Tripocyclia spp.																				
Xiphostylus fragilis, n. sp.																				
Xiphostylus halli, n. sp.																				
Xiphostylus sp. aff. X. halli, n. sp.																				
Xiphostylus logdellensis, n. sp.																				
Xiphostylus vallieri, n. sp.																				
Xiphostylus whalenae, n. sp.																				
Xiphostylus spp.																				
Lanubus dickinsoni, n. sp.																				
Lanubus holdsworthi, n. sp.																				
Lanubus purus, n. sp.																				
Lanubus spp.																				
BIOSTRATIGRAPHIC  UNITS	SEE PESSAGNO ET AL. (1987A, B).																			
SUPERZONE					SUPERZONE 1--(part)															
ZONE	Z.05	ZONE 01			ZONE 1A			ZONE 1B			Z.1C									
SUBZONE		S.01A	S.01B		S. 1A <sub>2</sub>		S. 1A <sub>1</sub>													
KEY TO ABUNDANCE OF TAXA:																				
RARECOMMONABUNDANT																				

TEXT-FIGURE 7

Occurrence and relative abundance of selected xiphostylid and parvivaccid taxa in Lower Jurassic (Hettangian—Toarcian) to Middle Jurassic (lower Bajocian). Rare = 1-2 specimens. Common = 3-6 specimens. Abundant = >6 specimens. Lithostratigraphic units: 1 = Kunga Group, Sandilands Formation. 2 = Maude Group. 3 = Nicely Formation. 4 = Hyde Formation. Sample localities: QC = Queen Charlotte Islands, B.C. OR = Izee terrane, east-central Oregon. Samples arranged in ascending order chronostratigraphically.

at their vertices. The form figured as *Tripocyclia blakei* by Mizutani (1981, pl. 57, figs. 5-6). appears to be closely related to *T. hidalgoensis*.

**Etymology:** This species is named for the state of Hidalgo, Mexico.

**Measurements:** ( $\mu\text{m}$ ) Holotype + nine paratypes. See text-figure 6 for an explanation of the system of measurements.

	DD'	DS	cc'
Holotype	185.3	127.4	34.7
Mean	180.6	120.3	39.8
SD	13.2	7.2	3.4
Max.	208.5	127.4	44.0
Min.	162.1	111.2	34.7

**Type locality:** MX 82-3. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424140. Paratypes = USNM 424141 and Pessagno Collection.

**Range and Occurrence:** Upper Superzone 1 to Zone 2, Subzone 2 beta; lower Kimmeridgian (sensu gallico) to upper Kimmeridgian. Lower range not fully established. Lower, massively-bedded member of the Taman Formation, east-central Mexico, Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See text-figures 2 and 8.

***Triactoma* sp. aff. *T. hidalgoensis*** Pessagno and Yang Plate 7, figure 15.

*Triactoma* sp. AITA 1987, pl. 13, fig. 1.

**Remarks:** This form differs from *T. hidalgoensis*, n. sp., by having smaller and more numerous pore frames and spines with somewhat narrower longitudinal ridges. The form figured by Aita (1987, pl. 13, fig. 1) appears to be identical to *T. sp. aff. T. hidalgoensis*.

**Range:** Zone 2, Subzone 2 alpha. Uppermost Kimmeridgian/lowermost Tithonian. See Text-figures 2, 3.

It should be noted that Aita (ibid., pl. 13, fig. 1, p. 42) figured this morphotype from his Sta-6 in the Santa Ana section of Italy. Aita assigned radiolarian faunal assemblages from his horizons Sta-1 – Sta-2 to the "Oxfordian-Callovian" and faunal assemblages from his horizons Sta-3 – Sta-6 to the "Kimmeridgian" (undifferentiated). In contrast, De Wever et al. (1986) determined that their samples S-110 – S-104 are assignable to the upper Kimmeridgian sensu gallico and that their lowest sample, S-111, is assignable to the upper Oxfordian – Kimmeridgian (undifferentiated). Sta-3 – Sta-6 of Aita correspond approximately to De Wever et al.'s samples S-110 – S-104. Moreover, there is little question that Aita's sample Sta-6 corresponds closely to De Wever et al.'s sample S-104 (0.4 m below contact with overlying nodular limestone unit). De Wever et al. indicate that the overlying 2.8 m nodular limestone contains ammonites and is correlative with the lower and upper Tithonian and lower Berriasian (Hybonotum, Seimiforme, Microcanthum, Durangites,

and Jacobi-Occitanica standard zones). The interpretation of the Santa Ana succession presented by De Wever et al. is supported by the occurrence of *Triactoma* sp. aff. *T. hidalgoensis* in the Taman Formation (Subzone 2 alpha strata). In Sicily *T. sp. aff. hidalgoensis* occurs below strata (nodular limestone) bearing ammonites correlative with the basal Tithonian Hybonotum standard zone. As noted by Pessagno et al. (1987a,b), the Subzone 2 alpha faunas from the Taman Formation (MX-82-15, 82-16 herein) are either assignable to the uppermost part of Cantú Chapa's *Glochiceras* aff. *fialar* Zone (upper Kimmeridgian) or to the lower part of his *Virgatosphinctes mexicanus* – *Aulacomyella neogae* Zone (lower Tithonian).

**Occurrence:** Upper part of lower, massively-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986, 1987a). See Text-figure 9.

***Triactoma kellumi*** Pessagno and Yang, n. sp. Plate 8, figures 12, 13, 15, 21, 22.

**Description:** Spherical cortical shell with thick outer latticed layer composed predominantly of hexagonal (rarely pentagonal) pore frames with prominent bulbous nodes at their vertices. Ten to thirteen pore frames visible on test surface along an axis aligned with a given secondary spine. Three secondary spines bluntly terminating with rounded tips; triradial in axial section with three deep longitudinal grooves alternating with three rounded longitudinal ridges. Grooves wider than ridges proximally, progressively decreasing in width distally; ridges maintaining about the same width throughout, but merging at tips of spines. Secondary grooves developed on ridges proximally at juncture with cortical shell.

**Remarks:** *Triactoma kellumi*, n. sp., differs from *T. hidalgoensis*, n. sp., by having spines with rounded tips and longitudinal ridges that develop secondary grooves proximally and which maintain the same width throughout. In addition, the cortical shell of *T. kellumi* possesses hexagonal (rarely pentagonal) pore frames with well-developed bulbous nodes at their vertices.

**Etymology:** This species is named for Dr. L. B. Kellum in honor of his pioneering contributions to the study of the Sierra Madre Oriental and the Sierra San Carlos during the 1930's and 1940's.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See text-figure 6 for an explanation of the system of measurements.

	DD'	DS	cc'
Holotype	162.1	92.7	30.1
Mean	165.1	106.6	36.1
SD	13.1	8.2	42.2
Max.	185.3	115.8	44.0
Min.	139.0	92.7	25.4

**Type locality:** MX-82-20. See Locality Descriptions herein.

CHRONOSTRATIGRAPHIC  UNITS	MIDDLE TO UPPER JURASSIC Bathon.										UPPER JURASSIC											
	upper Bajocian					upper Bathon.	A	upper Callov.- Oxford.	middle Oxfordian													
LITHOSTRATIGRAPHIC  UNITS	Snowshoe Formation					4	VP strata	Galice Formation <i>s.l.</i>														
	1	2	1	3	1																	
SAMPLE LOCALITIES	OR										JO											
	523	515	513C	549C	549A	549B	550A	550C	501A	501B	501C	530	6	8	34	10.5	17	19	48	49	50	79
Archaeocenospheara spp.																						
Neotripocyclia harperi, n. sp.																						
Triactoma spp.																						
Tripocyclia brooksi, n. sp.																						
Tripocyclia saleebyi, n. sp.																						
Tripocyclia smithi, n. sp.																						
Tripocyclia southforkensis, n. sp.																						
Tripocyclia spp.																						
Xiphostylus gasquetensis, n. sp.																						
Xiphostylus sinuosus, n. sp.																						
Xiphostylus superbus, n. sp.																						
Xiphostylus spp.																						
Lanubus spp.																						
BIOSTRATIGRAPHIC  UNITS	SEE PESSAGNO ET AL. (1987A, B).																					
SUPERZONE	SUPERZONE 1--(part)																					
ZONE	1 C	1D		ZONE 1E				Z. 1F		1 G			ZONE 2									
SUBZONE																SUBZONE 2 GAMMA						
<div>KEY TO ABUNDANCE OF TAXA:</div> <div><div></div>RARE<div></div>COMMON<div></div>ABUNDANT</div>																						

TEXT-FIGURE 8

Occurrence and relative abundance of selected xiphostylid and parvivaccid taxa in Middle Jurassic (upper Bajocian) to Upper Jurassic (middle Oxfordian). Rare = 1-2 specimens. Common = 3-6 specimens. Abundant = 6 specimens. Chronostratigraphic units: A = middle Callovian. Lithostratigraphic units: 1 = South Fork Member, Snowshoe Formation. 2 = Silvies Member, Snowshoe Formation. Snowshoe Formation (undifferentiated; Seneca area). 4 = Lonesome Formation. VP = volcanopelagic strata; see text-figure 3. Sample localities: OR = Izee terrane, east-central Oregon. JO = Western Klamath terrane, Smith River subterrane, northwestern California.

**Deposition of types:** Holotype = USNM 424142. Paratypes = USNM 424143 and Pessagno Collection.

**Range:** Zone 3; lower Tithonian. See Pessagno et al. (1987a, b). See text-figures 2 and 3 herein.

**Occurrence:** Lower, massively-bedded member of the Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See text-figure 9.

***Triactoma mexicana* Pessagno and Yang, n. sp.**

Plate 1, figure 5; plate 9, figures 9, 16, 20.

**Description:** Cortical shell large for genus, spherical with thick outer layer (pl. 1, fig. 5). Pore frames of outer latticed layer massive, hexagonal and pentagonal in shape (predominantly hexagonal) with massive nodes at vertices. Nine to eleven large pore frames visible on test surface in line with axis of a given spine. Three secondary spines short, massive, bluntly terminating; length of each spine about one third to one fourth of the diameter of the cortical shell. Three longitudinal ridges of each spine maintaining approximately the same width as grooves and alternating with three deep longitudinal grooves which rapidly decrease in width distally.

**Remarks:** *Triactoma mexicana*, n. sp., can be distinguished by its large, spherical cortical shell and very short, massive, bluntly terminating, secondary spines. It is compared to *T. paramexicana*, n. sp., under the latter species.

**Etymology:** This species is named for the Republic of Mexico.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	225.0	59.0	31.0
Mean	208.8	59.4	29.2
SD	13.8	6.5	3.3
Max.	225.0	69.0	36.0
Min.	181.0	50.0	25.0

Type locality: MX-85-26. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424144. Paratypes = USNM 424145 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987a, b) and Text-figures 2-3 herein.

**Occurrence:** Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figures 9 and 10.

***Triactoma paramexicana* Pessagno and Yang, n. sp.**

Plate 1, figure 6; plate 9, figures 14, 18.

**Description:** Cortical shell large, spherical with thick outer latticed layer. Pore frames of outer latticed layer hexagonal and pentagonal in shape (predominantly hexagonal) with small nodes at vertices. Ten to twelve pore frames visible on test surface in line with axis of a given spine. Three secondary spines short, very thin, and pointed; length of each spine about one third of the diameter of the cortical shell. Each spine with three very narrow longitudinal ridges alternating with three shallow and relatively wide grooves.

**Remarks:** *Triactoma paramexicana*, n. sp., differs from *T. mexicana*, n. sp., by possessing three secondary spines which are much thinner with narrow ridges and shallow, wide grooves and by possessing less massive pore frames. Furthermore, the secondary spines of *T. paramexicana* are generally longer than those of *T. mexicana*. Both species share a large, spherical cortical shell and short spines.

**Etymology:** Para- (Latin, prefix) = almost, closely related to + mexicana.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6.

	DD'	DS	cc'
Holotype	203.0	65.0	20.0
Mean	199.9	55.8	14.3
SD	6.4	15.1	3.3
Max.	213.0	85.0	20.0
Min.	189.0	30.0	10.0

Type locality: MX-85-24. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424146. Paratypes = USNM 424147 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987a, b) and Text-figures 2-3 herein.




**Occurrence:** Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figures 9 and 10.

***Triactoma(?) prolongata* Pessagno and Yang, n. sp.**

Plate 9, figures 2, 6, 21.

**Description:** Cortical shell spherical to subspherical, small relative to length of spines. Outer latticed layer thick with a mixture of symmetrical hexagonal and pentagonal pore frames (hexagonal predominating) with weakly developed nodes at vertices. Nine to eleven pore frames visible on test surface along axis of a given spine. Three secondary spines parallel-sided, long; each spine about one and one half times the diameter of the cortical shell. Spines triradiate in axial section with three longitudinal ridges alternating with three deep and somewhat narrower longitudinal grooves; both ridges and grooves maintaining



CHRONOSTRATIGRAPHIC  UNITS	UPPER JURASSIC																							
	1	2	3	2	4	Kimmeridgian	Tithonian																	
							lower							upper										
LITHOSTRATIGRAPHIC UNITS	VP strata above CRO					TAMAN FORMATION																		
SAMPLE LOCALITIES						lower member							up. mem.											
						MX																		
	907	908	909	973	35	43	82-3	82-6	82-8	84-23	82-15	82-16	82-17	81-54	82-19	82-20	84-8	82-33	84-6	85-22	85-23	85-24		
Archaeocenospheara rusti, n. sp.																								
Archaeocenosphaera spp.																								
Triactoma blakei																								
Triactoma hidalgoensis, n. sp.																								
T. sp. aff. T. hidalgoensis, n. sp.																								
Triactoma kellumi, n. sp.																								
Triactoma mexicana, n. sp.																								
Triactoma paramexicana, n. sp.																								
Triactoma (?) prolongata, n. sp.																								
Triactoma spp.																								
Tripocyclia amajacensis, n. sp.																								
Tripocyclia foremanae, n. sp.																								
Tripocyclia frequens, n. sp.																								
Tripocyclia jonesi																								
Tripocyclia notabilis, n. sp.																								
Tripocyclia spinosa, n. sp.																								
T. sp. cf. T. spinosa, n. sp.																								
Tripocyclia spp.																								
Zanola sp. cf. Z. cornuta																								
Lanubus spp.																								
Parvivacca blomei, n. sp.																								
Parvivacca simplex, n. sp.																								
Parvivacca spp.																								
BIOSTRATIGRAPHIC UNITS	SEE PESSAGNO ET AL. (1987A, B).																							
SUPERZONE																								
ZONE	A	Zone 3		B	C	D	Zone 2					Zone 3					Zone 4							
SUBZONE	A	3 beta		B	C	D	2 beta		2 alpha							Subzone 4 beta								
KEY TO ABUNDANCE OF TAXA:  = RARE.  = COMMON.  = ABUNDANT.																								

TEXT-FIGURE 9

Occurrence and relative abundance of selected xiphostylid and parvivaccid taxa in Upper Jurassic (Kimmeridgian sensu gallico to Tithonian. Rare = 1-2 specimens. Common = 3-6 specimens. Abundant = >6 specimens. Chronostratigraphic units: 1 = uppermost Kimmeridgian; ?lowermost Tithonian. 2 = lower Tithonian. 3 = upper part of lower Kimmeridgian s.g. or lower part of upper Kimmeridgian s.g.. 4 = upper Tithonian. Sample localities: NSF, SA = volcanopelagic strata above Coast Range ophiolite, California Coast Ranges. MX = east-central Mexico. Biostratigraphic units: A = Zone 2, Subzone 2 alpha. B = Zone 2, Subzone 2 beta. C = Zone 3, Subzone 3 alpha. D = Zone 4, Subzone 4 beta.

approximately the same width throughout their length; ridges terminating abruptly at spinal tips. Minute thorn-like spines situated beyond the termination of longitudinal ridges on spinal tips of well-preserved specimens.

**Remarks:** This species is questionably assigned to *Triactoma* because it appears to display spinal bases that either lack cortical buttresses or possess very weakly developed cortical buttresses. Moreover, its spinal tips are the type often displayed by species of *Tripocyclia*.

*Triactoma(?) prolongata*, n. sp., is distinguished from other species of *Triactoma* by possessing a relatively small, weakly nodose cortical shell and long, parallel-sided spines with deep grooves and parallel ridges. Furthermore, it displays a spinal tip more characteristic *Tripocyclia foremanae*, n. sp. *T. (?) prolongata* superficially, in fact, resembles *Tripocyclia foremanae*. It can be distinguished from the latter species by possessing shorter spines which have massive longitudinal ridges alternating with deeply incised longitudinal grooves. *T. foremanae* possesses wide longitudinal grooves which alternate with narrow longitudinal ridges. In addition, *T. foremanae* also possesses well-developed cortical buttresses.

**Etymology:** Prolongatus-a-um (Latin, adj.) = long, extended.

**Measurements:** (μm) Holotype + 9 paratypes. See Text-figure 6 for an explanation of the system of measurements

	DD'	DS	cc'
Holotype	150.0	243.0	40.0
Mean	147.1	242.3	34.2
SD	6.5	22.0	6.2
Max.	155.0	275.0	45.0
Min.	138.0	213.0	25.0

Type locality: MX-85-23. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424148. Paratypes = USNM 424149 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian sensu Pessagno et al. (1987a, b). See Text-figures 2, 3.

**Occurrence:** Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figures 9 and 10.

***Triactoma(?)* sp. A**  
Plate 10, figures 23, 24.

**Remarks:** This form is easily distinguished by its massive, broad, short secondary spines. The spines are primarily triradiate in axial section. Prominent subsidiary grooves are developed on the primary longitudinal ridges. The primary longitudinal ridges and grooves converge and terminate on the blunt spinal tips. The penultimate part of the spinal tip (beyond the blunt spinal tip) is comprised of an axially located conical spinal projection.

*T. (?)* sp. A is questionably assigned to *Triactoma* because the proximal portion of each spine (adjacent to cortical shell) possesses irregular, large, polygonal pores. Whereas the latticed cortical buttresses of *Tripocyclia* and *Xiphostylus* represent actual extensions of the cortical shell along the spinal axes, the pores displayed at the base of *T. (?)* sp. A appear to constitute an integral part of the spines themselves rather than being extensions of the cortical shell.

**Range and Occurrence:** Zone 4, Subzone 4 beta; upper Tithonian sensu Pessagno et al. (1984, 1987a). Volcanopelagic strata above the Coast Range ophiolite at Stanley Mountain (Alamo Creek; loc. SA-43; rare). Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986; 1987a).

***Triactoma* sp. B**  
Plate 7, figure 20.

**Remarks:** This form differs from *Triactoma hidalgoensis*, n. sp., by having a proportionately larger cortical shell with shorter, more tapered, and sharply pointed secondary spines.

**Range and Occurrence:** Zone 2, Subzone 2 beta; upper Kimmeridgian sensu gallico; see Pessagno et al. (1987a, b). Lower, massively-bedded member of the Taman Formation, east-central Mexico at USGS Mesozoic Loc. 20815; rare. See Locality Descriptions herein. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Triactoma* sp. C**  
Plate 7, figure 8; plate 8, figures 19, 24.

**Remarks:** This form is somewhat similar to *Triactoma tithonianum* Ruest (1885, pl. 3, fig. 5). Like the latter form it possesses long, slender secondary spines. However, it differs by having spines which decrease in width more gradually in a distal direction and by having a cortical shell with smaller and more numerous pore frames.

**Range and Occurrence:** Zone 3 (undifferentiated); lower Tithonian. Upper part of lower, massively-bedded member of the Taman Formation, east-central Mexico. MX-81-54; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

**Genus *Tripocyclia* Haeckel 1881, emend. herein.**  
**Type species:** *Tripocyclia trigonum* Ruest 1885. (Subsequent designation by Campbell, 1954, p. D-82)

**Emended definition:** Cortical shell with three symmetrically placed, equal length secondary spines occurring in same plane. Spines triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves; subsidiary grooves often developed on longitudinal ridges. Three latticed cortical buttresses (pl. 5, fig. 14) attach secondary spines to cortical shell. Cortical shell subtriangular to subcircular in outline in plane of three spines; elliptical to subcircular in cross section at right angles to plane of spines.

CHRONOSTRATIGRAPHIC	UPPER JURASSIC														
UNITS	upper Tithonian														
LITHOSTRATIGRAPHIC UNITS	TAMAN FORMATION upper thin-bedded member														
SAMPLE LOCALITIES	MX														
	85-25	85-26	85-27	84-9	85-39	84-13	84-15	84-12	84-11	84-10	82-37	85-18	84-26	84-38	
Archaeocenosphaera rusti, n. sp.															
Archaeocenosphaera spp.															
Triactoma mexicana, n. sp.															
Triactoma paramexicana, n. sp.															
Triactoma (?) prolongata, n. sp.															
Triactoma spp.															
Tripocyclia foremanae, n. sp.															
Tripocyclia frequens, n. sp.															
Tripocyclia notabilis, n. sp.															
Tripocyclia spinosa, n. sp.															
T. sp. cf. T. spinosa, n. sp.															
Tripocyclia spp.															
Lanubus spp.															
Parvivacca blomei, n. sp.															
Parvivacca simplex, n. sp.															
Parvivacca spp.															
BIOSTRATIGRAPHIC UNITS	SEE PESSAGNO ET AL. (1987A, B).														
ZONE	ZONE 4														
SUBZONE	SUBZONE 4 BETA														A
KEY TO ABUNDANCE OF TAXA:															
RARECOMMONABUNDANT															

TEXT-FIGURE 10

Occurrence and relative abundance of selected xiphostylid and parvivaccid taxa in Upper Jurassic (upper Tithonian). Rare = 1-2 specimens. Common = 3-6 specimens. Abundant = >6 specimens. Sample localities: MX = east-central Mexico.

**Remarks:** Pessagno (1977, pp. 79-80) originally considered *Triactoma* Ruest to be a junior synonym of *Tripocyclia* Haeckel (1881). In this report these two taxa are maintained as separate genera.

*Tripocyclia* can be distinguished from *Triactoma* by possessing cortical buttresses and by having a test which is subcircular to elliptical in outline and subcircular to elliptical in cross section. The test of *Triactoma* is quite spherical and lacks cortical buttresses.

**Range:** Lower Jurassic (lower Toarcian) to Lower Cretaceous so far as known.

**Occurrence:** Tethyan Realm: Central Tethyan Province to Northern Tethyan Province. Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986; 1987a).

***Tripocyclia amajacensis*** Pessagno and Yang, n. sp.  
Plate 8, figures 6, 8, 18, 26.

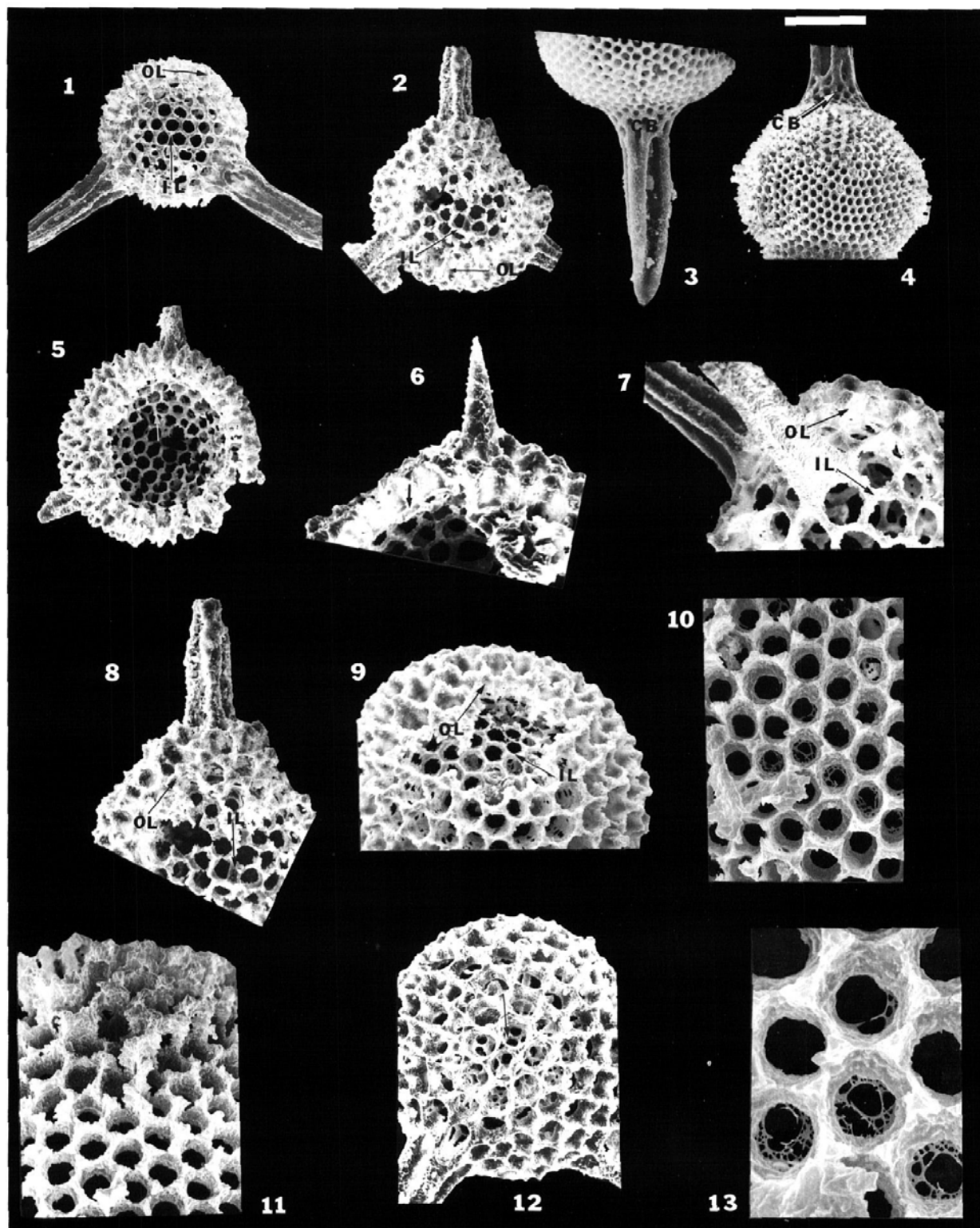
**Description:** Cortical shell subtriangular in outline, elliptical in cross-section, somewhat compressed in plane of spines. Outer latticed layer thin, poorly developed, comprised of a mixture of larger hexagonal pore frames and smaller pentagonal pores both with weakly developed nodes at vertices. Three secondary spines wide, triradiate in axial section with three wide longitudinal grooves alternating with three prominent longitudinal ridges. Longitudinal grooves deep proximally, gradually becoming shallower and decreasing in width distally. Each primary longitudinal ridge developing a narrow secondary groove on proximal one half. Well-developed cortical buttresses occurring at juncture of spines with cortical shell.

# PLATE 1

All figures are scanning electron micrographs of Jurassic *Xiphostylidae* and *Parvivaccidae*. Figures on this plate illustrate test structure and ultrastructure. Portions of outer latticed layer (OL) stripped away due to preservation of specimens illustrated in figures 1, 2, 4, 8, 9, 10, 11, 13. This has resulted in the exposure of inner latticed layer (IL). Scale (upper right) = number of  $\mu\text{m}$  cited for each illustration.

