To Dr. Zakharov,
with best wishes
S Damborenea

SONDER-ABDRUCK

aus

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EARLY JURASSIC BIVALVIA OF ARGENTINA

PART 1: STRATIGRAPHICAL INTRODUCTION AND SUPERFAMILIES NUCULANACEA, ARCACEA, MYTILACEA AND PINNACEA

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With 4 plates, 24 figures and 1 table in the text
and on 1 folder

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Zusammenfassung

In dieser Arbeit wird das Ergebnis einer ausführlichen systematischen Untersuchung von 23 unterjurassischen Arten der Bivalvia vorgelegt. Diese vertreten 15 Gattungen aus 6 Familien, die den folgenden Überfamilien angehören: Nuculanacea, Arcacea, Mytilacea und Pinnacea. Unter den bearbeiteten Arten werden vier neu aufgestellt: *Parallelodon groeberi* n. sp., *P. riccardii* n. sp., *Lycettia hypertrigona* n. sp. und *Modiolus* (*Gibbomodiola* ?) *gerthi* n. sp. Diese Untersuchung stützt sich hauptsächlich auf eigene Aufsammlungen, die unter strikter stratigraphischer Kontrolle durchgeführt wurden. Dreiundzwanzig detaillierte Jura-Profile wurden vermessen, sie werden hier synthetisch beschrieben. Es wurden etwa 50 fossilführende Fundorte aus den Provinzen San Juan, Mendoza und Neuquén (Argentinien) analysiert. Dadurch konnte die Kenntnis der stratigraphischen Verbreitung jeder der Arten grundlegend verbessert werden. Einige Taxa der Genus-Gruppe wurden zum ersten Mal im Unter-Jura Argentiniens beobachtet und illustriert. Verschiedene Taxa sind eng mit europäischen Bivalven verknüpft. Im allgemeinen bestehen unter den untersuchten Muscheln, was die Gattungen betrifft, klare Beziehungen zu den typischen Tethys-Faunen, obgleich vielen der Arten eine beschränkte geographische Verbreitung in den südamerikanischen Anden zukommt.

Ashcroftia CRICKMAY wird als eine Untergattung von *Cucullaea* LAMARCK aufgefaßt. Die neue Art *Modiolus gerthi* wird vorläufig der Untergattung *Gibbomodiola* SACCO zugeschrieben. Es werden Unterlagen zur Ontogenese einiger der Arten beigebracht, ferner eine Kurzbeschreibung ihrer paläoautökologischen Eigenschaften. Die Analyse von paläogeographischen Daten der Gattungen *Lycettia* COX und *Inoperna* CONRAD spricht zusätzlich für die Hypothese eines Faunenaustausches zwischen den Bivalven des östlichen Pazifik und denjenigen der westlichen Tethys während des frühen Jura.

Schlüsselwörter: Bivalvia - Unterjura - Argentinien - Palaeotaxodonta - Pteriomorphia.

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Abstract

A detailed systematic study has been made of 23 species of early Jurassic bivalves belonging to 15 genera and subgenera and to six families of the superfamilies Nuculanacea, Arcacea, Mytilacea and Pinnacea. Of these, four species are new: *Parallelodon groeberi* n. sp., *Parallelodon riccardii* n. sp., *Lycettia hypertrigona* n. sp. and *Modiolus* (*Gibbomodiola* ?) *gerthi* n. sp. The research was mainly based upon the author's own material collected stratigraphically. Twenty-three sections were measured and the summarized description of each of them is given. A total of about 50 fossiliferous localities were visited in the provinces of San Juan, Mendoza and Neuquén of western Argentina. Thus, the knowledge about the stratigraphical range of the species has been greatly improved.

Some of the genus-group taxa are recognized and illustrated for the first time in the early Jurassic of Argentina. Several species are identical or very closely related to European forms and the bivalves studied show, as a whole, strong affinities with typically Tethyan ones at the generic level. Nevertheless, many of the species have a restricted geographical distribution within the South American Andes.

The status of *Ashcroftia* Crickmay has been validated as a subgenus of *Cucullaea* Lamarck and a species of *Modiolus* Lamarck is tentatively referred to the subgenus *Gibbomodiola* Sacco. Furthermore, relevant data for a better understanding of the ontogenetic development of several of the described species and an outline of the palaeoautecology of each species are also given. Palaeogeographical data analysis of genera such as *Lycettia* Cox and *Inoperna* Conrad strengthens the available evidence favouring a faunal exchange between the east-central Pacific and the western Tethys during early Jurassic times.

Key words: Bivalvia - Lower Jurassic - Argentina - Palaeotaxodonta - Pteriomorphia.

Resumen

Se realiza un estudio sistemático detallado de 23 especies de bivalvos del Jurásico Inferior pertenecientes a 15 géneros y subgéneros y a seis familias de las superfamilias Nuculanacea, Arcacea, Mytilacea y Pinnacea. De ellas, cuatro especies son nuevas: *Parallelodon groeberi* n. sp., *Parallelodon riccardii* n. sp., *Lycettia hypertrigona* n. sp. y *Modiolus* (*Gibbomodiola*?) *gerthi* n. sp. El estudio se basó principalmente sobre material de colecciones propias realizadas con estricto control estratigráfico. Se midieron 23 perfiles columnares detallados, de los cuales se ofrece una descriptión sintética. Se visitaron en total alrededor de 50 localidades fosilíferas en las provincias de San Juan, Mendoza y Neuquén (Argentina). De esa manera se mejoró considerablemente el conocimiento sobre el rango estratigráfico de cada especie tratada.

Algunos de los taxa del grupo del género han sido reconocidos e ilustrados por primera vez para el Jurásico Inferior argentino. Varios taxa son referibles a (o están muy relacionados con) bivalvos europeos, y los bivalvos estudiados muestran, en conjunto, fuertes afinidades con las faunas típicamente tethyanas a nivel genérico. Sin embargo, muchas de las especies poseen una distribución geográfica restringida dentro de los Andes sudamericanos.

El status de *Ashcroftia* Crickmay se convalida como un subgénero de *Cucullaea* Lamarck, y una especie de *Modiolus* Lamarck se refiere tentativamente al subgénero *Gibbomodiola* Sacco. Asimismo se aportan datos sobre el desarrollo ontogenético de varias de las especies descriptas, y se da una pequeña reseña de las características paleoautoecológicas de cada especie tratada. El análisis de datos paleogeográficos de géneros como *Lycettia* Cox e *Inoperna* Conrad permite corroborar la existencia de una vía de intercambio faunístico accesible a los bivalvos entre el Pacífico oriental y el Tethys occidental durante el Jurásico temprano.

Palabras claves: Bivalvia - Jurásico inferior - Argentina - Palaeotaxodonta - Pteriomorphia.

Contents

Introduction

The early Jurassic faunas of Argentina are rich and diverse. The bivalves, which dominate the fossil assemblages, have not previously been treated in a monographic way. This work is an attempt to revise the systematics, geographical and stratigraphical distribution of this group. Accordingly, extensive collections were made at several localities in San Juan, Mendoza and Neuquén provinces. Where possible, the type localities for species described by previous authors were examined. The field work was carried out between 1973 and 1984. The greater part of the collecting was done in several trips 1973, 1974 and 1979 with A. C. RICCARDI and M. MANCEÑIDO. A second visit to the area of Cordón del Espinacito (San Juan province) was made in 1975 with M. MANCEÑIDO and W. VOLKHEIMER. Some additional localities in Neuquén province were examined with M. MANCEÑIDO and S. BALLENT in 1980. A. RICCARDI and M. MANCEÑIDO provided data and fossil material collected during their field trip to the Valle Hermoso region (Mendoza province) in 1982. Some stratigraphical sections in southern Mendoza were measured with M. MANCEÑIDO in 1983; and the central Neuquén region was visited with M. MANCEÑIDO and M. GRIFFIN in 1984. The study also included the examination of type specimens and other material from collections deposited in several museums (especially at the La Plata Natural Sciences Museum).

The first part of this monograph deals with the superfamilies Nuculanacea, Arcacea, Mytilacea and Pinnacea. The second part deals with the Pteriacea, Buchiacea and part of the Pectinacea. Further parts of this monograph will deal with the remaining Pectinacea and the subclasses Palaeoheterodonta, Heterodonta and Anomalodesmata.

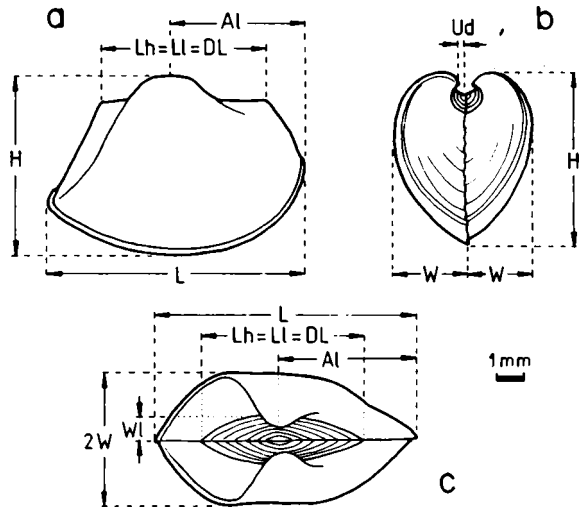
Previous work

The first published reference to an early Jurassic bivalve from Argentina appears to be the mention of *Pecten alatus* VON BUCH from the Andes of Mendoza in the accounts of STROBEL's voyage (1869, 1870, 1875). On the other hand, the first systematic description and illustration of several bivalve species was provided by BEHRENDSEN (1891, 1892) based upon material collected by BODENBENDER during his expeditions to Neuquén and Mendoza. The discovery made by ROTH of Lower Jurassic marine sediments at Piedra Pintada (Neuquén province) provided material for several studies on the bivalves from this locality, the first one by BURCKHARDT (1902). That author also described (1900 a, 1900 b, 1903) some early Jurassic bivalves collected by him and by HAUTHAL in Neuquén and Mendoza. JAWORSKI (1914, 1915, 1925 a, 1925 b, 1926) made important studies on the subject, and described material collected by STEINMANN, KEIDEL and GERTH. During the two decades of 1930 and 1940 some significant contributions to the knowledge of early Jurassic bivalves were made by WEAVER (1931), FERUGLIO (1934), WAHNISH (1942), A. LEANZA (1940 a, 1940 b, 1941, 1942 b, 1943) and LAMBERT (1944 b). Other papers were published by GROEBER (1924), RIGAL (1930) and LEVY (1967).

Terminology and Measurements

The morphological terms used in this work are those listed and defined by Cox et al. (1969), and by WALLER (1984) for pectinaceans. Measurements (see text-fig. 1) were made using either a pair of vernier calipers (accurate to 0.1 mm) or, on small specimens, an eye-piece micrometer (accurate to 0.01 mm). In order to facilitate comparisons, this procedure is indicated in the tables, as well as the mode of preservation of each measured specimen (S = shell present; IM = internal, EM = external, or CM = composite moulds) and the nature of the material (LV = left, RV = right, or BV = both valves). Measurements are recorded in mm. In addition to the numerical data, scatter diagrams have been plotted for certain species.

Length (L) was measured parallel to the antero-posterior axis of the shell, which in dimyarian bivalves is the line joining the centres of the adductor muscle scars. In species with a long, straight hinge-line length was measured parallel to the hinge-line. Height (H) was always measured as the maximum dimension perpendicular to the length. Likewise, width or inflation (W) is the distance between the commissure plane and the point of the shell outline perpendicularly fartherst away from this plane, and is perpendicular to L and H. When the two valves are preserved, 2W is the combined inflation of both. When the terms length, height and width are applied to shell features such as ligament, muscle scars, etc., these are measured parallel to the major dimensions.



Text-fig. 1. Schematic view of a Lower Jurassic bivalve species from Argentina showing the measurements used throughout the text. For abbreviations see Introduction. *Cucullaea* (*Idonearca*) *rothi* A. LEANZA, complete young specimen. a: exterior view of right valve ; b: posterior view; c: dorsal view. MLP 16291.

Other measurements and abbreviations are as follows: Lh = length of the hinge-line, which in some instances can be subdivided into the portions anterior (Lha) and posterior (Lhp) to the umbones; Ll = length of the ligamental area; Al = anterior length, i. e. distance from the umbones to the anterior margin of the shell; Lb = length of the byssal gape; DL = dorsal length, i. e. length of the dorsal margin of the shell; Ud = distance between the umbones of both valves; Hu = height of the shell along a line that passes through the umbones; Wl = width of the hinge-platform just below the umbones; AA = anterior adductor muscle scars; PA = posterior adductor muscle scars.

