

LATE TRIASSIC AND EARLY JURASSIC BIVALVES FROM SONORA, MEXICO

Susana E. Damborenea¹, and
Carlos M. González-León²

ABSTRACT

Four species of bivalves from the Antimonio Formation at Sierra del Álamo, Sonora, Mexico, are described. Two of them, *Mysidioptera mexicana* and *Myophoriopsis sonorensis* are new species; the others are referred or compared to Late Triassic European or American species. Species of *Mysidioptera*, *Myophoriopsis*, and *Costatoria?* indicate a Late Triassic age and confirm the probably early Norian age inferred by their position in the local sequence. None of the species had been previously mentioned for this region, and they show affinities with Tethyan and east Pacific species. Another 15 species of Early Jurassic bivalves from the Antimonio Formation in the Sierra del Álamo area and from the Sierra de Santa Rosa Formation in Sierra de Santa Rosa are also briefly described; of these, 12 species had not been mentioned for this region. *Weyla mexicana* (Jaworski) is regarded as a junior synonym of *Weyla alata* (von Buch). Again most of the species have great affinities with Tethyan and east Pacific Early Jurassic bivalves. They represent a wide array of bivalve life habits.

Key words: Bivalvia, Late Triassic, Early Jurassic, Sonora, Mexico.

RESUMEN

Cuatro especies de bivalvos de la Formación Antimonio aflorante en Sierra del Álamo, Sonora, México, son descritas. Dos de las especies, *Mysidioptera mexicana* n. sp. y *Myophoriopsis sonorensis* n. sp. son nuevas, las demás son referidas o comparadas con especies del Triásico Tardío de Europa y las Américas. La presencia de especies de *Mysidioptera*, *Myophoriopsis* y *Costatoria?* es evidencia inequívoca de la edad triásica tardía, confirmando la edad inferida (Nóricico temprano) indicada por la posición de los estratos portadores en la secuencia local. Ninguna de las especies descritas había sido mencionada antes para la región, y poseen afinidades con especies tethyanas y pacíficas orientales. Asimismo, son descritas 15 especies de bivalvos del Jurásico Temprano de la Formación Antimonio en el área de la sierra del Álamo y de la Formación Sierra de Santa Rosa, en la localidad homónima, 12 de las cuales no habían sido antes mencionadas para la región. *Weyla mexicana* (Jaworski) es considerada sinónimo posterior de *Weyla alata* (von Buch). Esta pequeña fauna presenta notables afinidades con faunas andinas y tethyanas de la misma antigüedad y representa una amplia variedad de habitats.

Palabras clave: Bivalvia, Triásico Tardío, Jurásico Temprano, Sonora, México.

INTRODUCTION

The purpose of this paper is to describe and illustrate some bivalves from Late Triassic and Early Jurassic beds from Sonora. They occur in the Antimonio and the Sierra de Santa Rosa Formations. Most of the species described here have not been mentioned before for the area, and thus increase the knowledge of the Triassic–Jurassic Mexican faunas and add valuable elements for the palaeobiogeographic and tectonic interpretations of these sequences.

A synthesis of the previous knowledge of Late Triassic faunas of the Antimonio Formation can be found in Stanley and collaborators (1994), Stanley and González-León (1995), González-León and collaborators (1996), Stanley (1997), and McRoberts (1997). Goodwin (1997) also listed the bivalves

and Lucas and Estep (1997) illustrated two of the species here described. Late Triassic bivalves from a different setting and age in Sonora were described by Alencáster (1961a, 1961b) from the Santa Clara Formation.

Early Jurassic bivalves from Sierra de Santa Rosa, on the other hand, were described by Jaworski (1929) based on material collected by Keller (1928) and still housed at the Naturhistorisches Museum in Basel, Switzerland (NHMB). Further lists of Early Jurassic faunas containing bivalves from this region are in Flores (1929), Keller (1928), King (1939), Hardy (1981), Lucas and Estep (1997), but these do not add any new elements to those described by Jaworski. The small fauna described here adds 12 species to that list. Though most of these are represented by few specimens and are thus not identified specifically, they indicate that the Early Jurassic fauna of Sonora was much more diverse than previously thought.

The fossils here described were collected by Carlos M. González-León, Spencer G. Lucas and John W. Estep. They are deposited in the collections of the Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México (ERNO).

¹Departamento Paleontología Invertebrados, Museo de Ciencias Naturales La Plata, 1900 La Plata, Argentina.

E-mail address: susanad@mmance.cyt.edu.ar

²Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México, Apartado Postal 1039, 83000 Hermosillo, Sonora, México.

STRATIGRAPHY AND OCCURRENCES

(C.M. González-León)

TRIASSIC BIVALVES

The Triassic bivalves here described occur at three localities, in a few intervals of a sedimentary section that forms the upper part of the lower member of the Antimonio Formation in the northern foothills of the Sierra del Álamo (Figure 1). The fossils were collected from strata located below and within the Norian carbonate interval that makes up this part of the formation. They occur in units 12 and 13 which form sequence VII of González-León (1997). The section is located in the northwestern part of the area, southeast of the ghost town of El Antimonio (Figure 1, section 1), and it is described below from base to top (Figure 2).

1. Covered interval about 100 m thick. It covers the contact with the underlying Carnian section.

Unit 12

2. Light gray, coarse-grained sandstones in massive beds with interbedded siltstones. Large fossil logs are present within the sandstone beds 30 m
3. Dark gray massive siltstones 10 m
4. Thick bedded, coarse-grained sandstones with planar cross-stratification that grade upwards to fine-grained sandstones and siltstones forming a fining-upward cycle 30 m
5. Covered 15 m
6. Siltstones and mudstones in beds up to 3 m thick with interbedded sandy limestones and fine-grained sandstones in beds less than 30 cm thick. Rare thicker beds (up to 50 cm) of sandy limestones contain these bivalves: *Palaeolopha* cf. *haidingeriana* (Emmrich), *Mysidioptera mexicana* n. sp., *Myophoriopsis sonorensis* n. sp., *Costatoria?* sp., *Ostreoidea* gen. et sp. indet., *Pectinoidea* gen. et sp. indet., and *Bivalvia?* gen. et sp. indet. (ERNO-805 to 813, 1950 to 1956, 2138, 2355 to 2373 and 2769) 98 m
7. Medium- to thin-bedded, fine-grained sandstones with interbedded mudstone/siltstones and bioclastic limestones. The upper part

of this package consists of calcareous mudstones and fine-grained, bioclastic and micritic limestones. The contact with unit 13 is covered but shown as gradational in a single good exposure 33 m

Unit 12 crops out also with similar lithologies but with a more complete thickness in the southeastern part of the area along section 2 (Figures 1 and 2). Bivalves at this locality, however, are poorly preserved and rarer, except for a single bed of sandy limestone that contains *Palaeolopha* cf. *haidingeriana* (Emmrich), *Mysidioptera mexicana* n. sp. and *Costatoria?* sp. (ERNO-814, 815, 816 and 817) and that occurs in the upper part of the section.

Unit 13

8. Dolomitized and locally recrystallized massive, light gray limestones 5 m
9. Massive siltstones and interbedded fine-grained sandstones and coquinoid limestone beds. Rare thin horizons within the siltstone have poorly preserved bivalves 20 m
10. Massive, locally recrystallized and dolomitized, dark-gray limestones with *Heterastridium* 5 m
11. Covered interval with poor exposures of siltstones. One bed 20 cm thick of coquinoid sandy limestone crops out locally and contains *Mysidioptera mexicana* n. sp. (ERNO-818 to 820).
12. Massive and mottled limestones with yellow colored patches of siltstone infills 3 m

The age of unit 12 is constrained by ages of the underlying Carnian sequence that contains abundant ammonoids (Estep *et al.*, 1997) in mudstones of its upper part, and by the Norian age of unit 13.

Other bivalves from the Antimonio Formation were collected from the lowermost part of the Jurassic section (unit 16 of González-León, 1997), just above the Triassic-Jurassic boundary. This sample (ERNO-2139) contains *Neocrassina?* sp. and is considered to be latest Hettangian or earliest Sinemurian in age according to preliminary identifications of ammonoids by D.G. Taylor (reported in González-León *et al.*, 1996). Also, the bivalve *Weyla* (*W.*) *alata* (von Buch) (ERNO-2374) occurs rarely in a few beds of bioclastic limestone with ammonoids that occupy higher positions in this section (unit 19 of González-León, 1997), in the middle part of the upper member of the Antimonio Formation. Ammonoids from these beds were preliminarily identified as *Asteroceras* sp. by D.G. Taylor (written communication, 1995) and are regarded as Sinemurian in age.

LOWER JURASSIC BIVALVES FROM THE SIERRA DE SANTA ROSA FORMATION

Most of the Lower Jurassic fossils herein reported were collected from the lower and middle members of the Sierra de Santa Rosa Formation (Hardy, 1981) in the locality of the same name in northwestern Sonora (Figures 3 and 4). The Sierra de Santa Rosa Formation according to Hardy (1981) is a sedimentary, mostly terrigenous succession reaching a com-

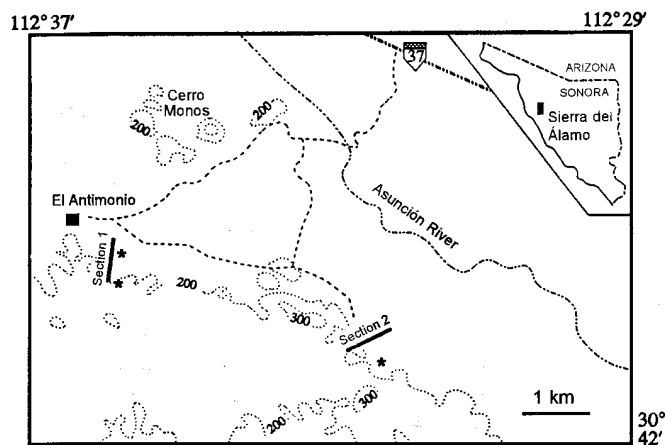


Figure 1. Location map of the northern foothills of the Sierra del Álamo, northwestern Sonora (inset map). It shows location of stratigraphic sections reported in Figure 2 that were measured along sections 1 and 2. Also indicated with * are locations of Late Triassic bivalves.

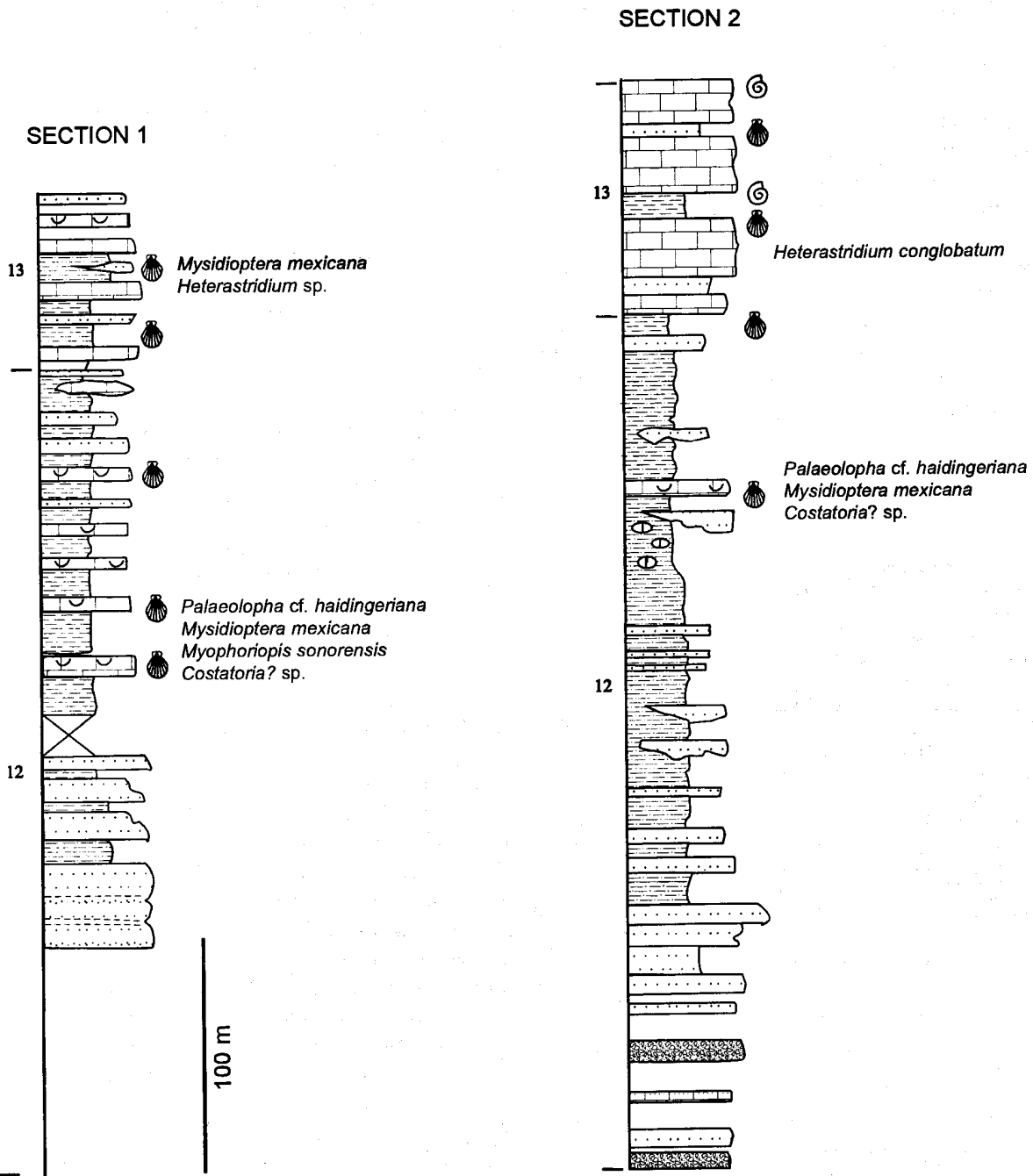


Figure 2. Stratigraphic columns of the upper part of lower member of the Antimonio Formation indicating position of Late Triassic (Norian) bivalves.

posite thickness of 1,450 m and divided into three members. Fossils are more abundant in the middle member and include the list of species reported in Hardy (1981) from information of previous authors including Burckhardt (1930), Flores (1929), Jaworski (1929), and Keller (1928).