- |           |   |    |   |
|-----------|---|----|---|
| 1         | <i>Lanubus</i> sp. OR-554. Arrow OL points to outer latticed layer. Arrow IL points to inner latticed layer. Scale = 60 $\mu\text{m}$ .   |    | nature of the outer latticed layer. See plate 9 for other illustrations of this species. Scale = 85.7 $\mu\text{m}$ .   |
| 2, 8      | <i>Triactoma hidalgoensis</i> Pessagno and Yang, n. sp. MX-82-3. Paratype (Pessagno Collection). Arrow OL points to outer latticed layer. Arrow IL points to inner latticed layer. Scale = 86.1, 60 $\mu\text{m}$ .   | 6  | <i>Triactoma paramexicana</i> Pessagno and Yang, n. sp. MX-85-24. Paratype (Pessagno Collection). Arrow points to juncture (primary lamella) of inner latticed layer and outer latticed layer. Note the difference in thickness of two layers. Scale = 39.9 $\mu\text{m}$ . |
| 3         | <i>Xiphostylus whalenae</i> Pessagno and Yang, n. sp. OR-554. Holotype (USNM 424184) View to illustrate prominent cortical buttress (CB). Same view repeated on plate 4. Scale = 48 $\mu\text{m}$ .   | 7  | <i>Parvivacca</i> sp. D. MX-82-37. Side view of specimen showing absence of outer latticed layer (OL) on sides of cortical shell. Sides of cortical shell with inner latticed layer (IL) only. See other illustrations on plate 10. Scale = 39.9 $\mu\text{m}$ .            |
| 4, 10, 13 | <i>Xiphostylus vallieri</i> Pessagno and Yang, n. sp. OR-705. Holotype (USNM 424182). Figure 4 illustrates prominent cortical buttress (CB). Note that portion of outer latticed layer has been stripped away. Figures 10 and 13 are views from SW $\frac{1}{4}$ of figure 4 showing inner latticed layer and occasional remnants of outer latticed layer. See plate 2 for other illustrations of the holotype. Scale = 60, 15, 6 $\mu\text{m}$ . | 9  | <i>Archaeocenosphaera ruesti</i> Pessagno and Yang, n. sp. MX-84-13. Holotype (USNM 424136). Arrow IL points to inner latticed layer. Arrow OL points to outer latticed layer. See plate 9, figure 23. Scale = 57.0 $\mu\text{m}$ .   |
| 5         | <i>Triactoma mexicana</i> Pessagno and Yang, n. sp. MX-85-26. Paratype (Pessagno Collection). Arrow points to thin, fragile inner latticed layer. Note the very thick   | 11 | <i>Xiphostylus</i> sp. D. OR-705. Most of outer latticed layer stripped away in lower half of illustration. Other views on plate 3. Scale = 15 $\mu\text{m}$ .  |
|           |   | 12 | <i>Lanubus</i> sp. G. OR-554. Arrow points to fragile first medullary shell. Scale = 39.9 $\mu\text{m}$ .   |





**Remarks:** *Tripocyclia amajacensis*, n. sp., differs from *T. jonesi* Pessagno (1977a) by possessing much larger pore frames, a poorly developed, thin outer latticed layer, and spines which are pointed rather than bluntly terminating.

**Etymology:** This species is named for the Rio Amajac in its type area near Tamazunchale, San Luis Potosi, east-central Mexico.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 7 paratypes. See Text-figure 6 for explanation of the system of measurements.

	DD'	DS	cc'
Holotype	99.6	139.0	46.3
Mean	108.6	138.6	44.0
SD	8.7	13.0	3.8
Max.	120.4	157.5	46.3
Min.	92.7	139.0	34.7

**Type locality:** MX-81-54. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424150. Paratypes = USNM 424151 and Pessagno Collection.

**Range:** Zone 3; lower Tithonian so far as known. See Pessagno et al. (1987a, b). Text-figures 2 and 3 herein.

**Occurrence:** Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 9 herein.

***Tripocyclia brooksi* Pessagno and Yang, n. sp.**  
Plate 5, figures 7-9; 11-13; 15, 20.

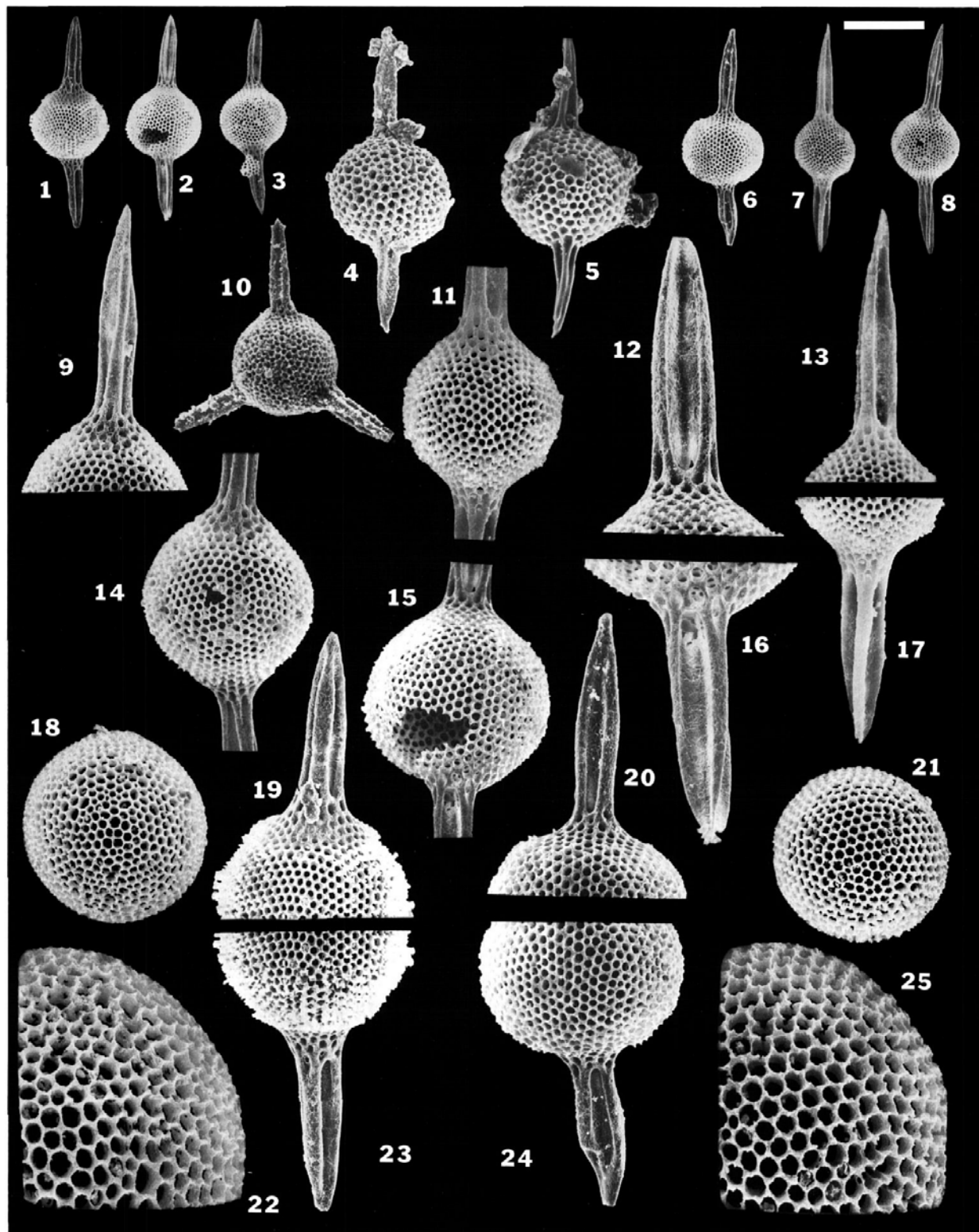
**Description:** Cortical shell heart-shaped in outline, subelliptical in cross-section. Outer latticed layer thick with mixture of small pentagonal and hexagonal pore frames with nodes at vertices; pentagonal pore frames about equal in number to hexagonal pore frames; slightly smaller in size. Three secondary spines bluntly terminating, triradiate in axial section with three longitudinal ridges alternating with three deep longitudinal grooves. Grooves widest adjacent to cortical buttresses, decreasing width on proximal one third of spine, but maintaining same width and remaining open to spine tips. Bluntly terminating spines with three ridges turned outward to form crown-like structures. Cortical buttresses very prominent.

**Remarks:** *Tripocyclia brooksi*, n. sp., differs from *T. jonesi* Pessagno by having a cortical shell which is heart-shaped in outline, by possessing primary longitudinal ridges lack-

## PLATE 2

All illustrations are scanning electron micrographs of Lower Jurassic (Hettangian) to Middle Jurassic (lower Pliensbachian) Xiphostylidae from the Queen Charlotte Islands (=QC) and east-central Oregon (=OR). Scale (upper right) = number of  $\mu\text{m}$  cited for each illustration.

- |                  |  |               |  |
|------------------|--|---------------|--|
| 1, 19, 23        | <i>Xiphostylus vallieri</i> Pessagno and Yang, n. sp. OR-705; lower Bajocian. Warm Springs Member, Snowshoe Formation. Holotype (USNM 424182). Scale = 150, 60, 60 $\mu\text{m}$ .   | 7, 11, 13, 17 | <i>Xiphostylus logdellensis</i> Pessagno and Yang, n. sp. OR-516; lower Bajocian. Warm Springs Member, Snowshoe Formation. Paratype (Pessagno Collection). Scale = 120, 48, 48, 48 $\mu\text{m}$ . |
| 2, 3, 12, 15, 16 | <i>Xiphostylus vallieri</i> Pessagno and Yang, n. sp. OR-705; lower Bajocian. Warm Springs Member, Snowshoe Formation. Paratypes (Pessagno Collection). Figs. 2, 12, 15, 16 = views of same specimen; scale = 150, 39.9, 60, 39.9 $\mu\text{m}$ . Fig. 3 view of different specimen; scale = 150 $\mu\text{m}$ . | 8, 9, 14      | <i>Xiphostylus logdellensis</i> Pessagno and Yang, n. sp. OR-705; lower Bajocian. Warm Springs Member, Snowshoe Formation. Holotype (USNM 424176). Scale = 150, 60, 60, $\mu\text{m}$ .            |
| 4                | <i>Xiphostylus</i> sp. F. OR-536; upper Pliensbachian. Nicely Formation. Note spherical shape of cortical shell. Test replaced by pyrite. Scale = 99 $\mu\text{m}$ .   | 10            | <i>Tripocyclia</i> sp. A. OR-593; Aalenian. Warm Springs Member, Snowshoe Formation. Scale = 99 $\mu\text{m}$ .  |
| 5                | <i>Xiphostylus</i> sp. G. QC-622; upper Pliensbachian. Maude Group. Note spherical shape of cortical shell. Scale = 93 $\mu\text{m}$ .   | 18, 22        | <i>Archaeocenosphaera laseekensis</i> Pessagno and Yang, n. sp. QC-543; Hettangian. Holotype (USNM 424134). Scale = 78, 42 $\mu\text{m}$ .   |
| 6, 20, 24        | <i>Xiphostylus</i> sp. C. OR-705; lower Bajocian. Warm Springs Member, Snowshoe Formation. Scale = 150, 60, 60 $\mu\text{m}$ .   | 21, 25        | <i>Archaeocenosphaera laseekensis</i> Pessagno and Yang, n. sp., QC-543; Hettangian. Paratype (Pessagno Collection). Scale = 81.9, 42.8 $\mu\text{m}$ .  |



ing secondary grooves, and by having more prominent cortical buttresses. Both species share spines with similar spine tips.

**Etymology:** This species is named for Dr. Howard C. Brooks (Oregon State Department of Geology and Mineral Industries, Baker, Ore.) in honor of his many contributions to the study of the geology of the Blue Mountains Province of eastern Oregon, eastern Washington, and western Idaho. **Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	150.6	134.3	46.3
Mean	143.4	125.9	44.9
SD	8.3	13.0	2.1
Max.	157.5	150.6	46.3
Min.	139.0	104.2	41.7

**Type locality:** OR-501B. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424152. Paratypes = USNM 424153 and Pessagno Collection.

**Range:** Superzone 1, Zone 1F or higher; upper Bathonian or higher so far as known. See Pessagno et al. (1987b). Text-figure 1 herein.

**Occurrence:** South Fork Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Boreal Realm, Southern Boreal Province (sensu Pessagno and Blome 1986; Pessagno et al. 1986; 1987a). See Text-figure 8.

# ***Tripocyclia foremanae* Pessagno and Yang, n. sp.**

Plate 9, figures 3-5; 7, 8, 17, 22.

**Description:** Cortical shell subcircular in outline; subelliptical in cross-section. Outer latticed layer thick with small, symmetrical, hexagonal pore frames and rare pentagonal pore frames with weakly developed nodes at vertices. Three secondary spines triradiate in axial section, quite long, over twice as long as diameter of cortical shell. Spines with three longitudinal ridges alternating with three deep, narrow, parallel sided longitudinal grooves. Spine tips terminating abruptly; longitudinal ridges turned outwards on spine tips giving them a crown-like aspect. Minute, centrally placed, thorn-like spine situated beyond termination of longitudinal ridges on spine tips of well-preserved specimens. Spines attached to cortical shell by well-developed cortical buttresses.

**Remarks:** *Tripocyclia foremanae*, n. sp., differs from *T. jonesi* Pessagno by having much longer, more slender spines which lack the development of secondary grooves on the longitudinal ridges.

**Etymology:** This species is named for the late Dr. Helen P. Foreman (Oberlin College) in honor of her valuable contributions to the study of Mesozoic Radiolaria.

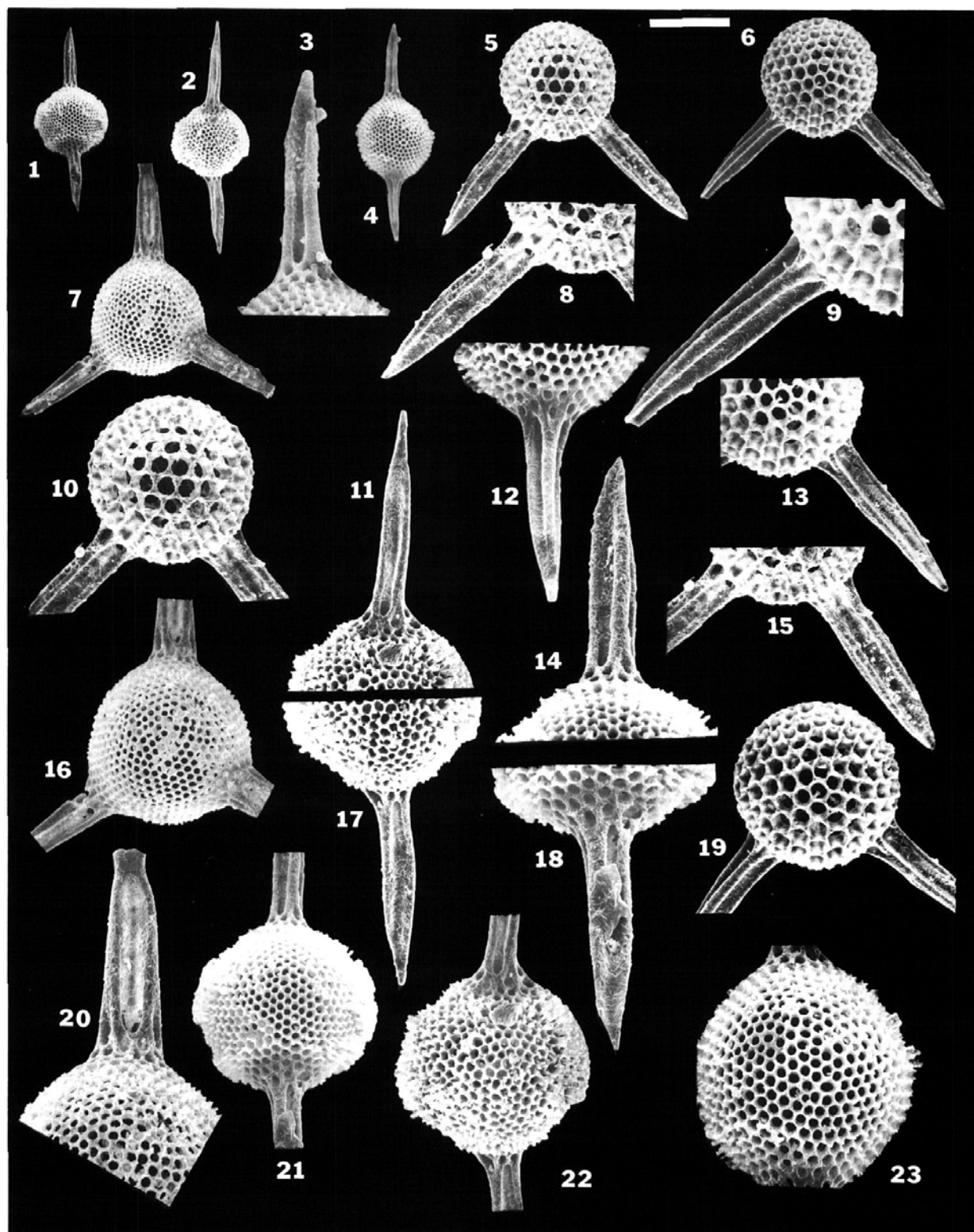
## PLATE 3

All illustrations are scanning electron micrographs of Middle Jurassic (lower Bajocian) Parvivaccidae, n. fam., and Xiphostylidae from the Warm Springs Member, Snowshoe Formation, east-central Oregon (=OR). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- 1, 14, *Xiphostylus* sp. D. OR-705. Note (fig. 21) that much of the thick outer latticed layer has been stripped away exposing the inner latticed layer beneath. See plate 1. Scale = 150, 39.9, 39.9, 60  $\mu\text{m}$ .
- 2, 11, *Xiphostylus* sp. E. OR-705. Note (fig. 22) that outer latticed layer has been stripped away exposing inner latticed layer. Scale = 150, 60, 60, 60  $\mu\text{m}$ .
- 3, 4, 12, *Xiphostylus fragilis* Pessagno and Yang, n. sp. OR-554. Holotype (USNM 424170). Note exposure of inner latticed layer in fig. 23. Scale = 42, 120, 42, 42  $\mu\text{m}$ .

- 5, 8, 10, *Lanubus dickinsoni* Pessagno and Yang, n. sp. OR-705. Holotype (USNM 424186). Scale = 85.7, 60, 60, 60  $\mu\text{m}$ .
- 6, 9, 13, *Lanubus purus* Pessagno and Yang, n. sp. OR-705. Holotype (USNM 424190). Scale = 85.7, 39.9, 60, 60  $\mu\text{m}$ .
- 7, 16, 20 *Tripocyclia wickiupensis* Pessagno and Yang, n. sp. OR-705. Holotype (USNM 424168). Scale = 85.7, 60, 39.9  $\mu\text{m}$ .





**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	115.8	252.5	34.7
Mean	122.9	257.1	35.5
SD	6.5	17.8	11.5
Max.	134.3	278.0	46.3
Min.	115.8	220.1	30.1

**Type locality:** MX-82-37. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424154. Paratypes = USNM 424155 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987b). Text-figures 2, 3.

**Occurrence:** Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Taman Formation, east-central Mexico. See Text-figures 9 and 10.

***Tripocyclia frequens*** Pessagno and Yang, n. sp.  
Plate 9, figures 1, 11, 12, 13, 19.

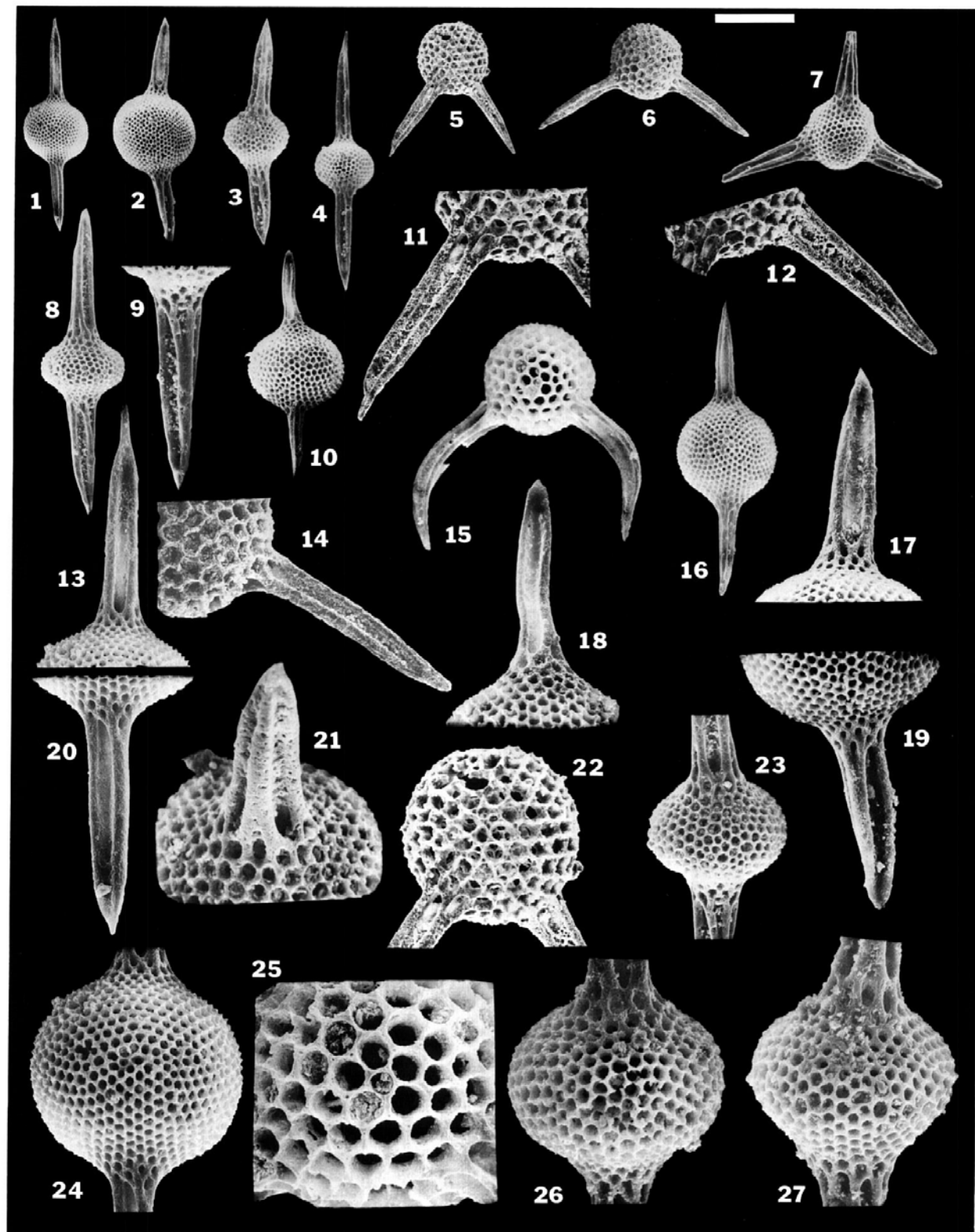
**Description:** Cortical shell subelliptical to subcircular in outline, elliptical in cross-section. Outer latticed layer thick, comprised predominantly of hexagonal pore frames (pentagonal pore frames rare). Ten to eleven pore frames visible on test surface in line with axis of a given spine. Three secondary spines of medium length (for genus), slightly longer than diameter of cortical shell (about 1.2 x diameter of cortical shell). Each spine bluntly terminating, subparallel-sided, triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Grooves slightly expanding medially at point where spines likewise expand in width. Ridges on each spine turned outwards on spinal tips, yielding a crown-like aspect to tip of a given spine. Minute, centrally placed, thorn-like spine situated beyond termination of out-turned longitudinal ridges. Cortical buttresses not prominent at juncture of spines with cortical shell.

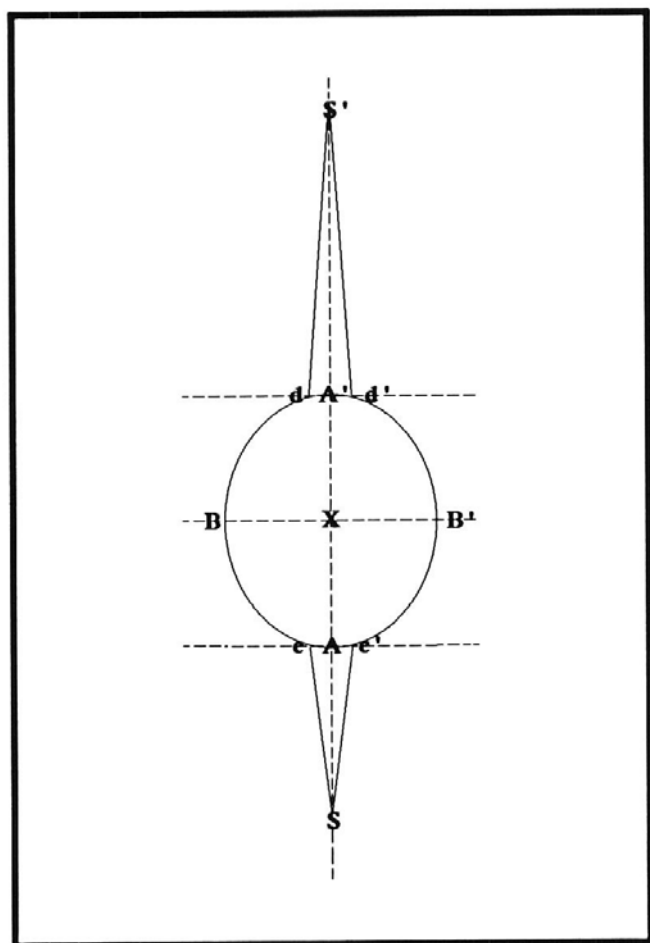
**Remarks:** *Tripocyclia frequens*, n. sp., differs from *T. notabilis*, n. sp., by lacking well-developed subsidiary grooves on its longitudinal ridges, by possessing slender, parallel-sided secondary spines, and by having a less inflated cortical shell. *T. frequens* differs from *T. foremanae*, n. sp., by having considerably shorter and more robust secondary spines. Both species, however, share slender subparallel to parallel sided spines and similar spinal tip structure. It is probable that these two species are closely related.

#### PLATE 4

All figures are scanning electron micrographs of Middle Jurassic (Bajocian) Parvivaccidae, n. fam., and Xiphostylidae from the Snowshoe Formation, east-central Oregon (=OR). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- |                           |  |                   |  |
|---------------------------|--|-------------------|--|
| 1, 13,<br>20, 24          | <i>Xiphostylus halli</i> Pessagno and Yang, n. sp. OR-554; lower Bajocian. Warm Springs Member. Holotype = USNM 424174). Note that spinal tips (figs. 13, 20) are quite constricted and are circular in axial section. Scale = 120, 60, 48, 48 $\mu\text{m}$ . | 5, 11,<br>12, 22, | <i>Lanubus</i> sp. G. OR-554; lower Bajocian. Warm Springs Member. Scale = 150, 60, 60, 60 $\mu\text{m}$ .   |
| 2, 17, 19                 | <i>Xiphostylus whalenae</i> Pessagno and Yang, n. sp. OR-554. Warm Springs Member. Holotype (USNM 424184). Note prominent cortical buttresses. Scale = 108, 48, 48 $\mu\text{m}$ .   | 6, 14             | <i>Lanubus</i> sp. F. OR-554; lower Bajocian. Warm Springs Member. Scale = 150, 60 $\mu\text{m}$ .   |
| 3, 8, 9,<br>21, 23,<br>27 | <i>Xiphostylus superbus</i> Pessagno and Yang, n. sp. OR-513; upper Bajocian. South Fork Member. 3, 27 = paratypes (Pessagno Collection). Scale = 150, 48 $\mu\text{m}$ . 8, 9, 21, 23 = holotype (USNM 424180). Scale = 150, 84, 48, 84 $\mu\text{m}$ .       | 7                 | <i>Tripocyclia</i> sp. F. OR-513; upper Bajocian. South Fork Member. Scale = 150 $\mu\text{m}$ .   |
| 4, 26                     | <i>Xiphostylus</i> sp. B. OR-513; upper Bajocian. South Fork Member. Scale = 171, 48 $\mu\text{m}$ .   | 10, 18            | <i>Xiphostylus</i> sp. A. OR-549C; upper Bajocian. Snowshoe Formation undifferentiated. Scale = 99, 42 $\mu\text{m}$ .   |
|                           |  | 15, 25            | <i>Lanubus holdsworthi</i> Pessagno and Yang, n. sp. OR-554; lower Bajocian. Warm Springs Member. Note long, curved secondary spines giving test a bovine appearance. Holotype (USNM 424188). Scale = 84, 33 $\mu\text{m}$ . |
|                           |  | 16                | <i>Xiphostylus</i> sp. aff. <i>X. halli</i> Pessagno and Yang, n. sp. OR-554; lower Bajocian. Warm Springs Member. Scale = 84 $\mu\text{m}$ .  |





TEXT-FIGURE 11

System of measurement for *Xiphostylus* Haeckel. AA' = dimension of cortical shell along an axis defined by bipolar spines A'S' and AS. BB' = dimension of cortical shell at right angles to spinal axis; drawn through X. A'S' = length of longer spine including cortical buttress (cf. pl. 1, fig. 3). dd' = width of base of spine A'S' including cortical buttress. AS = length of shorter spine including cortical buttress. cc' = width of base of spine AS including cortical buttress.