Angular measurements are accurate to the nearest degree (°): α = angle between the dorsal and anterior margins of the shell; β = angle between the dorsal and posterior margins; γ = angle between the hinge-line and a line from the umbones to the posteroventral corner of the shell; ξ = umbonal angle in pectinaceans. Other angular measurements used in special cases are explained in the text.

Shell size is said to be small, medium or large as compared with other members of the same genus or family.

The synonymy lists were prepared according to the indications given by MATTHEWS (1973) to indicate the degree of confidence in allocation of each entry.

Repositories

The specimens studied are deposited in the following collections under the catalogue numbers listed in the text and figure captions:

BMNH = British Museum (Natural History), Cromwell Road, London SW7 5BD, Great Britain.
DNGM = Servicio Geológico Nacional de Argentina, Avenida Santa Fe 1548, 1060 Buenos Aires, Argentina.
FCENBA = Facultad de Ciencias Exactas y Naturales (Departamento de Geología), Universidad de Buenos Aires, Ciudad Universitaria, Pabellón 2, 1428 Buenos Aires, Argentina.
MLP = Museo de Ciencias Naturales de La Plata (División Paleozoología Invertebrados), Paseo del Bosque, 1900 La Plata, Argentina.
NHMB = Naturhistorisches Museum Basel, CH-4051 Basel, Augustinergasse 2, Switzerland.
SGO-PI = Museo Nacional de Historia Natural, Santiago de Chile, Chile.
SMNHL = Staatliches Museum für Naturkunde, Zweigstelle, Arsenalplatz 3, Ludwigsburg, Germany.
USNM = United States National Museum of Natural History, Washington, D. C. 20560, United States.

The numbers in brackets that are given after catalogue numbers represent field sample numbers. Their location in the stratigraphical sections is given in text-fig. 2 to 5 and within the text.

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Several colleagues have aided in the various seasons of joint field-work: Drs. A. C. RICCARDI, M. O. MANCEÑIDO, S. BALLENT and Lic. M. GRIFFIN (La Plata Museum); Dr. W. VOLKHEIMER, then at Museo Argentino de Ciencias Naturales; as well as D. DELLAPÉ, G. PANDO, M. ULIANA, C. GULISANO, L. LEGARRETA, E. KOZLOWSKI, F. BETTINI, A. GUTIÉRREZ and R. DIGREGORIO, geologists of the National Oil Company (YPF), who have also maintained fruitful exchanges of ideas through the years. Hardly accessible sites in the Main Andean Cordillera of San Juan province could be visited thanks to the cooperation of Drs. W. SILL (then at the University of San Juan) and A. LENCINAS (Minera Aguilar).

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Fossil localities

The marine lower Jurassic sediments of Argentina crop out in a discontinuous belt about 1500 km long, extending from southern San Juan province (about 32° S) across western Mendoza and Neuquén provinces to southwestern Chubut province (nearly 45° S) (see text-fig. 2). They are characterized by their wide diversity of facies and, in most cases, by the scarcity or even lack of ammonites. The early Jurassic transgressive deposits rest on top of a thick volcanic complex (known as "Serie Porfirítica", "Choiyoilitense" or "Formación Choiyoi") usually interpreted as Permo-Triassic in age. Similar volcanic activity persisted during the Jurassic in several places and at several times.

Although marine lower Jurassic sediments in Argentina have been known from the last century (STROBEL 1869, 1870, 1875; BODENBENDER 1889, 1892; BEHRENDSEN 1891, 1892; VALENTIN 1897; WEHRLI & BURCKHARDT 1898; ROTH 1899), and since then they have been subject of many studies, a comprehensive and clear picture of their stratigraphy, facies distribution and faunas has not been developed. GROEBER (1946 to 1953) included all the Lower Jurassic sediments in the "Cuyano" cycle of his chronostratigraphic scheme. This terminology was later modified and adapted to a lithostratigraphic nomenclature (STIPANICIC et al. 1968; STIPANICIC 1969) and a large number of formational names have been proposed in the last decades (see RICCARDI 1983). There was also a recent attempt to interpret the development of the "Cuyano" using the seismic stratigraphy approach (see GULISANO 1981; GULISANO et al. 1984). Nevertheless, even the basic lithostratigraphic nomenclature is not properly established for all the areas (as was already pointed out for middle Jurassic sediments by WESTERMANN & RICCARDI 1972: 6, 9; RICCARDI 1983). Therefore, the formational names used here are only intended to be for reference, and their suitability is not analyzed.

The biostratigraphical terminology used is according to RICCARDI (1983, 1984), who summarized Argentinian ammonite assemblages and their equivalence to European Standard Zones and Subzones (see table 1).

A summary of some of the sections measured during field work for this monograph is given below. The exact location of each fossiliferous bed within the stratigraphical sections is depicted on text-figs. 2 to 5. Each fossiliferous locality is given a letter-number symbol that is used throughout the text.

A. San Juan Province

The Lower Jurassic sediments of the cordillera of southern San Juan province are poorly known. The published data and personal observations indicate that in San Juan the lowest recorded marine Jurassic sediments are progressively older from north to south. At Paso de La Guardia (31° 53′ S) the succession begins with early

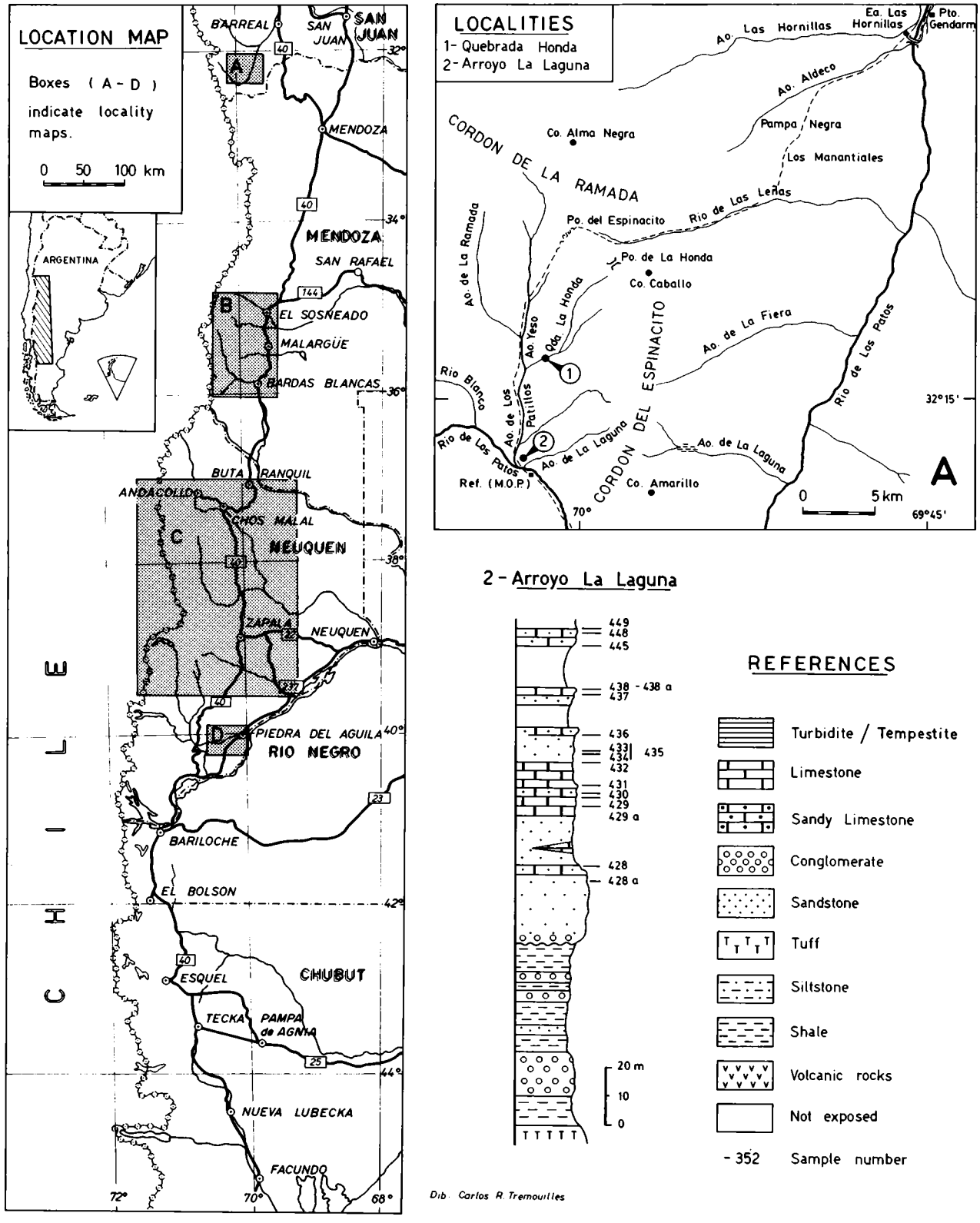
Table 1.
Early Jurassic ammonoid assemblages from Argentina compared to standard European chronozones (simplified from RICCARDI, 1984).

STAGES & SUBSTAGES		EUROPE	ARGENTINA
TOARCIAN	UPPER	*Dumortieria levesquei*	*Dumortieria* faunule
			Phlyseogrammoceras tenuicostatum Z.
		Grammoceras thouarsense	*Phymatoceras* faunule
		Haugia variabilis	
	LOWER	*Hildoceras bifrons*	*Collina chilensis* Zone
			Peronoceras pacificum Zone
			Peronoceras largaense Zone
		Harpoceras falcifer	*Dactylioceras hoelderi* Zone
		Dactylioceras tenuicostatum	*D. tenuicostatum chilense* Zone
			Dactylioceras simplex Zone
PLIENSBACHIAN	UPPER = DOMERIAN	*Pleuroceras spinatum*	*Fanninoceras* Zone
		Amaltheus margaritatus	
	LOWER = CARIXIAN	*Prodactylioceras davoei*	
		Tragophylloceras ibex	*Uptonia* faunule
		Uptonia jamesoni	
SINEMURIAN	UPPER	*Echioceras raricostatum*	*Miltoceras* faunule
		Oxynoticeras oxynotum	*Oxynoticeras* faunule
		Asteroceras obtusum	*Epophioceras* faunule
	LOWER	*Caenisites turneri*	
		Arnioceras semicostatum	
		Arietites bucklandi	
HETTANGIAN		*Schlotheimia angulata*	
		Alsatites liasicus	
		Psiloceras planorbis	

Bajocian deposits (cf. WESTERMANN & RICCARDI, 1979: 106) whereas at Arroyo La Laguna (32° 17′ S) the first marine sediments are early Pliensbachian in age (see VOLKHEIMER et al., 1978 a, 1978 b).

A.1. Quebrada Honda (32° 13′ S, 70° 01′ W; text-fig. 2–A): The presence of lower Jurassic sediments al Quebrada Honda, Cordillera del Espinacito, was reported by RIGAL (1930), who illustrated a specimen of "*Pecten prodoanus* (sic) VERN. & COLL." and one of "*Deroceras subarmatum* Y. a. B." This ammonite was subsequently re-interpreted as a *Crucilobiceras* and hence the sediments were considered to be late Sinemurian in age (ARKELL 1956: 587; STIPANICIC 1969: 373). Recently HILLEBRANDT (1970: 182–183; 1972: 18–19) referred the specimen to *Peronoceras* and thus confirmed an early Toarcian age for the assemblage. RIGAL's locality could not be re-located during a brief survey of the area in 1975, but the material is housed at the DNGM.

A.2. Arroyo La Laguna, southern part of Los Patos river (32° 17′ S, 70° 02′ W; text-fig. 2–A): An almost complete Jurassic succession crops out on the western slope of the southern end of the Espinacito range, on both banks of the Los Patos river. This sequence was first described by LAMBERT (1943, 1944 a), who also mentioned some early Jurassic fossils (later quoted by A. LEANZA 1958: 238).



Text-fig. 2. Index map of the regions investigated in western Argentina. A: Locality map of southern San Juan province. Locality numbers and sample numbers as in description of stratigraphic sections.