A composite, incomplete stratigraphic column that includes part of the lower member and the middle and upper members of the Sierra de Santa Rosa Formation (division according to Hardy, 1981) was measured during the present study and is

shown in Figure 4. Location of fossils from this area is also labeled in these stratigraphic columns. Abundant ammonoids collected from this area are also presently under study by D.G. Taylor. Fossils are much more abundant within several intervals of the middle member, which is more calcareous.

Part of the lower member was measured in the southwestern part of the Sierra de Santa Rosa, about 4 km southwest of Rancho San Carlos (section 3, Figures 3 and 4). The most complete type section for this member, however, was

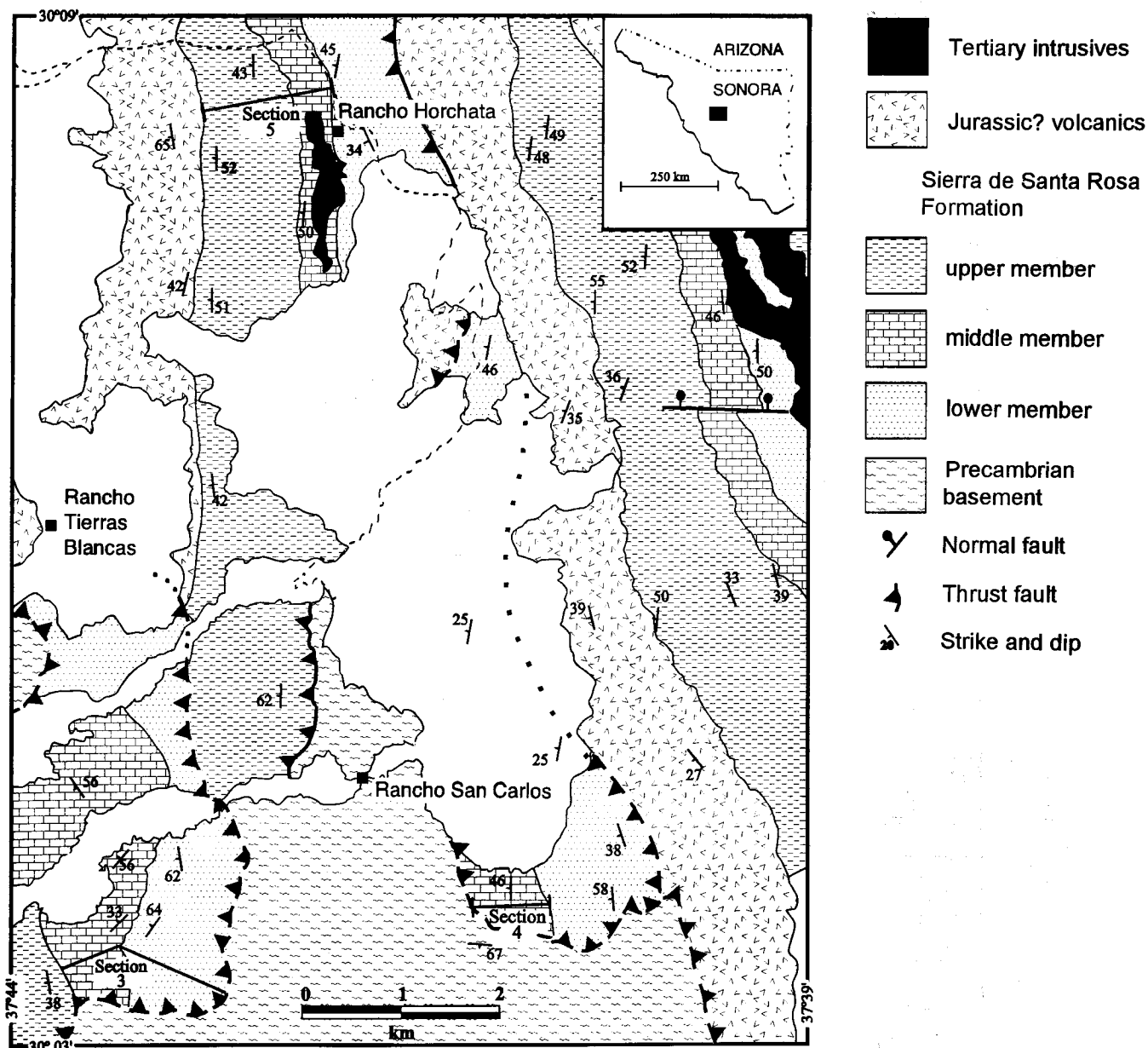


Figure 3. Geologic map of the Sierra de Santa Rosa (modified from Hardy, 1981), showing location of measured stratigraphic sections 3, 4 and 5.

proposed to be located in the northern part of the Sierra de Santa Rosa by Hardy (1981). At the locality southwest of Rancho San Carlos, the lower member thrusts over Precambrian metamorphic basement and consists in its lowermost 90 m of fine- to coarse-grained sandstone and interbedded dark gray mudstone/siltstone, and minor medium bedded, fine-pebble conglomerate with well-rounded clasts, and probably represents marginal marine environments. The sandstones become finer-grained upwards and grade into a 60-m-thick interval composed of fine-grained sandstones in thin to medium beds, thin-bedded bioclastic and sandy limestones and calcareous, locally laminated mudstones. A single 3 m thick interval of sandy limestone within these lithologies yielded poorly preserved bivalves including *Weyla (W.) alata* (von Buch), Lucinidae gen. et sp. indet. (ERNO-2419) and

ammonoids. This section continues upwards with a 50 m thick interval of fine- to coarse-grained sandstone locally parallel-laminated, massive, reddish mudstone and siltstone with local thin beds of limestone and pebbly conglomerate. The upper part of the lower member along section 1 consists of a 150-m-thick interval composed of fine-grained, parallel laminated, thin to medium bedded sandstones, calcareous mudstones with calcareous nodules, subordinate sandy limestones, encrinitic limestones, and a single bed of fine-pebbly conglomerate.

We interpret the uppermost 160 m of this section measured along section 3 as part of the middle member of the Sierra de Santa Rosa Formation based on the lithologic description and geologic map of Hardy (1981). This member was measured along sections 3, 4, and 5 (Figures 3 and 4).

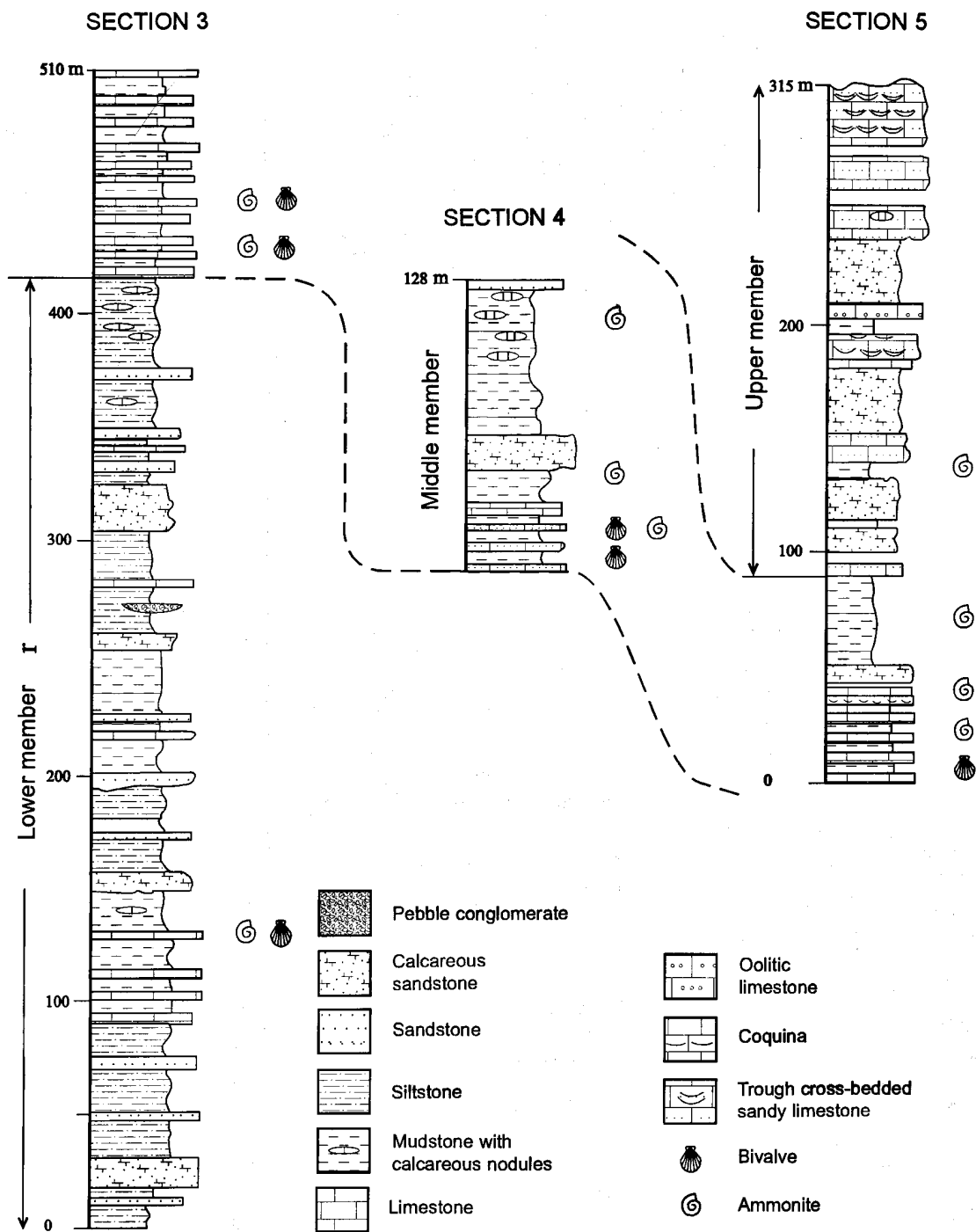


Figure 4. Stratigraphic columns of the Sierra de Santa Rosa Formation that include part of the lower member, and middle and upper members measured along sections 3, 4, and 5. For location of sections see Figure 3.

The contact between the middle and lower members is gradational as observed along section 3. The middle member consists in the lower part of calcareous mudstones with calcareous nodules that grade into middle and upper parts of thin- to medium-bedded sandy to silty limestones with interbedded siltstones. Ammonoids and bivalves are abundant in the limestone beds of this member: *Plagiostoma* cf. *punctatum* Sowerby, *Entolium* (*E.*) *disciforme* (Schübler), *Weyla* (*W.*)

alata (von Buch) and *Pholadomya* cf. *fidicula* (Sowerby) (ERNO-2397 to 2418).

The middle member in section 4 (Figures 3 and 4) consists of medium-bedded, sandy limestone and interbedded massive mudstone with *Weyla* (*W.*) *alata*, other bivalves (*Pinna* sp., *Entolium* [*E.*] *disciforme*, *Falcimyltilus* sp., *Modiolus* cf. *baylei* Philippi, *Myoconcha neuquena* Lanza, *Pholadomya* cf. *fidicula*, *P.* cf. *ambigua* [Sowerby], *Pachymya*? sp., *Ceratomya*

sp., *Gresslya* cf. *striata* Agassiz and *Platymyoidea* sp.), and a few beds contain also ammonoids, brachiopods (ERNO-2375 to 2396, 2420 to 2438) and corals. This grade upwards to blue, micritic and sparsely bioclastic limestones. The upper part of this section is composed of massive to finely laminated mudstones with calcareous nodules with ammonoids.

The middle member in section 5 (Figures 3 and 4) is 90 m thick and composed at its base of micritic to bioclastic, blue limestones with rare bivalves and ammonoids. It grades upwards to fine-grained sandstones and massive to finely laminated calcareous mudstones with intervals containing abundant ammonoids. Preliminary identification of these ammonoids indicates a Pliensbachian age (D.G. Taylor, written communication, 1996). Other fossils at this locality are poorly preserved and were not collected for study. This member grades along section 5 to the upper member of this formation which consists of calcareous sandstone, thin beds of fine-grained sandstones, and interbeds of calcareous mudstones with ammonoids in its lower part. Its middle part is composed of fine- to medium-grained sandstones, bioclastic sandy limestones with no fossils, and in its upper part this member is composed of medium-grained sandstones and local trough cross-bedded calcareous sandstones.