**Etymology:** Frequens, -tis (Latin) = frequent, common.

**Measurements:** (μm) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	153.8	221.3	37.5
Mean	145.9	197.7	38.2
SD	13.4	23.5	2.4
Max.	157.5	231.3	43.8
Min.	116.3	156.3	35.0

**Co-type localities:** Holotype from MX-84-13. Paratypes from MX-85-22 and MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424156. Paratypes = USNM 424157 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987a, b). Text-figures 2 and 3 herein.

**Occurrence:** Upper, thin-bedded member of the Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figures 9 and 10 herein.

***Tripocyclia jonesi* Pessagno, emend. herein.**

Plate 7, figures 5, 11, 21.

*Tripocyclia jonesi* PESSAGNO 1977a, p. 80, pl. 7, figs. 1-3; not figs. 4-6; NOT *Triactoma jonesi* (Pessagno). — FOREMAN 1978, p. 743, pl. 1, figs. 13-14; NOT *Triactoma jonesi* (Pessagno). — BAUMGARTNER 1984, p. 790, pl. 10, fig. 4.

**Emended definition:** Cortical shell subtriangular in outline, quite elliptical in cross-section with well-developed outer latticed layer comprised of a mixture of medium sized hexagonal and pentagonal pore frames (predominantly hexagonal) with small, weakly developed nodes at vertices. Three secondary spines massive, bluntly terminating, gradually decreasing in width in a distal direction; spines triradiate in axial section with three primary longitudinal ridges alternating with three primary longitudinal grooves. Primary grooves quite deep; decreasing slightly in width in a distal direction, remaining open to blunted tips of spines. Primary ridges about same width as primary grooves; developing secondary grooves on their proximal half. Primary ridges and grooves abruptly terminating on blunted spine tips. Cortical buttresses well-developed at interface between spines and cortical shell.

**Remarks:** The paratype figured by Pessagno (1977a, pl. 7, figs. 4-6) is excluded from *T. jonesi* because it displays different spinal tip structure from that of the holotype (pl. 7, figs. 1-3). Whereas the primary longitudinal grooves of the holotype extend to the tips of its bluntly terminating spines, those of the figured paratype become closed off distally by the merging with the ridges on the three spinal tips. As a result, the distal portions of the spines of the paratype are circular rather than triradiate in axial section.

The form figured by Foreman (1978) as *Triactoma jonesi* (Pessagno) possesses a proportionately larger cortical shell than that of the holotype of *Tripocyclia jonesi*. In addition, it lacks cortical buttresses at the juncture of the spines with the cortical shell and possesses spines with very narrow, subparallel longitudinal grooves. We interpret Foreman's specimen as representing an unnamed species of *Triactoma*.

The specimen figured by Baumgartner (1984) as *Triactoma jonesi* is assignable to *Tripocyclia* rather than *Triactoma* because it possesses well-developed cortical buttresses at the juncture between the cortical shell and the three secondary spines. This form differs from the holotype of *T. jonesi* by possessing cortical buttresses with much larger and more irregular pore frames and secondary spines which decrease rapidly in width at their tips. In



addition, the primary ridges of Baumgartner's form tend to merge near the tips of the spines.

**Range:** Zone 2, Subzone 2 alpha to Zone 4, Subzone 4 beta or higher; uppermost upper Kimmeridgian or lowermost lower Tithonian to upper Tithonian or higher. See Pessagno et al. (1987b). See Text-figures 2 and 3 herein.

**Occurrence:** California Coast Ranges in volcanopelagic strata above the Coast Range ophiolite at Point Sal (Santa Barbara Co.) and Alamo Creek (San Luis Obispo Co.); Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province to Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986; 1987a). See Text-figure 9 herein.

***Tripocyclia notabilis*** Pessagno and Yang, n. sp.  
Plate 10, figures 1-4; 17, 19, 26, 27, 29.

**Description:** Cortical shell subcircular both in outline and cross-section. Outer latticed layer thick, well-developed; inner latticed layer thin. Pore frames of outer latticed layer mostly hexagonal, rarely pentagonal; about ten to eleven pore frames visible on test surface along an axis in line with that of a given spine. Three secondary spines triradiate in axial section, massive, bluntly terminating; each spine with three primary longitudinal ridges alternating with three deep, narrower primary grooves. Spines expanding submedially through expansion in width of primary ridges. Primary ridges developing pronounced subsidiary grooves on proximal one half to three fourths of spines. Primary ridges turned outwards on spinal tips, yielding a crown-like aspect to spinal tips. Minute, centrally placed, thorn-like spines situated beyond termination of longitudinal ridges on spinal tips of well-preserved specimens. Moderately well-developed cortical buttresses at juncture of cortical shell with secondary spines.

**Remarks:** *Tripocyclia notabilis*, n. sp., is compared to *T. frequens*, n. sp., under the latter species.

**Etymology:** Notabilis, -e (Latin) = remarkable, noteworthy.  
**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	148.0	228.0	45.0
Mean	127.1	184.1	40.2
SD	12.4	33.6	3.2
Max.	148.0	235.0	45.0
Min.	110.0	137.5	36.3

**Type locality:** MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424158. Paratypes = USNM 424159 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987b). Text-figures 2 and 3 herein.

**Occurrence:** Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al., 1987a). Text-figures 9 and 10 herein.

***Tripocyclia saleebyi*** Pessagno and Yang, n. sp.  
Plate 6, figures 5, 6, 24.

**Description:** Cortical shell subtriangular in outline in plane of spines; elliptical in cross-section. Outer latticed layer of medium thickness for genus; comprised of mixture of small, uniformly sized pentagonal and hexagonal pore frames. Three secondary spines long, slender, sharply pointed, triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves; longitudinal ridges and grooves about the same width. Longitudinal ridges gradually decreasing in width distally; developing subsidiary grooves proximally near the juncture with the cortical shell. Longitudinal grooves with subparallel sides which suddenly merge on distal one quarter. Distal one quarter of spine (spinal tip) circular in axial section, lacking longitudinal ridges and grooves. Cortical buttresses not prominent.

**Remarks:** *Tripocyclia saleebyi*, n. sp., differs from *T. sp. E*, by having slender, more sharply pointed spines. Moreover, the spinal tips of *T. saleebyi* are circular rather than triradiate in axial section.

**Etymology:** This species is named for Dr. Jason B. Saleeby (California Institute of Technology) in honor of his important contributions to the geology of the Sierra Nevada and Klamath Mountains.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 6 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	162.2	208.5	46.3
Mean	143.9	164.8	38.0
SD	21.3	33.7	9.2
Max.	162.2	208.5	46.3
Min.	115.8	115.8	39.3

**Type locality:** JO-34. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424160. Paratypes = USNM 424161 and Pessagno Collection.

**Range:** Zone 2, Subzone 2 gamma; Oxfordian. See Text-figures 2 and 3.

**Occurrence:** Volcanopelagic strata above the Josephine ophiolite, Smith River subterranean. Tethyan Realm, Central Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figure 8 herein.

***Tripocyclia smithi*** Pessagno and Yang, n. sp.  
Plate 5, figures 4-6; 10, 14, 17-19.

**Description:** Cortical shell medium-sized, subcircular to nearly heart-shaped in outline, elliptical in cross-section

with thick, well-developed outer latticed layer. Pore frames of outer latticed layer predominantly hexagonal in shape (rare pentagonal), thin-rimmed, slightly nodose, approximately seventeen to eighteen pore frames visible on test surface along an axis in line with that of a given secondary spine. Three secondary spines triradiate in axial section, very wide, terminating in a broad V-shaped spinal tip; three longitudinal ridges alternating with three longitudinal grooves. Longitudinal ridges prominent, massive, high in relief, extending to V-shaped spinal tips; proximal two thirds of a given ridge gradually decreasing in width toward spinal tip; distal one third decreasing in width on spinal tip. Longitudinal grooves very broad and shallow, about three times wider than ridges; gradually increasing in width on proximal two thirds of a given spine; decreasing in width on V-shaped spinal tip. Two of three secondary spines usually with one longitudinal ridge exposed in its entirety (rim facing upwards in plane of spines); third spine usually exposing a longitudinal groove in its entirety and only portions of flanking ridges. Cortical buttresses very prominent (cf. pl. 5, fig. 14).

**Remarks:** *Tripocyclia smithi*, n. sp., differs from all other species of *Tripocyclia* figured in this report by possessing very broad, massive secondary spines with extremely wide grooves and distinctive broad, V-shaped spinal tips.

**Etymology:** This species is named for Dr. Paul L. Smith (Univ. of British Columbia) in honor of his contributions to the stratigraphy of the Izee terrane, east-central Oregon. **Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	139.0	150.6	48.7
Mean	133.4	147.1	48.3
SD	7.3	5.3	3.6
Max.	139.0	150.6	57.9
Min.	115.8	139.0	46.3

**Type locality:** OR-501B. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424162. Paratypes = USNM 424163 and Pessagno Collection.

**Range:** Superzone 1, Zone 1F or higher; upper Bathonian or higher so far as known (text-fig. 1). See Pessagno et al. (1987b).

**Occurrence:** South Fork member of Snowshoe Formation, Izee terrane, east-central Oregon. Boreal Realm, Southern Boreal Province (sensu Pessagno and Blome 1986; Pessagno et al. 1986; 1987a). See Text-figure 8.

***Tripocyclia southforkensis* Pessagno and Yang, n. sp.**

Plate 5, figures 1-3; 16, 21.

**Description:** Cortical shell large, circular in outline, elliptical in cross-section, high in relief at right angles to plane of three spines. Outer latticed layer of medium thickness for genus; comprised of medium-sized, slightly nodose, pentagonal and hexagonal pore frames with thin rims; about sixteen to seventeen pore frames visible along an axis of a given spine. Three secondary spines narrow, triradiate in axial section with three narrow longitudinal ridges alternating with three deeply incised, narrow longitudinal grooves; grooves and ridges about equal in width; both gradually decreasing in width distally. Ridges merging at spinal tips. Spinal tips bluntly terminating, circular in axial section. Cortical buttresses not prominent.

**Remarks:** *Tripocyclia southforkensis*, n. sp., differs from *T. brooksi*, n. sp., by having slender, less massive spines with tips which are circular in axial section and by having a cortical shell which is circular rather than heart-shaped in outline.

**Etymology:** This species is named for the South Fork of the John Day River adjacent to its type locality.

## PLATE 5

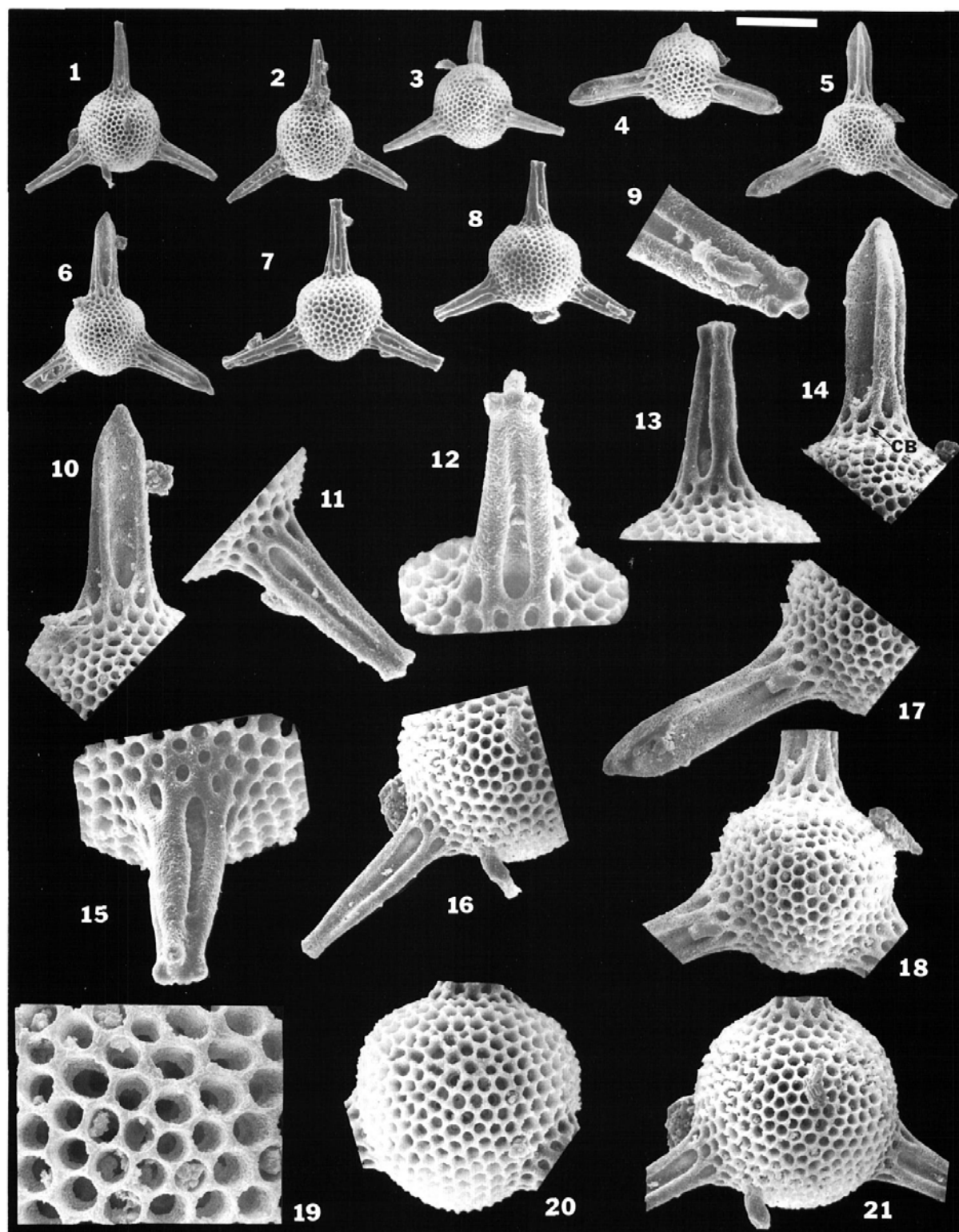
All illustrations are scanning electron micrographs of Middle Jurassic (upper Bathonian) Xiphostylidae from the South Fork Member, Snowshoe Formation, east-central Oregon. Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

1-3, 16, *Tripocyclia southforkensis* Pessagno and Yang, n. sp. OR-501B. 1, 3, 16, 21 = Holotype (USNM 424164). Scale = 142.8, 142.8, 60, 60  $\mu\text{m}$ . 2 = Paratype (Pessagno Collection). Scale = 142.8  $\mu\text{m}$ .

4-6, 10, *Tripocyclia smithi* Pessagno and Yang, n. sp. OR-14, 17-19 501B. 4, 5, 14, 17, 18 = Holotype (USNM 424162). Arrow (CB, fig. 14) points to area of well-developed cortical buttress. Scale = 150, 150, 60, 60, 60  $\mu\text{m}$ . 6,

10, 19 = Paratype (Pessagno Collection). Scale = 150, 60, 20  $\mu\text{m}$ .

7-9, 11-13, 15, 20 *Tripocyclia brooksi* Pessagno and Yang, n. sp. OR-501B. 7, 11, 12, 20 = Holotype (USNM 424152). Note heart-shaped cortical shell with prominent cortical buttresses. Scale = 150, 60, 42, 60  $\mu\text{m}$ . 8, 9, 13, 15 = Paratype (Pessagno Collection) Scale = 150, 42, 60, 42  $\mu\text{m}$ .



**Measurements:** ( $\mu\text{m}$ ) Holotype + 8 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	139.0	115.8	39.3
Mean	137.7	124.5	42.9
SD	2.49	12.4	3.3
Max.	139.0	139.0	50.7
Min.	132.0	101.9	39.3

**Co-type localities:** Holotype from OR-501B. Paratypes from OR-501B and 501C. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424164. Paratypes = 424165 and Pessagno Collection.

**Range:** Same as for *Tripocyclia smithi*, n. sp. (See above).

**Occurrence:** Same as for *Tripocyclia smithi*, n. sp. (See above).

***Tripocyclia spinosa* Pessagno and Yang, n. sp.**  
Plate 10, figures 6, 8, 12, 25.

**Description:** Cortical shell subcircular in outline, elliptical in cross-section. Outer latticed layer well-developed, consisting of hexagonal pore frames and rare, smaller pentagonal pore frames both with weakly developed nodes at vertices; ten to eleven pore frames visible on test surface along axis of a given spine. Three secondary spines triradiate in axial section, quite slender, sharply pointed, and gradually tapering in a distal direction. Spines long, about one and a half times the diameter of the cortical shell; three longitudinal ridges alternating with three longitudinal grooves. Three longitudinal ridges decreasing slightly in width distally, usually terminating well before reaching spinal tip; distal one third of each spine circular in axial section, lacking ridges and grooves. Three longitudinal grooves deep, narrow, subparallel. Cortical buttresses moderately well-developed (for genus).

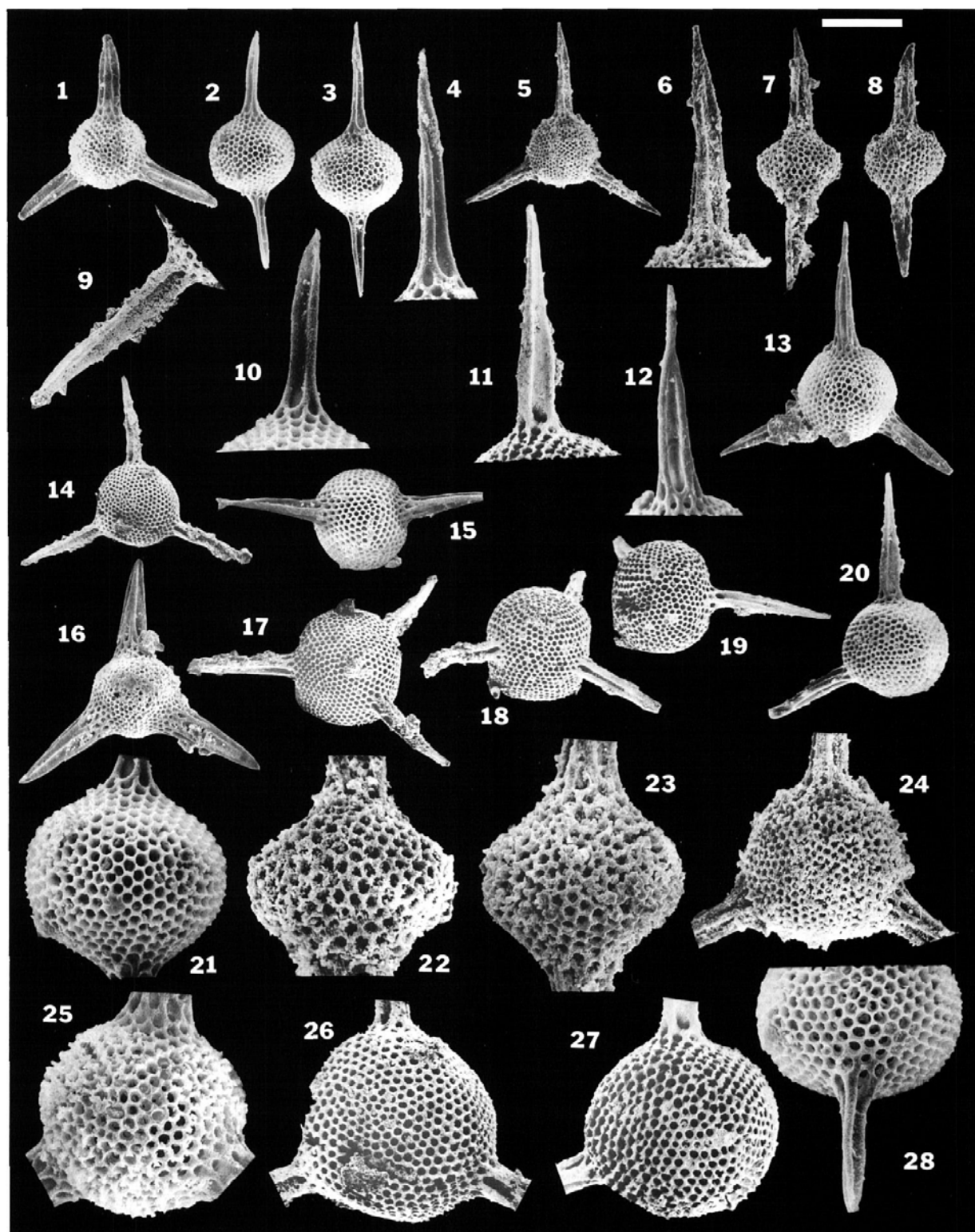
**Remarks:** *Tripocyclia spinosa*, n. sp., differs from *T. amajacensis*, n. sp., by having spines which are proportionately longer, more slender and sharply pointed. In addition, it differs from the latter species by possessing a more inflated cortical shell with smaller and accordingly, more numerous pore frames.

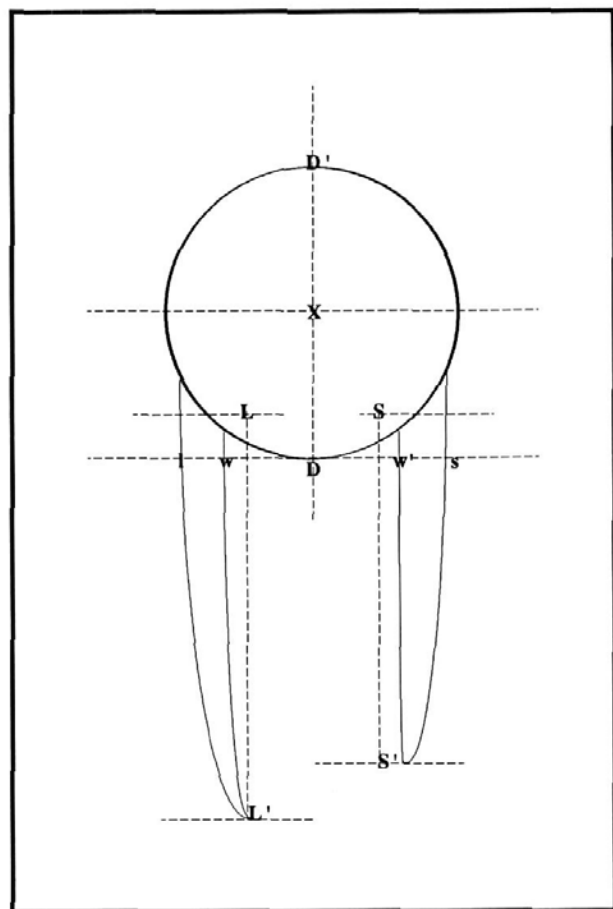
## PLATE 6

All illustrations are scanning electron micrographs of *Xiphostylidae* from the Middle Jurassic (upper Bathonian) of east-central Oregon (OR) and the Upper Jurassic of northwestern California (JO). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- |                 |   |                    |  |
|-----------------|---|--------------------|--|
| 1, 25           | <i>Tripocyclia</i> sp. G. OR-501B; upper Bathonian. South Fork Member, Snowshoe Formation. Scale = 150, 60 $\mu\text{m}$ .  | 8, 23              | <i>Xiphostylus gasquetensis</i> Pessagno and Yang, n. sp. JO-8; Oxfordian. Same unit as JO-34 above. Paratype (Pessagno Collection). Scale = 150, 60 $\mu\text{m}$ .   |
| 2-4, 10, 21, 28 | <i>Xiphostylus sinuosus</i> Pessagno and Yang, n. sp. OR-501B; upper Bathonian. South Fork Member, Snowshoe Formation. 2, 10, 21, 28 = Holotype (USNM 424178). Scale = 150, 66, 66, 66 $\mu\text{m}$ . 3, 4 = Paratype (Pessagno Collection). Scale = 150, 66 $\mu\text{m}$ .                                 | 9, 14, 17, 26      | <i>Neotripocyclia harperi</i> Pessagno and Yang, n. sp. JO-48; middle Oxfordian. Galice Formation s.l. Holotype (USNM 424138). Note cylindrical shape of cortical shell in figure 17. Scale = 85.7, 201.3, 150, 85.7 $\mu\text{m}$ .   |
| 5, 6, 24        | <i>Tripocyclia saleebyi</i> Pessagno and Yang, n. sp. JO-34; middle Oxfordian. Volcanopelagic strata overlying Josephine Ophiolite and underlying Galice Formation s.l. Holotype (USNM 424160). Note distal portion of spine (fig. 6) is circular in axial section. Scale = 199.9, 85.7, 85.7 $\mu\text{m}$ . | 11, 18, 19, 20, 27 | <i>Neotripocyclia harperi</i> Pessagno and Yang, n. sp. JO-48; middle Oxfordian (See above). 18 = Paratype (Pessagno Collection). Note cylindrical shape of cortical shell. Same paratype figured on pl. 7, fig. 22. Scale = 150 $\mu\text{m}$ . 11, 19, 20, 27 = Paratype (Pessagno Collection). Scale = 85.7, 150, 150, 85.7 $\mu\text{m}$ . |
| 7, 22           | <i>Xiphostylus gasquetensis</i> Pessagno and Yang, n. sp. JO-34; middle Oxfordian. Holotype (USNM 424172). Volcanopelagic strata overlying Josephine Ophiolite and underlying Galice Formation s.l. Scale = 150, 60 $\mu\text{m}$ .   | 12, 13, 15         | <i>Tripocyclia</i> sp. H. OR-501B; upper Bathonian. South Fork Member, Snowshoe Formation. Note that distal one third of spines are circular in axial section. Scale = 85.7, 150, 150 $\mu\text{m}$ .  |
|                 |   | 16                 | <i>Tripocyclia</i> sp. I. OR-501B; upper Bathonian. South Fork Member, Snowshoe Formation. Scale = 150 $\mu\text{m}$ .   |







TEXT-FIGURE 12

System of measurement for *Lanubus*, n. gen., and *Parvivacca*, n. gen. DD' = diameter of cortical shell measured through X. LL' = length of longer spine. lw = width of base of longer spine LL'. SS' = length of shorter spine. w's = width of base of shorter spine. ww' = distance between spinal bases measured through D. ht (*Parvivacca* only; not shown in text-figure) = height of cortical shell in edge view. Height measured from "top" surface to "bottom" surface; see plate 1, figure 7.