The Lower Jurassic sediments, dipping about 37° W, were examined by DAMBORENEA, MANCEÑIDO and VOLKHEIMER in 1975 at Arroyo La Laguna, a left tributary of the Los Patos river, and a preliminary report with a detailed lithological description was published by VOLKHEIMER et al. (1978 a, 1978 b). The fossil lists provided there must be updated after the studies of MANCEÑIDO (1978, 1981), HERBST (1980) and DAMBORENEA (1982, and this paper).

The Lower Jurassic part of this section was called Los Patos Formation by VOLKHEIMER et al. (1978 b). As the name is pre-occupied by a Tertiary formation described by HOLMBERG (1973) it cannot be used in VOLKHEIMER's sense. In order to avoid the proliferation of superfluous formation names, a replacement term is not proposed here, bearing in mind that the lower part (60 m) of the section may be referred to the El Freno Formation and the upper marine portion (90 m) to the El Cholo (or Puesto Araya) Formation of Mendoza province.

Towards the north, in the Paso del Espinacito, the marine calcareous sandstones and limestones change laterally into a predominantly tuffaceous rock, apparently without marine invertebrates.

The lower part of the section at Arroyo La Laguna near the place where it joins Los Patos river is as follows (see text-fig. 2):

Formation	Age	Thickness	Bed	
?	Late	?		Calcareous sandstone and sandstone.
	Toarcian		449	*Brodieia* cf. *alticarinata* (MERLE).
	Late Early		448	*Harpoceras* aff. *subexaratum* (YOUNG & BIRD) and *Harpoceratoides* sp.
	Toarcian		445	*Frenguelliella* sp.
—?—	—?—	~ 15 m		Not exposed.
El Cholo ?	Early	~ 6 m		Grey-brown sandstones and limestones, highly fossiliferous:
	Toarcian		438–	153 m above the base: *Cucullaea rothi* LEANZA, *Grammatodon* ? sp.,
	(*D. hoelderi*		438a	*Frenguelliella* sp., *Myophorella* sp., *Vaugonia* sp., other bivales and
	Zone)			*Nodicoeloceras* sp.
			437	150 m above the base: *Cucullaea rothi, Parallelodon* sp., *Lycettia hypertrigona* n. sp.?, *Pinna cf. folium* YOUNG & BIRD, *Gervillia* (*Cultriopsis*) sp., *Myophorella* sp., other bivalves, Harpoceratinae indet., gastropods and brachiopods.
		~ 8 m		Not exposed.
		12 m		Fine calcareous sandstone, light-grey, with interbedded fossiliferous beds.
			436	137 m above the base: *Myophorella* sp., other bivalves, Dactylioceratidae indet. and *Harpoceras* sp.
	—?—		433–435	130 and 131 m above the base: *Weyla bodenbenderi* (BEHRENDSEN), *Posidonotis cancellata* (LEANZA), *Myophorella* cf. *araucana* (LEANZA), other bivalves and brachiopods.
	Early Toarcian (pre-			
	D. hoelderi	18.4 m		Fine calcareous sandstones and sandy limestones, with tuff grains and several shell-beds with a diverse invertebrate fauna. Plant remains near the base.
	Zone)			
	—?—		432	127 m above the base: *Myophorella* cf. *araucana*, other bivalves and gastropods.
	Late early		431	118 m above the base: *Cucullaea rothi, Parallelodon* sp., *Frenguelliella* sp.,
	to late			*Modiolus* sp., *Modiolus baylei* PHILIPPI, *Isognomon jupiter* (LEANZA), *Posi-*
	Pliensbachian			*donotis cancellata*, other bivalves, gastropods, *Protogrammoceras* sp., *Spiriferina*
	(*Fanninoceras*			*tumida ericensis* DE GREGORIO and other brachiopods.
	Zone)		430	116 m above the base: *Weyla bodenbenderi, Myophorella* cf. *araucana* and other bivalves.
			429	114 m above the base: *Weyla bodenbenderi, Nuculana* cf. *ovum* (SOWERBY)?, *Inoperna* sp., other bivalves and *Protogrammoceras* ex gr. *normannianum* (D'ORBIGNY).
			429a	111 m above the base: *Myophorella* ? sp., *Montlivaltia* ? sp.
		18 m		Calcareous sandstone, fine-grained, with lenticular lumachelles containing poorly preserved bivalves and brachiopods.
		26 m		Calcareous and tuffaceous sandstones, medium to fine-grained, thick-bedded. These beds form a steep bluff to the west of Arroyo La Laguna. There are some coarse sandstones near the base and some lenticular lumachelles near the top.
			428	90 m above the base: *Weyla bodenbenderi, Myophorella* ? sp., other bivalves, brachiopods and corals.

			428a	85 m above the base: *Weyla bodenbenderi,* gastropods and indeterminate ammonoids.
		0.1/0.5 m		Medium-grained to coarse conglomerate, with porphyritic and tuffaceous pebbles. Its thickness changes laterally and its base is irregular.
—	—?—			
El	Early	66 m		Conglomerates, sandstones and dark shales.
Freno ?	Pliensbachian ? to Late Sinemurian			Several beds bear plant remains that have been studied by HERBST (1980): *Equisetites* sp., *Cladophlebis* cf. *kurtzi* FRENGUELLI, *Pachypteris sanjuanina* HERBST, *Otozamites volkheimeri* HERBST and *Brachyphyllum menendezi* HERBST. Further information about lithology and palynomorph content is given in VOLKHEIMER et al. (1978a).
				Base of measured section
Remoredo?	Triassic?			Purple and green tuffs and shales, with some levels of re-worked breccias.

B. Mendoza Province

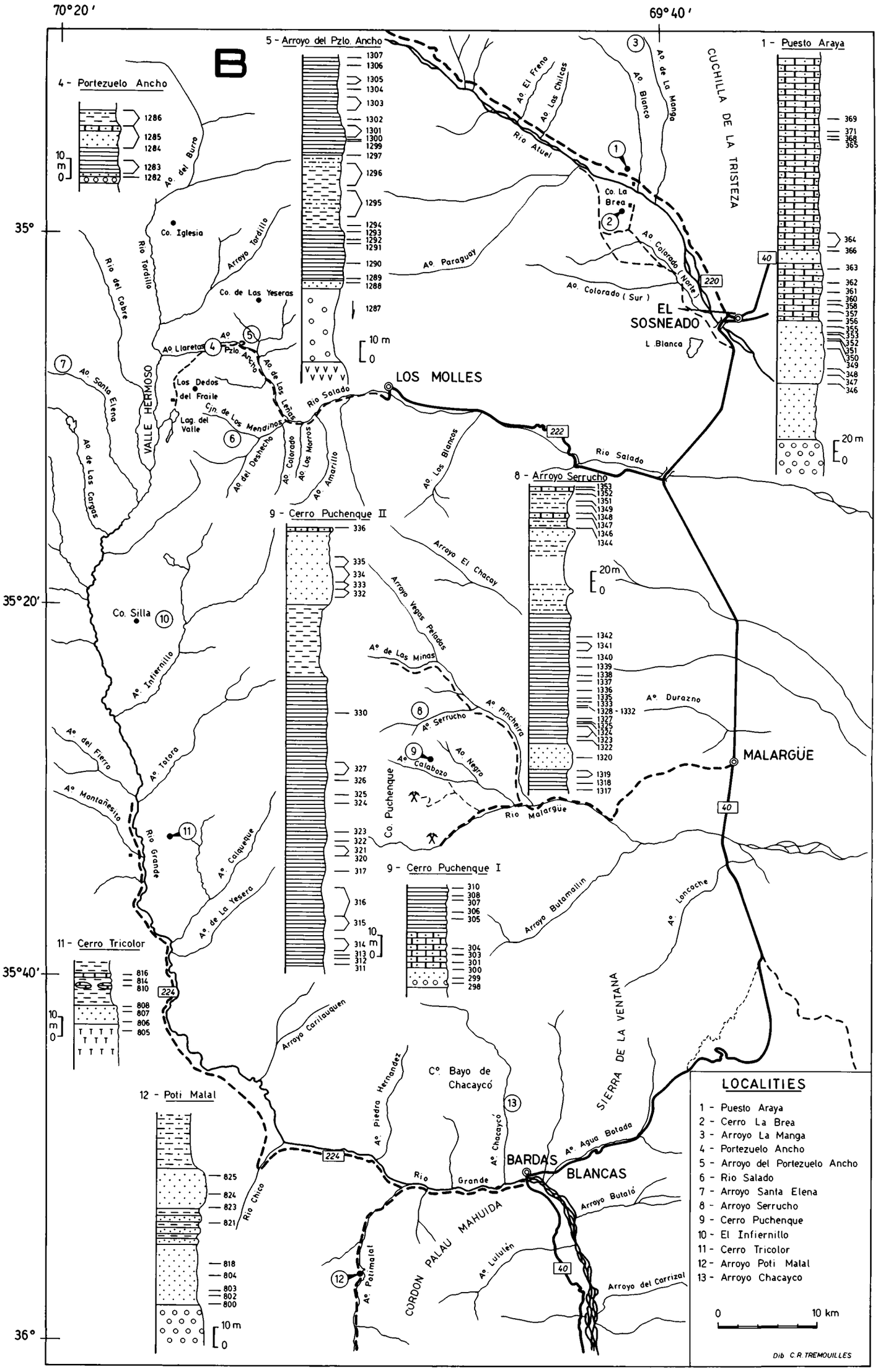
Rio Atuel Region

Lower Jurassic sediments crop out on both banks of the Atuel river, to the west of El Sosneado. These deposits begin with conglomerates and coarse sandstones of probable continental origin, and are overlain by fossiliferous marine beds. They were discovered during the exploratory works of J. SALAS, HAUTHAL (1896), WEHRLI & BURCKHARDT (1898) and BODENBENDER (1902), and since the early studies by BURCKHARDT (1900 a) and KEIDEL (1910) they have been the object of several studies.

B.1. Left bank of the Atuel river near Puesto Araya (34° 57′ S, 69° 43′ W; text-fig. 3): GERTH (1925, lám. 1, perfil 6), REIJENSTEIN (1967), VOLKHEIMER (1970, Taf. 2, Prof. 1-2) and WESTERMANN & RICCARDI (1973, perf. 7) provided stratigraphic sections of the Lower Jurassic sediments of this area. The greatest part of the measured sections seem to belong to the early Pliensbachian. The specimens referred to *Fanninoceras fannini* MCLEARN and *Gleviceras* sp. indet. (both determined by M. K. HOWARTH, BMNH) add new elements to the lists previously published by HILLEBRANDT (1973 b: 196; 1981: 510) that included species of *Eoderoceras, Miltoceras* ?, *Tropidoceras, Uptonia, Tragophylloceras, Gemmellaroceras, Dayiceras, Eoamaltheus, Fanninoceras (= "Radstockiceras").* HILLEBRANDT also noted the presence of upper Sinemurian arietitids below. The brachiopods were studied by MANCEÑIDO (1978, 1981).

The Lower Jurassic sediments were also examined by RICCARDI, MANCEÑIDO and DAMBORENEA in 1973, who measured a marine sequence on the left (northern) bank of the Atuel river, near Puesto Araya, just to the west of the mouth of the Arroyo Blanco, where the beds dip about 45° SE.

Formation	Age	Thickness	Bed	
El Cholo (or Puesto Araya)	Late Early to Late Pliensbachian	196 m		Massive greyish-green and very hard calcareous sandstones and sandy limestones, with several shell-beds that contain a diverse mollusc and brachiopod fauna. Local variations of grain size and calcareous content are common.
	(Fanninoceras Zone)		369, 371	308 and 320 m above the base: bivalves and brachiopods.
			368	305 m above the base: *Weyla bodenbenderi* (BEHRENDSEN) and brachiopods.
			365	300 m above the base: *Pinna* cf. *folium* YOUNG & BIRD, *Oxytoma inequivalvis* (SOWERBY), *Frenguelliella* sp. and gastropods.
			364, 366	192–208 m above the base: *Fanninoceras fannini* MCLEARN, *Eoamaltheus* sp. and *Pholadomya* sp.
	—?—	70 m		Very hard greenish calcareous sandstones, with medium-grained sandstone; interbedded shell beds and calcareous shales. Rich molluscan and brachiopod fauna.
	Early Pliensbachian		363	173 m above the base: ammonoids and brachiopods.
	(*Uptonia* faunule)		362	158 m above the base: *Pholadomya* sp. and ammonoids.
			361	148 m above the base: *Otapiria* ? sp., *Weyla* sp. and other bivalves, ammonoids and brachiopods.