SYSTEMATIC DESCRIPTIONS

(*S.E. Damborenea*)

The geographic and stratigraphic location of each taxon here described are summarized in Table 1 (see also Figures 1–4). Only sufficiently well preserved material is described; other taxa are merely listed in Table 1.

In the systematic descriptions, the synonymy lists have been restricted to the original reference and the American ones.

Subclass Pteriomorpha Beurlen, 1944
Order Pterioidea Newell, 1965
Suborder Pinnina Waller, 1978
Superfamily Pinnoidea Leach, 1819
Family Pinnidae Leach, 1819

Genus *Pinna* Linné, 1758

Type species—*Pinna rudis* Linné, 1758, from tropical seas, subsequent designation by Children, 1823.

***Pinna* sp.**
(Figure 5.1)

Material—Four specimens in the same sample, of which two can be seen in lateral view, the others only in cross-section (ERNO-2376). Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Table 1. Occurrence of taxa.

AGE FORMATION SECTION UNIT*	Late TRIASSIC		Early JURASSIC					
	Antimonio				Sierra de Santa Rosa			
	1		2		3		4	
	12	13	12	16	19	L.M.	M.M.	M.M.
<i>Mysidioptera mexicana</i> n. sp.	●	●	●					
<i>Palaeolopha</i> cf. <i>haidingeriana</i> (Emm.)	●		●					
<i>Myophonopis sonorensis</i> n. sp.	●							
<i>Costatoria</i> ? sp.			●					
<i>Pectinoidea</i> gen. et sp. indet.	○		○					
<i>Ostreoidea</i> gen. et sp. indet.	○							
<i>Bivalvia</i> ? gen. et sp. indet.	○							
<i>Neocrassina</i> ? sp.				●				
<i>Weylia</i> (<i>W.</i>) <i>alata</i> (v. Buch)					●	●	●	●
Lucinidae gen. et sp. indet.						●		
<i>Plagiostoma</i> cf. <i>punctatum</i> Sowerby							●	
<i>Ertolium</i> (<i>E.</i>) <i>disciforme</i> (Schubler)							●	●
<i>Pholadomya</i> cf. <i>fidicula</i> (Sowerby)							●	●
<i>Bivalvia</i> gen. et sp. indet.							○	
<i>Falciomytilus</i> sp.								●
<i>Pinna</i> (<i>P.</i>) sp.								●
<i>Modiolus</i> cf. <i>baylei</i> Philippi								●
<i>Myoconcha neuquena</i> Leanza								●
<i>Pholadomya</i> cf. <i>ambigua</i> (Sowerby)								●
<i>Pachymya</i> ? sp.								●
<i>Ceratomya</i> sp.								●
<i>Gresslya</i> cf. <i>striata</i> Agassiz								●
<i>Platymyoidea</i> sp.								●

* For stratigraphic location of these units see also González-León, 1997

● Taxa here described
○ Taxa not described here

L.M. Lower Member
M.M. Middle Member

Remarks—All specimens are fragments, which do not allow a specific determination or close comparison with the numerous species of this ubiquitous genus. They are mostly preserved as internal moulds with traces of shell. These fragments show very faint irregular radial ribbing and stronger commarginal ornamentation, consisting of closely-spaced narrow folds separated from each other by interspaces only slightly wider than the folds. The overall triangular shape with straight dorsal and ventral margins, acute apical angle (about 40°) and the disposition of the inner nacreous lobes are typical of a large group of species of this genus. The mode of preservation suggests local concentration but not long transport, since all specimens are preserved with articulated valves which appear to have been complete, but not in life position.

Order Limoida Rafinesque, 1815
Superfamily Limoidea Rafinesque, 1815
Family Limidae Rafinesque, 1815

Genus *Mysidioptera* Salomon, 1895

Type species—*Mysidioptera ornata* Salomon, 1895, from Ladinian–Carnian of southern Alps, subsequent designation by Diener, 1923.

The genus *Mysidioptera* includes species with a very wide range of ornamentation patterns, from smooth to strongly ribbed (Salomon, 1895). This range of ornamentation and also the shape and size of the shell, very small anterior auricle, large but not clearly separated posterior auricle, edentulous hinge and posteriorly directed resilifer recall the genus *Acesta* Adams and

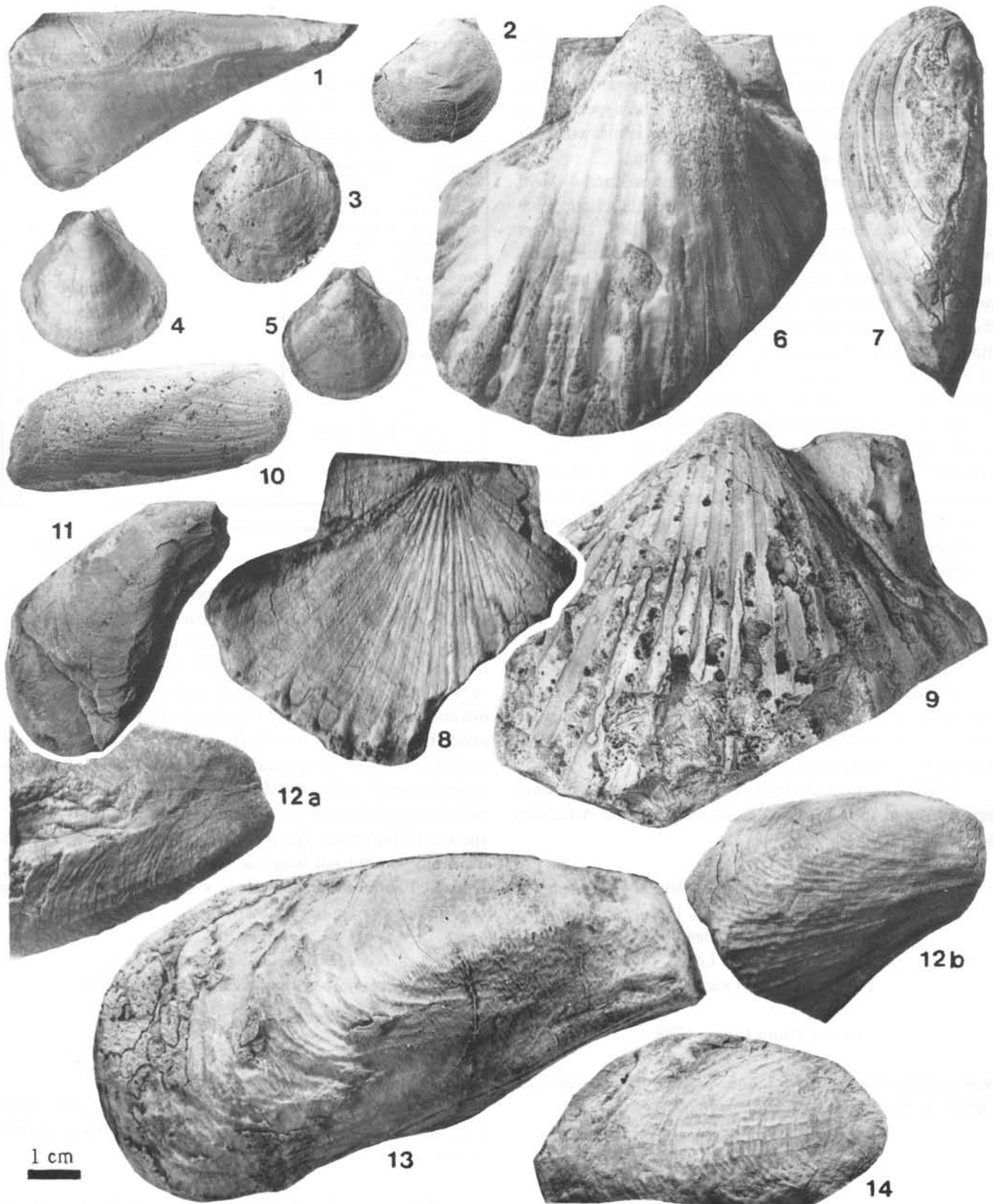


Figure 5. Early Jurassic bivalves. 1, *Pinna* sp., lateral view, ERNO-2376. 2, *Plagiostoma* cf. *punctatum* J. Sowerby, left valve, ERNO-2415. 3–5, *Entolium* (*E.*) *disciforme* (Schübler); 3, ERNO-2416; 4, ERNO-2412; 5, ERNO-2417. 6–9, *Weyla* (*W.*) *alata* (von Buch); 6, right valve, ERNO-2436; 7, specimen with both valves, anterior view, ERNO-2437; 8, left valve, ERNO-2419; 9, right valve of a very large specimen, ERNO-2380. 10, *Modiolus* cf. *baylei* Philippi, lateral view of right valve, ERNO-2396. 11, *Falcimyltilus* sp., right valve exterior, ERNO-2395. 12–14, *Myoconcha neuquena* Leanza; 12, incomplete specimen with both valves, ERNO-2420, 12a: dorsal view, 12b: lateral view of right valve; 13, lateral view of an almost complete right valve, ERNO-2388; 14, detail of ornamentation on a portion of a right valve, ERNO-2426. All x1.

Adams, 1858, which is known from Late Jurassic to Holocene but nowadays is restricted to cold waters or great depths. Particularly, the group of large coarsely ribbed *Mysidioptera*, with radial ribs that affect the whole thickness of the test, and to which the species here described belongs, is morphologically related to the subgenus *Acesta* (*Plicacesta*) Vokes, 1963.

Waagen (1907) distinguished the subgenus *Mysidioptera* (*Pseudacesta*), with *M. (P.) dieneri* Waagen as type, on account of the presence of a relatively conspicuous anterior auricle (see also Allasinaz, 1966).

The genus *Mysidioptera* is here used in a wide sense, with no attempt to distinguish subgenera.

***Mysidioptera mexicana* Damborenea n. sp.**

(Figures 6.1–6.6, 7.2a–c)

p. 1997. *Weyla*; Lucas and Estep, p. 45, figs. 1C–1D (only).

Material—Four specimens with both valves together, 11 right valves, 13 left valves and many fragments (ERNO 805 to 814, 817 to 820, 1950 to 1952, 1954, 2355 to 2372), from the Antimonio Formation (units 12 and 13); Upper Triassic (Norian?); Sierra del Álamo, Sonora (sections 1 and 2).

Holotype—ERNO-2355 (Figure 6.1a–c), an almost complete left valve.

Diagnosis—Large, strongly ribbed *Mysidioptera* with 11 to 13 straight, smooth ribs on body of shell, anterior auricle very small and posterior auricle large. Posterior auricle and anterior disk flank ornamented by narrow radial riblets. Triangular inequilateral cardinal area with posteriorly directed triangular resilifer.

Description—Shell large for genus, equivalve, moderately inflated, suborbicular to subtrigonal in outline, higher than long, ortho- to opisthoclinal, dorsal and anterior margins at slightly more than 90°. Umbones narrow and small. Anterior disk flank (= lunular area in Vokes, 1963) flat to concave, extending ventrally for more than half the total height of the shell, and separated from disk by a sharp change in shell convexity. Anterior auricle very small, not seen in lateral view and appearing to be absent in some specimens. A narrow and short byssal gape appears just below the anterior auricle (Figures 6.3b, 7.2b). Posterior auricle rather large but not well differentiated from disk.

Disk ornamented by 11 to 13 straight and wide equally strong ribs separated by slightly narrower intervals. Ribs and intervals are U-shaped in cross section and extend without interruption from umbo to margin. Surface of ribs smooth. In well preserved specimens the outermost layer of shell on each rib top bears 4 or 5 dark longitudinal lines, which do not show in relief over the surface (Figure 6.6b). These could either be remains of colour pattern or else reflect some detail of shell

structure. Anterior disk flank with about 10 narrow radial riblets, extending from umbo to margin; anterior auricle bears only growth-lines. Posterior auricle also with up to 10 thin radial riblets similar to those of lunular area. Shell moderately thin, the main ribs are seen on internal moulds for at least half their length, being the inner umbonal region smooth. Growth-lines more conspicuous on lunular area and on posterior wing. On the disk the growth-lines are concave towards the margin on the ribs and convex towards the margin on the interspaces, suggesting a scalloped and interlocking ventral margin.

Triangular inequilateral cardinal area with shallow triangular ligamental pit directed posteriorly from beak (Figures 6.2a, 7.2c). In some specimens the cardinal area has longitudinal striations. Area anterior to ligamental pit wider than posterior area. Cardinal area at an acute angle with the commissural plane, producing separation of beaks (Figure 6.4). Hinge edentulous. Other internal characters unknown.

Measurements: In mm.

Specimen	Valve	Length	Height	Width	No. of ribs
ERNO-805	R	54	71	19	11
ERNO-808	L	57	70	[18]	[11]
ERNO-811	L	72	84	21	12
ERNO-813	R	82	73	23	12
ERNO-2355	L	70	82	22	12
ERNO-2356	R	75	81	19	[10]

Discussion—This species was previously figured by Lucas and Estep (1997, fig. 1C–1D only) but referred to the pectinoid *Weyla*. It is referred to *Mysidioptera* (used in a wide sense) on account of its shape, anterior auricle nearly absent, edentulous hinge and details of the ligamental area.