**Etymology:** Spinosus-a-um (Latin, adj.) = thorny, prickly.

**Measurements:** (μm) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	125.0	195.0	33.0
Mean	125.4	183.5	29.4
SD	10.5	24.1	4.9
Max.	153.0	225.0	40.0
Min.	108.0	133.0	25.0

**Type locality:** MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424166. Paratypes = USNM 424167 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. (1987 a, b). Text-figures 2 and 3 herein.

**Occurrence:** Upper, thin-bedded member of Taman Formation. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986, 1987a). See Text-figures 9 and 10 herein.

***Tripocyclia* sp. cf. *T. spinosa* Pessagno and Yang, n. sp.**

Plate 10, figures 9, 15.

**Remarks:** This form differs from *T. spinosa*, n. sp., by possessing more massive, pointed secondary spines which develop pronounced subsidiary grooves on the primary ridges of each spine. Moreover, the spines appear to be less symmetrically arranged.

**Range and Occurrence:** Zone 4, Subzone 4 beta; upper Tithonian. See Text-figures 2, 9, and 10 herein. Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Tripocyclia wickiupensis* Pessagno and Yang, n. sp.**

Plate 3, figures 7, 16, 20.

**Description:** Cortical shell subtriangular in outline, elliptical in cross-section with a thin outer layer of latticed meshwork consisting predominantly of small, symmetrical hexagonal pore frames. Pore frames with thin bars and small, weakly developed nodes at vertices. Secondary spines triradiate in axial section with three primary longitudinal grooves alternating with three primary longitudinal ridges; ridges very gradually decreasing in width proximally to a point just adjacent to constricted spinal tips. Proximal portion of each primary ridge developing subsidiary grooves. Primary grooves wide, deeply incised, subparallel-sided, closing off before spinal tips. Spinal tips bluntly terminating, displaying weakly developed triradiate structure in axial section. Cortical buttresses not prominent.

**Remarks:** *Tripocyclia wickiupensis*, n. sp., differs from *T. brooksi*, n. sp., by having a cortical shell which is subtriangular rather than heart-shaped in outline and which is more compressed at right angles to the plane of the three secondary spines. In addition, *T. wickiupensis* possesses spines with broad, deep, longitudinal grooves rather than narrow, deep, tapering longitudinal grooves.

**Etymology:** This species is named for Wickiup Creek near its type locality.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 6 for explanation of system of measurements.

	DD'	DS	cc'
Holotype	127.4	111.2	34.7
Mean	119.3	106.5	35.4
SD	5.6	9.8	4.6
Max.	127.4	115.8	41.7
Min.	111.2	92.6	30.1

**Type locality:** OR-705. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424168. Paratypes = USNM 424169 and Pessagno Collection.

**Range:** Superzone 1, Zone 1B; lower Bajocian. See Pessagno et al. (1987b). See Text-figure 1 herein.

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

***Tripocyclia* sp. A**  
Plate 2, figure 10.

**Remarks:** This form is easily distinguished from *Tripocyclia wickiupensis*, n. sp., by having proportionately longer secondary spines with much narrower longitudinal grooves and different spinal tips. It should be noted, however, that *T. sp. A* likewise has longitudinal grooves with subparallel sides.

**Range and Occurrence:** Superzone 1, Zone 1A, Subzone 1A<sub>1</sub>; Aalenian (?). See Pessagno et al. (1987b). Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). OR-593B. Rare.

***Tripocyclia* sp. B**  
Plate 7, figures 2, 10.

**Remarks:** This form differs from *Tripocyclia amajacensis*, n. sp., by having slender, more sharply pointed spines with narrow longitudinal ridges and grooves. Moreover, its cortical shell possesses smaller and more numerous pore frames.

**Range and Occurrence:** Zone 2, Subzone 2 beta (upper part); upper Kimmeridgian. See Pessagno et al. (1987a, b). Lower, massively-bedded member of the Taman Formation, east-central Mexico. MX-80-23; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Tripocyclia* sp. C**  
Plate 7, figures 3, 4, 9.

**Remarks:** *Tripocyclia* sp. C appears to be very closely related to *Tripocyclia spinosa*, n. sp. It differs, however, from the latter species by possessing a cortical shell with

less numerous pore frames and by having spines which display torsion of the longitudinal ridges distally.

**Range and Occurrence:** Zone 2, Subzone 2 alpha; uppermost Kimmeridgian or lowermost Tithonian. See Pessagno et al. (1987a, b). Lower, massively-bedded member of the Taman Formation, east-central Mexico. MX-82-16; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Tripocyclia* sp. D**  
Plate 8, figures 5, 20.

**Remarks:** *Tripocyclia* sp. D differs from *Tripocyclia foremanae*, n. sp., by having shorter, broader, more massive spines. Both forms, however, display similar spinal structure.

**Range and Occurrence:** Zone 3 (undifferentiated); lowermost Tithonian; ?uppermost Kimmeridgian so far as known. Upper part of lower, massively-bedded member of Taman Formation, east-central Mexico. MX-81-54 and MX-82-20; rare. Tethyan Realm, Northern Tethyan Province.

***Tripocyclia* sp. E**  
Plate 8, figures 4, 11, 17.

**Remarks:** *Tripocyclia* sp. E, was first figured by Pessagno (1977a) as *T. trigonum* Ruest. Ruest's illustration is too schematic to allow accurate correlation with any known species-level morphotype. Until a neotype is selected for *T. trigonum*, it will be impossible to identify this species accurately.

***Tripocyclia* sp. E** differs from *T. amajacensis*, n. sp., by having a cortical shell with smaller and more numerous pore frames and by having spines which do not show more than a rudimentary development of secondary grooves on their longitudinal ridges.

**Range:** Zone 2, Subzone 2 alpha to Zone 3, Subzone 3 beta so far as known; uppermost upper Kimmeridgian or lowermost lower Tithonian to lower Tithonian. See Pessagno et al. (1987b).

**Occurrence:** California Coast Ranges. Volcanopelagic strata overlying the Coast Range ophiolite at Point Sal (Santa Barbara Co., Calif.). NSF-907 and 908 of Pessagno 1977a and Pessagno et al. 1984. Boreal Realm, Southern Boreal Province.

***Tripocyclia* sp. F**  
Plate 4, figures 7.

**Remarks:** *Tripocyclia* sp. F, can be readily distinguished from *T. wickiupensis*, n. sp., by possessing spines with longitudinal ridges and grooves which gradually taper in a distal direction. Furthermore, *T. sp. F* develops pronounced subsidiary grooves on the proximal one half to two thirds of each primary longitudinal ridge. Spinal tip structure differs between the two forms. *T. wickiupensis*

shows a constricted spinal tip whereas *T. sp. F* shows no break in spinal tip profile.

**Range and Occurrence:** Superzone 1, Zone 1D; lower upper Bajocian so far as known. See Pessagno et al. (1987b). South Fork Member of Snowshoe Formation, Izee terrane, east-central Oregon. OR-513; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Tripocyclia sp. G***  
Plate 6, figures 1, 25.

**Remarks:** *Tripocyclia sp. G* differs from *T. sp. E* by having secondary spines which develop subsidiary grooves on the proximal two thirds of each longitudinal ridge.

**Range and Occurrence:** Superzone 1, Zone 1F; upper Bathonian so far as known. South Fork Member of Snowshoe Formation, Izee terrane, east-central Oregon. OR-

501B; rare. Boreal Realm, Southern Boreal Province. See Pessagno et al. (1986; 1987a, b).

***Tripocyclia sp. H***  
Plate 6, figures 12, 13, 15.

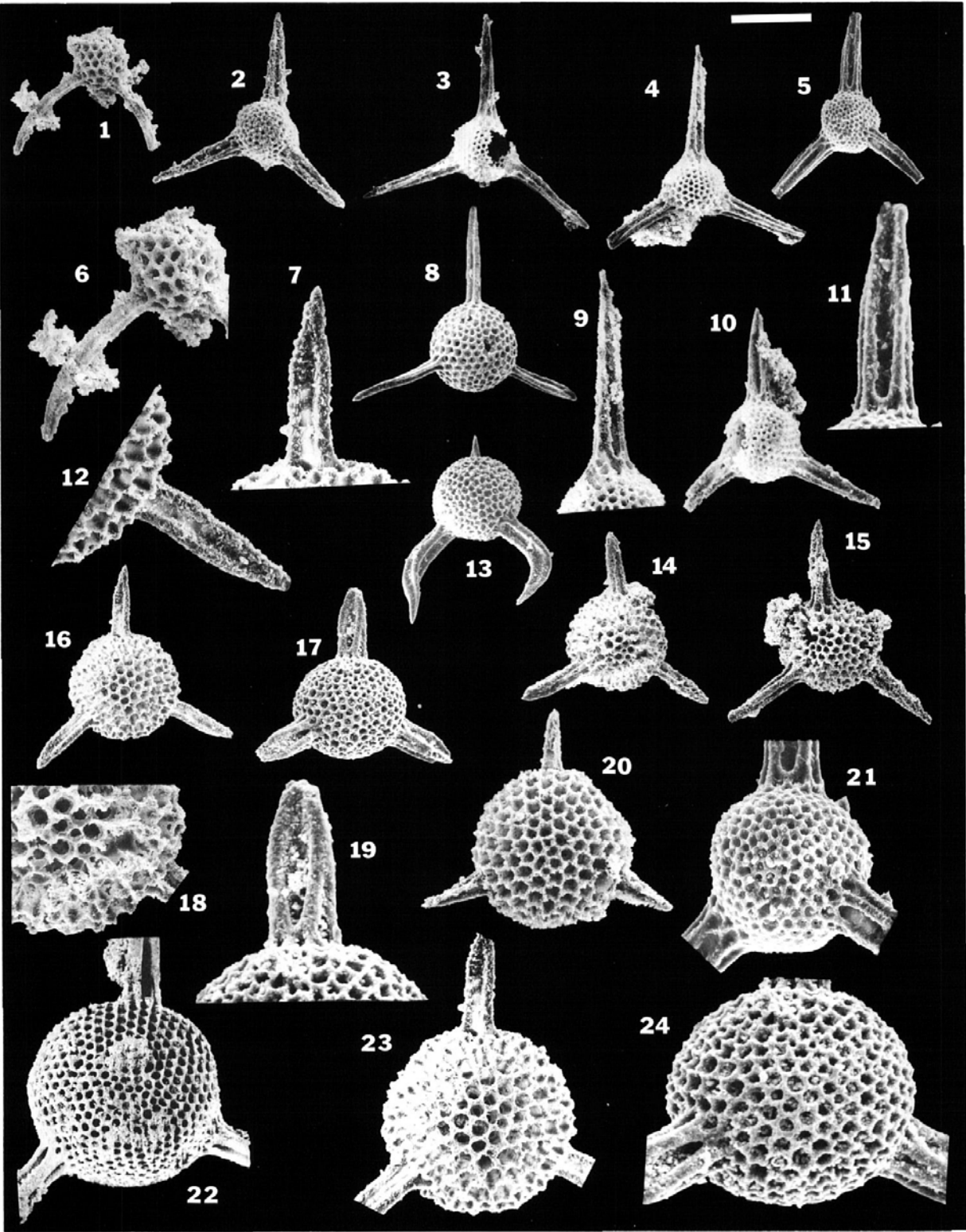
**Remarks:** This form is characterized by having very prominent cortical buttresses and quite long, slender, secondary spines. Moreover, the distal one third of each spine is circular in axial section and markedly constricted.

*Tripocyclia sp. H* is somewhat similar to the form figured by Baumgartner (1984, pl. 10, fig. 5) as *Triactoma tithonianum* Ruest. Both specimens display markedly constricted secondary spines distally. However, whereas the distal constricted portion of *Tripocyclia sp. H* is clearly circular in axial section that of Baumgartner's specimen is triradiate in axial section and displays very narrow longitudinal grooves. Baumgartner's specimen is characterized also by having highly nodose, less numerous pore

## PLATE 7

All illustrations are scanning electron micrographs of Upper Jurassic Parvivaccidae, n. fam., and Xiphostylidae from California (NSF, JO) and Mexico (MX, USGS). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- |                       |   |            |  |
|-----------------------|---|------------|--|
| 1, 6                  | <i>Lanubus sp. B.</i> JO-34; middle Oxfordian. Volcanopelagic strata overlying Josephine Ophiolite and underlying Galice Formation s. l. Scale = 150, 85.7 $\mu\text{m}$ .  | 13         | <i>Zanola sp. cf. Z. cornuta</i> (Baumgartner). NSF-907; uppermost Kimmeridgian or lowermost Tithonian. Volcanopelagic strata overlying Coast Range ophiolite. Scale = 198 $\mu\text{m}$ .   |
| 2, 10                 | <i>Tripocyclia sp. B.</i> MX-80-23; upper Kimmeridgian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Scale = 120, 120 $\mu\text{m}$ .  | 15         | <i>Triactoma sp. aff. T. hidalgoensis</i> Pessagno and Yang, n. sp. MX-82-16; upper-most Kimmeridgian or lowermost Tithonian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Scale = 150 $\mu\text{m}$ .  |
| 3, 4, 9               | <i>Tripocyclia sp. C.</i> MX-82-16; upper Kimmeridgian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Scale = 150, 150, 85.7 $\mu\text{m}$ .  | 17, 19, 24 | <i>Triactoma blakei</i> (Pessagno). NSF-907; uppermost Kimmeridgian or lowermost Tithonian. Volcanopelagic strata overlying Coast Range ophiolite. Holotype (USNM 21968). Note spinal structure (fig. 19) is critical for properly identifying this species. Scale = 171, 70.5, 78.2 $\mu\text{m}$ . |
| 5, 11, 21             | <i>Tripocyclia jonesi</i> Pessagno. NSF-907; uppermost Kimmeridgian or lowermost Tithonian. Volcanopelagic strata overlying Coast Range ophiolite. Holotype (USNM 21970). Note that spinal structure (fig. 11) is critical for the identification of this species. Scale = 150, 57.3, 60 $\mu\text{m}$ .  | 20         | <i>Triactoma sp. B.</i> USGS Mesozoic Locality 20815; upper Kimmeridgian. Lower massively-bedded member of Taman Formation, east-central Mexico. Scale = 99 $\mu\text{m}$ .  |
| 7, 12, 14, 16, 18, 23 | <i>Triactoma hidalgoensis</i> Pessagno and Yang, n. sp. MX-82-3; lower Kimmeridgian. Lower, massively-bedded member of Taman Formation, east-central Mexico. 7, 12, 16, 23 = Holotype (USNM 424140). Scale = 60, 60, 150, 85.7 $\mu\text{m}$ . 14, 18 = Paratype (Pessagno Collection). Scale = 150, 60 $\mu\text{m}$ . See also pl. 1, figs. 2, 8. | 22         | <i>Neotripocyclia harperi</i> Pessagno and Yang, n. sp. JO-48; middle Oxfordian. Galice Formation s.l. Paratype (Pessagno Collection). Same paratype figured on pl. 6, fig. 18. Scale = 85.7 $\mu\text{m}$ .   |
| 8                     | <i>Triactoma sp. C.</i> MX-81-54; lower Tithonian. Scale = 198 $\mu\text{m}$ . See also pl. 8, fig. 24.   |            |  |





frames, a proportionately smaller cortical shell, and weakly developed cortical buttresses.

*Range and Occurrence:* Same as for *Tripocyclia* sp. G (See above).

***Tripocyclia* sp. I**  
Plate 6, figure 16.

*Remarks:* This form is characterized by having massive triradiate secondary spines and quite prominent cortical buttresses.

*Range and Occurrence:* Same as for sp. *Tripocyclia* G (See above).

Genus *Xiphostylus* Haeckel 1881, **emend.** herein.

*Type species:* *Xiphostylus attenuatus* Ruest (Subsequent designation by Campbell 1954, p. D54).

NOT *Xiphosphaera* Haeckel 1881, p. 450. *Type species:* *Xiphosphaera gaea* Haeckel 1887 (Subsequent designation by Frizell and Middour 1951, p. 13).

*Emended definition:* Test with subspherical to ellipsoidal cortical shell with opposed secondary spines. Secondary spines subequal in length, predominantly triradiate in axial section with three longitudinal grooves alternating

with three longitudinal ridges. Shorter spine often more massive and wider than longer spine. Spines attached to latticed cortical shell by means of latticed protrusions of cortical shell referred to herein as cortical buttresses (pl. 1, figs. 3, 4). Outer latticed layer of cortical shell usually not as thick as that of *Tripocyclia* Haeckel or *Triactoma* Ruest (cf. pl. 1, figs. 2, 5, 6, 8, 10, 11, 13).

*Remarks:* *Xiphostylus* Haeckel differs from *Triactoma* Ruest by possessing two opposed secondary spines with cortical buttresses, and a less spherical cortical shell.

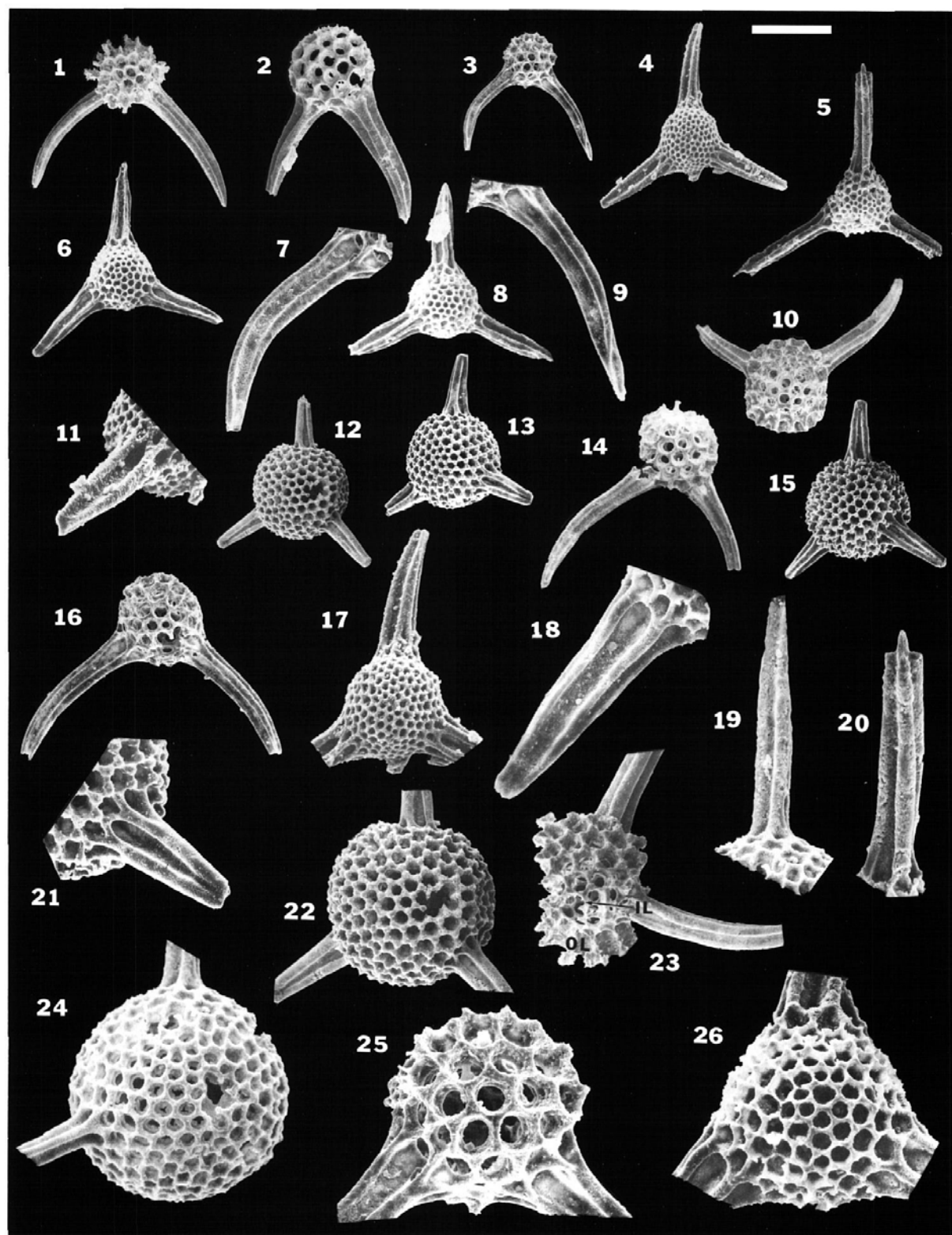
The type species of *Xiphostylus*, *X. attenuatus* Ruest, was originally described by Ruest (1885) from Germany (Koprolithen of Ilsede; upper Lias to lower Dogger). The taxonomic problems surrounding the type species as well as the genus *Xiphostylus* are discussed in detail under the Family Xiphostylidae (See pp. 202 herein).

It is important to note that many Japanese workers have included what we refer to herein as *Xiphostylus* under *Xiphosphaera* Haeckel 1881 (e.g. Mizutani and Koike 1982; Hattori 1987). *Xiphosphaera* differs from *Xiphostylus* by lacking cortical buttresses and by seemingly lacking a two layered cortical shell. Moreover, it is apparent that there is no direct phylogenetic link between *Xiphos-*

## PLATE 8

All illustrations are scanning electron micrographs of Upper Jurassic Xiphostylidae and Parvivaccidae, n. fam., from east-central Mexico (MX) and the California Coast Ranges (NSF). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- |              |  |  |   |
|--------------|--|--|---|
| 1, 23        | <i>Parvivacca</i> sp. B. MX-82-20; lower Tithonian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Note (fig. 23) the cylindrical nature of the cortical shell and the absence of the outer latticed layer on its sides. Letters OL position in area of very thick outer latticed layer. Arrow IL points to thin, fragile inner latticed layer. Scale = 150, 85.7 $\mu\text{m}$ . | (USNM 424150). Scale = 150, 45, 45 $\mu\text{m}$ . 8 = Paratype (Pessagno Collection). Scale = 150 $\mu\text{m}$ . |   |
| 2            | <i>Lanubus</i> sp. E. MX-82-20; see above. Scale = 85.7 $\mu\text{m}$ .  | 10, 14   | <i>Parvivacca</i> sp. A. MX-82-20; lower Tithonian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Note (fig. 10) the cylindrical shape of the cortical shell in edge view and the absence of the outer latticed layer on its sides. Scale = 85.7, 85.7 $\mu\text{m}$ .  |
| 3, 7, 9, 25  | <i>Lanubus</i> sp. C. MX-81-54; lower Tithonian. Lower, massively-bedded member of Taman Formation, east-central Mexico. Scale = 150, 60, 60, 39.9 $\mu\text{m}$ .   | 12, 13, 15, 21, 22   | <i>Triactoma kellumi</i> Pessagno and Yang, n. sp. MX-82-20; see fig. 10 above. 12, 22 = Holotype (USNM 424142). Scale = 150, 85.7 $\mu\text{m}$ . 13, 21 = Paratype (Pessagno Collection). Scale = 150, 60 $\mu\text{m}$ . 15 = Paratype (Pessagno Collection). Note that the nodes on pore frame vertices are higher in relief on this specimen than on holotype or other paratype. Scale = 150 $\mu\text{m}$ . |
| 4, 11, 17    | <i>Tripocyclia</i> sp. E. NSF-908; lower Tithonian. Volcanopelagic strata above the Coast Range Ophiolite. Scale = 150, 75, 99 $\mu\text{m}$ .   | 16   | <i>Lanubus</i> sp. D. MX-82-20; see fig. 10 above. Scale = 85.7 $\mu\text{m}$ .   |
| 5, 20        | <i>Tripocyclia</i> sp. D. MX-81-54; see fig. 3 above. Scale = 150, 60 $\mu\text{m}$ .  | 19, 24   | <i>Triactoma</i> sp. C. MX-81-54; lower Tithonian. Lower, massively-bedded member of Taman Formation, east-central Mexico. See also pl. 7, fig. 8. Scale = 75, 75 $\mu\text{m}$ .   |
| 6, 8, 18, 26 | <i>Tripocyclia amajacensis</i> Pessagno and Yang, n. sp. MX-81-54; see fig. 3 above. 6, 18, 26 = Holotype  |  |   |



*tylus* which became extinct in the Late Jurassic (Oxfordian) and *Xiphosphaera* which first appeared in the Cenozoic (Neogene).

**Range:** Zone 01, Subzone 01A to top of Zone 2, Subzone 2 gamma; Lower Jurassic: upper Pliensbachian to Upper Jurassic: middle Oxfordian (See Pessagno et al. 1987b and text-figs. 1-4 and p. 195 herein).

**Occurrence:** North America: Maude Group, Queen Charlotte Islands, Wrangellia terrane. Nicely, Hyde, Snowshoe formations, east-central Oregon, Izee terrane. Volcanopelagic strata overlying Josephine Ophiolite, Klamath Mountains, Smith River terrane. Germany (Ruest 1885). Japan (Mizutani and Koike 1982; Wakita 1982; Hattori 1987). Tethyan Realm: Central Tethyan Province to Northern Tethyan Province. Boreal Realm: Southern Boreal Province so far as known.

***Xiphostylus fragilis*** Pessagno and Yang, *n. sp.*  
Plate 3, figures 3, 4, 12, 23.

**Description:** Cortical shell ellipsoidal in shape, elongate parallel to axis of polar spines. Outer latticed layer relatively thin, consisting of small hexagonal and rare pentagonal pore frames; hexagonal pore frames about seven times more abundant than pentagonal pore frames; all pore frames in outer latticed layer with small, weakly developed nodes at vertices. Opposed secondary (polar) spines short, narrow, about equal in length to maximum width of cortical shell; one spine slightly shorter than

other. Both spines triradiate in axial section with three narrow, deep grooves alternating with three longitudinal ridges; grooves about same width as ridges. Grooves of shorter spine parallel-sided, terminated by closure of ridges near spinal tips. Cortical buttresses well-developed relative to those of other species.