Text-fig. 3. Locality map of southern Mendoza province (B). Locality numbers and sample numbers as indicated in description of stratigraphic sections. For references see text-fig. 2.

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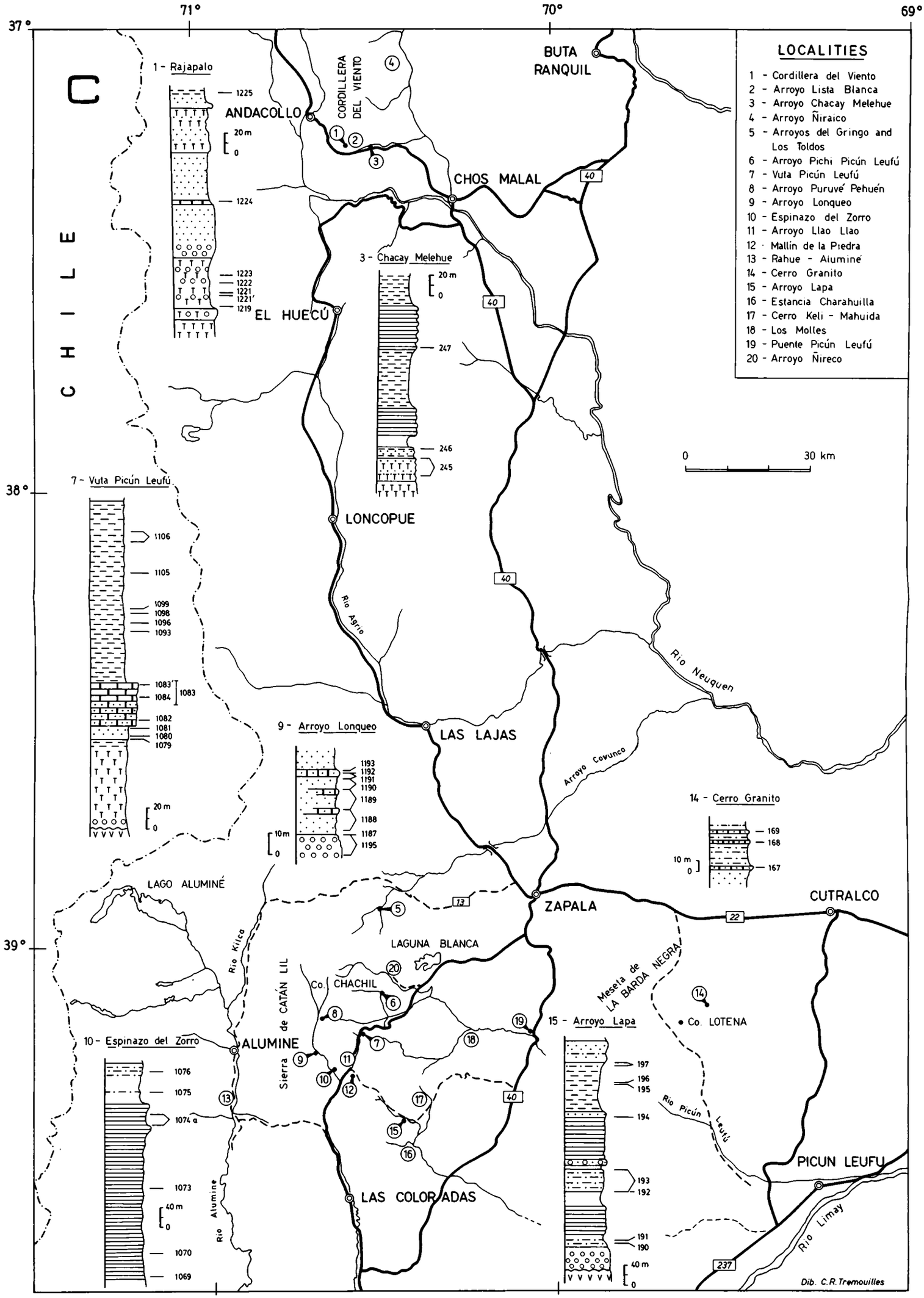
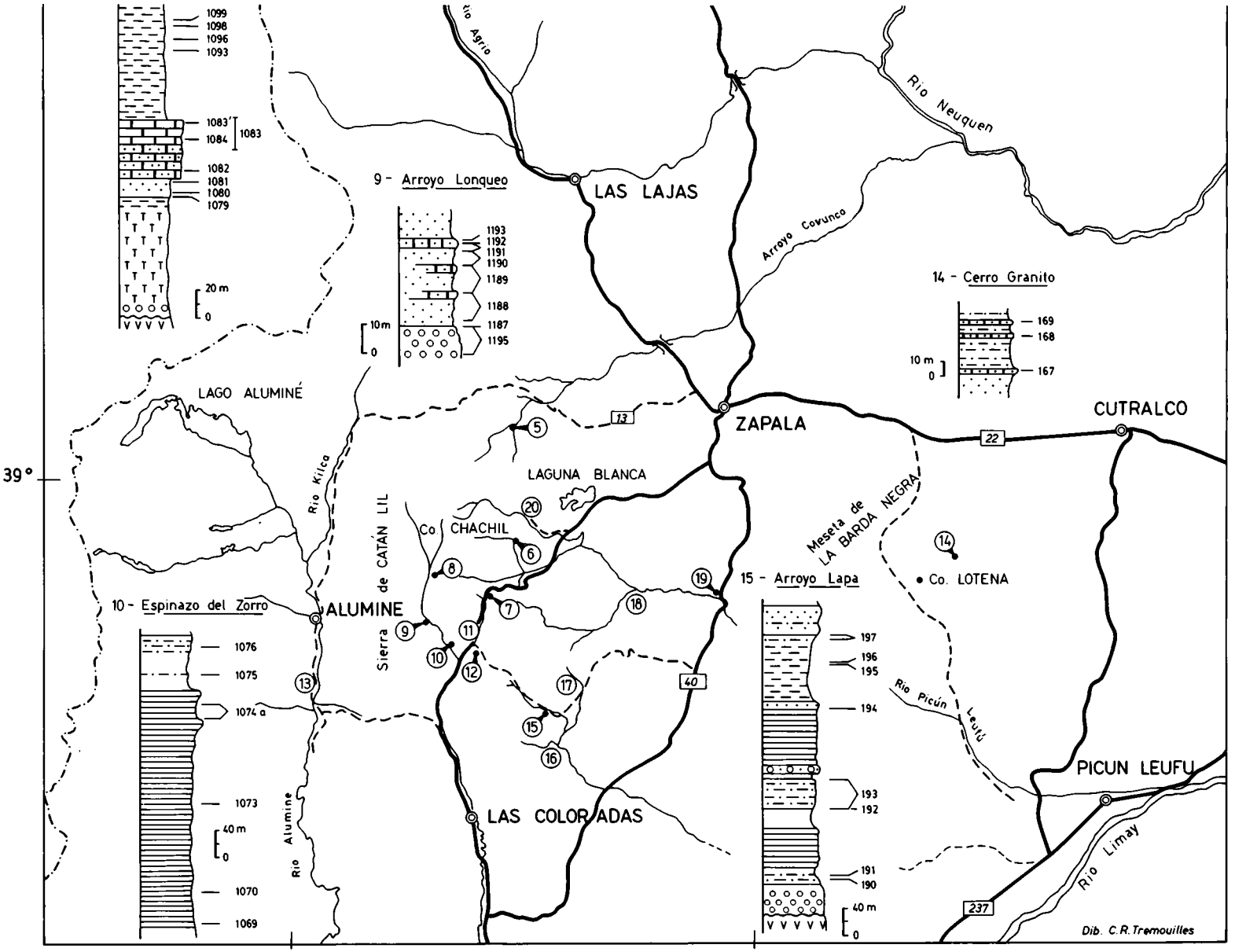


Text-fig. 4. Locality map of northern and central Neuquén province (C). Locality numbers and sample numbers as indicated in description of stratigraphic sections. For references see text-fig. 2.



Text-fig. 4. Locality map of northern and central Neuquén province (C). Locality numbers and sample numbers as indicated in description of stratigraphic sections. For references see text-fig. 2.

		361	148 m above the base: *Otapiria* ? sp., *Weyla* sp. and other bivalves, ammonpids and brachiopods.
		360	138 m above the base: *Ctenostreon* sp.
		356–358	120, 127 and 136 m above the base: bivalves, *Tropidoceras* sp. and brachiopods.
	63 m		Fine grey sandstones, massive or laminate, with lenticular and tabular beds of calcareous sandstones and limestones. Several fossiliferous horizons bear molluscs, brachiopods and corals.
		355, 353	108 and 113 m above the base: *Pholadomya* sp., *Tropidoceras* sp. and brachiopods.
		352	107 m above the base: *Plicatula (Harpax) rapa* BAYLE & COQUAND, *Trichites* ? sp., *Weyla alata alata* (VON BUCH), *Frenguelliella* sp., other bivalves and brachiopods.
		351	101 m above the base: *Gervillella* n. sp., *Pinna* cf. *folium*, *Weyla* sp., other bivalves and brachiopods.
		350	99 m above the base: corals: *Isastrea* sp. and *Thecosmilia* sp.
		349	93 m above the base: *Gervillaria* ? *pallas* (LEANZA), *Weyla alata* and other bivalves.
		348	72 m above the base: *Weyla* sp.
		347	65 m above the base: bivalves and gastropods.
		346	58 m above the base: corals and brachiopods.
—?— Sinemurian	57 m		Coarse, medium and fine sandstones. Beds of coarser sediments intercalated, and several cross-bedded horizons.
			Base of measured section
El Freno			Conglomerates with plant remains.

B.2. Cerro La Brea (34° 59′ S, 69° 43′ W; text-fig. 3): This locality is located opposite Puesto Araya, on the right bank of the Atuel river. The core of the small anticline that crops out there (cf. GROEBER et al. 1953, lám. 26, fig. 1) is made up of conglomerates referable to El Freno Formation, overlain by marine fossiliferous sandstones. The locality was first mentioned by BOEHM (1937) and later studied by UGARTE (1951, 1955), LEVY (1964) and VOLKHEIMER (1978). The present author examined UGARTE's collection (at MLP), part of LEVY's collection (at DNGM) and a small collection of her own.

B.3. Arroyo La Manga (34° 49′ S, 69° 41′ W; text-fig. 3): The Lower Jurassic sediments extend upstream in the middle part of the Arroyo La Manga, west of Cuchilla de La Tristeza and south of the Cerro El Toscal (or Tres Lagunas), and to the NW of the place called "Tres Esquinas". Since the preliminary report by HAUTHAL (1896) this area was included in the geological maps by GERTH (1931), GROEBER (1947a), SACCONE (1948) and VOLKHEIMER (1978). The last author records a thickness of 400 to 500 m (p. 24). Some of the fossil samples collected by SACCONE are housed at the MLP.

Upper Rio Salado – Valle Hermoso Region

Since the early discovery made by STROBEL (1869–1875) several authors have studied the geology and fauna of the Jurassic deposits of the upper Salado river region: BODENBENDER (1892), BEHRENDSEN (1892), GERTH (1925, 1928, 1931), JAWORSKI (1925 a, 1926). Subsequent syntheses were built up on data from these authors (e. gr. GROEBER 1947b: 412; GROEBER et al. 1953: 214–215; DAVIDSON & VICENTE 1973: 16).