Mysidioptera mexicana n. sp. belongs to the group of large and strongly ribbed forms, which includes several species from the Late Triassic beds of the Alps, such as *M. beneckeii* Bittner, *M. spinigera* (Bittner), *M. risiensis* Allasinaz, *M. incurvostriata* (Gümbel), *M. latifissa* Broili, *M. acuta* Broili, *M. elongata* Broili, *M. emiliae* Bittner and *M. waageni* Zapfe.

Of these, *M. spinigera* was described also from Oregon, USA (Newton *et al.*, 1987, p. 31–33, figs. 25.7–25.9), but differs from *M. mexicana* in its smaller size and nodose to squamose rib tops, though they have a similar shape and cardinal area (see Bittner, 1895, pl. 20, fig. 32). The related species *M. waageni* Zapfe (1963, pl. 1, figs. 1–3; pl. 2, fig. 4), from the Rhaetian of the Alps, has a very large size and about 12 radial ribs, but these are nodose.

The most similar species appears to be *M. elongata* Broili (1904, pl. 21, fig. 18), but the rib tops of this species bear nodes.

Mysidioptera emiliae Bittner (1900, pl. 6, figs. 1–7; see also Broili, 1904, pl. 21, figs. 4–5), from the Seisser Alps, has a smaller size and much better developed anterior auricle, but the ornamentation of the body of the shell is quite similar

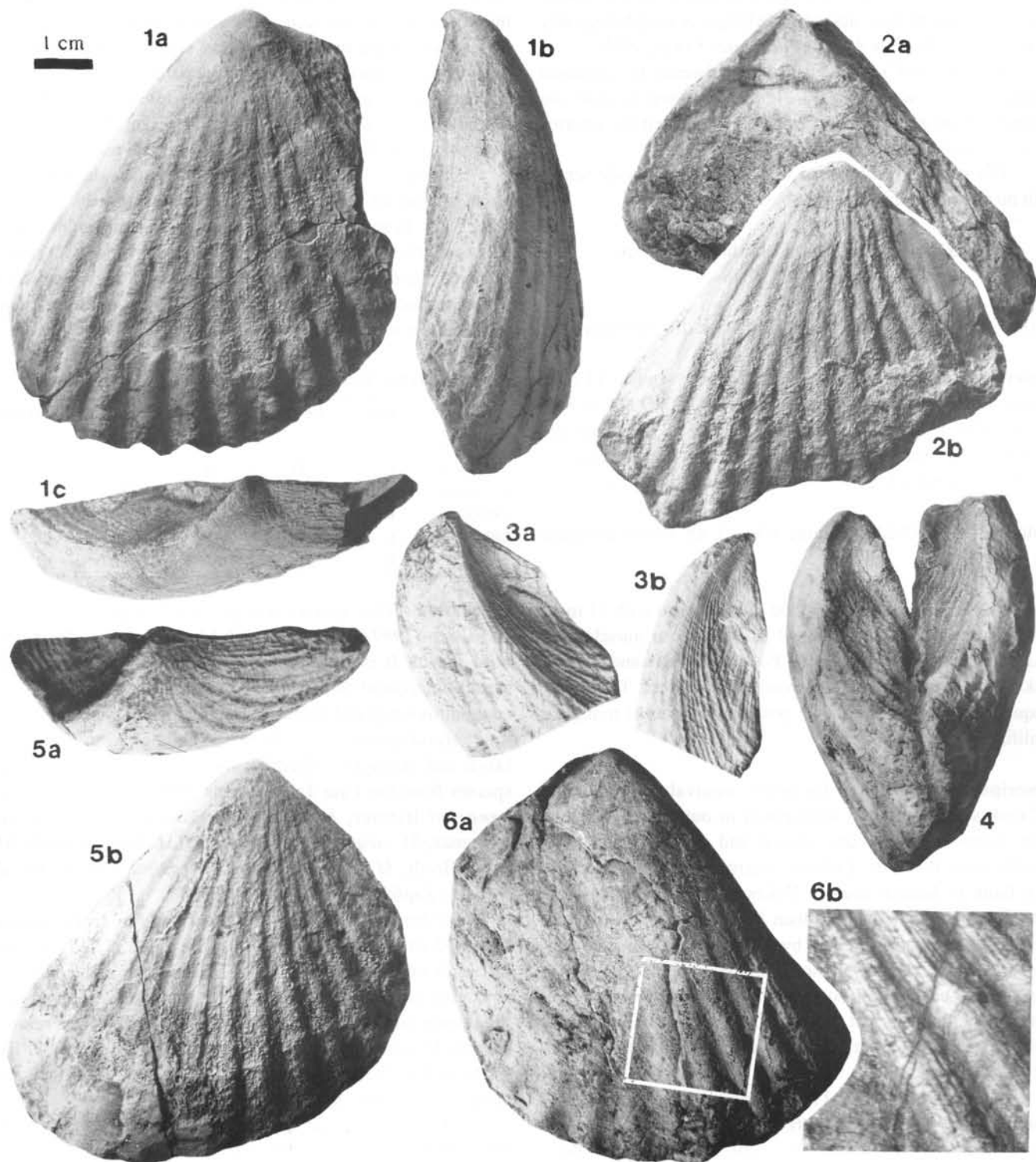


Figure 6. Late Triassic bivalves. *Mysidioptera mexicana* n. sp. 1, Holotype, left valve, ERNO-2355; 1a, lateral; 1b, anterior; and 1c, dorsal views. 2, Paratype, left valve, ERNO-812; 2a, inner view showing hinge region; 2b, outer view. 3, Paratype, right valve, ERNO-810; 3a, oblique dorso-anterior view showing byssal gape; 3b, anterior view. 4, Paratype, complete specimen in anterior view, ERNO-813. 5, Paratype, left valve, ERNO-811; 5a, dorsal; and 5b, lateral views. 6, Paratype, right valve, ERNO-2356; 6a, lateral view; 6b, detail of ornamentation (x2) without coating. All x1, except where otherwise indicated.

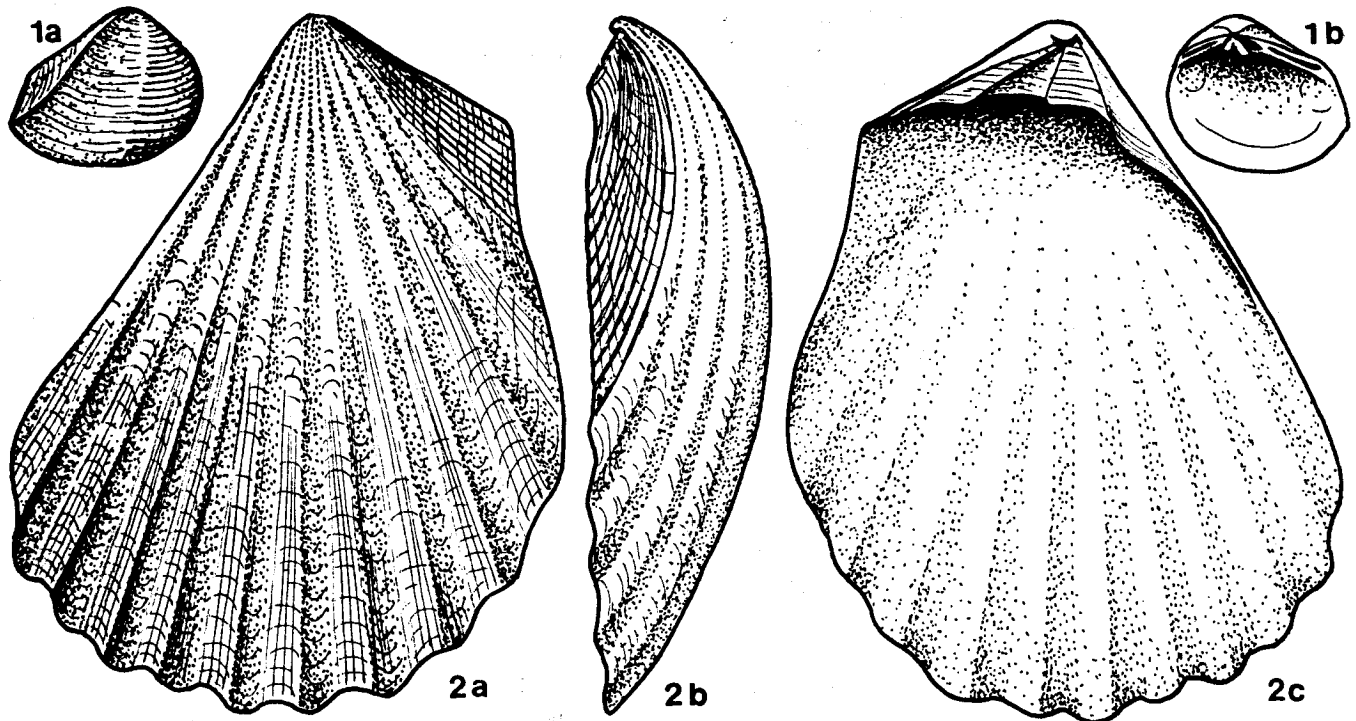


Figure 7. Morphological characters of the new species described here, sketches based on several specimens. 1, *Myophoriopsis sonorensis* n. sp., right valve, x2; 1a, outer view; 1b, inner view. 2, *Mysidioptera mexicana* n. sp., left valve, x1; 2a, outer view; 2b, anterior view; 2c, inner view.

to that of *M. mexicana*, with straight ribs of U-section and equal interspaces. *Mysidioptera beneckeii* Bittner (1895, pl. 21, fig. 11) is also smaller and has more radial ribs. Also *M. risiensis* Allasinaz (1966, pl. 47, figs. 7–9) and *M. incurvostriata* (Gümbel) (see Bittner, 1895, pl. 22, figs. 11–12; Wöhrmann, 1889, pl. 6, figs. 10–11; Philippi, 1900, pl. 24, fig. 2; Broili, 1904, pl. 20, figs. 17–18; Mansuy, 1919, pl. 1, fig. 5; Allasinaz, 1966, pl. 47, figs. 6a–b) have a similar shape and size, but more numerous, finer and wavy radial ribs.

Mysidioptera latifissa Broili (1904, pl. 22, figure 1) has the same shape and number of radial ribs, but the ribs are narrower and nodose and the anterior auricle is larger, while *M. acuta* Broili (1904, pl. 21, figs. 16–17) is smaller and has fewer radial ribs. Even some species referred to *M. (Pseudacesta)*, such as *M. inaequicostata* (Schafhäütl), also from the Carnian of the Alps (see Allasinaz, 1966, pl. 48, figs. 3–6), have a similar shape, but this species differs in having much more numerous and irregular radial costae.

The species *M. poyana* (McLearn), from the (upper?) Carnian of British Columbia (see Tozer, 1970, pl. 18, fig. 2) shares with *M. mexicana* n. sp. the strong radial ribs, but these are fewer and the shell is smaller and more elongated posteriorly in the Canadian species.

Lima recticostata Meek (1864, p. 44, pl. 7, fig. 5) and *L. sinuata* Meek (1864, p. 43, pl. 7, figs. 4–4a) are probably two names for the same species, both based on incomplete material from the Jurassic (?) of California. This species differs from *M. mexicana* n. sp. by the subnodose appearance of the ribs,

smooth posterior auricle, and large byssal gape, but has a similar shape and number of radial ribs. Damborenea and Manceñido (1979, p. 98) regarded *L. recticostata* and *L. sinuata* as doubtfully referable to *Weyla*, but the whereabouts of Meek's specimens could not be traced, and there are no updated records. Hyatt (*in* Diller [1908]) regarded these two nominal species, together with *Pecten acutiplicatus* Meek, as allied to the European *Lima acuticostata* Schübler from the Inferior Oolite, and he listed these three from the Hardgrave Sandstone of the Taylorsville region, and referred them to the Early Jurassic. Of these, only *P. acutiplicatus* [now regarded as a species of *Weyla* and renamed *W. meeki* by Damborenea, 1987b, p. 186, t-fig. 26] was listed by Crickmay (1933, p. 897) among the fossils from the Mount Jura (California) and by Muller and Ferguson (1939, p. 1612) from the Sunrise Formation in Nevada.

The other species of *Mysidioptera* described from the Americas is *M. williamsi* (McLearn, 1941, pl. 1, figs. 10–12; see also Newton, 1986, pl. 2.1, figs. 14–15; Newton *et al.*, 1987, figs. 25.1–25.6, 26.2), known to occur in Norian beds of Oregon and British Columbia, but this has large flat shells with pointed posterior auricles and concentric ornament only.

Biogeography—*Mysidioptera* is regarded as a cosmopolitan genus, but it is undoubtedly more diverse in Tethyan regions, where the group of large strongly ribbed species lived during the Late Triassic. The genus has been reported from several North American Upper Triassic localities. Surprisingly, no species have yet been described from South America.

Ecology—*Mysidioptera mexicana* was an epibyssate bivalve. In the Antimonio Formation it is found in packstones with a high density of complete valves and even complete shells with both valves together or slightly displaced. These packstones contain a low diversity bivalve fauna, of which *Mysidioptera mexicana* is the most abundant species.