**Remarks:** This species is compared to *Xiphostylus whalenae*, *n. sp.*, under the latter species.

**Etymology:** *Fragilis*, -e (Latin) = fragile, weak.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 7 paratypes. See Text-figure 11 for explanation of system of measurements. Note: In some cases the spines were broken and their length could not be measured. The number in parenthesis (e.g., 6) indicates the number of specimens that could be measured.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	115.8	92.6	106.5	25.4	92.6	32.4
Mean	115.8	106.3	120.4(6)	21.6	101.6(6)	28.6
SD	0.0	6.2	10.8(6)	3.4	11.7(6)	6.5
Max.	115.8	111.2	134.3(6)	25.4	122.8(6)	41.7
Min.	115.8	92.6	106.5(6)	17.3	92.6(6)	23.17

**Type locality:** OR-554. See Locality Descriptions herein.

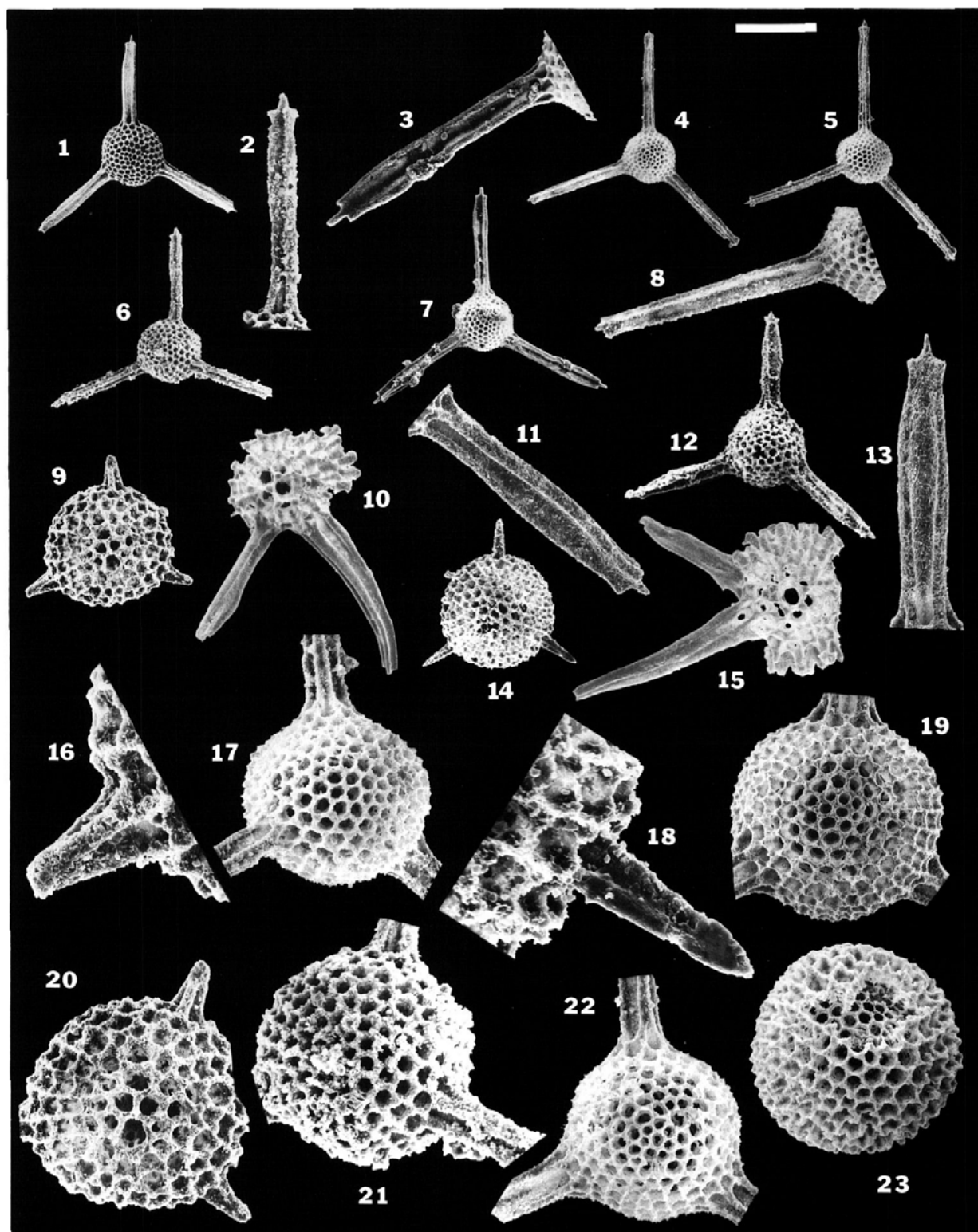
**Deposition of types:** Holotype = USNM 424170. Paratypes = USNM 424171 and Pessagno Collection.

## PLATE 9

All illustrations except figures 10 and 15 are scanning electron micrographs of Upper Jurassic (upper Tithonian) *Xiphostylidae* and *Parvivaccidae* from the upper, thin-bedded member of the Taman Formation, east-central Mexico (MX). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

- 1, 11, *Tripocyclia frequens* Pessagno and Yang, *n. sp.* MX-84-13. Holotype (USNM 424156). Scale = 214.2, 60, 60, 60  $\mu\text{m}$ .
- 12, 13
- 19 *Tripocyclia frequens* Pessagno and Yang, *n. sp.* MX-85-22. Paratype (Pessagno Collection). Scale = 150  $\mu\text{m}$ .
- 2, 6, 21 *Triactoma(?) prolongata* Pessagno and Yang, *n. sp.* MX-85-23. Holotype (USNM 424148). Scale = 79.9, 199.9, 60.0  $\mu\text{m}$ .
- 3-5, 7, *Tripocyclia foremanae* Pessagno and Yang, *n. sp.* MX-82-37. 3, 7 = Paratype (Pessagno Collection). Scale = 85.7, 199.9  $\mu\text{m}$ . 4, 8, 22 = Holotype (USNM 424154). Scale = 199.9, 85.7, 60, 60  $\mu\text{m}$ . 5, 17 = Paratype (Pessagno Collection). Scale = 199.9, 60  $\mu\text{m}$ .

- 9, 16, 20 *Triactoma mexicana* Pessagno and Yang, *n. sp.* MX-85-26. Holotype (USNM 424144). Scale = 150, 39.9, 83.3  $\mu\text{m}$ .
- 10, 15 *Parvivacca* sp. C. MX-82-20; lower Tithonian. Lower, massively-bedded member of the Taman Formation, east-central Mexico. Note (fig. 15) the very cylindrical shape of the cortical shell and the absence of the outer latticed layer on the sides of the test. The outer latticed layer on the top and bottom surfaces is quite thick. Scale = 85.7, 85.7  $\mu\text{m}$ .
- 14, 18 *Triactoma paramexicana* Pessagno and Yang, *n. sp.* MX-85-24. Holotype (USNM 424146). Scale = 150, 30.0  $\mu\text{m}$ .
- 23 *Archaeocenosphaera ruesti* Pessagno and Yang, *n. sp.* MX-84-13. Holotype (USNM 424136). See also plate 1, figure 9. Scale = 85.7  $\mu\text{m}$ .



**Range:** Superzone 1, Zone 1B to lower half of Zone 1C; lower Bajocian. See Pessagno et al. (1987b) and Text-figure 1 herein.

**Occurrence:** Warms Springs Member, Snowshoe Formation, Izee terrane, east-central Oregon. Text-figure 7.

***Xiphostylus gasquetensis*** Pessagno and Yang, n. sp.  
Plate 6, figures 7, 8, 22, 23.

**Description:** Cortical shell almost diamond-shaped in outline with widest part occurring in center at right angles to longitudinal axis of spines. Outer latticed layer with mixture of symmetrical hexagonal and pentagonal pore frames; pentagonal pore frames less numerous; all pore frames with small nodes at vertices. Secondary spines subequal in length; seemingly sharply pointed when entire; triradiate in axial section; consisting of three longitudinal grooves alternating with three longitudinal ridges. Longitudinal ridges rounded, massive about equal in width to grooves. Longitudinal grooves deep with sides converging rapidly in a distal direction and merging well before spinal tips. Distal portion of each spine circular in axial section and lacking longitudinal ridges and grooves. Shorter spine somewhat broader and more massive than longer spine; longer spine terminating in very sharp spinal tip.

**Remarks:** *Xiphostylus gasquetensis*, n. sp., differs from other species of *Xiphostylus* figured in this report by developing a test which is diamond-like outline and which is wider in a medial position.

**Etymology:** This species is named for the town of Gasquet near its type locality.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 8 paratypes. See Text-figure 11 for explanation of the system of measurements. Note: Some paratypes have broken spines and the length of their spines could not be measured. In such cases, the number in parenthesis indicates the number of specimens that were actually measured.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	115.8	139.0	201.5	46.3	14.59	57.9
Mean	118.3	140.7	186.8(6)	43.5	153.9(8)	56.3
SD	4.8	6.7	20.6(6)	3.7	27.6(8)	5.5
Max.	127.4	157.5	220.1(6)	46.3	213.1(8)	64.8
Min.	115.8	134.3	162.1(6)	34.7	115.8(8)	50.9

**Co-type localities:** Holotype from JO-34. Paratypes from JO-34 and JO-8. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424172. Paratypes = USNM 424173 and Pessagno Collection.

## PLATE 10

All illustrations are scanning electron micrographs of Upper Jurassic (upper Tithonian) *Xiphostylidae* and *Parvivaccidae* from east-central Mexico (MX) and the California Coast Ranges (NSF). Scale (upper right) = number of  $\mu\text{m}$ . cited for each illustration.

1, 17, *Tripocyclia notabilis* Pessagno and Yang, n. sp. MX-19, 29 84-13. Upper, thin-bedded member of Taman Formation. Holotype (USNM 424158). Scale = 199.9, 60, 60, 60  $\mu\text{m}$ .

2-4, 26, *Tripocyclia notabilis* Pessagno and Yang, n. sp. 2, 27 = Paratype (Pessagno Collection). MX-84-13; see fig. 1 above. Scale = 199.9, 60  $\mu\text{m}$ . 3, 26 = Paratype (Pessagno Collection). MX-84-13; see fig. 1 above. Scale = 199.9, 60  $\mu\text{m}$ . 4 = specimen (non-type) from MX-82-37. Upper, thin-bedded member of Taman Formation. Scale = 199.9  $\mu\text{m}$ .

5 *Parvivacca* sp. D. MX-82-37. Upper, thin-bedded member of Taman Formation, east-central Mexico. See plate 1, figure 7. Scale = 150  $\mu\text{m}$ .

6, 8, 12, *Tripocyclia spinosa* Pessagno and Yang, n. sp. MX-25 84-13. Upper, thin-bedded member of Taman Formation, east-central Mexico. 6 = topotype. Scale = 142.9  $\mu\text{m}$ . 8, 12, 25 = Holotype (USNM 424166). Scale = 142.9, 60, 60  $\mu\text{m}$ .

7, 11, *Parvivacca simplex* Pessagno and Yang, n. sp. MX-20, 21 84-13; see figure 6 above. 7 = Paratype (Pessagno Collection). Scale = 199.9  $\mu\text{m}$ . 11, 20, 21 = Holotype (USNM 424194). Scale = 199.9, 85.7, 85.7  $\mu\text{m}$ .

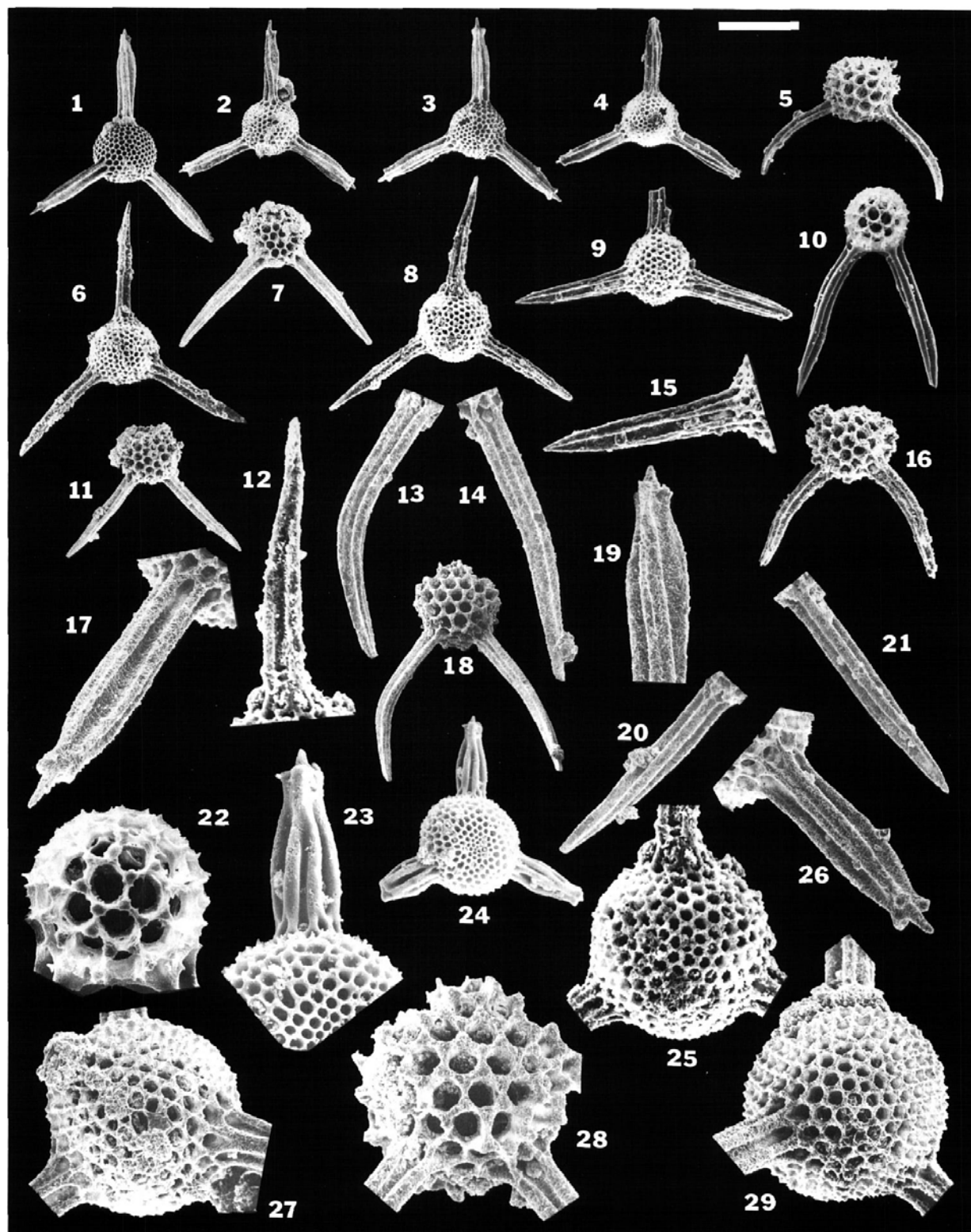
9, 15 *Tripocyclia* sp. cf. *T. spinosa* Pessagno and Yang, n. sp. MX-84-13; see figure 6 above. Scale = 142.9, 80.0  $\mu\text{m}$ .

10, 22 *Lanubus* sp. A. SA-43. Volcanopelagic strata above the Coast Range ophiolite at Stanley Mountain (Alamo Creek). Scale = 132, 42  $\mu\text{m}$ .

13, 14, *Parvivacca blomei* Pessagno and Yang, n. sp. MX-16, 18, 28 84-13. Upper, thin-bedded member of Taman Formation, east-central Mexico. 13, 14, 18, 28 = Holotype (USNM 424192). Scale = 85.7, 85.7, 150, 60  $\mu\text{m}$ . 16 = Paratype (Pessagno Collection). Scale = 150  $\mu\text{m}$ .

23, 24 *Triactoma*(?) sp. A. SA-43; see figure 10 above. Scale = 60, 150  $\mu\text{m}$ .





**Range:** Uppermost part of Superzone 1 to Zone 2, Subzone 2 gamma (Oxfordian). Lower part of range not fully established. See Text-figures 2-3 herein.

**Occurrence:** Volcanopelagic strata above Josephine ophiolite, Klamath Mountains, Northwestern California, Smith River subterranean. Tethyan Realm, Central Tethyan Province so far as known. See Text-figures 4, 8.

***Xiphostylus halli*** Pessagno and Yang, n. sp.  
Plate 4, figures 1, 13, 20, 24.

**Description:** Cortical shell subellipsoidal, somewhat compressed at right angles to axis of two opposed (polar) secondary spines. Outer latticed layer thin, consisting of small, symmetrical pentagonal and hexagonal pore frames with small nodes at vertices; hexagonal pore frames somewhat more numerous than pentagonal pore frames. Secondary spines subequal in length; one spine somewhat shorter than the other. Both spines triradiate in axial section with three deep longitudinal grooves alternating with three rounded longitudinal ridges; ridges and grooves about equal in width; ridges parallel, converging at a point near the spinal tips. Distal-most part of both spines beyond convergence of ridges, decreasing rapidly in width, becoming circular in axial section. Width of narrow distal portion of each spine about equal to that of longitudinal grooves on more proximal portions of the spine; narrow distal spinal tip better developed on longer spine. Cortical buttresses present, well-developed relative to other species of the genus.

**Remarks:** *Xiphostylus halli*, n. sp., differs from *X. whalenae*, n. sp., by having a proportionately smaller cortical shell and by having longer secondary spines that possess parallel-sided longitudinal grooves and distinctive spinal tips which are circular in axial section.

**Etymology:** This species is named for Dr. Russell Hall (Univ. of Alberta) for his contributions to the Middle Jurassic stratigraphy of North America.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 11 for explanation of system of measurements.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	101.9	120.4	145.9	30.1	134.3	41.7
Mean	100.2	117.1	146.6	28.5	127.9	38.4
SD	7.7	2.7	11.5	5.6	13.3	4.5
Max.	115.8	122.8	162.1	41.7	145.9	46.3
Min.	92.6	113.5	127.4	23.2	111.2	32.4

**Type locality:** OR-554. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424174. Paratypes = USNM 424175 and Pessagno Collection.

**Range:** Superzone 1, Zone 1C (lower half); lower Bajocian. See Pessagno et al. (1987b). Text-figure 1 herein.

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm,

Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

***Xiphostylus* sp. aff. *X. halli*** Pessagno and Yang  
Plate 4, figure 16.

**Remarks:** This form differs from *Xiphostylus halli*, n. sp., by having secondary spines with longitudinal grooves lacking parallel sides. Furthermore, it lacks the peculiar spinal tips displayed by *X. halli*.

**Range:** Superzone 1, Zone 1B (upper half) to Zone 1C (lower half); lower Bajocian. See Pessagno et al. (1987b) and Text-figure 1 herein.

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7.

***Xiphostylus logdellensis*** Pessagno and Yang, n. sp.  
Plate 2, figures 7-9; 11, 13, 14.

**Description:** Cortical shell elliptical in outline. Pore frames of outer latticed layer very small, nodose, hexagonal and pentagonal in shape; hexagonal pore frames more numerous than pentagonal pore frames. Two bipolar secondary spines wide, massive, triradiate in axial section, subequal in length; both spines long relative to size of cortical shell, comprised of three massive, longitudinal ridges alternating with three deep grooves; grooves somewhat wider than ridges, decreasing in width in a distal direction; longitudinal ridges often displaying slight torsion; converging just proximally to spinal tips resulting in spinal tips which are circular in axial section; both spines with well-developed cortical buttresses.

**Remarks:** This species is compared to *Xiphostylus sinuosus*, n. sp., under the latter species.

**Etymology:** *Xiphostylus logdellensis*, n. sp., is named for the settlement of Logdell to the east of its type locality.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 11 for explanation of measurements.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	127.0	127.0	150.6	23.2	150.6	41.7
Mean	112.2	113.9	149.2	27.0	137.6	41.6
SD	14.6	11.4	14.5	3.5	22.3	2.9
Max.	127.0	127.0	162.2	34.7	150.6	46.3
Min.	69.5	81.0	115.8	23.17	92.7	34.7

**Co-type localities:** Holotype and some paratypes from OR-516. Other paratypes from OR-705.

**Deposition of types:** Holotype = USNM 424176. Paratypes = USNM 424177 and Pessagno Collection.

**Range:** Superzone 1, Zone 1B; lower Bajocian. See Pessagno et al. (1987a). Text-figure 1 herein.

**Occurrence:** Warm Springs Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm,

Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

*Xiphostylus sinuosus* Pessagno and Yang, n. sp.  
Plate 6, figures 2-4; 10, 21, 28.

**Description:** Cortical shell elliptical in outline, compressed in a direction parallel to spinal axis. Outer latticed layer comprised predominantly of large (for genus) hexagonal pore frames and a minor number of smaller pentagonal and hexagonal pore frames; all pore frames with weakly developed nodes at vertices; walls of pore frames quite thin. Opposed secondary spines thin, sharply pointed, subequal in length, triradial in axial section with three narrow longitudinal ridges alternating with three narrow longitudinal grooves. Ridges and grooves about equal in width, decreasing in width in a distal direction. Spines with well-developed cortical buttresses.

**Remarks:** *Xiphostylus sinuosus*, n. sp., differs from *X. logdellensis*, n. sp., by having a cortical shell which is compressed in a direction parallel rather than at right angles to the spinal axis. In addition, *X. sinuosus* possesses proportionately larger pore frames and spines which are shorter, narrower, and less massive.

**Etymology:** Sinuosus-a-um (Latin, adj.) = full of curves, sinuous.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 11 for explanation of the system of measurements. Total of 10 specimens measured unless otherwise indicated by the number in parenthesis.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	122.8	152.9	139.0	39.9	122.8	44.0
Mean	122.5	151.0	143.3(9)	42.3	118.8	49.7
SD	11.8	7.7	13.6(9)	3.4	14.4	4.9
Max.	150.6	162.1	162.1(9)	46.3	139.0	57.9
Min.	111.2	139.0	115.8(9)	34.7	104.2	41.7

**Type locality:** OR-501B. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424178. Paratypes = USNM 424179 and Pessagno Collection.

**Range:** Superzone 1, Zone 1F so far as known; uppermost Bathonian. See Pessagno et al. (1987b) and Text-figure 1 herein.

**Occurrence:** South Fork Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986, 1987a). Text-figure 8 herein.

*Xiphostylus superbis* Pessagno and Yang, n. sp.  
Plate 4, figures 3, 8, 9, 21, 23, 27.

**Description:** Cortical shell ellipsoidal, proportionately small, markedly compressed parallel to axis of opposed bipolar spines. Outer layer of meshwork consisting of large pentagonal and hexagonal pore frames with weakly developed nodes at vertices. Bipolar secondary spines

long, wide, massive, unequal in length, triradial in axial section. Both spines with rounded ridges separated by deep grooves. Grooves and ridges about equal in width; ridges converging at spinal tips. Subsidiary grooves developed on proximal-most part of primary ridges of both spines. Shorter spine with primary grooves which progressively decrease in width in a distal direction; longer spine with grooves having subparallel sides. Prominent cortical buttresses linking spines to cortical shell.

**Remarks:** *Xiphostylus superbis*, n. sp., differs from all other species of *Xiphostylus* figured herein by having a cortical shell which is markedly compressed parallel to the bipolar spinal axis and by having both long and very massive spines. It is without question the most distinctive species of *Xiphostylus* figured in this report.

**Etymology:** Superbus-a-um (Latin, adj.) = superb.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 7 paratypes. See Text-figure 11 for explanation of the system of measurements. Total of 7 specimens measured unless otherwise indicated by the number in parenthesis.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	92.6	139.0	254.8	50.9	220.1	69.5
Mean	94.0	125.9	198.6	48.0	171.7(6)	57.5
SD	3.8	12.1	27.4	6.8	25.4(6)	9.5
Max.	104.2	143.6	254.8	57.9	220.1(6)	69.5
Min.	92.6	111.2	162.1	37.0	139.0(6)	41.7

**Type locality:** OR-513C. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424180. Paratypes = USNM 424181 and Pessagno Collection.

**Range:** Superzone 1, Zone 1D; lower upper Bajocian. See Pessagno et al. (1987b). Text-figure 1 herein.

**Occurrence:** South Fork Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986, 1987a). Text-figure 7 herein.

*Xiphostylus vallieri* Pessagno and Yang, n. sp.

Plate 1, figures 4, 10, 13; plate 2, figures 1-3; 12, 15, 16, 19, 23.

**Description:** Cortical shell subspherical with both latticed layers consisting of a equal number of small, symmetrical, pentagonal and hexagonal pore frames with weakly developed nodes at pore frame vertices. Bipolar secondary spines short, wide, massive, triradial in axial section, nearly equal in length. Longitudinal ridges of both spines rounded, subparallel; ridges on proximal nine tenths of spine maintaining same width, rapidly decreasing in width on distal one tenth, closing off grooves and yielding a spinal tip which is circular in axial section. Ridges of longer spine usually not merging distally to close off grooves (i.e., grooves remain open). Longitudinal grooves of each spine often quite deep proximally. Both spines with very well-developed cortical buttresses.

**Remarks:** *Xiphostylus vallieri*, n. sp., differs from *X. whalenae*, n. sp., by having a cortical shell which is proportionately smaller and subspherical rather than ellipsoidal in shape. Moreover, its cortical shell does not display compression in a direction parallel to the bipolar spinal axis. In addition, because of its proportionately larger cortical shell, *X. whalenae* possesses more numerous pore frames. Both species share an equal number of pentagonal and hexagonal pore frames and subequal secondary spines with similar structure and may be phylogenetically related.

**Etymology:** This species is named for Dr. Tracy L. Vallier (U.S. Geological Survey, Menlo Park, Calif.) in honor of his many contributions to the geology of the Blue Mountains Province of eastern Oregon, eastern Washington, and western Idaho.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 7 paratypes. See Text-figure 11 for explanation of the system of measurements.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	111.2	139.0	145.9	46.3	136.7	57.9
Mean	109.5	122.7	129.7	35.3	116.9	46.0
SD	6.7	7.5	10.2	5.2	13.0	7.7
Max.	115.8	139.0	145.9	46.3	136.7	57.9
Min.	99.6	115.8	115.8	30.1	92.6	34.7

**Type locality:** OR-705. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424182. Paratypes = USNM 424183 and Pessagno Collection.

**Range:** Superzone 1, Zone 1B; lower Bajocian. See Pessagno et al. (1987b). See Text-figure 1.

**Occurrence:** Warm Springs Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

***Xiphostylus whalenae*** Pessagno and Yang, n. sp.  
Plate 1, figure 3; plate 4, figs. 2, 17, 19.

**Description:** Cortical shell globular, subellipsoidal, somewhat compressed in a direction parallel to spinal axis. Outer layer of latticed meshwork relatively thick (for genus) with equal number of small, uniformly sized pentagonal and hexagonal pore frames bearing small nodes at their vertices. Bipolar secondary spines short, wide, massive, triradiate in axial section, about equal in length to maximum dimension of cortical shell; one spine slightly shorter than the other. Shorter spine with three massive, broad longitudinal ridges alternating with three deep, broad longitudinal grooves. Ridges of shorter spine maintaining same width throughout, but merging distally on spinal tip; longitudinal grooves decreasing slightly in width in a distal direction. Longer spine with similar structure, but having longitudinal ridges that decrease gradually distally. Both spines with prominent cortical buttresses.

**Remarks:** *Xiphostylus whalenae*, n. sp., differs from *X. fragilis*, n. sp., by having a cortical shell which is globular and compressed in a direction parallel to the spinal axis. Moreover, it differs from the latter species by having considerably broader, shorter, more massive, and structurally different spines.

**Etymology:** This species is named for Dr. Patricia A. Whalen (University of Texas at Dallas) in honor of her contributions to the study of Jurassic Radiolaria.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 9 paratypes. See Text-figure 11 for explanation of the system of measurements. Total of 10 specimens measured unless otherwise indicated by the number in parenthesis.

	AA'	BB'	A'S'	dd'	AS	cc'
Holotype	115.8	134.3	115.8	34.7	104.2	57.9
Mean	104.2	123.5	114.2(9)	32.6	100.3	41.6
SD	10.3	10.3	15.9(9)	5.2	10.5	6.6
Max.	115.8	139.0	134.3(9)	41.7	115.8	57.9
Min.	92.6	111.2	99.6(9)	25.4	88.0	34.7

**Type locality:** OR-554. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424184. Paratypes = USNM 424185 and Pessagno Collection.

**Range:** Superzone 1, lower half of Zone 1C so far as known; lower Bajocian. See Pessagno et al. (1987b). Text-figure 1 herein.

**Occurrence:** Warm Springs Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

***Xiphostylus* sp. A**  
Plate 4, figures 10, 18.

**Range and Occurrence:** Superzone 1, Zone 1E; upper Bajocian so far as known. Snowshoe Formation (undifferentiated), Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). OR-549C; rare. See Locality Descriptions herein.

***Xiphostylus* sp. B**  
Plate 4, figures 4, 26.

**Range and Occurrence:** Superzone 1, Zone 1D; lower part of upper Bajocian. See Pessagno et al. (1987b). Schoolhouse Member(?) of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). OR-513; rare. See Locality Descriptions herein.

***Xiphostylus* sp. C**  
Plate 2, figures 6, 20, 24.

**Remarks:** This form is characterized by having an ellipsoidal cortical shell which is compressed in a direction



parallel to the axis of the polar spines and by its peculiar spinal structure.

**Range and Occurrence:** Superzone 1, Zone 1 B; lower Bajocian so far as known. Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987b). OR-705; rare.