B.4/5. Portezuelo Ancho: BODENBENDER (1892: 12–16; see also VALENTIN 1897: 24) collected fossil material from two different localities between Rio Salado and Valle Hermoso: (B.4.) at the Portezuelo Ancho Pass, between Arroyo de Las Llaretas and Arroyo del Portezuelo Ancho, and (B.5.) on the eastern slope of the pass at the Arroyo Portezuelo Ancho. This last locality corresponds approximately to the place of the original discovery by STROBEL (1869–1875). On the other hand GERTH (1925: 17–19, lám. 2, perfil 10) did not distinguish between the observations he made at both sites, and provided a composite stratigraphical section and a single faunal list that also includes specimens from further south of the Cerro Dedos del Fraile. In 1983 MANCEÑIDO and DAMBORENEA measured two sections, roughly corresponding with each of BODENBENDER's localities:

B.4. It is not easy to follow the stratigraphical succession at this locality (35° 06′ S and 70° 07′ W; text-fig. 3), as the dip and topographical slope almost coincide, and both base and top of the section are not exposed. Nevertheless, the sequence was measured as follows:

Formation	Age	Thickness	Bed	
Puchenque ?	Late	8.20 m		Green sandy mudstone with interbedded shell beds.
	Pliensbachian		1286	*Weyla bodenbenderi* (BEHRENDSEN), *W. unca* (PHILIPPI), *Pinna* cf. *folium* YOUNG & BIRD, *Ctenostreon* sp., *Plagiostoma* sp., other bivalves and gastropods.
	(*Fanninoceras*	11 m		Sandstone and mudstone with calcareous mudstones to the top. With a diverse
	Zone)		1285	bivalve fauna: *Parallelodon* sp., *Modiolus* sp., *Pulvinites (Hypotrema)* n. sp., *Pinna* cf. *folium, Weyla unca, Cucullaea* cf. *rothi* LEANZA, *Myophorella* sp. and others.
		9.5 m		Greyish green shales and calcareous sandstones in fining-upwards sequences.
			1284	Very fossiliferous, with *Cucullaea* cf. *rothi, Weyla bodenbenderi, W. unca, Eopecten hartzi* (ROSENKRANTZ) ? and other bivalves.
		8.20 m		Sandstones and shales in fining-upwards sequences, with coarser sandstones and conglomerates bearing abundant plant débris near the base. Several shell beds:
			1283	Tuffaceous sandstones with *Cucullaea* cf. *rothi, C.* cf. *jaworskii* LEANZA, *Weyla bodenbenderi, W. unca, Pinna* cf. *folium, Myophorella* sp., other bivalves, inarticulate brachiopods, corals and *Fanninoceras* sp.
			1282	*Eopecten hartzi* ?, *Weyla unca, Isognomon* sp., other bivalves and corals (*Montlivaltia* ? sp.).

B.5. On the northern bank of the Arroyo del Portezuelo Ancho (35° 06′ S and 70° 06′ W; text-fig. 3) the bottom of the Lower Jurassic sequence can be clearly seen. The section measured in 1983 by MANCEÑIDO and DAMBORENEA is as follows:

Formation	Age	Thickness	Bed	
Puchenque ?	Late	34.5 m		Greenish shales and sandstones in fining-upwards sequences, highly fossiliferous, with brown reddish sandstones at the top.
	Pliensbachian			
	(*Fanninoceras*		1302–1307	133, 142–147, 152, 155–159, 161 and 165 m above the base: *Oxytoma inequivalvis* (SOWERBY), *Weyla unca* (PHILIPPI), *Frenguelliella* cf. *tapiai* (LAMBERT), *Pinna* cf. *folium* YOUNG & BIRD, *Plicatula (Harpax) rapa* BAYLE & COQUAND, other bivalves, brachiopods and gastropods.
	Zone) to			
	Early			
	Toarcian ?			
		14.5 m		Greyish green tuffaceous shales and sandstones, in fining-upwards sequences, with several shell beds very rich in bivalves and brachiopods.
			1299–1301	126, 127 and 127–131 m above the base: *Weyla unca, Plicatula (Harpax) rapa, Pholadomya* sp., other bivalves, brachiopods and serpulids.
		38.1 m		Highly fossiliferous green shales and mudstones.
			1294–1297	80–85, 86–102, 103–114 and 116 m above the base: *Weyla bodenbenderi* (BEHRENDSEN), *W. unca, Pinna* sp. in life position, *Pholadomya* spp., *Montlivaltia* sp., gastropods and *Fanninoceras* sp.
	—?—			
	Early	25.4 m		Medium to coarse-grained tuffaceous sandstones that bear diverse invertebrate faunas and plant detritus at the base of fining-upwards sequences.
	Pliensbachian			
	(mainly		1293	79 m above the base: *Cardinia andium* (GIEBEL), other bivalves, *Isastrea* sp., *Spiriferina* sp. and *Fanninoceras* sp.
	Uptonia and			
	Miltoceras		1290–1292	60, 72 and 75 m above the base: *Weyla alata* (VON BUCH), *W. unca, Myoconcha neuquena* LEANZA, other bivalves, *Andenipora* sp., *Thecosmilia* sp., *Montlivaltia* sp. and *Uptonia* sp.
	faunules)			
			1289	55 m above the base: *Weyla alata, Weyla unca,* other bivalves, *Montlivaltia* ? sp., brachiopods and *Apoderoceras* ? sp.
		3.8 m		Hard tuffaceous sandstones with isolated pebbles, followed by fossiliferous calcareous and tuffaceous sandstones.
	Late		1288	53 m above the base: *Weyla alata, Weyla unca,* other bivalves, gastropods and brachiopods.
	Sinemurian ?			
	—?—	36.8 m		Partly covered.
	?	12.7 m		Purple and green volcanic breccias.

Base of section

B.6. Headwaters of the Salado river (35° 12′ S, 70° 07′ W; text-fig. 3): The distribution of the Lower Jurassic sediments to the south of the preceding two localities was mapped by GERTH (1925, 1931), and later other authors (APARICIO 1950; GUERRERO 1957) provided additional information. This region was recently visited by RICCARDI, MANCEÑIDO and others, who collected marine fossils and observed, between the Cajón de Los Mendinos and Arroyo La Bajada, the presence of a basal conglomerate of variable thickness. This conglomerate either lies unconformably on porphyritic rocks of the Choiyoi Formation, or, locally, overlies a thin succession of the Remoredo Formation. The section continues upwards with more than 10 m of purple sandstones, about 15 m of laminated yellow sandstones that contain a Pliensbachian fauna, 20 m of calcareous and tuffaceous sandstones with at least two coral beds, and about 24 m of limestones and calcareous sandstones with a marine Toarcian fauna.

B.7. Arroyo Santa Elena (35° 08′ S, 70° 35′ W; text-fig. 3): BURCKHARDT (see WEHRLI & BURCKHARDT 1898: 379–380; BURCKHARDT 1900a, 1903) made the pioneer studies in this area. He recognized the presence of the Jurassic System on the basis of his own fossil collection and also studied the structure and stratigraphy of the region. He described faunas of mid and late Jurassic age, and referred the oldest strata to the Aalenian on the basis of their ammonite content and the presence of *"Posidonia"*.

Few geologists appear to have visited the region since then (GERTH 1925: 26, 32, lám. 8, perfil 15; STIPANICIC & MINGRAMM in GROEBER et al. 1953: 225–228 and in STIPANICIC 1966: 433–440; KLOHN GIEHM 1960; DAVIDSON & VICENTE 1973). They provided new data on the thickness of the Middle and Upper Jurassic beds, but on the whole confirmed BURCKHARDT's interpretation. DAVIDSON & VICENTE (1973), on the grounds of BURCKHARDT's data of the aparent absence of marine lower Jurassic deposits between the Cordillera de la Costa (Chile) and Portezuelo Ancho (Mendoza province, Argentina), postulated the existence of a positive region between the Curepto basin and the Neuquén basin. This palaeogeographical interpretation must now be revised in the light of the recent discovery by RICCARDI, MANCEÑIDO, GULISANO and others in 1982 of marine invertebrate faunas referable to the Pliensbachian and Toarcian in the middle course of the Arroyo Santa Elena.

According to these authors' unpublished data, the overturned Lower Jurassic strata crop out dipping 69° E. The stratigraphical succession begins with about 60–80 m of hard, grey, coarse sandstones with subangular clasts, then there is a 3 m continuous exposure of tuffaceous porphyritic beds in 20–25 cm thick beds that yielded Pliensbachian fossils preserved as moulds (about *Fanninoceras* Zone, samples G 872 to G 876). The section is covered for the next 6 m but then there are hard limestone beds with an abundant fauna that probably belongs near the Domerian-Toarcian boundary (G 877). Exposure is very poor above these beds, but sandstones and calcareous sandstones can be seen locally for the next 50 m. On top of this succession, some limestone concretions yielded ammonoids and *Bositra* (G 879) of early Aalenian age. A sample taken "ex situ" at an intermediate position (G 878) has some harpoceratids and probably represents a Toarcian level.

Cerro Puchenque Region

A thick Jurassic sequence crops out to the west of Malargüe (formerly Villa Beltrán), in the area of Paramillos Altos and Cerro Puchenque (= Cerro Puchén, Cerro de la Calle del Yeso or Cerro Colorado). It has been known since the end of the last century (WEHRLI & BURCKHARDT 1898; BODENBENDER 1892: 20–23; BURCKHARDT 1900a: 56, pl. 30, 32). Other information about the Jurassic deposits of this region and their faunas can be found in GERTH (1925; 1931), JAWORSKI (1925 a; 1926), WEAVER (1931), GROEBER (1918: 26; 1947 b: 412), GROEBER et al. (1953: 212), DESSANTI (1973: 22–25; 1978: 17–20), WESTERMANN & RICCARDI (1972: 15–17; 1973, fig. 6; 1979: 100–101), and RICCARDI & WESTERMANN (1984).

Jurassic sediments also crop out just west of Malargüe, at a locality formerly known in the geological literature as "Cañada Colorada" (BODENBENDER 1892; BURCKHARDT 1900 a, 1903; GROEBER 1918; WEAVER 1931).

B.8. Arroyo Serrucho (35° 26′ S, 69° 55′ W; text-fig. 3): GERTH (1925: 16; 1931: 134) pointed out that on the right bank of the Arroyo Serrucho there are early Jurassic fossiliferous limestones. The fossils were described by JAWORSKI (1925 a, 1926). The place was visited by GULISANO and PANDO in 1978, and their collection is deposited at the MLP. In 1983 MANCEÑIDO and DAMBORENEA there measured a stratigraphical section, as follows:

Formation	Age	Thickness	Bed	
Puchenque?	Toarcian	5 m		Shelly limestone with tuffaceous shales towards the top and a rich invertebrate fauna.
			1353	305 m above the base: *Propeamussium* sp., *Pinna* cf. *folium* YOUNG & BIRD, other bivalves and brachiopods.
			1352	302 m above the base: a diverse bivalve fauna that includes *Cucullaea* cf. *rothi* LEANZA, *Lycettia hypertrigona* n. sp., *Modiolus gerthi* n. sp., *Pinna* cf. *folium*, and also gastropods and brachiopods.
		21 m		Greenish grey siltstones and shales with dark sandy limestones interbedded, which bear very rich invertebrate assemblages.
			1348–1351	*Cucullaea* cf. *rothi*, *Lycettia hypertrigona* n. sp., *Modiolus gerthi* n. sp., *Pinna* cf. *folium*, *Vaugonia* sp., other bivalves and also brachiopods (284, 290, 294 and 297 m above the base).
		6 m		Grey shelly mudstones with interbedded siltstones.
			1346–1347	273 and 279 m above the base: *Pinna* cf. *folium*, *Plicatula* sp., *Cucullaea* sp., *Modiolus gerthi* n. sp., other bivalves, gastropods and brachiopods.
		9 m		Grey and green siltstones and mudstones.
		89 m		Siltstones and sandy mudstones, partly covered, fossiliferous towards the top.
			1344	264 m above the base: *Pinna* cf. *folium* in life position.
	——			
		128 m		Alternating pairs of sandstones and shales in graded sequences, with a very rich invertebrate fauna, especially brachiopods.
	Late Pliensbachian		1324–1343	69, 70, 72, 73, 84, 86, 88, 89, 90, 91, 93, 99, 110, 114, 125, 134, 141–149 and 154 m above the base: *Palaeoneilo* cf. *patagonidica* (LEANZA), *Cucullaea* cf. *rothi*, *Parallelodon* sp., *Modiolus* cf. *thiollierei* (DUMORTIER), *Isognomon jupiter* (LEANZA), *Gervillaria* ? *pallas* (LEANZA), *Weyla bodenbenderi* (BEHRENDSEN), *W. unca* (PHIL.), *Pteroperna sp.*, *Oxytoma inequivalvis* (SOWERBY), *Eopecten hartzi* (ROSENKRANTZ) ?, *Pinna* cf. *folium* in life position, *Plicatula* (*Harpax*) *rapa* BAYLE & COQUAND, *Frenguelliella tapiai* (LAMPERT), also brachiopods and serpulids.
			1322–1323	50 and 54–65 m above the base: *Weyla alata* (VON BUCH), *Weyla unca*, *Eopecten hartzi* ?, *Pinna* cf. *folium* in life position, *Parallelodon* sp., also echinoderms, brachiopods and corals.
		27 m		Thick-bedded grey sandstones, medium-grained, with cross-bedding. Towards the top there are some coarser shelly lenses that show great lateral variation in thickness and grain-size (surge channels ?). Some dark bioturbated shales are also intercalated.
			1320	37–41 m above the base: *Weyla alata*, *Myophorella* sp., other bivalves and gastropods.
		20 m		Alternating pairs of dark sandstones and shales in fining upwards sequences. The sandstone beds vary between 0.5 and 1 m thick, whilst the shale beds are thinner.
			1317–1319	1, 6–12 and 13–20 m above the base: *Weyla alata*, *Weyla unca*, *Modiolus baylei* PHILIPPI ?, large *Pinna* cf. *folium* in life position, *Plicatula* (*Harpax*) *rapa*, other bivalves, gastropods, corals, serpulids and brachiopods.