In the southern Alps, *Mysidioptera* has a wide range of facies distribution (see Fürsich and Wendt, 1977), from reef-dwelling or related to reef deposits (see also Zapfe, 1963) to shallow-water basin deposits.

Genus *Plagiostoma* J. Sowerby, 1814

Type species—*Plagiostoma giganteum* J. Sowerby, 1814, from the Lower Jurassic of Europe, subsequent designation by Stoliczka, 1871.

Plagiostoma cf. *P. punctatum* J. Sowerby, 1815 (Figure 5.2)

1815. *Plagiostoma punctata* sp. nov.; J. Sowerby; p. 116; pl. 113, figs. 1–2.
 1900. *Lima* (*Plagiostoma*) cf. *punctata* Ziet.; Burckhardt, p. 25.
 1926. *Lima* (*Plagiostoma*) *punctata* Sow.; Jaworski, p. 161–162.
 1929. *Plagiostoma* cf. *exaltata* Terqu.; Jaworski, p. 5, lám. 1, figs. 5a–b.
 1994. *Plagiostoma punctatum* J. Sowerby; Aberhan, p. 25–26; pl. 9, figs. 3–5.

Material—One almost complete left valve (ERNO-2415) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 3.

Remarks—This is a small, orbicular, opisthocline shell characterized by many flat-topped radial riblets separated by very narrow undulating and punctuated grooves. The material illustrated by Jaworski (1929), from the same region, is very fragmentary and only shows details of the ornamentation pattern (NHMB-52⁴). Jaworski (1929, p. 5) already remarked on the similarity between the Mexican material and specimens from the Lower Jurassic of Argentina (Burckhardt, 1900; Jaworski, 1926) which had been referred to *P. punctatum* Sowerby. Direct comparison with specimens from several localities along the Andes does confirm his opinion. The species is now also known from Chile (Aberhan, 1994).

Plagiostoma punctatum is known from Rhaetian to Toarcian beds of several localities around the world. Early Jurassic records of this species from Britain were nevertheless not accepted by Cox (1943, p. 185), and he referred them to *P. schimperii* (Branco).

The material from Sierra de Santa Rosa also shows affinities with other Early Jurassic species from France and Britain, such as *P. exaltatum* (Terquem, 1855, pl. 22, fig. 2),

which has a much larger size, and especially with *P. compressum* (Terquem, 1855, pl. 22, figs. 4a–4).

Order Ostreoida Férussac, 1822
 Superfamily Ostreoidae Rafinesque, 1815
 Family Palaeolophidae Malchus, 1990

Genus *Palaeolopha* Malchus, 1990

Type species—*Ostrea haidingeriana* Emmrich, 1853, from the Rhaetian of Austria, by original designation.

Several authors have pointed out that the genus name *Lopha* Röding, 1798 included a rather heterogeneous stock, but had traditionally maintained that name in a wide sense because they regarded that these forms represented an evolutionary line (see for instance Stenzel, 1971; Siewert, 1972). On the other hand Malchus (1990, p. 187) considered that Triassic and Jurassic species previously referred to *Lopha* do not have any phylogenetic relationship with the living Lophinae. Consequently, he erected the new family Palaeolophidae to accommodate them and the new name *Palaeolopha*, mainly based on details of shell structure. Although the genus is not well characterized on morphological grounds and there is no possibility to study the shell structure of the Mexican specimens, it is adopted here because it is the best available generic name for the species *O. haidingeriana*, which cannot be referred to either *Lopha* or *Actinostreon* Bayle, 1878.

Palaeolopha cf. *P. haidingeriana* (Emmrich, 1853) (Figure 8.5–8.7)

- Cf. 1853. *Ostrea haidingeriana* Emmrich, p. 377.
 Cf. 1860. "*Ostrea*" *marcignyana* Martin, p. 90; pl. 90, figs. 24–25.
 Cf. 1908. *Alectryonia* cf. *haidingeriana* Emm.; Healey, p. 37, pl. 5, figs. 17–19.
 Cf. 1971. *Lopha haidingeriana* (Emmrich); Stenzel, fig. J62.4.

Material—Four almost complete shells and several shell fragments, preserved as internal or external moulds (ERNO-814 to 816, 1954 to 1956) from the Antimonio Formation, unit 12; Upper Triassic (Norian?); Sierra del Álamo, sections 1 and 2.

Description—Medium-sized, narrow, ventrally elongated flat shells, with height about twice the length. Subrectangular shape, with almost parallel anterior and posterior margins. Up to 6 cm high and 3 cm wide. Right valve (?) more convex than left valve. Ornamented by up to 14 subequal sharp-crested plicae which increase in number by intercalation. The 3 or 4 main plicae are straight and run parallel to each other for most of the shell length, curving and dichotomising only near the shell margin. Plicae extend almost to the umbo, suggesting a very small attachment area. One specimen (ERNO-1954) shows

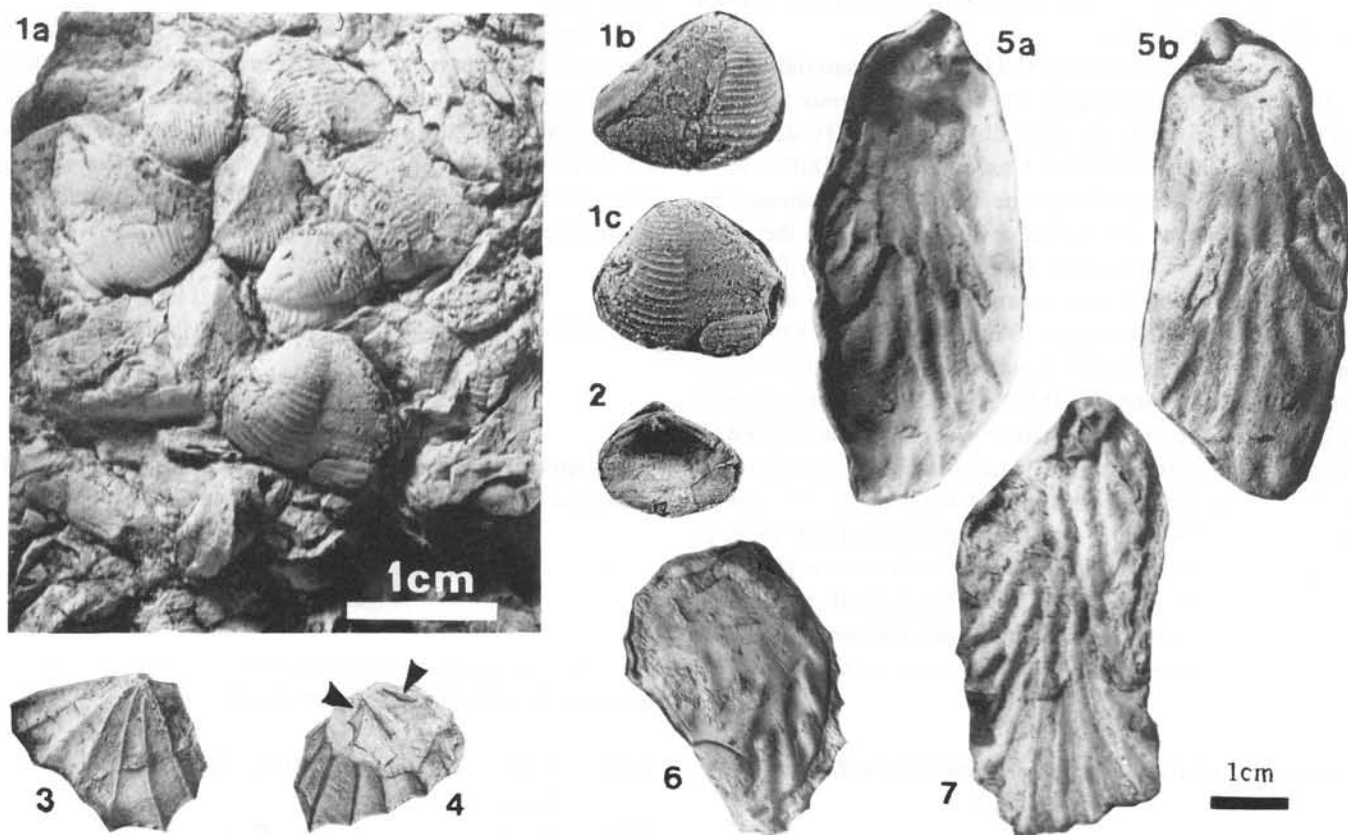


Figure 8. Late Triassic bivalves. 1–2, *Myophoriopsis sonorensis* n. sp., ERNO-2373, x2; 1a, general view of slab with many specimens; 1b, holotype, right valve, 1c, paratype, left valve; 2, paratype, right valve interior. 3–4, *Costatoria?* sp.; 3, right valve exterior, latex cast, ERNO-815; 4, partially filled external mould of valve showing crenulated teeth (arrows), ERNO-816. 5–7, *Palaeolopha* cf. *haidingeriana* (Emmrich); 5, ERNO-1954; 5a, latex cast; 5b, composite mould; 6, incomplete specimen, internal mould, ERNO-1956; 7, latex cast, ERNO-814. All x1 except where otherwise indicated.

part of the ligament area, with posteriorly (?) arcuate oyster-like resilifer limited by strong bourrelets.

Remarks—The material here described shows remarkable similarities in shape, size and ornament pattern with *P. haidingeriana* (Emmrich), which is known from the Upper Triassic (Norian–Rhaetian) of Europe (Austria, Switzerland, Germany, France, the Carpathians, Poland, Rumania), and probably Myanmar and New Zealand, especially with the material figured by Martin (1860, p. 90, pl. 6, figs. 24–25 as “*Ostrea*” *marcignyana*; see also Stenzel, 1971, fig. J62-4) and also with “*Ostrea*” *calceiformis* Broili (1904, pl. 23, figs. 10–11). The Mexican specimens differ from those described by Zapfe (1967, p. 438, pl. 3, figs. 7a–b) from the Rhaetian of the Alps, and Newton and collaborators (1987, p. 40, figs. 32, 33) as *Lopha* cf. *haidingeriana* from Oregon, by their larger size and elongated outline, and also by the probably small attachment area. Also *Lopha* cf. *haidingeriana* (Emmrich) from the Rhaetian of New Zealand (Fleming, 1953, p. 276, figs. 1–3) has larger attachment areas.

Also similar in shape and ornamentation pattern is *Lopha blanfordi* (Lees), from Norian beds of the Arabian Peninsula

and Vietnam (Hudson and Jefferies, 1961, text-figs. 3B, 8d, 8e), but this species has smaller shells with strongly curved (exogyroid?) umbones.

Relationships of these specimens to *Lopha? cordillerana* McRoberts (1997) from the Norian of Sonora and probably also Nevada are of special interest since this species was found in the same area though higher up in the sections. Nevertheless, they seem to be quite different. *Lopha? cordillerana* has thick, very large, elongated, slightly crescentically curved shells with large attachment area and up to 10 curved plicae, while *P. cf. haidingeriana* has medium-sized, narrowly elongated shells with apparently very small attachment area and up to 14 plicae.

Order Pectinoida Rafinesque, 1815
Superfamily Pectinoidea Wilkes, 1810
Family Entoliidae von Teppner, 1922

Genus *Entolium* Meek, 1865

Type species—*Entolium demissum* Meek, 1865 (non Phillips, 1829), figured by Quenstedt, 1858, p. 353, pl. 48, figs. 6, 7 as

Pecten demissus Phillips, original designation (Meek, 1865, p. 478), from the Aalenian of Germany (= *Pecten disciformis* Schübler in Zieten, 1833).

Note: Most authors regard Quenstedt's material (1858, pl. 48, figs. 6–7) as belonging to *Pecten disciformis* Schübler in Zieten (1833) and not to Phillips' species *P. demissus* (Burckhardt, 1903; Hertlein in Cox *et al.*, 1969; Duff, 1978). This misidentification of the type species was discussed by Duff (1978), whose criteria are followed here. On the other hand some authors (Jaworski, 1926; Johnson, 1984) followed Staesche (1926, p. 99) and regarded *E. disciforme* as a synonym of *Entolium corneolum* (Young and Bird, 1828). It is impossible to decide on this point without seeing the original material. Recently Johnson (1984) revised European species of the genus and recognized only three species, and he referred all Early Jurassic material to only one species. Nevertheless, on the basis of the available illustrations, the neotype of *E. corneolum* (Arkell, 1930, pl. 7, fig. 4, designated by Duff, 1978, p. 62) and the holotype of its synonym *E. demissum* (Phillips, 1829, pl. 6, fig. 5; Arkell, 1930, pl. 9, fig. 8; Duff, 1978, pl. 5, fig. 3) have a less orbicular form, larger auricles and smaller umbonal angle than typical *E. disciforme*, as noted by Duff (1978, p. 64).