***Xiphostylus* sp. D**

Plate 1, figure 11; plate 3, figures 1, 14, 18, 21.

**Range and Occurrence:** Same as for *Xiphostylus* sp. C. See above. OR-705. Rare.

***Xiphostylus* sp. E**

Plate 3, figures 2, 11, 17, 22.

**Remarks:** This form differs from other species of *Xiphostylus* by possessing extremely narrow secondary spines that both have spinal tips which are circular in axial section. With the longer of the two spines, this sort of spinal tip is quite pronounced and includes the distal one third of the spine.

**Range and Occurrence:** Same as for *Xiphostylus* sp. C; see above. OR-705. Rare.

***Xiphostylus* sp. F**

Plate 2, figure 4.

**Remarks:** This Lower Jurassic form is characterized by its large spherical cortical shell which possesses large, nodose, pentagonal and hexagonal pore frames. Its subequal, opposed secondary spines are inserted between the narrow longitudinal ridges.

**Range and Occurrence:** Zone 01, Subzone 01A; upper Pliensbachian. See Pessagno et al. (1987b). Nicely Formation, Izee terrane, east-central Oregon. OR-536; rare. Tethyan Realm (sensu Pessagno et al. 1986; 1987a).

***Xiphostylus* sp. G**

Plate 2, figure 5.

**Remarks:** *Xiphostylus* sp. G differs from *X. sp. F* by having a subspherical, proportionately larger cortical shell with more numerous pore frames. The pore frames of *Xiphostylus* sp. G are large like those of *X. sp. F*, but tend to possess only weakly developed nodes; furthermore, they tend to be predominantly pentagonal in shape. In addition, *X. sp. G* has opposed secondary spines with very deep narrow grooves which decrease progressively in width in a distal direction.

**Range and Occurrence:** Zone 01, Subzone 01B; upper Pliensbachian. Maude Formation, Wrangellia terrane, Queen Charlotte Islands, B. C. Tethyan Realm (sensu Pessagno et al. 1986; 1987a). QC-622; rare. Note: Pessagno and Whalen (1982) originally assigned sample QC-622 to the lower Toarcian on the basis of ammonites occurring at adjacent horizons. Changes in the ammonite biostratigraphy of the Maude Formation have resulted

in sample QC-622 being reassigned to the upper Pliensbachian (See Locality Descriptions herein).

**Genus *Zanola* Pessagno and Yang, n. gen.**

**Type species:** *Triactoma cornuta* Baumgartner (1980b).

**Description:** Cortical shell subelliptical to circular in outline, circular to subelliptical in cross-section usually with thick outer latticed layer comprised of symmetrical polygonal pore frames. Test with three asymmetrically placed secondary spines lacking cortical buttresses; two spines long, massive, about equal in length, situated close together. Third spine very short, widely separated from two longer spines, centered along longitudinal axis of test. Two longer spines triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Shorter spine triradiate in axial section proximally, often becoming circular in axial section distally.

**Remarks:** *Zanola*, n. gen., differs from *Triactoma* Ruest (1885) by having a cortical shell which is subelliptical to circular in outline and by possessing three asymmetrically arranged secondary spines. Moreover, one of its secondary spines is shorter in length and widely separated from the remaining two spines.

**Etymology:** *Zanola* (F.) is a name formed by an arbitrary combination of letters (ICZN, 1985, p. 21, Art. 11b).

**Range:** Superzone 1?; Zone 2 to Zone 4, Subzone 4 beta; Callovian?; Oxfordian to upper Tithonian. See Pessagno et al. (1987b).

**Occurrence:** Tethyan Realm: Central Tethyan Province to Northern Tethyan Province. Boreal Realm: Southern Boreal Province.

***Zanola* sp. cf. *Z. cornuta* (Baumgartner)**

Plate 7, figures 13.

**Remarks:** Baumgartner (1980b, pl. 2, figs. 2-3) figured two radically different morphotypes for *Z. cornuta*. His holotype (fig. 2) possesses two adjacent spines with inwardly curved spinal tips. Moreover, the third spine of the holotype is shorter and is completely circular in axial section. Baumgartner's paratype (fig. 3) possesses two adjacent spines which are wider, more massive, and lack strongly incurved spinal tips. In addition, the paratype has a third spine which is triradiate in axial section proximally and circular in axial section distally and a cortical shell that is more elliptical in outline.

The form figured here (pl. 7, fig. 13) as *Z. sp. cf. Z. cornuta* (Baumgartner) is more closely related to Baumgartner's paratype. It differs from the paratype by possessing a cortical shell which is subcircular in outline and by having more massive adjacent secondary spines. One of its two adjacent spines shows torsion of the longitudinal ridges and grooves distally.

**Range and Occurrence:** Zone 2, Subzone 2 alpha to Zone 3, Subzone 3 beta; uppermost Kimmeridgian to lower Tithonian so far as known; see Pessagno et al. (1987b) and



Text-figures 2 and 9 herein. Volcanopelagic sequence above Coast Range ophiolite at Point Sal. Boreal Realm, Northern Boreal Province (sensu Pessagno et al. 1986, 1987a).

Family **PARVIVACCIDAE** Pessagno and Yang, n. fam.  
Type genus: *Parvivacca* Pessagno and Yang, n. gen.

**Description:** Test with cortical shell and single medullary shell both having symmetrical polygonal (usually pentagonal and hexagonal) nodose pore frames. Medullary shell (pl. 1, fig. 12) spherical, fragile, frequently not preserved. Cortical shell circular to subcircular in outline with two adjacent, asymmetrically placed, unequal length, straight to curved, triradiate (axial section) primary spines. Cortical shell spherical (*Lanubus*, n. gen.) or cylindrical (*Parvivacca*, n. gen.), flattened on two opposed surfaces. Meshwork of cortical shell divided into two latticed layers: a thin inner latticed layer and a thick outer latticed layer (pl. 1, fig. 1; pl. 8, fig. 23). Junction between inner and outer latticed layers referred to herein as the primary lamella. Outer latticed layer either completely developed (e.g., *Lanubus*, n. gen.) or incompletely developed (e.g., *Parvivacca*, n. gen.).

**Remarks:** The Parvivaccidae, n. fam., differ from the Pantanelliidae Pessagno by having a cortical shell comprised of two distinct latticed layers separated by a primary lamella. Taxa in both families share a single medullary shell, symmetrical, proportionately large, nodose polygonal pore frames, and similar spinal structure. It is conceivable that the Parvivaccidae were derived from the Pantanelliidae through the acquisition of a two layered, latticed cortical shell.

The Parvivaccidae differ from the Xiphostylidae Haeckel by possessing a medullary shell, proportionately larger pore frames, and by sometimes displaying a cortical shell with an incompletely formed outer latticed layer. Both families share a cortical shell with two distinct latticed layers.

**Range:** Superzone 1, Zone 1A, Subzone 1A<sub>1</sub> to Zone 4, Subzone 4 beta; Aalenian to upper Tithonian so far as known. See Pessagno et al. (1987b).

**Occurrence:** Tethyan Realm: Central Tethyan to Northern Tethyan Province. Boreal Realm: southern Boreal Province (sensu Pessagno et al. 1986; 1987a).

Genus *Lanubus* Pessagno and Yang, n. gen.

Type species: *Lanubus holdsworthi* Pessagno and Yang, n. sp.

**Description:** Cortical shell spherical, proportionately small with two adjacent, asymmetrically placed primary spines. Primary spines straight to curved, often quite long, usually unequal in length, triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Cortical shell with two complete layers of latticed meshwork (pl. 1, fig. 1).

**Remarks:** *Lanubus*, n. gen., differs from *Parvivacca*, n. gen., by having a cortical shell which is spherical in shape and by having two completely developed layers of latticed meshwork.

**Etymology:** *Lanubus* (M.) is a name formed by an arbitrary combination of letters (ICZN, 1985, p. 21, Art. 11b).

**Range:** Superzone 1, Zone 1A, Subzone 1A<sub>1</sub> to Zone 4, Subzone 4 beta; Aalenian to upper Tithonian so far as known. See Pessagno et al. (1987b).

**Occurrence:** Tethyan Realm: Central Tethyan Province to Northern Tethyan Province. Boreal Realm: Southern Boreal Province (sensu Pessagno et al. 1986; 1987a).

*Lanubus dickinsoni* Pessagno and Yang, n. sp.  
Plate 3, figures 5, 8, 10, 15.

**Description:** Cortical shell large, spherical; outer latticed layer with a mixture of hexagonal and rare pentagonal pore frames having small nodes at their vertices. Both primary spines wide, massive, subequal in length, widely separated, triradiate in axial section with three longitudinal grooves alternating with three longitudinal ridges; longitudinal grooves about two to three times as wide as ridges, extending to spinal tips; sides of grooves of shorter spine subparallel, converging on distal one quarter; sides of grooves of longer spine subparallel, converging on distal one third. Sides of shorter spine straight, subparallel except distally; inner edge of longer spine straight to spinal tip; distal half of outer edge of longer spine curved. Spinal tips pointed.

**Remarks:** *Lanubus dickinsoni*, n. sp., is compared to *L. purus*, n. sp., under the latter species.

**Etymology:** This species is named for Dr. William R. Dickinson (Univ. of Arizona) in honor of his many contributions to the geology of eastern Oregon.

**Measurements:** (μm) Holotype + 9 paratypes. See Text-figure 12 for explanation of the system of measurements.

	DD'	LL'	lw	SS'	w's	ww'
Holotype	115.8	162.2	34.7	139.0	30.1	46.3
Mean	120.9	160.8	40.5	144.7	27.7	54.4
SD	9.0	10.0	9.4	11.5	4.2	10.4
Max.	132.0	180.7	62.5	157.5	34.7	69.5
Min.	108.8	139.0	25.4	115.8	23.2	34.7

Type locality: OR-705. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424186. Paratypes = USNM 424187 and Pessagno Collection.

**Range:** Superzone 1, Zone 1B; lower Bajocian. See Pessagno et al. (1987b) and Text-figure 1 herein.

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figure 7.

***Lanubus holdsworthi*** Pessagno and Yang, n. sp.  
Plate 4, figures 15, 25.

**Description:** Cortical shell large, spherical; outer latticed layer of medium thickness (for genus), comprised of large hexagonal pore frames with interspersed smaller pentagonal pore frames. Pore frames thin-walled, having weakly developed nodes at vertices. Two primary spines subequal in length, widely separated proximally; proximal half of each spine curving outwards, distal half curving inwards; spinal tips pointed, both turned out of the spinal plane. Spines triradiate in axial section with three longitudinal ridges alternating with three longitudinal grooves. Ridges slightly narrower than grooves proximally, but progressively decreasing in width distally, merging at spinal tips. Grooves relatively shallow, gradually decreasing in width distally on longer spine; decreasing in width more rapidly on the distal half of the shorter spine.

**Remarks:** *Lanubus holdsworthi*, n. sp., differs from other species of *Lanubus*, n. gen., described herein by possessing primary spines which are quite curved and by having spinal tips which are both turned out of the spinal plane.

**Etymology:** This species is named for Dr. Brian Holdsworth (Univ. of Keele, U. K.) in honor of his pioneering contributions to the study of Paleozoic Radiolaria.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 6 paratypes. See Text-figure 12 for explanation of measurements.

	DD'	LL'	lw	SS'	w's	ww'
Holotype	126.0	160.0	46.3	140.0	33.6	84.0
Mean	115.6	170.4	43.6	150.0	33.9	74.8
SD	4.9	12.4	4.3	9.9	6.3	6.2
Max.	126.0	185.3	46.3	162.1	46.3	84.0
Min.	108.9	155.2	34.7	139.0	23.2	69.5

**Type locality:** OR-554. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424188. Paratypes = USNM 424189 and Pessagno Collection.

**Range:** Superzone 1, upper half of Zone 1B to lower half of Zone 1C; lower Bajocian. See Pessagno et al. (1987b) and Text-figure 1 herein.

**Occurrence:** Warm Springs Member of the Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. (1986, 1987a). See Text-figure 7.

***Lanubus purus*** Pessagno and Yang, n. sp.  
Plate 3, figures 6, 9, 13, 19.

**Description:** Cortical shell large, spherical with thick outer latticed layer consisting of a mixture of hexagonal and pentagonal pore frames with well-developed nodes at vertices. Hexagonal and pentagonal pore frames about equal in number, thin-walled. Bases of primary spines widely separated. Primary spines long, straight, medium width (for genus), subequal in length with three longitudinal ridges alternating with three deep longitudinal

grooves. Ridges and grooves about equal in width proximally, decreasing in width distally to spinal tips.

**Remarks:** *Lanubus purus*, n. sp., differs from *L. dickinsoni*, n. sp., by having more numerous pentagonal pore frames and by having longer, somewhat more slender primary spines with ridges and grooves which progressively decrease in width in a distal direction; the ridges and grooves of *L. dickinsoni* are for the most part parallel-sided. Moreover, the longitudinal grooves of *L. purus* tend to be deep whereas those of *L. dickinsoni* are shallow.

**Etymology:** Purus-a-um (Latin, adj.) = clean, pure.

**Measurements:** ( $\mu\text{m}$ ) Holotype + 7 paratypes. See Text-figure 12 for explanation of measurements.

	DD'	LL'	lw	SS'	w's	ww'
Holotype	115.8	139.0	34.7	115.8	27.8	64.8
Mean	116.3	146.2	30.0	120.7	23.8	66.8
SD	8.9	9.9	4.4	12.5	1.5	11.5
Max.	134.3	162.2	34.7	143.6	27.8	88.0
Min.	104.2	139.0	23.2	104.2	23.2	57.9

**Type locality:** OR-705. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424190. Paratypes = USNM 424191 and Pessagno Collection.

**Range:** Superzone 1, upper half of Zone 1B to lower half of Zone 1C; lower Bajocian. See Pessagno et al. (1987b). Text-figure 1 herein.

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). Text-figure 7 herein.

***Lanubus* sp. A**  
Plate 10, figures 10, 22.

**Remarks:** This form can be distinguished by its extremely long triradiate primary spines and its relatively small, nodose cortical shell. Moreover, one of its primary spines is longer than the other and displays slight curvature proximally.

**Range and Occurrence:** Zone 4, Subzone 4 beta; upper Tithonian so far as known. Loc. SA-43: volcanopelagic strata above the Stanley Mountain remnant of the Coast Range ophiolite at Alamo Creek; rare. See Locality Descriptions herein. Boreal Realm, Southern Boreal Province (sensu Pessagno et al. 1986; 1987a).

***Lanubus* sp. B**  
Plate 7, figures 1, 6.

**Remarks:** This form is characterized by its proportionately small cortical shell and by its slender, curved triradiate secondary spines.

**Range and Occurrence:** Upper part of Superzone 1; middle Oxfordian to lower Kimmeridgian. See Pessagno et al.

(1987b). Volcanopelagic strata above the Josephine ophiolite, Smith River subterranean, Klamath Mountains of northwestern California. Loc. JO-34; rare. Tethyan Realm, Central Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Lanubus* sp. C**

Plate 8, figures 3, 7, 9, 25.

**Remarks:** This form differs from *Lanubus* sp. B by having broad, massive, triradiate secondary spines.

**Range and Occurrence:** Zone 3 (undifferentiated) so far as known; lower Tithonian. Lower more massively-bedded member of the Taman Formation, east-central Mexico. MX-82-20; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Lanubus* sp. D**

Plate 8, figure 16.

**Range and Occurrence:** Same as for *Lanubus* sp. C.

***Lanubus* sp. E**

Plate 8, figure 2.

**Remarks:** Two primary spines closely spaced; longer spine much more massive than shorter spine.

**Range and Occurrence:** Same as for *Lanubus* sp. C. Rare.

***Lanubus* sp. F**

Plate 4, figures 6, 14.

**Remarks:** This species differs from *L.* sp. G, by having more widely separated spinal bases and by having straighter, narrower spines.

**Range:** Superzone 1, lower half of Zone 1C; lower Bajocian so far as known. See Pessagno et al. (1987b).

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. OR-554; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Lanubus* sp. G**

Plate 4, figures 5, 11, 12, 22.

**Remarks:** *Lanubus* sp. G differs from *Lanubus dickinsoni*, n. sp., by having closely spaced, narrower, less massive, primary spines with considerably narrower and deeper longitudinal grooves. In addition, *Lanubus* sp. G possesses a proportionately smaller cortical shell.

**Range:** Superzone 1, Zone 1C; lower Bajocian. See Pessagno et al. (1987b).

**Occurrence:** Warm Springs Member of Snowshoe Formation, Izee terrane, east-central Oregon. OR-554; rare. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

**Genus *Parvivacca* Pessagno and Yang, n. gen.**

**Type species:** *Parvivacca blomei* Pessagno and Yang, n. sp.

**Description:** Cortical shell cylindrical to subcylindrical, flattened on two opposed surfaces. Opposed flattened surfaces with two distinct layers of latticed meshwork. Outer layer of latticed meshwork missing on sides of test (pl. 1, fig. 7). Cortical shell with two asymmetrically placed, curved to straight primary spines which are triradiate in axial section. Spines with three longitudinal ridges alternating with three longitudinal grooves.

**Remarks:** *Parvivacca*, n. gen., differs from *Lanubus*, n. gen., by having a cylindrical to subcylindrical cortical shell with two flattened surfaces and by developing two layers of latticed meshwork only on the two flattened test surfaces (e.g., pl. 8, fig. 10).

**Etymology:** From *parvus*-a-um (Latin, adj.) = small + *vacca* (Latin, n.) = cow. Test resembling head of cow.

**Range:** Zone 2, Subzone 2 gamma to Zone 4, Subzone 4 beta; middle Oxfordian to upper Tithonian so far as known. At present we know of no occurrences of this genus from the Lower Cretaceous. See Pessagno et al. (1987 a, b).

**Occurrence:** Tethyan Realm: Central Tethyan Province to Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Parvivacca blomei* Pessagno and Yang, n. sp.**

Plate 10; figures 13, 14, 16, 18, 28.

**Description:** Cortical shell small, subcylindrical with two slightly arched opposed surfaces more or less paralleling spinal plane. Outer latticed layer of opposed surfaces quite thick, nodose. Cortical shell with hexagonal and rare pentagonal pore frames; pore frames with prominent nodes at vertices on opposed surfaces and with weakly developed nodes on sides. Approximately nineteen pore frames visible on opposed surfaces. Two primary spines long, curved, triradiate in axial section; one spine longer and more curved than other. Each spine with three massive, wide longitudinal ridges alternating with three deep, narrow longitudinal grooves. Grooves on proximal two thirds of each spine parallel sided; sides of grooves converging on distal one third. Proximal half of longer spine straight; distal half curved with spinal tip curved slightly inwards towards other spine. Distal one third of shorter spine straight; proximal two thirds slightly curved.

**Remarks:** *Parvivacca blomei*, n. sp., is distinguished from other species of *Parvivacca* by possessing long primary spines with broad longitudinal ridges and deeply incised, predominantly parallel-sided longitudinal grooves.

**Etymology:** This species is named for Dr. Charles D. Blome (U. S. Geol. Survey, Denver, Colorado) in honor of his contributions to the study of Mesozoic Radiolaria.

**Measurements:** ( $\mu\text{m}$ ). Holotype + nine paratypes. See Text-figure 12 for system of measurements.

	DD'	LL'	lw	SS'	w's	ww'	ht
Holotype	139.0	266.4	34.7	254.8	34.7	46.3	115.8
Mean	132.5	276.0	33.8	225.8	30.7	64.8	111.8
SD	22.5	61.1	7.0	32.7	8.5	18.0	17.0
Max.	185.3	405.4	41.7	266.4	46.3	92.6	150.6
Min.	97.3	208.4	20.8	162.1	20.8	46.3	88.0

**Type locality:** MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424192. Paratypes = USNM 424193 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian. See Pessagno et al. 1987a, b) and Text-figure 2 herein.

**Occurrence:** Upper, thin-bedded member of Taman Formation, east-central Mexico. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a). See Text-figures 9-10.

***Parvivacca simplex*** Pessagno and Yang, n. sp.  
Plate 10, figures 7, 11, 20, 21.

**Description:** Cortical shell quite cylindrical with two opposed, flat surfaces and with hexagonal (rare pentagonal) pore frames. Outer latticed layer on two opposed surfaces thick; nineteen pore frames( $\pm$ ) visible on each surface. Sides of cortical shell flat to slightly concave, lacking thick outer latticed layer. Two primary spines long, straight, triradiate in axial section with spinal axes approximately at right angles to each other; one spine slightly shorter than other. Three longitudinal ridges alternating with three deeply incised longitudinal grooves; ridges and grooves about the same width, very gradually decreasing in width distally. Facing sides of both spines relatively straight; opposite sides (outside) slightly curved.

**Remarks:** *Parvivacca simplex*, n. sp., differs from *P. blomei*, n. sp., by possessing long, straight primary spines and longitudinal grooves and ridges of about the same width. In addition, the ridges and grooves of *P. simplex* gradually decrease in width in a distal direction.

**Etymology:** Simplex-icis (Latin, adj.) = plain, simple.

**Measurements:** ( $\mu\text{m}$ ) Ten specimens: Holotype + nine paratypes. See Text-figure 12 for system of measurements.

	DD'	LL'	lw	SS'	w's	ww'	ht
Holotype	139.0	259.5	53.2	243.2	44.0	71.8	104.2
Mean	118.6	249.0	41.9	225.8	38.6	68.5	108.1
SD	14.0	24.7	8.3	18.1	7.2	6.3	13.7
Max.	139.0	296.5	53.2	254.8	44.0	81.0	139.0
Min.	104.2	208.5	23.2	185.3	23.2	57.9	97.6

**Type locality:** MX-84-13. See Locality Descriptions herein.

**Deposition of types:** Holotype = USNM 424194. Paratypes = USNM 424195 and Pessagno Collection.

**Range:** Zone 4, Subzone 4 beta; upper Tithonian so far as known. See Text-figure 2 herein and Pessagno et al. (1987a, b).

**Occurrence:** Taman Formation, east-central Mexico. Text-figures 9 and 10 herein. Tethyan Realm, Northern Tethyan Province (sensu Pessagno et al. 1986; 1987a).

***Parvivacca* sp. A**  
Plate 8, figures 10, 14.

**Remarks:** Cortical shell cylindrical; superficially resembling that of *Lanubus*, n. gen., viewed at right angles to plane of two spines.

**Range and Occurrence:** Zone 3 (undifferentiated); lower Tithonian. Tethyan Realm, Northern Tethyan Province. Upper part of lower, massively-bedded member of Taman Formation, east-central Mexico. MX-82-20: rare. See Pessagno et al. (1987a, b).

***Parvivacca* sp. B**  
Plate 8, figures 1, 23.

**Remarks:** Cortical shell very cylindrical with pore frames quite thickened in Z direction (sensu Pessagno et al. 1987a) on opposed surfaces parallel to plane of two spines. Pore frames on opposed surfaces with prominent irregular nodes. Two primary spines massive.

**Range and Occurrence:** Same as for *Parvivacca* sp. A.

***Parvivacca* sp. C**  
Plate 9, figures 10, 15.

**Remarks:** Similar to *Parvivacca* sp. B, but having slender, shorter, and more closely spaced primary spines. Nodes on opposed surfaces quite prominent, but rounded rather than irregular (pl. 9, fig. 15).

**Range and Occurrence:** Same as for *Parvivacca* sp. A.

***Parvivacca* sp. D**  
Plate 1, figure 7; plate 10, figure 5.

**Remarks:** This form differs from *Parvivacca blomei*, n. sp., by having shorter, more widely separated, and less curved secondary spines.

**Range and Occurrence:** Zone 4, Subzone 4 beta; upper Tithonian so far as known. Upper, thin-bedded member of Taman Formation, east-central Mexico. MX-82-37; rare. Tethyan Realm, Northern Tethyan Province. See Pessagno et al. (1987a, b).

## APPENDIX—LOCALITY DESCRIPTIONS

### Introduction

Localities in each of the terranes or geographic regions are listed in ascending order both chronostratigraphically and biostratigraphically. For a description of lithostratigraphic



units see Stratigraphic Summary herein. The following letter prefixes are used:

**QC** = Wrangellia terrane, Queen Charlotte Islands.

**OR** = Izee terrane, Blue Mountains Province, east-central Oregon.

**JO** = Smith River subterrane, northwestern California.

**NSF, SA** = Strata overlying Coast Range ophiolite, California Coast Ranges at Point Sal and Stanley Mountain (Alamo Creek).

**MX, USGS** = Taman—Tamazunchale area, east-central Mexico.

**Wrangellia terrane, Queen Charlotte Island, British Columbia**

**Kunga Group, Sandilands Formation. North Shore of Kunga Island**

**QC-543.** Thin-bedded "argillites" with limestone nodules. Sample a dark gray micritic limestone nodule from 34.4 m (113 f) above contact with "black limestone member". This sample occurs in an interval in the Sandilands Formation that is above the last occurrence of *Monotis subcircularis* Gabb (upper Norian) in the upper part of the "black limestone member" and below the first occurrence of Sinemurian ammonites (56.4 m) in the Sandilands Formation. See Stratigraphic Summary herein. Zone 05 (Hettangian); see Pessagno et al. 1987b).

**QC-545.** Dark gray micritic limestone nodule from 41.5 m (136 f) above the base of the Sandilands Formation. See comments under QC-543 above. Zone 05 (Hettangian); see Pessagno et al. 1987b.

**Maude Group, South Shore of Skidegate Inlet**

**QC-622.** Light gray micritic limestone bed about 20 cm thick from 38.2 m (125.5 f) above the base of the Maude Group. This horizon is situated 12.3 m (40.5 f) above a horizon where an ammonite submitted to Dr. Howard W. Tipper (Geol. Survey of Canada) was identified as *Dayiceras dayiceroides* (Mouterde). According to Dr. Tipper this ammonite is characteristic of the *Tragophylloceras ibex* Zone (lower Pliensbachian). Moreover, this horizon is situated 44.0 m below a horizon where an ammonite submitted to Dr. Tipper was identified as *Harpoceras* sp. cf. *H. exaratum* (Young and Bird). As noted by Pessagno et al. (1987b, p. 13), this ammonite was originally assigned by Dr. Tipper to the lower Toarcian. However, Cameron and Tipper (1985, p. 21, 23) now assign this species to the highest upper Pliensbachian (their "*Tiltoniceras*" *propinquum* fauna).

We assign sample QC-622 to Zone 01, Subzone 01A (upper Pliensbachian) because it contains *Gorgansium morganense* Pessagno and Blome, *Trillus elkhornensis* Pessagno and Blome, and *Xiphostylus* spp. and lacks zonal elements such as *Turanta* spp. and *Higumastra* spp. which mark the base of Subzone 01B. *Gorgansium morganense*,

*Trillus elkhornensis*, and *Xiphostylus* spp. are known from the upper Pliensbachian Nicely Formation in east-central Oregon. Furthermore, they are unknown from the lower Pliensbachian in the Queen Charlotte Islands or elsewhere.

**Blue Mountains Province, Izee terrane, east-central Oregon (John Day Inlier)**

**Nicely Formation**

**OR-536J, 536P.** Reddish-brown weathering, dark-gray, silty mudstone and shale with abundant dark-gray to black micritic limestone nodules varying from 15 cm to 0.9 m (6 in to 3 f). Limestone nodules containing common ammonites and abundant well-preserved pyritized Radiolaria. Sample OR-536J from 21 m (63 f) above base of Nicely Formation. Sample OR-536P from 38 m (125 f) above the base of the Nicely Formation. Zone 01, Subzone 01A. See Stratigraphic Summary above. U.S.G.S. Izee Quadrangle (15'): T17S; R27E; NE ¼ of section 14. Southeast side of Morgan Mountain; small creek west of Elkhorn Creek.