Base of section

B.9. Cerro Puchenque, between Arroyos Calabozo and Negro (35° 29′ S, 69° 55′ W; text-fig. 3): GERTH (1925, lám. 5, perfil 9) provided a generalized stratigraphical section of the Jurassic outcrops between Arroyos Calabozo and Negro. WESTERMANN & RICCARDI (1972) described a Toarcian-Mid Jurassic section just to the south of Arroyo Negro. In 1973 RICCARDI, MANCEÑIDO and DAMBORENEA measured a detailed section of the sediments that crop out in the area below the La Manga Formation. The lower part of this section (i.e. the Lower Jurassic beds) was measured in two different places: first (I) at the headwaters of the Arroyo Negro where the beds dip about 5° E, and then (II) on the ridge that separates the Arroyo Negro and Arroyo Calabozo, where they dip about 30° SE. The sequence described below is covered for nearly 45 m and after that the beds contain Aalenian ammonites. Brachiopods are especially abundant in this section, and were studied by MANCEÑIDO (1978, 1981).

The compound stratigraphical sequence is as follows:

Formation	Age	Thickness	Bed	
Puchenque	Early Toarcian (*Collina chilensis* Zone)	1 m	336	217 m above the base: dark grey limestones with *Parallelodon* sp., *Vaugonia* sp., other bivalves, *Frechiella* cf. *helvetica* RENZ, *Peronoceras* sp., *Harpoceras* sp. and brachiopods.
		34 m		Dark grey or greenish calcareous sandstone, very hard, with crossed-bedded sandstones.
	(*D. hoelderi* Zone)		332–335	182–188, 188–190, 190–197 and 197–203 m above the base: several fossiliferous levels with an abundant fauna of bivalves, *Hildaites* sp., brachiopods and gastropods.
	Late Pliensbachian to Early Toarcian	36.5 m		Greyish-green shales, partly covered.
		145.5 m		Fine light-green calcareous sandstones, very hard, with interbedded shell-beds. They are highly fossiliferous, containing bivalves and brachiopods and, in less abundance, gastropods, corals and some ammonites. There are local intercalations of laminated sandstones and shales and also of medium to coarse sandstones. The individual sequences are graded, suggesting either storm or turbiditic origin for this portion of the section.
			330	138 m above the base: *Weyla unca* (PHILIPPI), other bivalves and brachiopods.
			326–327	102 and 105–113 m above the base: pectinids, *Pholadomya* sp. and brachiopods.
	Pliensbachian (*Fanninoceras* Zone)		324–325	81 and 88 m above the base: *Modiolus* cf. *thiollierei* (DUMORTIER), other bivalves and brachiopods.
			321–323	55–62, 63, 67 m above the base: *Pinna* cf. *folium* YOUNG & BIRD, *Pulvinites* (*Hypotrema*) n. sp. ?, *Plicatula* (*Harpax*) *rapa* BAYLE & COQUAND, *Isognomon jupiter* (LEANZA), other bivalves, brachiopods and ammonites
			320	55 m above the base: *Parallelodon* sp., *Grammatodon costulatus* (LEANZA), *Pinna* cf. *folium, Isognomon jupiter, Pulvinites* (*Hypotrema*) n. sp., *Plicatula* (*Harpax*) *rapa, Pholadomya* sp. and brachiopods.
			317	45 m above the base: *Parallelodon* sp., *Weyla unca, Fanninoceras* sp., corals and brachiopods.
			316	25–36 m above the base: *Cucullaea* cf. *rothi* LEANZA, *Eopecten hartzi* (ROSENKRANTZ) ?, *Weyla unca, Fanninoceras* sp., brachiopods, gastropods and corals.
			315	25 m above the base: *Pinna* cf. *folium, Weyla bodenbenderi* (BEHRENDSEN), *W. unca, Myrophorella* sp., other bivalves, gastropods and brachiopods.
			311–314	1, 4, 6 and 7–14 m above the base: *Parallelodon* sp., *Modiolus* sp., *Pinna* cf. *folium, Eopecten hartzi* ?, *Weyla alata alata* (VON BUCH), *Myophorella* sp., other bivalves, brachiopods, gastropods, corals and ammonites.
			Base of section	

The outcrops are not well exposed and although the strata described below appear to underlie the above succession, the actual relationships are not clear.

Puchenque	Pliensbachian (*Fanninoceras* Zone)	21 m		Calcareous sandstones, very fine and hard, with bivalves, brachiopods, corals and gastropods.
			305–310	35, 38, 44, 46 and 49 m above the base: *Weyla alata alata, W. unca, Myophorella* sp., *Fanninoceras* sp.
		18.5 m		Dark grey calcareous sandstone, with several shell-beds containing bivalves, brachiopods and gastropods.
			300–304	10, 13, 18 and 21 m above the base: *Grammatodon costulatus* (LEANZA), *Weyla unca, Modiolus* sp., gastropods and brachiopods.
		10 m		Fine to medium sandstone, very hard, with interbedded calcareous sandstone. Coarse to conglomeratic sandstone towards the base.
			298–299	2 and 5 m above the base: *Weyla alata, W. unca, Pinna* cf. *folium.*
			Base of section	

Upper Rio Grande Region

With the exception of the first geological observations made by BODENBENDER (1892: 21) and by BURCKHARDT (1900 a, pl. 32) who did not mention any fossils, knowledge about the Jurassic deposits exposed near the upper Rio Grande (between Cerro Silla and Arroyo Calquenque) is due to the work of GERTH (1925: 193). He also collected at Cerro Tricolor the Aalenian ammonite fauna later described by JAWORSKI (1925 a, 1926). GROEBER (1947 b) repeated GERTH's observations.

In this area the Jurassic deposits form both limbs of an anticlinal fold that is elongated from NNE to SSW, and is diagonally crossed by the Rio Grande. The outcrops are thus two parallel strips, from each of which one locality is considered below.

B.10. El Infiernillo (text-fig. 3): Arroyo El Infiernillo is a left tributary of the upper Rio Grande, which flows in a nearly N–S direction downstream from La Estrechura. GERTH (1925, lám. 6, perfil 11; 1931: 134) referred to the sequence exposed on the eastern slope of Cerro Silla, i. e. on the right bank of Arroyo El Infiernillo. He described porphyritic tuffs that are overlain by unfossiliferous silicified limestones. He compared these to the brachiopod-bearing beds of the upper Rio Salado. They are in turn covered by dark shales with "*Posidonia*" which were mentioned by JAWORSKI (1925 a, 1926).

B.11. Cerro Tricolor (35° 31′ S, 70° 11′ W; text-fig. 3): The fundamental outline of the stratigraphy of Cerro Tricolor was provided by GERTH (1925, lám. 6, perfil 12; 1931), who pointed out that at its top there is an ammonite and *Posidonia* fauna included in black shales and marls that he referred to the Aalenian (1931: 137–138; see also WESTERMANN & RICCARDI 1979: 102). GERTH mentioned the sandy and tuffaceous underlying strata that crop out on the western slope, and tentatively assigned these to the lower and middle Early Jurassic, although he did not find any fossils (1931: 135).

In 1979 RICCARDI, MANCEÑIDO, DAMBORENEA and GULISANO went over the lower portion of the Jurassic sequence that crops out on the left bank of Rio Grande, opposite the Paso de La Piedra, on the western slope of Cerro Tricolor, and that continues upwards to the Auquilco Formation near Arroyo Calquenque. The measured section was published by WESTERMANN & RICCARDI (1982, see also RICCARDI & WESTERMANN 1984), who also described the Aalenian-Bajocian ammonites. The beds dip about 15° ESE, and the lower part of the section is as follows:

Formation	Age	Thickness	Bed	
"Cuyo"	Aalenian-Bajocian	1 m	816	Calcareous sandstones with *Bositra ornati* (QUENSTEDT) and *Meleagrinella* sp.
Group		3 m	813, 814	Black shales, two fossiliferous beds with *Bositra ornati,* ammonites, bivalves and bones.
		1.5 m	812	Black shales with big calcareous concretions that yielded ammonites and *Bositra ornati.*
		2 m	809–811	Dark micritic limestones with *Bositra ornati* and ammonoids.
	Late Toarcian	9 m		Partly covered.
	(*Phymatoceras*	1.5 m	808	Grey calcareous sandstones, with oysters and other bivalves.
	faunule)	8 m		Medium platy sandstones, cross-bedded, some beds with a higher calcareous content.
	(*D. hoelderi*		806–807	*Plicatula* ? sp., *Myophorella* sp., *Modiolus* cf. *thiollierei* (DUMORTIER), pteriaceans, *Frenguelliella* sp., other bivalves, gastropods and brachiopods.
	Zone ?)			
	(pre- *D. hoelderi*	6 m	805	Yellowish brown tuffs with *Posidonotis cancellata* (LEANZA), *Weyla alata angustecostata* (PHILIPPI), *Weyla unca* (PHILIPPI), *Myophorella* sp., other bivalves, gastropods, brachiopods and corals.
	Zone ?)			
Remoredo	??	300–400 m		Green and purple tuffs.

Rio Grande near Bardas Blancas Region

This is a classical study area for Argentinian Jurassic sequences, due to the magnificent outcrops on both banks of the Rio Grande valley between Rio Chico and Bardas Blancas. BURCKHARDT (in WEHRLI & BURCKHARDT 1898: 381 and profile; also BURCKHARDT 1900 a: 58, pl. 30, 32; 1903: 90, 102) provided the first scientific references to the

structure, stratigraphy and presence of marine Jurassic fossils. The region was later referred to in articles by GERTH (1925: 22, 23, 30; 1931), GROEBER (1918: 18–22; 1947 b: 412–413; in GROEBER et al. 1953: 210–211), STIPANICIC (1966: 429), DESSANTI (1973: 22–23) and WESTERMANN & RICCARDI (1972: 14–15; 1973, fig. 5; 1979: 99–100). Most of these authors agreed that the oldest fossiliferous deposits are of Mid Jurassic age, except those discovered by GERTH (op. cit.) at Arroyo Chacayco (locality B.13 on text-fig. 3), that suggest an earlier age (late Toarcian). Fossils from these localities have been figured by BURCKHARDT (1900 a, 1903), JAWORSKI (1925 a) and WESTERMANN & RICCARDI (1972, 1982).

B.12. Arroyo Poti Malal (35° 57′ S, 69° 59′ W; text-fig. 3): Geological knowledge of the area of Arroyo Poti Malal (right tributary of the Rio Grande) was very poor. The locality was included as "Cuyano superior y Loteniano" in the geological maps by GROEBER (1947 b) and as "Formación Puchenque" in DESSANTI's (1973) map, on the grounds of a small collection of fossils considered by GROEBER (1918: 20) as doubtfully belonging to an age between the lower and middle Jurassic. Later STIPANICIC (in GROEBER et al. 1953, lám. 22; STIPANICIC 1966: 432) provided more details but concentrated mainly on the upper portion of the Jurassic column.

RICCARDI, MACEÑIDO, GULISANO and DAMBORENEA visited the area in 1979 and made observations of the lower part of the section that crops out on the left bank of the Arroyo Poti Malal about 12 km upstream of its junction with the Rio Grande. WESTERMANN & RICCARDI (1982) published the stratigraphical section given below when they described the Aalenian-Bajocian ammonites. ROSENFELD & VOLKHEIMER (1981: 155) interpreted the basal conglomerates as mud-flows that formed during the late Toarcian.

The documentation of marine Lower Jurassic sediments at this locality is of great importance due to the long held assumption that marine Lower Jurassic deposits were absent southwards from the limit between the upper and middle course of the Rio Grande (GERTH 1925: 20; 1931: 134; GROEBER 1947 b: 412–413; GROEBER et al. 1953: 212).