***Entolium (Entolium) disciforme* (Schübler in Zieten, 1833)**
(Figures 5.3–5.5)

1833. *Pecten disciformis* sp. nov.; Schübler in Zieten, p. 69; pl. 53, fig. 2.
1894. *Pecten (Entolium) disciformis* Schübl.; Möricke, p. 37–38.
1899. *Pecten bisulcatus* Philippi; Philippi, p. 28, pl. 16, fig. 7.
1900. *Pecten (Entolium) disciformis* Schübl.; Burckhardt, p. 32, pl. 21, fig. 2 (only).
1903. *Pecten (Entolium) disciformis* Schübl.; Burckhardt, p. 22.
1915. *Pecten (Entolium) disciformis* Schübl.; Jaworski, p. 438.
1925. *Entolium disciformis* Schübl.; Jaworski, p. 54–55.
1926. *Pecten (Entolium) disciformis* Schübl. = *demissus* Phil.; Jaworski, p. 164–165.
1931. *Pecten (Entolium) disciformis* Schuebler; Weaver, p. 273–274, pl. 28, fig. 170.
1942. *Pecten (Entolium) disciformis* Schuebler; Leanza, p. 174–175, pl. 11, fig. 1.

Material—About 20 isolated valves, most of them complete but preserved as moulds (ERNO-2377 to 2379, 2393, 2395, 2397, 2398, 2405 to 2412, 2416 to 2418), from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, sections 3 and 4.

Remarks—Orbicular compressed shells with umbonal angle wider than 100°, subequal auricles with rounded dorsal corners, dorsal margin slightly projecting above hinge-line, with

strong auricular crura and well-developed dorsal longitudinal hinge-crura.

This material can confidently be referred to *E. disciforme* (Schübler), a widespread species of nearly cosmopolitan distribution. In the Andes this species is common in Pliensbachian to Bajocian beds (see synonymy list). The material described by McLearn (1924, pl. 5, figs. 3, 11) as *Entolium leachi* McLearn from the Fernie Formation in Canada probably also belongs here.

Family Neitheidae Sobetzky, 1960

Subfamily Weylinae Damborenea and Manceñido, 1988

Genus *Weyla* J. Böhm, 1920

Type species—*Pecten alatus* von Buch, 1838, from South American Lower Jurassic, original designation.

***Weyla (Weyla) alata* (von Buch, 1838)**
(Figures 5.6–5.9)

See synonymy list in Damborenea (1987b, p. 170–171), to which the following should be added:

1929. *Neithea mexicana* nov. spec., Jaworski, p. 2–5; pl. 1, figs. 1–3.
1986. *Weyla alata* (von Buch), Smith and Tipper; fig. 2.5
1987b. *Weyla mexicana* (Jaworski?); Damborenea, p. 189–190; pl. 11, fig. 3; t-fig. 22d.
1994. *Weyla (Weyla) alata* (von Buch); Aberhan, p. 43–44; pl. 22, figs. 1–3; pl. 23, figs. 1–2.
p. 1997. *Weyla*; Lucas and Estep, p. 45; figs. 1A–1B (only).

Material—Seven specimens with both valves, six left valves and eight right valves, most of them incomplete and not very well preserved (ERNO-2375, 2380 to 2387, 2399 to 2403, 2413, 2414, 2419, 2421, 2436 to 2438) from Sierra de Santa Rosa Formation, lower and middle members; Lower Jurassic (Sinemurian–Pliensbachian?); Sierra de Santa Rosa, sections 3 and 4. One right valve (ERNO-2374) from Antimonio Formation, unit 19; Sierra del Álamo.

Remarks—The specimens at hand do not show any differences from those referred to *W. alata* from other localities in South and North America (see Smith and Tipper, 1986; Damborenea, 1987b; Damborenea and Manceñido, 1988) and are thus referred to this species. The name *W. mexicana* (Jaworski) is here regarded as a junior synonym of *W. alata* (von Buch). It might only be maintained as a subspecific name if some distinctive morphological characters could be found.

Most of the specimens here described, as well as those figured by Lucas and Estep (1997, fig. 1A–1B) were collected in Sierra de Santa Rosa, *i.e.* the type locality of *W. mexicana* (Jaworski, 1929). Jaworski characterized his new species by

the presence of V-shaped ribs on both valves. Nevertheless, examination of all the material from Sierra de Santa Rosa (NHMB and ERNO collections) shows that this feature, together with some peculiar surface "ornament pattern", is merely a preservational artifact. It is also interesting to note that the specimens available to Jaworski (1929) were small to medium-sized (up to 6 cm high), and *Weyla* shells tend to have more acute ribs at that size.

The collection examined here contains specimens of a wide range of sizes and different degrees of corrosion of the shell, but clearly conspecific. Small specimens (up to 4 cm high), such as ERNO-2374, 2375, 2384, 2385, 2387, 2402, 2414 and 2421, can be closely compared with the three specimens figured by Jaworski (NHMB-51^{b1}, 52¹ and 52²), but these, together with medium-sized specimens, show the same range of morphological variation as *W. alata* from other localities. On the other hand, very large specimens (between 12 and 16 cm high), such as ERNO-2380 (Figure 5.9) and 2399, have flat-topped ribs and a few faint radial costae on the anterior auricle of the right valve (this last characteristic is also present on smaller shells). These features, together with the large size, were used by Aberhan (1994) to characterize *Weyla titan* (Möricke) as a distinct species. This was described (but not figured) by Möricke (1894) as a variety of *W. alata*, and as such was mentioned (but again never figured) by several later authors (Philippi, 1899; Jaworski, 1914, 1915, 1925). The few known specimens of *W. alata titan* always appear associated with *W. alata* along the Andes (as in Sonora) and all their characteristic features could be due to the large size attained. It was regarded as a subspecies of *W. alata* by Pérez and Reyes (1994), and it seems that it could be just a "gerontic" variant of *W. alata*. Thus *Weyla* specimens from Sierra de Santa Rosa are here regarded as belonging to a single species, and if deemed necessary, they could be referred to *W. alata mexicana* (Jaworski) (Figures 5.6–5.8) and *W. alata titan* (Möricke) (Figure 5.9).

Weyla alata has a wide stratigraphical distribution in the Americas, from at least Sinemurian to lower Toarcian (Damborenea and Manceñido, 1988; Pérez and Reyes, 1994).

The material figured as *Weyla* by Lucas and Estep (1997, p. 45, figs. 1C–1D) from Sierra del Álamo does not belong to this species but to a coarsely ribbed limoid, which is here described as *Mysidioptera mexicana* n. sp.

Subclass Isofilibranchia Iredale, 1939

Order Mytiloidea Férussac, 1822

Superfamily Mytiloidea Rafinesque, 1815

Family Mytilidae Rafinesque, 1815

Subfamily Modiolinae Keen, 1958

Genus *Falcimylus* Cox, 1937

Type species—*Mytilus suprajurensis* Cox, 1925, from the Upper Jurassic of England, original designation.

Falcimylus sp.

(Figure 5.11)

Material—One right valve (ERNO-2395) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—There is only one poorly preserved specimen available, but this has the typical sickle-shaped shell of species referred to *Falcimylus*, with terminal umbones and arcuate anterior margin. It is comparable in shape and size to *F.?* *gigantoides* (Leanza) from the Lower Jurassic of Argentina and Chile (Leanza, 1942; Damborenea, 1987a; Aberhan, 1994).

Genus *Modiolus* Lamarck, 1799

Type species—*Mytilus modiolus* Linné, 1758, Recent of Europe, subsequent designation by Gray, 1847, by absolute tautonymy.

Modiolus cf. *M. baylei* Philippi, 1899

(Figure 5.10)

Cf. 1899. *Modiola baylei* Ph., R. Philippi, p. 48; lám. 24, fig. 8 [= *Mytilus scalprum* Gott. in Bayle and Coquand, 1851, p. 15–16; pl. 7, figs. 3–4]

See Damborenea (1987a) and Aberhan (1994) for further synonymy.

Material—One specimen with both valves (ERNO-2396) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—The only available specimen agrees with the material from South America described as *M. baylei* Philippi (Damborenea, 1987a, pl. 4, figs. 2–5; Aberhan, 1994, pl. 26, figs. 1–4) by its elongated shell with straight low umbonal ridge. The Mexican shell is more elongated than those specimens, but nevertheless it is thought to be closely related, if not the same, species.

The shell is also more narrow and elongated than *M. mandannaensis* Lees (see Frebald, 1964, pl. 3, fig. 7), from the lower Lias of Yukon, Canada.

Subclass Palaeoheterodonta Newell, 1965

Order Trigonioidea Dall, 1889

Superfamily Trigonioidea Lamarck, 1819

Family Minetrigoniidae Kobayashi 1954

Genus *Costatoria* Waagen, 1907

Type species—*Donax costatus* Zenker, 1833, from Scythian of Germany, subsequently designated by Nakazawa, 1960.

Costatoria? sp.
(Figures 8.3–8.4)

Material—Three fragments, preserved as external moulds (ERNO-815 to 816) from the Antimonio Formation, unit 12; Upper Triassic (Norian?); Sierra del Álamo, section 2.

Remarks—These fragments are doubtfully referred to *Costatoria* on account of the ornamentation pattern and the presence of two laterally grooved strong teeth (Figure 8.4). The shell was inflated with prominent prosogyrous umbones. The most complete specimens have about six acute narrow ribs separated by wide concave intervals, which bear very faint growth lines. Two or three short ribs are present in the anterior (?) region of the shell and the posteriormost (?) rib is separated by an interval wider than the others. The material is very incomplete. Neither the complete valve shape nor details of hinge region can be seen, and thus no proper comparisons at the specific level can be done.

Nevertheless, it is evident that several species of *Costatoria* have a similar appearance, such as *C. chenopus* (Laube) from the Carnian of Europe (Bittner, 1895, pl. 11, figs. 1–2; Allasinaz, 1966, pl. 50, figs. 1–6) and *C. harpa* (Münster) from the Cassian beds of the Alps (Newell and Boyd, 1975, fig. 94A–B).

The shell shape, size and number of ribs are similar to those in *Myophoria napengensis* Healey (1908, pl. 6, figs. 1–29) from the Upper Triassic of Burma, but this has smooth teeth and nodose ribs.

- Subclass Heterodonta Neumayr, 1884
- Order Veneroida H. Adams and A. Adams, 1856
- Superfamily Carditoidea Fleming, 1820
- Family Kalenteridae Marwick, 1953
- Subfamily Myoconchinae Newell, 1957

Genus *Myoconcha* J. de C. Sowerby, 1824

Type species—*Myoconcha crassa* J. de C. Sowerby, 1824, by monotypy.

***Myoconcha neuquena* Leanza, 1940**
(Figures 5.12–5.14)

- 1915. *Myoconcha transatlantica* Burckh.; Jaworski, p. 443 (non Burckhardt, 1903).
- 1925. *Myoconcha transatlantica* Burckh.; Jaworski, p. 65 (non Burckhardt, 1903).
- 1929. *Myoconcha* cf. *Valienciennesi* Bayle u. Coquand; Jaworski, p. 8–9; pl. 1, figs. 8a–b (non Bayle and Coquand).
- 1940. *Myoconcha neuquena* Leanza, p. 126; pls. 1–2.
- 1942. *Myoconcha neuquena* Leanza; Leanza, p. 181; pl. 14, fig. 5.

1942. *Myoconcha neuquena* Leanza var. *torulosa* n. var. Leanza, p. 181; pl. 12, fig. 1.

Material—Ten specimens with both valves, none of them complete (ERNO-2388, 2420, 2422 to 2429), from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—This species was already described and figured by Jaworski (1929) from the same area (Mina Santa Rosa and Cajón Las Amarillas) and compared to the species *M. valiencennesi* (Bayle and Coquand, 1851, p. 16–17; pl. 6, fig. 1–2).

Many authors (including Burckhardt, 1903; Weaver, 1931; Leanza, 1940) have regarded *M. valiencennesi* (B. and C.) as probably a junior synonym of the Neocomian species *M. transatlantica* Burckhardt (1903, p. 78–79; pl. 16, figs. 3–5), widely distributed along the South American Andes. Nevertheless, the true relationships between *M. valiencennesi* with either *M. transatlantica* (of Neocomian age) or *M. neuquena* (of Early Jurassic age) have not been analyzed in detail, and thus it is not clear to which of the two large *Myoconcha* from the Andes should the name *M. valiencennesi* be applied. As already pointed out by Weaver (1931) the collection of further material with accurate stratigraphical provenance from its type locality seem crucial to this matter.

According to the original figures and description of *M. valiencennesi* by Bayle and Coquand (1851, pl. 6, figs. 1–2), this species seems to be the first available name for the Neocomian species, which is characterized by a very globose and thick shell, with ovate lateral outline and surface only covered by growth lines. On the other hand, the Early Jurassic species, to which the material here described belongs, is subtriangular in outline, less globose, and well-preserved specimens show straight narrow radial lines over most of the shell (see Figures 5.12a and 5.14). All these characteristics, together with the dimensions of the specimens and details of the internal characters seen in one almost complete inner mould, agree with the Early Jurassic species *M. neuquena* Leanza. The specimens which have the shell best preserved also show the corded commarginal ornamentation which Leanza (1942) used to distinguish his variety *torulosa*, which is not given a separate taxonomic status here. The species *M. neuquena* is known to occur along the Andes in northern Chile and central western Argentina from Pliensbachian and lower Toarcian deposits (see Damborenea, 1996).

Most of the specimens here described show signs of bioerosion and are heavily perforated, others are superficially eroded or have the posterior portion of the valves encrusted by different kinds of epizoans.