**Hyde Formation**

**OR-600A.** Massive, blue-gray volcanic wacke and andesitic tuff with thinner beds of dark-gray tuffaceous mudstone. Mudstone with dark-gray to black micritic limestone nodules near the base of the unit. Sample OR-600A from 61 m (200 f) above base of Hyde. Zone 01, Subzone 01B; highest upper Pliensbachian or lower Toarcian; see Stratigraphic Summary above. U.S.G.S. Izee Quadrangle (15'): T17S; R28E; SW ¼ section 30 adjacent to eastern boundary of section 25. Grant Co. Rd. 63 along South Fork of John Day River; just west juncture (bridge over river) of Rd. 63 and road to "Hole-in-the-Ground".

**Snowshoe Formation**

**OR-589A, 589H.** Warm Springs Member. Reddish-brown weathering, dark-gray, silty mudstone and shale with thin-bedded, discontinuous lenses of dark gray, micritic limestone bearing well-preserved silicified Radiolaria. Separate samples of micritic limestone from float from interval 1.5 m to 3.0 m (5 to 10 f) above and downhill from the contact with the volcanic wacke of the underlying Hyde Formation. Zone 01, Subzone 01B; lower or middle Toarcian. See discussion in Pessagno, Whalen, and Yeh (1986, p. 47) and Pessagno et al. (1987b, pp. 11-13). U.S.G.S. Izee Quadrangle (15'): T17S; R28E; NW ¼ section 29 (incorrectly cited as NE ¼ sec. 29 by Pessagno, Whalen, and Yeh 1986, p. 47) near southern boundary of section 20. West side of Schoolhouse Gulch, north-northwest of Izee.

**OR-84-8-7.** (= sample SG-84-8-7; Dr. Norman MacLeod, Museum of Paleon., Univ. Michigan, Ann Arbor). Sample collected by MacLeod for Ph. D. Dissertation at the University of Texas at Dallas. Warm Springs Member. Reddish-brown weathering, dark gray shale with common dark gray, micritic limestone nodules bearing well-preserved silicified Radiolaria. Sample from 10.6 m (35 f) above contact with underlying Hyde Formation. Super-



zone 1, Zone 1A, Subzone 1A<sub>2</sub>; upper middle Toarcian or lower upper Toarcian (see Pessagno, Whalen, and Yeh 1986, p. 47; Pessagno et al. 1987b, p. 11. U.S.G.S. Izee Quadrangle (15'): T17S; R28E; NE ¼ section 29 along southern boundary with section 20. Tributary gully to Schoolhouse Gulch; situated on east side of Schoolhouse Gulch, north-northeast of Izee.

**OR-84-8-8.** (= sample SG 84-8-8; Dr. Norman MacLeod, Museum of Paleon., Univ. Michigan, Ann Arbor). Sample collected 13.7 m (45 f) above contact with underlying Hyde Formation. Warm Springs Member. Reddish-brown weathering, dark gray shale with common dark gray, micritic limestone nodules bearing well-preserved Radiolaria. Superzone 1, Zone 1A, Subzone 1A<sub>2</sub>; upper middle to upper Toarcian. Same section as OR-84-8-7 (see above).

**OR-593.** Warm Springs Member. Reddish-brown weathering dark gray shale with common micritic limestone nodules bearing well-preserved silicified Radiolaria. Sample a limestone nodule from 36.5 m (120 f) above base of the Warm Springs Member. Superzone 1, Zone 1A, Subzone 1A<sub>1</sub>. Middle Jurassic, tentatively Aalenian. See discussion in Pessagno, Whalen, and Yeh (1986, pp. 47-48). Same section as OR-84-8-7 (see above for locality data).

**OR-580.** Warm Springs Member. Reddish-brown weathering fissile shale with 7.6 to 10.1 cm (3 to 4 in) layers of dark-gray silty micritic limestone. Position above contact with underlying Hyde Formation because of the contortion of the strata and the faulted nature of the contact. Superzone 1, Zone 1A, Subzone 1A<sub>1</sub>. Middle Jurassic; tentatively Aalenian. See discussion in Pessagno, Whalen, and Yeh (1986, pp. 47-48). U.S.G.S. Izee Quadrangle (15'): T17S; R28E; SW ¼ of section 30 near bridge over the South Fork of the John Day River; about 46 m (150 f) east of first turn in road to "Hole-in-the-Ground".

**OR-555.** Warm Springs Member. Reddish-brown weathering, dark gray shale with dark gray micritic limestone nodules and lenticular masses of dark gray silty limestone. Sample a limestone nodule with well-preserved silicified Radiolaria; collected 70m (230 f) above the base of the Warm Springs Member. Superzone 1, Zone 1B; uppermost Aalenian to lowermost lower Bajocian. See discussion in Pessagno, Whalen, and Yeh (1986, pp. 47-48). U.S.G.S. Izee Quadrangle (15'): T17S; R28E; SW ¼ of section 1. National Forest Service Rd. 16020 near Duncan Hollow; 2.88 km (1.8 m) west of intersection with Grant Co. Rd. 63 (Izee—Paulina road).

**OR-594.** Warm Springs Member. Same lithology as OR-555. Sample a limestone nodule from 41 m (135 f) above the contact with the Hyde Formation in same section with OR-84-8-7, 84-8-8, 593, and 595. Superzone 1, Zone 1B; lower Bajocian. See Pessagno, Whalen, and Yeh (1986, p. 48). Same section as OR-84-8-7 (see loc. OR-84-8-7 above for locality data).

**OR-595.** Same lithology as OR-555. Sample a limestone nodule containing well-preserved silicified Radiolaria;

from 44.2 m (145 f) above the contact with the Hyde Formation in same section with OR-84-8-7, 84-8-8, 593, 594. Superzone 1, Zone 1 B; lower Bajocian. See Pessagno, Whalen, and Yeh (1986, p. 48) for discussion of ammonite biostratigraphic data and its chronostratigraphic implications.

**OR-705.** Warm Springs Member. Reddish-weathering, fissile, dark-gray shale with lenticular masses of dark-gray silty limestone and dark-gray micritic limestone nodules bearing well-preserved silicified Radiolaria. Superzone 1, Zone 1B; lower Bajocian. Below OR-516 (see below) in section; near fault contact (high angle reverse fault) with Silvies Member of Snowshoe Formation. USGS Logdell Quadrangle (15'): T16S; R29E; SE ¼ of section 21 along logging road on west side of ridge that crosses Grant Co. Rd. 63; just south of Grant Co. Rd. 63.

**OR-706.** Warm Springs Member. Dark-gray, fissile shale with lenticular masses of dark-gray silty limestone and micritic limestone nodules exposed in bed of Wickiup Creek. Sample a limestone nodule bearing well-preserved silicified Radiolaria. Superzone 1, Zone 1B; lower Bajocian. U.S.G.S. Logdell Quadrangle (15'): T16S; R29E; at extreme NE corner of section 22 near juncture of sections 14, 15, 22, and 23. Bed of Wickiup Creek; opposite a point 0.19 km (0.12 mi) from intersection of NFS Rd. 24 and Grant Co. Road 63.

**OR-709.** Warm Springs Member. Reddish-brown weathering dark-gray shale with beds and lenticular masses of dark-gray silty limestone. Shale with very abundant dark-gray micritic limestone nodules containing well-preserved silicified Radiolaria. Sample a limestone nodule collected about 106 m (350 f) above contact between the Warm Springs Member and the underlying Hyde Formation. Superzone 1, Zone 1B; upper part of lower Bajocian. A large ammonite (MA-15-5) that we collected from the same horizon as the radiolarian sample was identified by Dr. Paul Smith (Univ. British Columbia; report 5-24-85) as *Stephanoceras (Skirrocera) kirschneri* Imlay. According to Dr. Smith this ammonite taxon is characteristic of the North American Kirschneri Zone of Hall and Westermann (1980) and is correlative with the upper part of the Sauzei Standard Zone and the Humphriesianum Standard Zone of Europe. USGS Izee Quadrangle (15'): T16S; R28E; NE ¼ section 36. NFS Road 509 1.28 km (0.8 mi) from juncture with trunk NFS road and 1.9 km (1.2 mi) west of intersection with Grant Co. Road 63 (Not "0.79 km"; 1.3 mi as stated in Pessagno, Whalen, and Yeh, *ibid.*, p.48).

**OR-554.** Warm Springs Member. Dark-gray shale with dark-gray micritic limestone nodules bearing well-preserved silicified Radiolaria. Approximately 168 m (550 f) above base of Warm Springs Member; east of fault of unknown displacement. Same section with OR-555 (See above). Superzone 1, Zone 1C; upper part of lower Bajocian; associated ammonites include *Stephanoceras (Skirrocera) juhlei* Imlay (See Pessagno, Whalen, and Yeh 1986, p. 48 for detailed discussion of biostratigraphic and chronostratigraphic implications). USGS Izee Quadrangle (15'): T17S; R28E; SE ¼ of section 1. NFS road

16020; 2.0 km (1.3 mi) west of intersection with Grant Co. road 63 (Izee—Paulina Rd.). Divide between Duncan Hollow and Bunton Creek.

**OR-516.** Warm Springs Member. Reddish-brown weathering, dark gray shale and mudstone with rare dark-gray micritic limestone nodules bearing silicified well-preserved silicified Radiolaria. Same area as OR-705. Superzone 1, Zone 1C (upper part); upper part of lower Bajocian; see discussion of biostratigraphy and chronostratigraphy in Pessagno, Whalen, and Yeh, p. 48. Radiolarian assemblage with *Turanta barbara* Pessagno and Blome and *Zartus imlayi* Pessagno and Blome. USGS Logdell Quadrangle (15'): T16S; R29E; SE ¼ section 21. Northwest side of Grant Co. road 63 (Izee—Paulina Rd.) at elevation of 1585 m (5200 f); somewhat north of Little Snowshoe Creek. 6.2 km (4.2 mi) west of Bear Valley Ranger Station.

**OR-523.** South Fork Member. Dark-gray mudstone with abundant dark-gray micritic limestone nodules and interbedded graywacke. Limestone nodules bearing sparse assemblage of well-preserved silicified Radiolaria. Overturned succession adjacent to and above contact with underlying Silvie Member. Superzone 1, Zone 1C. The most diagnostic elements in the sparse radiolaria assemblage are *Zartus imlayi* Pessagno and Blome and *Turanta barbara* Pessagno and Blome. *Zartus imlayi* makes its first appearance in the upper half of Zone 1C and its final appearance at the top of Zone 1D. *Turanta barbara* first appears at the base of Zone 1B and ranges up to the top of Zone 1D. Because the underlying Schoolhouse Member (interfingers with the Silvie Member in this area) contains *Lupherites* Imlay and the lower part of the South Fork Member (this area) contains *Leptosphinctes* Buckman, we assign the strata at OR-523 to the lower part of the upper Bajocian (See Pessagno et al. 1987b, p. 10; Smith 1980, p. 1607). As noted by Smith (1980) and by Westermann and Ricardi (1979, table 9), both *Lupherites* and *Leptosphinctes* first appear at the base of the upper Bajocian ROTUNDUM Zone in the Western Hemisphere. It should be noted also that the Silvie Member is time-transgressive from west (Bunton Hollow area) to east (Seneca area). Thus, at OR-523, in the western part of the area that the Silvie Member crops out, the base of Silvie Member is assignable to the lower part of the ROTUNDUM Zone and to the upper part of Zone 1C (lower upper Bajocian); however, in the eastern part the area in which the Silvie crops out the base of the Silvie occurs higher in the ROTUNDUM Zone and in Zone 1E. USGS Izee Quadrangle (15'): T17S; R29E; SW ¼ section 6. 0.32 km (0.2 mi) on NFS 16020, west of intersection with Grant County Road 63. Same general area as OR-555, 554, and 513.

**OR-515.** Silvie Member. Distal turbidite facies. Massive, somewhat conglomeratic graywacke interbedded with lenticular masses of silty, dark-gray limestone and dark-gray siliceous mudstone containing common dark-gray, silty, micritic limestone nodules with well-preserved silicified Radiolaria. Superzone 1, Zone 1D; lower part of upper Bajocian. Ammonites collected from this locality were

identified by Dr. R. W. Imlay (formerly USGS, Washington, D. C. as *Stephanoceras* sp. cf. *S. nodosum* (Quenstedt). The presence of *Perispyridium dimitricai* Pessagno and Blome, *Zartus imlayi* Pessagno and Blome, *Pantanellium baileyi* Pessagno and Blome, and *Pantanellium malheureuse* Pessagno and Blome suggests that this Zone 1D assemblage is approximately equivalent to that present at OR-513 (South Fork Member; see below). The OR-513 assemblage differs by lacking *Perispyridium dimitricai*. The fact that this Silvie assemblage is younger than that occurring in the lower part of the South Fork Member at OR-523 demonstrates the time transgressive nature of the Silvie from west to east (See OR-523 above). USGS Logdell Quadrangle (15'): T16S; R30E; western edge of section 7 along Grant County Road 63 (Izee—Paulina Rd.). 0.48 km (0.3 mi) east of Bear Valley Ranger Station.

**OR-513C.** South Fork Member, near unconformable contact with overlying Trowbridge Formation (Callovian). Dark-gray mudstone and graywacke. Mudstone with common dark-gray limestone nodules containing well-preserved silicified Radiolaria the predominant lithofacies. Superzone 1, Zone 1D; lower upper Bajocian (equivalent to lower ROTUNDUM Zone; see discussion under OR-523 above.). U.S.G.S. Izee Quadrangle (15'): T17S; R29E; SW ¼ section 7.

**OR-549A,B,C.** Snowshoe Formation (undifferentiated). 76.2 m (250 f) of dark-gray mudstone with very abundant, dark-gray, micritic limestone nodules containing well-preserved silicified Radiolaria. Mudstone with minor amounts of thin-bedded graywacke. Superzone 1, Zone 1E; upper part of upper Bajocian. As indicated by Pessagno, Whalen, and Yeh (1986, p. 48), the ammonite assemblage at this locality contains *Leptosphinctes* Buckman and *Megasphaeroceras rotundum* Imlay and is assignable to the upper Bajocian ROTUNDUM Zone or its European equivalents. The radiolarian assemblage in samples OR-549A-C differs from that at OR-513C (See above) by containing *Parvicingula media* Pessagno and Whalen, *P. burnensis* Pessagno and Whalen, *P. grantensis* Pessagno and Whalen, *Turanta nodosa* Pessagno and Blome, and species of *Pachyonchus* Pessagno and Blome. Moreover, it lacks *Zartus imlayi*, *Pantanellium baileyi*, and *Pantanellium malheureuse* which are characteristic of Zone 1D (See OR-515). The strata at OR-549 rest conformably(?) beneath the base of massive conglomerate and graywacke of the basal part of the Silvie Member in the eastern-most part of its area of exposure (See OR-523 above). Samples OR-549 A and OR-549-B represent limestone nodules collected 6.0 m (20 f) below the contact with the overlying Silvie Member; sample OR-549C represents a limestone nodule collected approximately 21 m (70 f) below OR-549A,B. U.S.G.S. Seneca Quadrangle (15'): T17S; R31E; SW ¼ section 2. Prominent exposure on northeast side of U.S. Highway 395; 1.44 km (0.9 mi) south of Seneca and intersection with Shirttail Creek Road on the north side of Soda Valley.

**OR-550A,C.** Upper part of Silvie Member. Interbedded dark-gray mudstone, massive graywacke, and dark-gray

micritic, tuffaceous limestone. Samples from dark-gray limestone. Superzone 1, upper part of Zone 1E; upper Bajocian. Imlay (1973, p. 29) recorded a rich ammonite assemblage from this quarry. He indicated that these strata are definitely late Bajocian as shown by the presence of *Spiroceras bifurcatum* (Quenstedt). See Pessagno, Whalen, and Yeh (1986, p. 49) for discussion of radiolarian biostratigraphic data. U.S.G.S. Seneca Quadrangle (15'): T17S; R31E; NE ¼ section 3. Large quarried area on both sides of Shirttail Creek. Samples A and C collected east and west of creek respectively.

**OR-501A,B,C.** Uppermost part of South Fork Member. Dark-gray mudstone with common small limestone nodules just below contact with green vitric tuff at base of overlying Trowbridge Formation. Interbedded graywacke becoming more common down section at this locality. Samples OR-501A-C collected in 1 m (3.28 f) interval immediately below the contact with the overlying Trowbridge Formation in order shown on occurrence chart (text-fig. 8). Superzone 1, Zone 1F; upper Bathonian. See discussion of ammonite and radiolarian biostratigraphic data in Pessagno, Whalen, and Yeh (1986, p. 49) and in Pessagno et al. (1987b, p. 9). USGS Izee Quadrangle (15'): T17S; R29E; SE ¼ section 29. Strata cropping out on northeast side of Grant County Road 63 (Izee—Paulina Rd.) about 0.65 km (0.4 mi) east of Izee.

#### LONESOME FORMATION

**OR-530.** Interbedded graywacke and dark-gray siliceous mudstone bearing small, dark-gray micritic limestone nodules. Sample from a small limestone nodule bearing well-preserved silicified Radiolaria. U.S.G.S. Izee Quadrangle (15'): T18S; R28E; NW ¼ section 3; about 0.16 km (0.1 mi) west of BM 4186 on road between Izee and Burns. North side of road adjacent to South Fork of John Day River near prominent meander bend.

#### WESTERN KLAMATH TERRANE, SMITH RIVER SUBTERRANE: VOLCANOPELAGIC STRATA AND GALICE STRATA OVERLYING THE JOSEPHINE OPHIOLITE, KLAMATH MOUNTAINS, NORTHWESTERN CALIFORNIA

*Measured section of sedimentary strata overlying the Josephine ophiolite (JO) at Harper (1983) Locality 1: Localities JO-6—JO-50 herein. 44.8 m (147 f) of volcanopelagic strata (VP) overlain by 56.0 m (184 f) of flysch (Galice s.l.). USGS Gasquet Quadrangle (15'): T17N; R2E; eastern edge of section 16. Middle Fork of Smith River; just upstream from mouth of Little Jones Creek.*

**VP strata (See Text-figure 4 and Stratigraphic Summary herein)**

**JO-6.** Medium gray pelagic limestone with well-preserved silicified Radiolaria. 4.1 m (13.5 f) above contact with JO. Upper part of Superzone 1 (undifferentiated); upper Callovian to Oxfordian.

**JO-8.** Same. 12.8 m (42.2 f) above contact with JO. Upper part of Superzone 1 (undifferentiated); upper Callovian to Oxfordian.

**JO-34.** Same. 17.6 m (58.0 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-10.5.** Same. 20.3 m (66.7 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**Galice Formation s.l. (See Text-figure 4 and Stratigraphic Summary herein)**

**JO-17.** Light-gray pelagic limestone with well-preserved silicified Radiolaria. 60.2 m (197.7 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-19.** Same. 64.2 m (210.7 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-48.** Same. 66.6 m (219 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-49.** Same. 70 m (229 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-50.** Same. 73.3 m (240.7 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

**JO-79.** Same. 91.4 m (300.0 f) above contact with JO. Zone 2, Subzone 2 gamma (middle Oxfordian).

#### CALIFORNIA COAST RANGES

**Volcanopelagic strata (VP) overlying Coast Range ophiolite remnants**

**Point Sal remnant:** USGS Point Sal Quadrangle (7.5'): T10N; R36W; near western edge of section 34 along shore. 0.9 km (0.6 mi) N15° W of west side of Lion Rock. Santa Barbara Co., California. See Pessagno, Blome, and Longoria (1984, p. 31).

**NSF-907.** VP succession. Lens about 0.4 m (1.5 f) thick of light-gray tuffaceous limestone occurring in light-green to light-gray tuffaceous chert. 11.5 m (38 f) above contact with CRO. Zone 2, Subzone 2 alpha; uppermost Kimmeridgian (lowermost Tithonian). See Pessagno et al. (1987b).

**NSF-908.** VP succession. Small, light-gray, micritic limestone nodules occurring in light-green tuffaceous chert at 13.4 m (44 f) above contact with the CRO. Zone 3, Subzone 3 beta; lower Tithonian (uppermost Kimmeridgian?). See Pessagno et al. (1987a, p. 14; 1987b, pp. 6-7).

**NSF-909.** VP succession. Small light-gray, micritic limestone nodules occurring in light-green to gray tuffaceous chert at 15.8 m (52 f) above contact with the CRO. Zone 3, Subzone 3 beta.

**Stanley Mountain remnant:** USGS Huasna Peak Quadrangle (7.5'): T12N; R32W; northwestern part of section 32; southwestern part of section 29. Alamo Creek, San Luis Obispo Co., California. See Pessagno, Blome, and Longoria (1984, p. 31).



**SA-973** in Text-figure 9 (= NSF-973 of Pessagno 1977a; Pessagno, Blome, and Longoria 1984). VP succession. Thin-bedded, dark-gray micritic limestone interbedded with dark-gray, thin-bedded tuffaceous chert. Sample from limestone bed 15 to 20 cms (6 to 8 in) thick. 45.5 m (149.5 f) above contact with CRO. Zone 2, Subzone 2 beta; upper part of lower Kimmeridgian or lower part of upper Kimmeridgian sensu gallico.

**SA-35.** VP succession. Dark-gray, tuffaceous, micritic limestone bed 20.3 cm (8 in) thick. 79.5 m (261 f) above contact with CRO. Zone 3, Subzone 3 alpha; lower Tithonian.

**SA-43.** VP succession. Silty, dark-gray limestone bed 5 cm (2 in) thick interbedded with thin-bedded, reddish-brown, tuffaceous chert. 100.6 m (330 f) above the contact with CRO; 2.4 m (8 f) below top of exposed (VP) section. Covered interval separates reddish-brown chert of VP succession from faulted contact with Great Valley Supergroup. Zone 4, Subzone 4 beta; upper Tithonian.

#### HUAYACOCOTLA SEGMENT OF THE SIERRA MADRE ORIENTAL, EAST-CENTRAL MEXICO

##### Taman Formation

**Taman-Tamazunchale area, San Luis Potosi.** See Pessagno, Longoria, MacLeod, and Six (1987a, pp. 4-5; figs. 1-2) or Yang and Pessagno (1989, text-figs 1-2).

**MX-82-3.** Lower, massively-bedded member of Taman Formation. Sample from platy, thin-bedded black micritic limestone beds about 2.54 to 7.5 cm (0.99 to 2.9 in) thick which are interbedded with black, massive, micritic limestone. Zone 2, Subzone 2 beta; somewhat above first occurrence of *Aulacomyella Furlani*. No lower than *Idoceras* Zone (Cantú Chapa 1971); upper part of lower Kimmeridgian. Radiolarian faunal assemblage lacks *Mirifusus* Pessagno. Somewhat west of Km. 266 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-6.** Lower, massively-bedded member of Taman Formation. Sample from platy, thin-bedded, black micritic limestone bed about 15 cm thick. Zone 2, Subzone 2 beta. About 45 m (147 f) west of Km. 266 on Rt. 85 (Mexico, D.F.—Nuevo Laredo highway).

**MX-82-8A,B.** Lower, massively-bedded member of Taman Formation. Samples A and B from adjacent 10 cm and 20 cm (respectively) beds consisting of medium gray, micritic limestone interbedded with massive, medium gray micrite. Zone 2, Subzone 2 beta (lower part) with *Mirifusus mediodilatata* Ruest; upper Kimmeridgian. Just east of Km. 266 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**USGS Mesozoic Locality 20815.** Sample from Dr. Ralph Imlay (retired USGS, Washington, D.C.). Collector Alvarez; November 17, 1947. Sample with abundant *Aulacomyella neogae* Imlay and silicified Radiolaria. Lower, massively-bedded member of Taman Formation. Zone 2, Subzone 2 beta. About 8 km south of Tamazunchale near La Cuesta and old kilometer post Km

360 on Rt. 85 (México, D.F.—Nuevo Laredo highway). Note: Kilometer posts have been re-numbered in reverse order on this highway during the last 25 years.

**MX-84-23.** Lower, massively-bedded member of Taman Formation. Medium to massively-bedded, dark-gray, micritic limestone. Sample from flattened dark-gray micritic limestone nodule 15 cm (5.9 in) in diameter. Zone 2, Subzone 2 beta; upper Kimmeridgian. About 30.5 m (100 f) west of Km. 265 on Rt. 85 (México, D.F.—Nuevo Laredo highway). At MX-80-20 which is situated at Km 264.9 (not Km 264.2 as stated by Pessagno, Blome, and Longoria 1984, p. 33), an ammonite submitted to Dr. Ralph Imlay (USGS, Washington, D.C.; report referred fossils directed to E.A.P.; Nov. 1980) was said to greatly resemble *Subneumayria profulgens* (Burckhardt) of "Middle Kimmeridgian" age. *Aulacomyella neogae* Imlay also occurs in abundance at MX-80-20.

**MX-80-23A1,A2:** Lower, massively-bedded member of the Taman Formation. Black, medium to massively-bedded micritic limestone with abundant *Aulacomyella neogae*. Samples A<sub>1</sub>, A<sub>2</sub> from adjacent beds. Zone 2, Subzone 2 beta; upper Kimmeridgian. About midway between Km 266 and Km 267 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-15.** Lower, massively-bedded member of Taman Formation. Massively-bedded, dark-gray, micritic limestone with thin shale interbeds. Sample from large, spherical limestone nodule containing *Aulacomyella neogae* and an indeterminate ammonite. Zone 2, Subzone 2 alpha; uppermost Kimmeridgian sensu gallico (lowermost Tithonian?). Just east of Km 267; opposite store before turn in road. Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-16.** Lithology as with MX-82-15. Sample from large, medium-gray, micritic limestone nodule; strata with well-developed chevron folds. Zone 2, Subzone 2 alpha; uppermost Kimmeridgian (lowermost Tithonian). See Pessagno et al. 1987b, pp. 7-8. (Note: In addition, to containing *Parvicingula* s.s., the radiolarian assemblage at MX-82-15 and 82-16 is characterized by the presence of *Napora boneti* Pessagno, Whalen, and Yeh.) Km 267.2 just east of turn in road. Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-17.** Lower, massively-bedded member of Taman Formation. Medium to massively-bedded, dark-gray, micritic limestone with dark-gray micritic limestone nodules in thin shale interbeds. Sample is a 8.8 cm limestone nodule containing pyritized Radiolaria. Zone 3 (undifferentiated); lower Tithonian. Radiolarian assemblage with common *Napora burckhardti* Pessagno, Whalen, and Yeh. Km 267.35 just west of stream crossing. Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-81-54.** Lower, massively-bedded member of Taman Formation. Medium to massively-bedded, dark-gray, micritic limestone with thin shale interbeds bearing small, dark-gray, micritic limestone nodules. Sample from limestone nodule in shale bed. Abundant, well-preserved



pyritized Radiolaria. *Aulacomyella neogae* Imlay occurring just above this horizon. Zone 3 (undifferentiated); lower Tithonian. Radiolarian assemblage with common *Napora burckhardti* Pessagno, Whalen, and Yeh. 0.48 km west of Km 268 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-19A,B.** Lower, massively-bedded member of Taman Formation. Medium to massively-bedded, dark-gray, micritic limestone with thin shale interbeds bearing limestone nodules. Samples from two limestone nodules about 15 cm in diameter; limestone nodules bearing well-preserved pyritized Radiolaria. Zone 3 (undifferentiated); lower Tithonian. Radiolarian assemblage with common *Napora burckhardti* Pessagno, Whalen, and Yeh. 20 m (65.6 f) below the first occurrence of *Crassicollaria intermedia* (Durand Delga) in the lower, massively-bedded member. Slightly east of MX-81-54 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-20A,B.** Lower, massively-bedded member of Taman Formation. Same lithology as MX-82-19. 10 m (32.8 f) below the first occurrence of *Crassicollaria intermedia*. Note: Contact between lower and upper members of the Taman Formation occurs immediately west of Km. 268 on Rt. 85 (México, D.F.—Nuevo Laredo highway). *Crassicollaria intermedia* first occurs in the lower Taman about 6 m (20 f) below the contact with the upper Taman. *Aulacomyella neogae* observed just below contact with upper Taman.