The lower portion of the sequence is as follows:

Formation	Age	Thickness	Bed	
"Cuyo"	Bajocian	85 m	829	Dark shales with bivalves.
Group		20 m		Fine to medium calcareous sandstones with some cross-laminated beds and
	Aalenian			lumachelles.
			823–825	49, 56 and 65 m above the base: bivalves.
		18 m		Fine calcareous sandstones and dark shales.
			821–822	42 m above the base: Some beds with bivalves and ammonoids
	Late	30 m		Fine to medium-grained calcareous sandstones with interbedded coarser beds and
	Toarcian			shell-beds.
			818	22 m above the base: *Pinna* cf. *folium* YOUNG & BIRD, *Modiolus* sp., other bivalves and brachiopods.
			804	15 m above the base: *Entolium* sp.
			803	8 m above the base: *Myophorella* sp. and other bivalves.
			802	5 m above the base: bivalves and ammonites.
			800	1 m above the base: *Cucullaea* ? sp., other bivalves, corals, bones and wood.
				Base of measured section
		more than 10 m		Coarse green conglomerates and coarse sandstones.
Remoredo	??			Variegated tuffs.

C. Northern and Central Neuquén Province

Cordillera del Viento Region

The discovery of Jurassic fossiliferous deposits in the Cordillera del Viento can be apparently traced back to 1886, when AVE-LALLEMENT (1887) visited the region leading a mining expedition. The area was later explored by BODENBENDER (1889, map; 1892: 28–31), who studied mainly the late Jurassic deposits that crop out to the south of the Neuquén River. BODENBENDER also reported the presence, in the Cerro Poanco, of grey tuffaceous limestones with ill-preserved specimens of a pectinid of the group of *Pecten alatus* v. BUCH and corals allied to *Montlivaltia.*

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	Zone ?)			
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		18 m		Fine calcareous sandstones and dark shales.
			821–822	42 m above the base: Some beds with bivalves and ammonoids
	Late Toarcian	30 m		Fine to medium-grained calcareous sandstones with interbedded coarser beds and shell-beds.
			818	22 m above the base: *Pinna* cf. *folium* YOUNG & BIRD, *Modiolus* sp., other bivalves and brachiopods.
			804	15 m above the base: *Entolium* sp.
			803	8 m above the base: *Myophorella* sp. and other bivalves.
			802	5 m above the base: bivalves and ammonites.
			800	1 m above the base: *Cucullaea* ? sp., other bivalves, corals, bones and wood.
				Base of measured section
		more than 10 m		Coarse green conglomerates and coarse sandstones.
Remoredo	??			Variegated tuffs.

C. Northern and Central Neuquén Province

Cordillera del Viento Region

The discovery of Jurassic fossiliferous deposits in the Cordillera del Viento can be apparently traced back to 1886, when AVE-LALLEMENT (1887) visited the region leading a mining expedition. The area was later explored by BODENBENDER (1889, map; 1892: 28–31), who studied mainly the late Jurassic deposits that crop out to the south of the Neuquén River. BODENBENDER also reported the presence, in the Cerro Poanco, of grey tuffaceous limestones with ill-preserved specimens of a pectinid of the group of *Pecten alatus* v. BUCH and corals allied to *Montlivaltia.*

This locality has not been re-located since then, so the presence of lower Jurassic sediments east of El Huecú, between the Arroyo Cucurmalal and the Arroyo Manzanas near the Cerro Epú Anca (also known as "Poanca") is doubtful and needs confirmation.

Geological research in the area to the north of the Neuquén river near the Arroyo Chacay Melehue began for the second time in 1907, and KEIDEL (1910: 59–60) handed over the lower Jurassic fossils he had collected then to JAWORSKI, who described some of them (1914; 1925 b).

FRENGUELLI was also interested in the area and he sent several students there (REGAIRAZ 1943; CLAVIJO 1944; CRIADO ROQUE 1944), but he only published a brief summary of their unpublished theses (FRENGUELLI 1948). Between 1948 and 1953 ZÖLLNER and others surveyed the area, and their map and observations were only published several years afterwards (ZÖLLNER & AMOS 1973).

The Cordillera del Viento is the porphyritic core of a large brachyanticline elongated from N to S. On its eastern and southern slopes there are numerous outcrops of Lower Jurassic deposits showing facial changes along. The study of the fossils indicate progressively younger ages from S to N for the beginning of the marine succession in the area.

C.1. Southern Cordillera del Viento (37° 16′ S, 70° 34′; text-fig. 4): The section here described was measured in 1980 by MANCEÑIDO, DAMBORENEA and BALLENT on the southernmost slope of the Cordillera del Viento, near the headwaters of the Arroyo Chacay Melehue, just opposite to the Rajapalo Radio Station. This section may correspond to "entre los arroyos Del Pino y Lista Blanca" in CLAVIJO's unpublished thesis (1944), and possibly also to the "Cerro Bigú" in ZÖLLNER & AMOS' work (1973, figs. 8–9). They were the first to record interbedded fossiliferous lenses within the volcanic sequence. These beds apparently lie conformably on the Porphyritic Series, dipping about 34° SE. The volcanic content, which is very high in the Lower Jurassic, diminishes gradually upwards. This section continues without any major interruptions through the whole Jurassic and is certainly one of the key sections for the study of this System in Neuquén Province.

The lower part of the section is as follows:

Formation	Age	Thickness	Bed	
"Cuyo"	Early	14 m		Medium tuffaceous flagstones that alternate with massive sandstones.
Group	Toarcian			The thickness of individual beds increases upwards. Towards the top there is a
	(*D. hoelderi*			tuffaceous shell bed that passes into black shales.
	Zone)		1225	219 m above the base: bivalves, gastropods and harpoceratids.
		5 m		Medium white quartzose sandstones. Tuffaceous sandstones and porphyritic tuffs, some cross-bedded beds.
		47 m		Conglomeratic sandstone, grain-size smaller towards the top.
		5 m		Silicified limestones or calcareous tuffs with an abundant marine fauna:
	(pre-*D. hoelderi*		1224	101 m above the base: *Weyla unca* (PHILIPPI), other bivalves and
	Zone)			brachiopods.
		45 m		Conglomerate in beds that vary considerably in grain-size and thickness.
				Towards the top it gradually changes into conglomeratic sandstones and
				sandstones. There are also lenses of cross-bedded sandstones and conglomerates
				with ill-preserved bivalves.
	—?—	45 m		Greenish grey tuffs and porphyritic tuffs interbedded with polymictic conglo-
	Pliensbachian			merates. There are several fossiliferous beds:
	(*Fanninoceras*		1223	42 m above the base: *Frenguelliella* sp. and other bivalves.
	Zone)		1222	35 m above the base: gastropods.
			1221	27 m above the base: *Weyla unca, Pinna* cf. *folium* YOUNG & BIRD, *Isognomon*
				jupiter (LEANZA), *Plicatula* (*Harpax*) *rapa* BAYLE & COQUAND, other bivalves and
				brachiopods.
			1219–1220	14 m above the base: *Weyla unca, Myophorella* sp., other bivalves, brachiopods,
				Andenipora sp. and corals.
		11 m		Volcanic agglomerate.
				Base of measured section

		~ 100 m	Tuffs, tuffaceous sandstones and volcanic agglomerate from which other authors reported marine fossils.
Choiyoi	??		

C.2. Arroyo Lista Blanca (37° 16′ S, 70° 33′ W; text-fig. 4): The Arroyo Lista Blanca runs down the southern slope of the Cordillera del Viento and flows into the Arroyo Chacay Melehue. It cuts the lower Jurassic sequence that was examined by CLAVIJO (1944), whose fossil collection is housed in the MLP.

C.3. Arroyo Chacay Melehue near Lomas Bayas (37° 16′ S, 70° 31′ W; text-fig. 4): One of the typical Middle Jurassic sections of Argentina crops out at Lomas Bayas, on the right bank of the Arroyo Chacay Melehue. This section has been described several times: REGAIRAZ (1943), GROEBER et al. (1953: 178–179, fig. 7), STIPANICIC (1966: 447, fig. 8), WESTERMANN & RICCARDI (1972: 13–14; 1973, fig. 4; 1979: 97–98), DELLAPÉ et al. (1979, fig. 1), RICCARDI (1984, 1985) and RICCARDI & WESTERMANN (1984). Unterlying this thick sequence of ammonitiferous black shales there are poorly fossiliferous Lower Jurassic sediments. The lower levels of this section, which are described below, can be laterally traced into the uppermost beds of the Rajapalo section (C.1). This succession was measured by RICCARDI, MANCEÑIDO and DAMBORENEA in 1973.

Formation	Age	Thickness	Bed	
"Cuyo" Group	Aalenian	> 30 m		Shales and calcareous shales with interbedded thin beds of sandstones and levels with fossiliferous concretions.
		40 m		Alternate pairs of sandstone and calcareous shales (graded sequences) with intraformational clasts and a high tuffaceous content.
			247	133 m above the base: scarce ammonites.
	—?—	57 m		Black shales, calcareous towards the top.
	Pliensbachian? – Toarcian	26 m		Interbedded limestones and black calcareous shales, laminated and graded sequences with ammonites.
		11 m		Partly covered.
		11 m		Black hard limestones, with interbedded shales and sandstones, tuffaceous in part.
			246	34 m above the base: ammonites.
		23 m		Very hard volcanic rocks, sandstones and tuffaceous shales.
			245	4–23 m above the base: bivalves.

C.4. Arroyo Ñiraico (37° 04′ S, 70° 26′ W; text-fig. 4): The changing relations between the underlying quartzitic porphyries and the first marine fossiliferous beds on the eastern slope of the Cordillera del Viento were diagrammatically represented by ZÖLLNER & AMOS (1973, fig. 9, perfiles 4–6). At Arroyo Ñiraico the stratigraphical section is made up of about 150 m of "quartzitic porphyries" which are overlain by 30 m of tuffs with fossiliferous silicified clays intercalated. On top of these there are fossiliferous limestones with oysters followed by more than 100 m of bituminous shales and clays that belong to the Middle Jurassic. The MLP collections house some bivalves obtained in this locality by GULISANO in 1981 from the lower fossiliferous tuffs, which also yielded early Toarcian ammonites.

West of Zapala Region

Between Zapala and the international boundary with Chile, the presence of Jurassic sediments was first mentioned by BODENBENDER (1889) and BURCKHARDT (1899). Whilst the former author discovered the Jurassic beds at the upper Arroyo Covunco, the latter mentioned the sequence of marls and micaceous sandstones that crop out in the Haichol – Cerro Guanaco region, which he called "Areniscas de Haichol" (BURCKHARDT 1899: 203–204; 1900 b: 44, 56, pl. 2, 5). These sediments have not provided any fossils yet, but were assigned to the early Jurassic (s. l.) by LAMBERT (1956: 20–21).

On the other hand, the extensive outcrops of the "Cuyano" to the west of Zapala, between Cerro Carreri and Arroyo Cochicó Grande, mapped by LAMBERT (1956) and GALLI (1969 a), are fossiliferous. The outcrops are located

to the east, north and west of the Cerro La Atravesada. LAMBERT (1956) has already described the lithology and facial changes that the Cuyano displays at these localities. MANCEÑIDO, DAMBORENEA and BALLENT visited the area in 1980, when they measured sections at Arroyo Carreri and the northwestern slope of the Cerro Carreri. As the ammonites collected belong to the Bajocian, most of the sediments mapped as "Liásico" by LAMBERT (1956), at least those to the east of Peña Carreri, must be included in the Middle Jurassic.

C.5. Confluence of Arroyo Del Gringo and Arroyo De Los Toldos (38° 56′ S, 70° 29′ W; text-fig. 4): Although BODENBENDER visited this area in 1887 (1889: 326 and map), the first significant data were given by LAMBERT (1956), who described the "Cuyano" as lying on a thick volcanic agglomerate on the eastern slope of the Cerro La Atravesada. According to this author, sandstones with "*Vola alata*" and other bivalves, followed by sandstones and shales with few fossils, crop out on top of a thick conglomeratic bed. The Toarcian and Aalenian ammonoids mentioned by that author at this locality have not been revised since the determinations by MAUBEGE & LAMBERT (1956).

Black laminated shales and sandstones, dipping about 21° SW, crop out near the Arroyos Del Gringo and De Los Toldos. They yielded poorly preserved bivalves collected by MANCEÑIDO, DAMBORENEA and BALLENT in 1980.