- Superfamily Lucinoidea Fleming, 1828
- Family Lucinidae Fleming, 1828
- Lucinidae gen. et sp. indet.
(Figure 9.2)

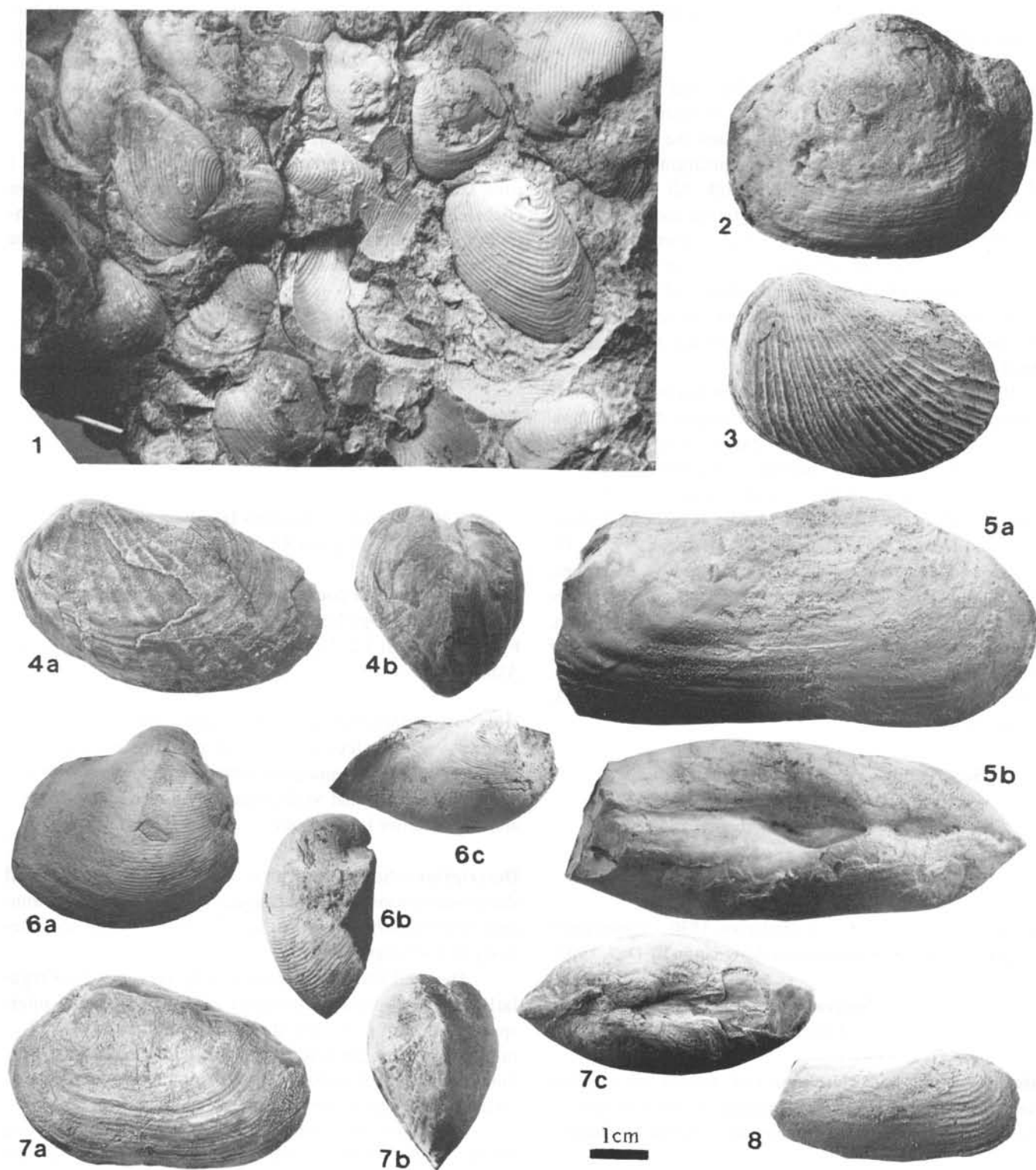


Figure 9. Early Jurassic bivalves. 1, *Neocrassina?* sp., portion of slab showing several specimens, ERNO-2139. 2, Lucinidae gen. et sp. indet., right valve, ERNO-2419. 3, *Pholadomya* cf. *fidicula* (Sowerby), lateral view of left valve, ERNO-2389. 4, *Pholadomya* cf. *ambigua* (Sowerby), ERNO-2432; 4a, view of left valve; 4b, anterior view. 5, *Pachymya?* sp., complete specimen, ERNO-2433; 5a, right valve; 5b, dorsal view. 6, *Ceratomya* sp., right valve, ERNO-2393; 6a, lateral view; 6b, anterior view; 6c, dorsal view. 7, *Gresslya* cf. *striata* Agassiz, complete specimen, ERNO-2435; 7a, left valve lateral view; 7b, anterior view; 7c, dorsal view. 8, *Platymyoidea* sp., lateral view of right valve, ERNO-2377. All x1.

Material: One almost complete right valve, very poorly preserved (ERNO-2419), Sierra de Santa Rosa Formation, lower member; Lower Jurassic (Sinemurian–Pliensbachian?); Sierra de Santa Rosa, Sonora, (section 3).

Remarks: The only available valve is large and flattened, and has a subquadrate outline with a posterior truncation. The anterior margin has a typical lucinoid shape, and the shell is ornamented by numerous, very regular, commarginal lines. The shell margin seems to be internally smooth. All these characteristics suggest assignment to the Myrteinae and probably to the genus *Mesomiltha* Chavan, 1838, but no attempt has been made to advance the identification beyond the family level because the hinge characteristics and details of muscle scars are unknown. Furthermore, although there are several comparable species from the Lower Jurassic of the Americas, no updated revision is available.

Its size and shape agree with those of *Lucina* sp. indet. II in Leanza (1942, pl. 18, fig. 1), while it is quite different from either *Mesomiltha? huayquimili* (Leanza) or *M.? payllalefi* (Leanza), both from the Pliensbachian of Argentina and Chile.

The shape of this valve is also similar to *M. bellona* (d'Orbigny) from the Lower and Middle Jurassic of Europe (Morris and Lycett, 1853, pl. 6, fig. 18; Fischer, 1969, pl. 12, fig. 15; and material seen at the Sedgwick Museum, Cambridge), but again there are not enough characteristics preserved in the Mexican material to allow closer comparison. *Mesomiltha bellona* has also been mentioned from the Lower Jurassic of Argentina and Chile (Jaworski, 1915, 1925; Wahnish, 1942, pl. 5, fig. 1; Pérez, 1982, pl. 16, figs. 9, 13; Aberhan, 1992).

Superfamily Crassatelloidea Férussac, 1822

Family Astartidae d'Orbigny, 1844

Subfamily Astartinae d'Orbigny, 1844

Genus *Neocrassina* Fischer, 1886

Type species—*Astarte obliqua* Deshayes, 1830 = *Cypricardia obliqua* Lamarck, 1819, subsequent designation by Dall, 1903.

Neocrassina? sp.

(Figure 9.1)

Material—A slab with closely packed isolated but complete valves (ERNO-2139); from the Antimonio Formation, unit 16; Lower Jurassic (Hettangian?, Sinemurian?); Sierra del Álamo.

Remarks—Trapezoidal to ovate shells, inequilateral, with the umbo placed at about 1/3 of the shell length from the anterior end. It is ornamented by very regular commarginal ribs separated by equally wide intervals. The ornamentation is stronger near the umbones but continues to the shell margin. Lunule and scutcheon seem to be present. Inner shell surface smooth

and ventral margin very slightly crenulated. Other internal characteristics unknown.

The lack of data about the internal features prevents further comparison. Nevertheless, in general shape and size it is similar to *N. aureliae* (Feruglio), a very common species in Lower Jurassic deposits of the Andes of South America (Feruglio, 1934, pl. 4, figs. 14–16; Wahnish, 1942, pl. 4, figs. 1–2; Leanza, 1942, pl. 17, figs. 4–7).

Jaworski (1929) referred two right valves (NHMB 51^{b2}) from the Sierra de Santa Rosa area to *Astarte cf. antipodum* Giebel, but these shells have a more circular outline with centrally placed umbones and a different ornamentation and are not conspecific with the species treated here.

Family Myophoricardiidae Chavan in Vokes, 1967

Genus *Myophoriopsis* von Wöhrmann, 1889

Type species—*Myophoria lineata* von Münster, 1841, p. 88 = *Lyrodon lineatus* von Münster in Goldfuss, 1838, by monotypy.

Myophoriopsis sonorensis Damborenea n. sp.

(Figures 8.1–8.2, 7.1a–b)

Material—Several complete specimens, some articulated, closely packed together (ERNO-2373) from the Antimonio Formation, unit 12; Upper Triassic (Norian?); Sierra del Álamo, section 1.

Diagnosis—*Myophoriopsis* with sharp umbonal carina and shallow ventral sulcus and truncate posterior margins, with regularly spaced commarginal riblets. Right valve with one strong median cardinal tooth posteriorly directed, one anterior and one posterior lateral tooth.

Description—Small, equivalve, subtrigonal to inequilateral shells with conspicuous umbonal carina, posterior margin truncate. Shell slightly longer than high. Umbones placed just anteriorly to mid-length.

The shell flanks are ornamented by very numerous regularly spaced commarginal riblets separated by equal interspaces. The carina is very sharp, and there are two or three radial riblets just posterior to it. The shell also bears a very faint lateral ventral sulcus, indicated by a shallow depression on the surface and by the weaker commarginal ribs.

The right-valve hinge (Figures 8.2, 7.1b) bears one strong median cardinal tooth somewhat posteriorly directed and two long laterals, one anterior and one posterior.

Discussion—The presence of a ventral sulcus distinguishes *M. sonorensis* from all other known *Myophoriopsis* species. *Myophoriopsis richthofeni* (Stur), from the Carnian of Italy (Wöhrmann and Koken, 1892, pl. 8, figs. 1–3; Broili, 1904, pl.

27, figs. 3–14; Allasinaz, 1966, pl. 55, figs. 1–2) has similarly shaped but shorter shells. The type species, *M. lineata* (Münster), from Ladinian beds of Austria, is more trigonal in shape (Bittner, 1895, pl. 13, fig. 1–6; Goldfuss, 1839, pl. 136, fig. 4).

Myophoriopsis sonorensis n. sp. is preserved in a mono-specific coquina made up mostly of complete valves, some of them conjoined (Figure 8.1a).

Subclass Anomalodesmata Dall, 1889
Order Pholadomyoidea Newell, 1965
Superfamily Pholadomyoidea Gray, 1847
Family Pholadomyidae Gray, 1847

Genus *Pholadomya* G.B. Sowerby, 1823

Type species—*Pholadomya candida* G.B. Sowerby, 1823, subsequent designation by Gray, 1847, p. 194.

***Pholadomya* cf. *P. fidicula* (J. Sowerby, 1819)**
(Figure 9.3)

- Cf. 1819. *Lutraria lirata* Sowerby, p. 47, t. 225.
Cf. 1845. *Pholadomya fidicula* Sowerby; Agassiz, p. 60, pl. 3c, figs. 10–13.
1851. *Pholadomya fidicula* Sow.; Bayle and Coquand, p. 27, pl. 7, fig. 7.
1894. *Pholadomya fidicula* Sowerby; Möricke, p. 55.
1926. *Pholadomya fidicula* Sow.; Jaworski, p. 192–193.
1931. *Pholadomya fidicula* Sowerby; Weaver, p. 309, pl. 36, fig. 204.

Material—Seven specimens preserved as moulds (ERNO-2389 to 2391, 2404, 2430, 2431, 2434) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, sections 3 and 4.

Remarks—Most of the *Pholadomya* specimens from Sonora belong to this species, characterized by inflated shells with anteriorly placed beaks and numerous radial costae, and can be compared with Sowerby's species *P. fidicula*, which has a very wide distribution.

Pholadomya plagemanni Möricke (1894, pl. 6, fig. 2), from the middle Jurassic of Chile, has a similar ornamentation pattern but with fewer ribs.

***Pholadomya* cf. *P. ambigua* (J. Sowerby, 1819)**
(Figure 9.4)

- Cf. 1819. *Lutraria ambigua* Sowerby, p. 48, t. 227.
1915. *Pholadomya ambigua* Sow.; Jaworski, p. 423–424.
1925. *Pholadomya ambigua* Sow.; Jaworski, p. 110.
Cf. 1991. *Pholadomya ambigua* Sowerby; Poulton, p. 33, pl. 4, fig. 13; pl. 12, figs. 1–4.

Material—One complete specimen (ERNO-2432) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—One of the *Pholadomya* specimens from Sonora is quite different from the others, having a more elongated shape and few radial costae, and it is comparable to *P. ambigua* (Sowerby), which has been mentioned and figured from several North and South American localities.

Pholadomya andina Möricke (1894, pl. 1, fig. 8), from the lower Jurassic of Chile, also has few radial ribs, but the general shell shape is very different, with prominent umbones and narrow posterior end. Other similar species are *P. kingii* Meek (Butler, 1920, pl. 10, figs. 1–2), from the Jurassic of Utah, and *P. oretiensis* Campbell and Grant Mackie (1995, figs. 2A–H), from the Lower Jurassic of New Zealand, but these have more rectangular shells.