**MX-84-8.** Lower, massively-bedded member of the Taman Formation. Medium to massively-bedded, medium gray, micritic limestone interbedded with thin-bedded shale and siltstone. Sample from medium-gray, micritic, ellipsoidal limestone nodule (61 x 45 cm). Section repeated by faulting. Zone 4, lowermost part of Subzone 4 beta; upper Tithonian. About 6 m (20 f) below contact with upper, thin-bedded member of Taman Formation. Just west of Longoria Station 0. Km 265.6 on Rt. 85 (México, D.F.—Nuevo Laredo highway).

**MX-82-33.** Lower, massively-bedded member of Taman Formation. Medium to massively-bedded, medium-gray micritic limestone and thin-bedded shale. Sample from large medium-gray, micritic limestone nodule bearing silicified Radiolaria and abundant *Aulacomyella neogae*. Zone 4, lower part of Subzone 4 beta. The radiolarian assemblage from this sample contains *Pantanellium westermanni* Pessagno and MacLeod and *Vallupus* spp. (See Pessagno, Longoria, MacLeod, and Six, 1987a). About 5.4 m (18 f) below the contact with upper, thin-bedded member of the Taman Formation. Río Moctezuma just west of old hanging foot bridge on east side of Barrio de Guadalupe (opposite Taman, S.L.P.). West side of anticlinorium.

**MX-84-6.** Upper, thin-bedded member of Taman Formation. Thin-bedded, medium to dark-gray micritic limestone interbedded with thick intervals of calcareous shale and siltstone bearing dark-gray micritic limestone nodules. Sample is a small limestone nodule (9 cm in diameter). Zone 4, Subzone 4 beta; upper Tithonian. About

10.6 m (35 f) above contact with lower Taman. West flank of small syncline along new road north (above) Barrio Guadalupe; beyond first major turn in road. 0.77 km (0.48 mi) from new highway bridge over Río Moctezuma.

**MX-85-22, 85-23, 85-24, 85-25, 85-26, 85-27.** Upper, thin-bedded member of Taman Formation. Lithology as at MX-84-6. Samples limestone nodules bearing well-preserved silicified Radiolaria. Zone 4, Subzone 4 beta. Measured section of upper Taman along north side of Río Moctezuma just west of Barrio Guadalupe along foot trail. Upper Taman infolded into lower Taman in small, tight synclinal fold. Cantú Chapa (1971, fig. 1, area 2, loc Af. 21) found *Mazapilites* Burckhardt in these beds (See Pessagno, Longoria, MacLeod, and Six 1987a, pp. 13-14; Yang and Pessagno 1989).

**MX-85-22.** Small limestone nodule 50 m (166.5 f) above contact with lower Taman on east side of syncline; Zone 4, Subzone 4 beta; upper Tithonian.

**MX-85-23A,B.** Samples A and B are small limestone nodules from same bed. 63.7 m (209 f) above contact with lower Taman on east flank of syncline. Zone 4, Subzone 4 beta; upper Tithonian.

**MX-85-24.** Small limestone nodule. 64.9 m (213 f) above contact with lower Taman on east flank of syncline. Zone 4, Subzone 4 beta; upper Tithonian.

**MX-85-25.** Small limestone nodule. 67.3 m (221 f) above contact with lower Taman on east flank of syncline. Zone 4, Subzone 4 beta; upper Tithonian.

**MX-85-26.** Same. 68.2 m (223.8 f) above contact with lower Taman on east flank of syncline. Zone 4, Subzone 4 beta.

**MX-85-27A,B.** Two small limestone nodules from same bed. 70.0 m (229.8 f) above contact with lower Taman on east flank of syncline. Zone 4, Subzone 4 beta; upper Tithonian.

**MX-84-9.** Upper, thin-bedded member of Taman Formation. Thin-bedded, medium to dark-gray micritic limestone interbedded with thick intervals of dark-gray, buff-weathering shale and siltstone bearing limestone nodules. Sample a limestone nodule with well-preserved silicified Radiolaria. Zone 4, Subzone 4 beta; upper Tithonian. 10.6 m (35 f) above contact with lower Taman. West flank of small syncline along new road north (above) Barrio de Guadalupe; beyond first major turn in road. 0.77 km (0.48 mi) from new highway bridge over Río Moctezuma.

**MX-85-39.** Upper, thin-bedded member of Taman Formation. Thin-bedded, dark-gray micritic limestone with relatively thick interbedded dark-gray shale and siltstone containing large, micritic limestone nodules. Zone 4, Subzone 4 beta; upper Tithonian. Rt. 85 (México, D.F.—Nuevo Laredo highway). 1.6 km (0.99 mi) west of Taman.

**MX-84-13.** Lithology and sample as at MX-84-9. Zone 4, Subzone 4 beta; upper Tithonian. About 62 m (204 f) above

contact with lower Taman on east side of same syncline as MX-84-9. 1.0 km (0.62 mi) from new highway bridge over Río Moctezuma at second major bend in road. Note: This horizon is about 32 m (105 f) above the occurrence of an ammonite tentatively identified by Dr. Arnold Zeiss (Universität Erlangen-Nürnberg) as *Hildoglochiceras* aff. *tenuicostatum* Collignon at MX-85-35. MX-85-35 is situated 30 m (96.8 f) above the contact with the lower Taman on the east flank of the same synclinal structure.

**MX-84-15.** Upper, thin-bedded member of Taman Formation. Thin-bedded, medium to dark-gray micritic limestone interbedded with thick intervals of dark-gray, buff-weathering shale and siltstone bearing limestone nodules. Sample a limestone nodule with well-preserved silicified Radiolaria. Zone 4, Subzone 4 beta; upper Tithonian. Approximately the same horizon as MX-84-13. 1.2 km (0.75 mi) from new highway bridge over Río Moctezuma; just beyond second major bend in new road north of (above) Barrio de Guadalupe.

**MX-84-12.** Same lithology as at MX-84-15. About 10 m (32 f) above MX-84-13 (See above) on east flank of same synclinal structure. Zone 4, Subzone 4 beta; upper Tithonian.

**MX-84-11A,C.** Same lithology as at MX-84-15. Samples A and C are separate limestone nodules from same bed. Zone 4, Subzone 4 beta; upper Tithonian. About 20 m (65.6 f) above MX-84-12. Approximately 0.99 km (0.62 mi) from new bridge over Río Moctezuma on road north of (above) Barrio de Guadalupe.

**MX-84-10 B,C.** Same lithology as at MX-84-15. Same horizon as MX-84-11, but on west side of synclinal axis. Samples from small limestone nodules. Zone 4, Subzone 4 beta; upper Tithonian. About 0.94 km (0.58 mi) from new highway bridge over Río Moctezuma on road north of (above) Barrio de Guadalupe.

**MX-82-37A,C,D,E,F,H,I.** Thin-bedded, dark-gray micritic limestone with thick interbeds of dark-gray shale and siltstone bearing very abundant fist-sized limestone nodules. Zone 4, Subzone 4 beta. Axial zone of synclinal structure on east side of Barrio de Guadalupe. About 10 m (32 f) above MX-84-11. Road north of (above) Barrio de Guadalupe; 0.94 km (0.58 mi) from new highway bridge over Río Moctezuma.

**MX-85-18.** Upper, thin-bedded member of Taman Formation. Thin-bedded, dark-gray to black, micritic limestone with very thick intervals of buff-weathering siltstone and shale with rare limestone nodules. Sample from thin-bedded, black, micritic limestone bed. Zone 4, Subzone 4 beta (upper part); upper Tithonian. Locality occurs west of NE-SW trending fault. Down road about 40 m from MX-84-26 (see below). About 2.5 km (1.55 mi) from new highway bridge over Río Moctezuma on road north of (above) Barrio de Guadalupe.

**MX-84-26.** Same as MX-85-18 lithologically, but containing large limestone nodules bearing *Salinites grossicostatum* (Imlay) (ammonites identified by Dr. Arnold Zeiss,

Universität Erlangen-Nürnberg) and abundant silicified Radiolaria. Zone 4, Subzone 4 beta (upper part); upper Tithonian. Exposed west of prominent NE-SW trending fault. 2.57 km (1.6 mi) from highway bridge over Río Moctezuma on new road north of (above) Barrio de Guadalupe. Note: Pimienta Formation s.s. exposed 0.48 km (0.3 mi) up road from MX-84-26; intervening interval covered.

**Huauchinango area, Puebla.** See Pessagno, Longoria, MacLeod, and Six (1987a, fig. 1). (cf. Cantú Chapa 1971, fig. 1, area, Af.-1).

**MX-84-38A—E.** Upper, thin-bedded member of Taman Formation. Black, carbonaceous, thin-bedded micritic limestone with medium-bedded intervals of buff-weathering shale and occasional olistostromal masses. Zone 4, Subzone 4 alpha; upper Tithonian. About 61 m (200 f) above Cantú Chapa's (1971) locality Af. 1 (= "*Suarites bituberculatum* Zone"). Four additional samples collected above Cantú Chapa's locality and below MX-84-38 also contain a Subzone 4 alpha radiolarian assemblage.

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## REFERENCES

- AITA, Y., 1987. Middle Jurassic to Lower Cretaceous radiolarian biostratigraphy of Shikoku with reference to selected sections in Lombardy Basin and Sicily. *Tohoku Univer., Sci. Rep., 2nd ser. (Geol.)*, 58(1):1-91, 37 figs., 1 table, 14 pls.

- ANDERSON, O. R., 1983. Radiolaria. Springer Verlag, New York:355 pp.
- BÉ, A. W. H. and ERICKSON, D. B., 1963. Aspects of calcification in planktonic foraminifera (Sarcodina). New York Acad. Sci., Ann., 109(1): 65-81, 10 text-figs.
- BAUMGARTNER, P. O., 1980a. Late Jurassic Hagiastriidae and Patulibracchiidae (Radiolaria) from the Argolis Peninsula (Peloponnesus, Greece). *Micropaleontology*, 26(3):274-322.
- , 1980b. Systematic Paleontology. In: Baumgartner, P. O., De Wever, P., and Kocher, R., Correlation of Tethyan Late Jurassic-Early Cretaceous radiolarian events. *Cah. Micropaeont.*, 2:23-73. (New taxa authored by Baumgartner).
- , 1984. A Middle Jurassic-Early Cretaceous low latitude radiolarian zonation based on unitary association and age of tethyan radiolarites. *Eclogae Geologicae Helvetiae*, 77(3):729-837, 12 pls.
- , 1986. Middle Jurassic-Early Cretaceous radiolarian zonation based on unitary associations: New data and implications for faunal realms. Abstract with Programs, Fourth North American Paleontological Convention, University of Colorado, Boulder, Colorado:A4..
- BLAKE, M. C., Jr., ENGEBRETSON, D. C., JAYKO, A. S., and JONES, D. L., 1985. Tectonostratigraphic terranes in southwest Oregon. In: Howell, G. D., Ed., Tectonostratigraphic terranes of Circum-Pacific Region: Circum-Pacific Council for Energy and Mineral Resources Earth Sciences Series, Volume 1:147-157.
- CACHON, J., and CACHON, M., 1972. Les modalités du dépôt de la Silice chez les Radiolaires. *Arch. für Protistenkunde*, 114:1-13.
- CAMERON, B. E. B. and TIPPER, H. W., 1985. Jurassic stratigraphy of the Queen Charlotte Islands, British Columbia. *Geol. Survey of Canada Bull.* 365:1-49.
- CAMPBELL, A. S., 1954. Protozoa (chiefly Radiolaria and Tintinnia), Part D. in: Moore, R. C., Ed., Treatise on Invertebrate Paleontology, Protista 3: Geological Society of America and University of Kansas Press, 92 p.
- CANTÚ CHAPA, A., 1969. Estratigraphia del Jurásico Medio-Superior del subsuelo de Poza Rica, Veracruz (Area de Soledad-Miquetla). *Inst. Mexicano Petroleo Rev.*, 1(1):3-9.
- , 1971. Le serie Huasteca (Jurásico medio-superior) del centro este de Mexico. *Instituto Mexicano del Petroleo Revista*, 3(2):17-40.
- DE WEVER, P., GEYSSANT, J. R., AZÉMA, J., DEVOS, I., DUÉE, G., MANVIT, H., and VRIELYNCK, B., 1986. La coupe de Santa Anna (Zone de Sciacca, Sicile): Une synthèse biostratigraphique des apports des macro-, micro-, et nannofossiles due Jurassique Supérieur et Crétacé Inférieur. *Rev. de Micropal.*, 29(3):141-186, 5 figs., 13 pls.
- DICKINSON, W. R., 1979. Mesozoic forearc basin in central Oregon. *Geology*, 7:166-170.
- DICKINSON, W. R. and VIGRASS, L. W., 1965. Geology of Supplee area, Crook, Grant, and Harney counties, Oregon. *Oregon Dept. Geol. Min. Indust., Bull.*, 58:1-109, pls. 1-3.
- EHRENBERG, C. G., 1838. Über die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen. *Klg. Akad. Wiss. Berlin, Abh. Jahrg.* 1838: 59-147, pls. 1-4.
- EHRENBERG, C. G., 1854. Über das organische Leben des Meeresgrundes in bis 10800 und 12000 Fuss Tiefe. *Klg. Preuss. Akad. Wiss. Berlin, Ber.*, Jahre 1854:54-75.
- ERBEN, H. K., 1956. Estratigrafía y paleontología de Jurásico Inferior y Medio marino de la región central de la Sierra Madre Oriental. In XX Congreso Geológico Internacional Excursion C-8: 1-54.
- FOREMAN, H. P., 1973. Radiolaria from DSDP Leg 20. In: Heezen et al., Eds., Initial Report of the Deep Sea Drilling Project, Volume 20:249-305 Washington D.C.: U.S. Government Printing Office.
- , 1978. Mesozoic Radiolaria in the Atlantic Ocean off the Northwest coast of Africa, DSDP, Leg 41. In: Lancelot, Y., Seibold, E., et al., Eds., Initial reports of the Deep Sea Drilling Project, Volume 41:739-761. Washington, D. C.: U. S. Government Printing Office.
- FRIZZELL, D. and MIDDOUR, E., 1951. Paleogene Radiolaria from southeastern Missouri. University of Missouri School of Mines and metallurgy, Rolla Bulletin, Tech. Series, 77: 1-41.
- GORICAN, S., 1987. Jurassic and Cretaceous radiolarians from the Budva Zone (Montenegro, Yugoslavia). *Reveu de Micropaléontologie*, vol. 30, No. 3, pp. 177-196, pls. 1-3.
- HAECKEL, E., 1881. Entwurf eines Radiolarien - Systems auf Grund von Studien der Challenger - Radiolarien. *Jenaische Zeitschr. Naturwiss.*, 15(8):418-472.
- , 1887. Report on the Radiolaria collected by H. M. S. Challenger during the years 1873-76. *Rept. Voy. Challenger, 1873-1876. Zool.*, 18(1-2):1-1803, pls. 1-140.
- HALL, R. L. and WESTERMANN, G. E. G., 1980. Lower Bajocian (Jurassic) cephalopod faunas from western Canada and proposed assemblage zones for the Lower Bajocian of North America. *Paleontographica Americana*, vol. 9(52):93 pp.
- HARPER, G. D., 1983. A depositional contact between the Galice Formation and a Late Jurassic ophiolite in northwestern California and southwestern Oregon. *Oregon Geology*, 45(1):3-9.
- , 1984. Josephine ophiolite, northwestern California. *Geological Society of America Bulletin*, 95(9):1009-1026.
- HATTORI, I., 1987. Jurassic radiolarian fossils from the Nanjo Massif, Fukui Prefecture, Central Japan. *Bull. Fukui Municipal Museum of Nat. Hist.* No. 34: 29-101.
- HEIM, A., 1926. Notes on the Jurassic of Tamazunchale, Sierra Madre Oriental, Mexico. *Eclogae Geologicae Helvetiae*, 20:84-89.
- , 1940. The front ranges of the Sierra Madre Oriental, Mexico from C. Victoria to Tamazunchale. *Eclogae Geologicae Helvetiae*, 33:313-362.
- HOPSON, C. A., MATTINSON, J. M., and PESSAGNO, E. A., JR., 1981. Coast Range ophiolite, western California. In: Ernst, W. G., Ed., The Geotectonic Development of California. Rubey Volume 1:419-510. Prentice-Hall, Englewood Cliffs, New Jersey.
- ICZN [International Code of Zoological Nomenclature], 1985. Adopted by the 20th General Assembly of the International Union of Biological Sciences. 338 pp.
- IMLAY, R. W., 1968. Lower Jurassic (Pliensbachian to Toarcian) ammonites from eastern Oregon and California. U. S. Geological Survey Prof. Paper 539C, 51 p.
- , 1973. Middle Jurassic (Bajocian) ammonites from eastern Oregon. U.S. Geological Survey Professional Paper 756, 99 p.
- , 1980. Jurassic paleobiogeography of conterminous United States in its continental setting. U.S. Geological Survey Professional Paper 1062, 134 p.

- , 1981. Jurassic (Bathonian and Callovian) ammonites in eastern Oregon and western Idaho. U.S. Geological Survey Professional Paper 1142, 24 p.
- INTERNATIONAL SUBCOMMISSION ON STRATIGRAPHIC CLASSIFICATION, 1976. International stratigraphic guide, Hedberg, H. D. (ed.), A guide to stratigraphic classification, terminology, and procedure. John Wiley and Sons, N.Y., 200 pp.
- KENT, D. V. and GRADSTEIN, F. M., 1985. A Cretaceous and Jurassic geochronology. Geological Society of America Bulletin, 96(11):1419-1427.
- KLUNZINGER, C. B., 1877. Die Korallthierie der rothen Meeres, Part I: Berlin (O. Enslin).
- LOEBLICH, A. R., JR. and TAPPAN, H., 1961. Remarks on the systematics of the Sarkodina (Protozoa), renamed homonyms and new and validated genera. Proceed. Biol. Soc. Wash., 74:213-234.
- LONGORIA, J. F., 1984. Mesozoic tectonostratigraphic domains in east-central Mexico. Geological Association of Canada Special Paper, 27:65-76.
- LUPHER, R. L., 1941. Jurassic stratigraphy of central Oregon. Geological Society of America Bulletin, 52:219-270, pls. 1-4.
- MACKENZIE, J. D., 1916. Geology of Graham Island, British Columbia. Geol. Survey Canada, Memoir 88.
- MATSUOKA, A. and YAO, A., 1986. A newly proposed radiolarian zonation for the Jurassic of Japan. Marine Micropaleon., 11: 95-105.
- MILLER, M. M. and SALEEBY, J. B., 1987. Detrital zircon studies of the Galice Formation: Common provenance of strata overlying the Josephine ophiolite and Rogue island arc—Western Klamath Mtns. terrane, Geol. Soc. Amer., Abstracts with Programs, 19 (7):772.
- MIZUTANI, S., 1981. A Jurassic formation in Hida-Kanayama area, central Japan. Mizunuma Fossil Museum, Bull., 8:147-190.
- MIZUTANI, S. and KOIKE, T., 1982. Radiolarians in the Jurassic siliceous shale and in the Triassic bedded chert of Unuma, Kagamigahara City, Gifu Prefecture, Central Japan. In Proceed. First Japanese radiolarian symposium. News of Osaka Micropaleontologists Special Vol. No. 5:117-134.
- ORLOV, Y. A., 1959. Fundamentals of Paleontology. A manual for paleontologists and geologists of the USSR, General Part Protozoa: Izdatel'stvo Akademii Nauk SSR, Moskva: 1-482. (English translation by Israel Program for Scientific Translations, 1962.)
- PESSAGNO, E. A., JR., 1973. Upper Cretaceous Spumellariina from the Great Valley sequence, California Coast Ranges. Bull. Amer. Paleont., 63(276):49-102, pls. 9-21.
- , 1977a. Upper Jurassic Radiolaria and radiolarian biostratigraphy of the California Coast Ranges. Micropaleontology, 23(1):117-134.
- , 1977b. Lower Cretaceous radiolarian biostratigraphy of the Great Valley sequence and Franciscan Complex, California Coast Ranges. Cushman Found. Foram. Res. Special Publ. No. 15:1-87.
- , 1979. Radiolaria in Mesozoic stratigraphy. In Ramsay, A. T. S., 1979. Oceanic micropaleontology, vol. 2:913-950.
- PESSAGNO, E. A., JR. and BLOME, C. D., 1984. Systematic Paleontology. In Pessagno, E. A., Jr., Blome, C. D., and Longoria, J. F. A revised radiolarian zonation for the Upper Jurassic of western North America. Bulletins Amer. Paleon. 87 (320): 1-51, pls. 1-5.
- , 1986 Faunal affinities and tectonogenesis of Mesozoic rocks in the Blue Mountains Province of Eastern Oregon and Western Idaho. In: Vallier, T. C. and Brooks, H., Eds., Geology of the Blue Mountains region of Oregon, Idaho, and Washington. Geologic implications of Paleozoic and Mesozoic paleontology and biostratigraphy, Blue Mountains Province, Oregon and Idaho: USGS Prof. Paper 1435: 65-78.
- , 1989. Biostratigraphic, chronostratigraphic, and U/Pb Geochronometric data from the Rogue and Galice Formations, Western Klamath terrane (Oregon and California):—Their bearing on the age of the Oxfordian—Kimmeridgian boundary and the *Mirifusus* first occurrence event. Proceedings of 2nd International Symposium on Jurassic stratigraphy, Lisbon, Portugal:14 pp., 2 figs.
- PESSAGNO, E. A., JR., BLOME, C. D., and LONGORIA, J. F., 1984. A revised radiolarian zonation for the Upper Jurassic of western North America. Bulletins of American Paleontology, 87(320):1-51, 5 pls., 3 text-figs.
- PESSAGNO, E. A., JR., FINCH, W., and ABBOTT, P. L., 1979. Upper Triassic Radiolaria from the San Hipolito Formation, Baja California. Micropaleontology, 25(2):160-197.
- PESSAGNO, E. A., JR. and MIZUTANI, S., in press. In Westermann, G. E. G. (Ed.) The Jurassic of the Circum-Pacific. Correlation of radiolarian biozones of the eastern and western Pacific (North America and Japan). Cambridge University Press, Chapter 3, 9 p. ms.
- PESSAGNO, E. A., JR., and WHALEN, P. A., 1982. Lower and Middle Jurassic Radiolaria from California, east-central Oregon, and the Queen Charlotte Islands, British Columbia. Micropaleontology, 28(2):111-169.
- PESSAGNO, E. A., JR., WHALEN, P. A., and YEH, K., 1986. Jurassic Nassellariina (Radiolaria) from North American geological terranes. Bulletins of American Paleontology, 91(326), 68 p.
- PESSAGNO, E. A., JR., LONGORIA, J. F., MACLEOD, N., and SIX, W. M., 1987a. Studies of North American Jurassic Radiolaria. Part I, Upper Jurassic (Kimmeridgian-upper Tithonian) Pantanelliidae from the Taman Formation, east-central Mexico: tectonostratigraphic, chronostratigraphic, and phylogenetic implications. Cushman Foundation for Foraminiferal Research Special Publication, 23(Part I):1-51; pls. 1-7; figs. 1-9.
- PESSAGNO, E. A., JR., BLOME, C. D., CARTER, E. S., MACLEOD, N., WHALEN, P. A., and YEH, K.-Y., 1987b. Studies of North American Jurassic Radiolaria. Part II, Preliminary Radiolarian Zonation for the Jurassic of North America. Cushman Foundation for Foraminiferal Research Special Publication, 23(Part II):1-18, figs. 1-7.
- RAUSER-CHERNOUSOVA, D. M. and FURSENKO, A. V., Eds., 1959. Subclass Radiolaria. In: Fundamentals of Paleontology, 552-629. Translated from Russian by the Israel Program for Scientific translation, Jerusalem, 1962.
- RIEDEL, W. R., 1971. Systematic classification of polycystine Radiolaria. In: Funnel, B. and Riedel, W. R., Eds., The micropaleontology of the oceans. Cambridge University Press: 649-661.
- RÜST, D., 1885. Beiträge zur kenntniss der fossilen Radiolarien aus Gesteinen des Jura. Palaeontographica, 31(ser. 3):269-321, pls. 26-45.
- , 1892. Radiolaria from the Pierre Formation of northwestern Manitoba, Canada. Geol. Nat. Hist. Survey, Contr. Canadian micropal., part 4:101-110, pls. 14-16.



- SALEEBY, J. B., 1984. Pb/U zircon ages from the Rogue River area, Western Jurassic belt, Klamath Mountains, Oregon. Geological Society of America, Abstracts with Programs, 16(5):331.
- , 1987. Discordance patterns in Pb/U zircon ages of the Sierra Nevada and Klamath Mountains. *ENOS*, 68(4): 1514-1515.
- SALEEBY, J. B., HARPER, G. D., SNOKE, A. W., and SHARP, W. D., 1982. Time relations and structural-stratigraphic patterns in ophiolite accretion, west-central Klamath Mountains, California. *Journal of Geophysical Research*, 87(B5):3831-3848.
- SILBERLING, N. J., JONES, D. L., BLAKE, M. C., Jr., and HOWELL, D. G., 1984. Part C—Lithotectonic terrane map of the western conterminous United States. In: Silberling, N. J. and Jones, D. L., Eds., *Lithotectonic terrane maps of the North American Cordillera*. U. S. Geol. Survey Open-File Report 84-523, C-1—C43.
- SILBERLING, N. J., JONES, D. L., BLAKE, M. C., Jr., and HOWELL, D. G., 1986. Lithotectonic terrane map of the western conterminous United States. In Silberling, N. J. and Jones, D. L., Eds., *Lithotectonic terrane maps of the North American Cordillera*. U. S. Geological Survey Miscellaneous Field Map 1874, part C:1-20.
- SMITH, P. L., 1980. Correlation of members of the Jurassic Snowshoe Formation in the Izee basin of east-central Oregon. *Canadian Journal of Earth Sciences*, 17(12):1603-1608.
- SOUTHERLAND-BROWN, A., 1968. Geology of the Queen Charlotte Islands, B. C. British Columbia Dept. Mines and Petrol. Res. Bull., 54:1-225.
- SOUTHERLAND BROWN, A. and JEFFREY, W. G., 1960. Preliminary geologic map, southern Queen Charlotte Islands. British Columbia Department of Mines.
- WAKITA, K., 1982. Jurassic radiolarians from Kuzuryu-ko—Gujo-hachiman area. In *Proceed. First Japanese radiolarian symposium*. News of Osaka Micropaleontologists Special Vol. No. 5:153-172.
- WESTERMANN, G. E. G., 1984. Gauging the duration of stages: a new approach for the Jurassic. *Episodes*, 7(2):26-28.
- WESTERMANN, G. E. G., and RICCARDI, A. C., 1979. Middle Jurassic ammonoid fauna and biochronology of the Argentine-Chilean Andes, Part II: Bajocian Stephanocerataceae. *Paleontographica, Abteilung A*, 164: 85-188.
- YANG, Q. and PESSAGNO, E. A., JR., 1989. Upper Tithonian Val-lupinae (Radiolaria) from the Taman Formation, east-central Mexico. *Micropaleontology* 35(2):114-134.
- YEH, K., 1987. Taxonomic studies of Lower Jurassic Radiolaria from east-central Oregon. Special Publications Number 2, National Museum of Natural Science, Taichung, Taiwan, R.O.C.: 1-169, 30 pls.

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