Genus *Pachymya* J. de C. Sowerby, 1826

Type species—*Pachymya gigas* J. de C. Sowerby, 1826, by monotypy.

***Pachymya*? sp.**
(Figure 9.5)

Material—One almost complete specimen (ERNO-2433) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—The shell is globose and elongated, equilateral, with dorsal and ventral margins nearly parallel to each other, with broad low orthogyrous umbones and obtuse umbonal carina. The greatest inflation of the shell is situated posteriorly from the beaks. There are deep dorsal cavities both anteriorly and posteriorly of the beak. The anterior margin is closed, the posterior margin appears to have been widely gaping. On some portions of the shell faint radial lines of small pustules can be seen. Otherwise the whole surface bears only irregularly spaced growth lines. The posterior adductor muscle scar appears to be rounded in shape and faintly impressed (Figure 9.5a).

This specimen has been doubtfully referred to *Pachymya* on account of the shell shape, with its greatest inflation on the umbonal carina and the presence of lines of radial pustules. Nevertheless, the very low umbonal carina indicates affinities with some species referred to *Homomya* Agassiz. *Homomya neuquena* Leanza (1942, pl. 16, fig. 2; Jaworski, 1915, 1925; Aberhan, 1992), from the Pliensbachian of Argentina and Chile has much larger shells with more anteriorly placed umbones and even less conspicuous carina, and a convex ventral margin. Also *H. gibbosa* (J. Sow.) has a more arcuate shape, with anteriorly placed umbones (J. Sowerby, 1813). *Homomya jurozephyriensis* Crickmay (1930, pl. 6, figs. g–h), from the Lower Jurassic of British Columbia, is less elongated

and the umbonal carina is nearly absent. *Homomya* sp. nov. (?) described by Pérez (1982, pl. 16, figs. 14–15) from the Pliensbachian of Chile, is larger and shorter. From the Lower Jurassic of the Andes Behrendsen (1891, pl. 22, fig. 10) described *H. bodenbenderi*, which is a small short shell of uncertain affinities, probably related to *Gresslya*.

Family Ceratomyidae Arkell, 1934

Genus *Ceratomya* Sandberger, 1864

Type species—*Isocardia excentrica* Roemer, 1836, from the Upper Jurassic of Europe.

Ceratomya sp. (Figure 9.6)

Material—One almost complete right valve (ERNO-2393) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—Well inflated shell, slightly longer than high, with broad prosogyrous incurved beaks situated somewhat anteriorly from mid-length.

Ornamented by very regularly spaced commarginal undulations, some of them disappearing towards the anterior end, at least three times along the shell growth, but never becoming oblique. About 12 lines per cm on middle portion of shell.

This genus is known from Lower Jurassic deposits of Argentina (Volkheimer *et al.*, 1978) and Chile (Mörcke, 1894). Some of that material was referred to the middle Jurassic species *C. steinmanni* (Mörcke, 1894) by Jaworski (1926), but this specimen has a somewhat triangular shape with narrow beaks, while the Early Jurassic material from the southern Andes is very similar to the Mexican specimen here described.

Ceratomya caudata (Dumortier, 1874, pl. 39, figs. 1–2), from the Lower Jurassic of France, is elongated posteriorly and has coarser commarginal ornamentation. Other Early Jurassic species, such as *C. petricosa* (Simpson) and *C. ludovicae* (Terquem) have apparently externally smooth shells. On the other hand, *C. madagascariensis* (Thevenin, 1908, pl. 3, figs. 9–9a), from the Toarcian of Madagascar, and *C. tanganyicensis* Cox (1965, pl. 21, figs. 1a–c), from the Bajocian? of Tanzania and probably the Toarcian of Vietnam (Hayami, 1972, pl. 36, figs. 1–2), have a similar ornamentation pattern but different shell shape. *Ceratomya gibbosa* (Etheridge, 1864, t-figs. 3–4), from the Sinemurian of Ireland, is more subtriangular and has more acuminate umbones.

Genus *Gresslya* Agassiz, 1843

Type species—*Lutraria 1997ia* Zieten, 1833, p. 85, from the Bajocian of Europe, subsequent designation by Herrmannsen, 1847, p. 490.

Gresslya cf. *G. striata* Agassiz, 1843 (Figure 9.7)

Cf. 1843. *Gresslya striata* Ag.; Agassiz, p. 219; pl. 13c, figs. 7–9.

? 1915. *Gresslya striata* Ag.; Jaworski, p. 423.

? 1925. *Gresslya striata* Ag.; Jaworski, p. 104–105.

? 1926. *Gresslya* spec. cf. *striata* Ag.; Jaworski, p. 190.

? 1931. *Gresslya striata* Agassiz; Weaver, p. 308.

? 1991. *Gresslya*(?) sp.; Poulton, p. 33, pl. 4, figs. 16–23, 25–27 (only).

Material—Two almost complete specimens (ERNO-2392, 2435) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—The specimens show all the diagnostic characteristics of the genus *Gresslya*: they are nearly equivalve shells, with the right valve umbo slightly higher than the left one and with an internal slit on the right valve dorsal posterior region. The umbones are broad and prosogyrous, placed at about 1/4 of the total length from the anterior end. The maximum shell width is placed at mid-length. The shell is ornamented by irregularly distributed growth lines and faint commarginal undulations. The shell outline is elongate oval, with anterior and posterior margins equally rounded, not gaping.

These specimens are regarded as probably conspecific with at least part of Pliensbachian material from Argentina which other authors (see synonymy) have referred to *G. striata* Ag., and with *G.*? sp. in Poulton (1991), from the upper Sinemurian of northern Canada.

Gresslya rotundata (Phillips), from the Sinemurian to Toarcian of Europe and Canada (Friebold, 1957, pl. 2, fig. 7; 1969, pl. 1, figs. 8–9) is shorter and has regular commarginal folds.

Superfamily Pandoroidea Rafinesque, 1815

Family Laternulidae Healey, 1918

Genus *Platymyoidea* Cox, 1964

Type species—*Platymya dilatata* Agassiz, 1843, from the lower Cretaceous of the Swiss Jura, by original designation.

Cox (1964, p. 42) proposed the name *Platymyoidea* as a substitute for *Platymya* Agassiz, 1843, non Robineau-Desvoidy, 1830 (Insecta).

Platymyoidea sp. (Figure 9.8)

Material—Two specimens preserved as moulds (ERNO-2377) from Sierra de Santa Rosa Formation, middle member; Lower Jurassic (Pliensbachian?); Sierra de Santa Rosa, section 4.

Remarks—Shell of medium to small size for genus, elongated and compressed, gaping posteriorly. Low and broad umbones at about 1/3 of anterior end of shell. Ventral margin long and straight, parallel to hinge margin. A faint trace of the internal umbonal plate can be seen on one valve. Ornamented by growth-lines and, only on the portion of shell anterior to the umbones, regular commarginal folds.

In shape and inflation it is similar to *P.?* *elongata* (Roemer), from the Pliensbachian of Europe and Argentina (Agassiz, 1842–45, pl. 10, figs. 2–5; Buckman, 1845, pl. 10, fig. 10; Richardson, 1904, pl. 19, figs. 2a–b; Jaworski, 1926, pl. 1, figs. 7a–b). However, *P.* sp. is of smaller size and has less prominent umbones, thus approaching *P. hispida* (Simpson), from the upper Pliensbachian of Great Britain (Tate, 1876, pl. 14, fig. 3), though this latter may be regarded as a synonym of *P. elongata* according to Jaworski (1926).

Platymyoidea aquarum (Lundgren), from the Lower Jurassic of Sweden (Troedsson, 1951, pl. 12, fig. 2) has a shorter shell with more prominent umbones. Also similar are some specimens figured by Hayami (1972, pl. 35, figs. 12–14) as "*Osteomya* cf. *dilata* (Phil.)", from the Toarcian of Vietnam.

DISCUSSION

LATE TRIASSIC FAUNA

The Triassic bivalve fauna described here (Figures 6–8), although of very low diversity, is interesting since it is different from other Late Triassic associations from Sonora and southern North America (Stanley, 1979; Laws, 1982; Stanley *et al.*, 1994; McRoberts, 1997). It is thought that this may be due to a peculiar and restricted paleoenvironmental setting of the association under consideration and perhaps also to slight differences in their age.

This small fauna is also of importance since it had been previously interpreted as Early Jurassic in age on the basis of the alleged presence of specimens belonging to the genus *Weyla* (see Lucas and Estep, 1997, fig. 1C–D). As shown above, the bivalves in question are not pectinoids but coarsely ribbed limoids assigned here to *Mysidiopetra*. This genus, together with the other taxa in the same levels (*Myophoriopsis*, *Palaeolopha* and probably *Costatoria*), evidently support a Late Triassic age for this fauna. This and the fact that *Mysidiopetra mexicana* n. sp. is present both below and above levels containing the hydrozoan *Heterastridium* (see Figure 2) indicate that the local section is not greatly disturbed tectonically (González León, 1997) and that the age of the fauna is consistent with its position within the sequence. It is younger than the Late Carnian (*dilleri* Zone) fauna described from unit 11 of the Antimonio Formation (Keller, 1928; Burckhardt, 1930; King, 1939; Stanley and González León, 1995) but older than and in part equivalent to the Norian biostromal limestones and associated sediments of unit 13 which provided the fauna described by Stanley and collaborators (1994) and McRoberts (1997).

Apart from the four species described here, the Late Triassic bivalve association contains at least three other taxa (see Table 1) whose description must await the availability of better material: one species with large and flat ostreoid-like valves, one medium-sized inflated pectinoid (?) with two orders of thin radial ribs, and a very large coiled shell here referred to as *Bivalvia?* gen. et sp. indet., which might have megalodontid or dicercocardiid affinities but is different from the "alatoform bivalve" figured by Stanley and collaborators (1994).

The biogeographic relationships of this fauna point to both the Tethys (especially the Alpine region) and the eastern Pacific margin. Two of the species are new but are clearly related to Tethyan species of *Myophoriopsis* and *Mysidiopetra*, and of the four genera, three are also present in southern North America (Nevada and Oregon).

EARLY JURASSIC FAUNA

The Early Jurassic bivalves described here (Figures 5, 9) provide a more complete account of the bivalve diversity in Sonora for that time. Though some of the taxa are represented by very few specimens or by material not sufficiently well preserved to be assigned to species, the whole fauna shows that Early Jurassic bivalves from Sonora were more varied and diverse than previously acknowledged and merit closer study.

Only one species from the lowest Lower Jurassic is described and referred to *Neocrassina?* sp. Most of the other bivalves come from approximately the same localities as those described by Jaworski (1929), and are thought to be of Pliensbachian age. Three of Jaworski's species are here re-interpreted, and, on the whole, the probably Pliensbachian fauna of Sierra de Santa Rosa includes now at least 19 species: the 14 species studied here (see Table 1), plus five species described by Jaworski (1929) which have not been found in the present collection: *Camptonectes* (*C.*) sp., "*Alectryonia*" *gregarea* (Sow.), "*Lima*" *nodulosa* Terquem, *Frenguelliella* cf. *inexpectata* (Jaw.) and *Astarte* cf. *antipodum* Giebel.

From a paleoecological point of view, the middle member of the Santa Rosa Formation contains a wide variety of life habit types:

- Relatively deep burrowers (*Pholadomya* cf. *fidicula*, *Pholadomya* cf. *ambigua*, *Ceratomya* sp., *Gresslya* sp., *Platymyoidea* sp. and *Pachymya?* sp.)
- Shallow burrowers (*Frenguelliella* cf. *inexpectata*, *Astarte* cf. *antipodum*)
- Semi-infaunal byssate (*Pinna* sp., *Myoconcha neuquena* and *Modiolus* sp.)
- Semi-infaunal recliner (*Weyla alata*)
- Epifaunal recliner to swimmer (*Entolium disciforme*)
- Byssate epifaunal (*Camptonectes* sp., *Plagiostoma* cf. *punctatum*, "*Lima*" *nodulosa*, and *Falcimytillus* sp.)
- Cemented epifauna ("*Alectryonia*" *gregarea*)

The distribution and relationships of these life habits within the Santa Rosa Formation cannot be attempted with the available data, but its detailed study will certainly add valuable elements to the understanding of the depositional environments of the Early Jurassic sediments in the region.

The biogeographical affinities of the species described point to an overwhelming east Pacific signature, with Tethyan elements also present. Thus, *Weyla alata*, *Myoconcha neuquena*, *Frenquelliella* cf. *inexpectata* are typical east Pacific species, whilst *Plagiostoma* cf. *punctatum*, *Entolium disciforme* and the other bivalves not determined at the species level belong to mostly cosmopolitan genera which are very common in both the Tethys and the east Pacific margin.

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Note added in proof:

In a recently published paper, Aberhan (1998, p. 122–127) described some specimens from Canada, which he referred to *Weyla meeki* Damborenea, 1987, and included *W. mexicana* (Jaworski, 1929) as a synonym. The subject cannot be adequately discussed here, but it is noted that if his synonymy is correct, the first available name for the taxon is *W. mexicana*.

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