Upper Catan Lil River Region

The discovery of the Jurassic deposits of this area was made in 1887 by BODENBENDER (1889: 326 and map), who visited the upper courses of the rivers Picún Leufú and Catán Lil and the eastern slope of the Sierra de Chachil. He provided a preliminary list of the fossils which he handed over to BEHRENDSEN for systematic description.

GROEBER renewed interest on the region through some papers (1924, 1929, GROEBER et al. 1953), giving rise to fundamental contributions on the geology and bivalve fauna by LAMBERT (1944 b, 1948). Several unpublished theses supervised by FRENGUELLI (CHINETTI 1945; BOZZOLO 1945; PALMA 1945; GENTILI 1946; PEIRANO 1947) covered the eastern slope of the Sierra de Catán Lil and both banks of the Catán Lil river from its junction with the Arroyo Del Fortín up to the Chachil massif. TURNER (1965, 1976) mapped the western slope of the Sierra de Catán Lil and the surroundings of the Arroyo La Jardinera.

C.6. Arroyo Pichi Picún Leufú to the east of Cerro Chachil (39° 07′ S, 70° 30′ W; text-fig. 4): This locality was described by LAMBERT (1944 b) as the upper part of the steep left slope of the narrow valley of the Arroyo Pichi Picún Leufú where it bends south, to the east of Cerro Chachil. The bivalve assemblage that he found near the base of the sequence is similar to the fauna collected at locality C.9, and was assigned by LAMBERT to the "Upper portion of the lower Lias" (i. e. Sinemurian). It is important because it contains the holotype of *Frenguelliella tapiai* (LAMBERT). H. LEANZA recently collected near this locality, at Arroyo Ñireco (locality C.20 on text-fig. 4) an early Jurassic fauna which is similar to the faunas of localities C.7 and C.9.

C.7. Vuta Picún Leufú (39° 11′ S, 70° 33′ W; text-fig. 4): Marine Lower Jurassic sediments crop out along the upper Arroyo Llao-Llao (or Yao-Yao) and also at the southern headwaters of the Picún Leufú river (called Arroyo Vuta Picún Leufú on the map in LAMBERT 1948). In some places the turbiditic deposits that normally make up the lower part of the Lower Jurassic succession in this area are replaced by hard silicified limestones, very fossiliferous, especially with bivalves and brachiopods.

The same situation possibly occurs on the left bank, at Morro Aguila. In 1980 MANCEÑIDO, DAMBORENEA and BALLENT measured a section at this locality, where the beds dip between 20° and 11° east. The section is as follows:

Formation	Age	Thickness	Bed	
"Cuyo" Group	Toarcian-Aalenian	178 m		Dark grey shales and black laminated shales with some very thin interbedded sandy beds. Some levels with calcareous concretions. Near the top the sandy beds become more frequent and yield bones.

			1093–1106	158, 166, 170, 180, 251 and 287 m above the base: several fossiliferous beds with *Bositra ornati* (QUENSTEDT) and ammonites.
	—?—			
	Pliensbachian	18 m		Silicified limestones in beds 10 to 50 cm thick. Some contacts show stylolites.
			1083–1084	142 and 131 m above the base: very rich in bivalves and brachiopods preserved as internal moulds.
		24 m		Hard calcareous sandstones.
			1082	105 m above the base: *Weyla* sp. and other bivalves.
		13 m		Conglomerate at the base, then medium to fine dark sandstones.
			1079–1081	87, and 96–100 m above the base: several fossiliferous beds with *Weyla bodenbenderi* (BEHRENDSEN), other bivalves, *Andenipora* sp., *Montlivaltia* sp. and brachiopods.
Lapa	Early Jurassic?	87 m		Sandy or porphyritic tuffs. Some volcanic agglomerates at the base, and a layer with micritic limestone concretions near the top.
				Base of measured section
Choiyoi	??			Purple and green porphyritic rocks.

C.8. Arroyo Puruvé Pehuén (39° 10′ S, 70° 40′ W; text-fig. 4): A very reduced outcrop is present on the mid-slope of the left bank of the Arroyo Puruvé Pehuén, halfway between the junctions of Arroyo Puruvé Pehuén with the Arroyos Resse-Ngelú and Chachil. It was discovered in 1923 by GROEBER, who, because of the presence of a new species of *Myophoria* and of *Mentzelia mentzeli* DUNKER, concluded the existence of marine middle Triassic (GROEBER 1924). Between 1942 and 1947 LAMBERT visited the place, located the outcrop on a map (LAMBERT 1948, lám. 1, fig. 1, and lám. 8) and re-interpreted it as belonging to the Lower Jurassic on the basis of new fossil material. Conclusive palaeontological arguments were presented by FRENGUELLI (1948) and A. LEANZA (1948). LEVY (1967) re-assigned GROEBER's material to *Myophorigonia.* The mention of *Mentzelia mentzeli* DUNKER could also be re-interpreted as a species of *Spiriferina,* as suggested by MANCEÑIDO (1981).

From GROEBER's (1924: 89) and LAMBERT's (1948: 250) data, the stratigraphy of this locality can be summarized as follows: on top of the dioritic or granodioritic basement, lies a 6–12 m thick arkose bed, followed by about 25 m of tuffaceous sandstones with some partially silicified calcareous horizons, that yielded the poorly preserved fossils (including *Weyla*). LAMBERT suggested that to the NW there may be some porphyritic rocks between the basement and the basal conglomerate, but the actual relationships are unknown.

C.9. Arroyo Lonqueo (39° 14′ S, 70° 41′ W; text-fig. 4): The Arroyo Lonqueo is the main tributary of the upper Catán Lil river. The Lower Jurassic sediments that crop out there were mapped by LAMBERT (1948, lám. 8), who also recorded a fossiliferous locality. In 1980 GULISANO, MANCEÑIDO, DAMBORENEA and BALLENT visited the area and measured the following succesion of Lower Jurassic strata, dipping 19° ESE:

Formation	Age	Thickness	Bed	
"Cuyo" Group	Late Early to Late Pliensbachian (*Fanninoceras* Zone)	~ 30 m		Sandstones and calcareous sandstones, tuffaceous in part, very fossiliferous, especially rich in bivalves and brachiopods.
			1191–1193	37–40, 40 and 41 m above the base: *Frenguelliella tapiai* (LAMBERT), *Myphorella* ? sp., *Weyla unca* (PHILIPPI), *Pinna* cf. *folium* YOUNG & BIRD, *Plicatula* (*Harpax*) *rapa* BAYLE & COQUAND, other bivalves and brachiopods.
			1188–1190	12–22, 22–32 and 32–37 m above the base: *Frenguelliella tapiai, Plicatula* (*Harpax*) *rapa,* other bivalves and brachiopods.
		~ 10 m		Medium conglomerates, with interbedded sandstones. Rounded pebbles mostly of porphyritic rocks. With poorly preserved bivalves and ammonites.
				Base of measured section
Lapa / Choiyoi	??			Porphyritic rocks.

C.10. Espinazo del Zorro (39° 16′ S, 70° 39′ W; text-fig. 4): The Lower Jurassic outcrops on the left bank of the upper Catán Lil river, between Cerro Mesa and the mouth of the Arroyo Llao-Llao were mapped by GENTILI (1946). This author recorded several fossiliferous localities near the Espinazo del Zorro, in some instances referred also to stratigraphical sections. Part of his collections are housed at the FCENBA.

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				Base of measured section
Choiyoi	??			Purple and green porphyritic rocks.

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			1188–1190	12–22, 22–32 and 32–37 m above the base: *Frenguelliella tapiai*, *Plicatula* (*Harpax*) *rapa*, other bivalves and brachiopods.
		~ 10 m		Medium conglomerates, with interbedded sandstones. Rounded pebbles mostly of porphyritic rocks. With poorly preserved bivalves and ammonites.
				Base of measured section
Lapa / Choiyoi	??			Porphyritic rocks.

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MANCEÑIDO, DAMBORENEA and BALLENT measured a section on the left bank of the upper Catán Lil river, to the north of Estancia Vieja and near three fords that cross the river. At this place the base of the Lower Jurassic sequence is not exposed, but a few km upstream GULISANO (personal communication) observed that over the Porphyritic Series there are 100–150 m of coarse conglomerates, followed up by dark shales that are overlain by the rocks here described. At that place the fossiliferous calcareous sandstones that crop out at Arroyo Lonqueo are apparently absent. The measured section, dipping between 33° and 55° E and NE, is as follows.

Formation	Age	Thickness	Bed	
"Cuyo" Group	Toarcian	52 m		Calcareous siltstones and mudstones, towards the top they become laminated, with harpoceratid and dactylioceratid ammonoids.
	—?—	28 m		Partly covered.
	Pliensbachian?	124 m		Turbiditic sequences with local variations in the thickness of individual beds. With lamination structures, normal graded bedding, convolute bedding and slip bedding, sometimes of large magnitude.
		216 m		Turbiditic sequence, with some coarse sandstones beds yielding plant remains.
			1069–1070	6 and 22–32 m above the base: very few dispersed bivalves.
				Base of measured section
		?		Dark turbiditic shales.
		100–150 m		Coarse to very coarse conglomerates.
Lapa / Choiyoi ??				Porphyritic rocks.

C.11. Arroyo Llao-Llao (or Yao-Yao) (text-fig. 4): At the MLP there is some fossil material collected by GENTILI and labelled "Arroyo Llao-Llao" that probably corresponds to the collection he made during his thesis work (1946). In his map and sections he indicated several fossiliferous localities on both banks of the Arroyo Llao-Llao between its headwaters and Mallín de la Piedra.

C.12. Mallín de la Piedra (39° 17′ S, 70° 35′ W; text-fig. 4): The base of the early Jurassic sequence crops out on the northern slope of the Cerro Mallín de Ibáñez. GENTILI (1946) mentioned some fossiliferous localities there, and in 1984 MANCEÑIDO, DAMBORENEA and GRIFFIN measured a stratigraphical section. At the base, a greenish grey conglomerate, 3 to 5 m thick, lies on volcanic breccias, and is covered by about 147 m of dark grey siltstones and shales in fining upwards sequences. These beds are fossiliferous at seversal levels (beds M 1365 to 1373), with ammonoids, brachiopods and bivalves of late Pliensbachian age. The section continues upwards with about 60 m of black shales and limestones, which yielded an ammointe and bivalve fauna (beds M 1374 to M 1381) of early Toarcian age. This fauna is very rich in *Posidonotis cancellata* (LEANZ A).

Note on WEAVER's locality 1029: WEAVER (1931: 23) described this locality as "located near the settlement of Catán-Lil, approximately 30 kilometers northwest of Piedra Pintada, and is in line with the southerly extension of the steeply dipping beds at Cerro Leon Mahuida". This locality could not be re-located following the indications given by WEAVER, but it should be searched for in the vicinity of either the present situation of Catán Lil or the old location of "Fortín Cataluin" or "Fortín Cataglún" (see for instance map in BODENBENDER 1889) i. e. near the Cordón de la Piedra Santa (see also ROLLERI et al. 1984). For the time being we only know the fossil material that was described and figured by GERTH (1928) and WEAVER (1931), which was found in light-coloured tuffaceous limestones.

C.13. Rahue-Aluminé (39° 20′ S, 70° 56′ W; text-fig. 4): Lower Jurassic sediments on the western slope of Sierra de Catán Lil were recorded by TURNER (1965: 167; 1976: 36) when he described his Jardinera Formation. He also mentioned some early Jurassic marine molluscs. CUERDA et al. (1981, 1982) reported an outcrop on the right bank of the Aluminé river, near the provincial road N° 23, about 4 km upstream of the Rahue bridge, and 13.5 km to the south of Aluminé. They ascribed these sediments to the Aluminé Formation, within which they recognized a lower volcanic facies (rhyolites, andesites, tuffs) about 100 m thick, and an upper volcano-sedimentary facies (with

silicified beds containing marine invertebrates) about 40 m thick. They mentioned seven fossiliferous beds. Their collection is housed at the MLP and was examined for the present study. The bivalves indicate a Pliensbachian (or ? Toarcian) age for these deposits.

Central Neuquén Region, Southeast of Zapala

East ot the Barda Negra basaltic meseta the known Jurassic outcrops are small and discontinous (Cerro Lotena, Loma α, Cerro Granito, Rincón del Aguila, etc.) and were overlooked for several years, apart from the Tithonian-Neocomian deposits described by HAUPT (1907). Most of these localities consist of Aalenian or younger strata (cf. WESTERMANN & RICCARDI 1972, 1979).

C.14. Cerro Granito (39° 09′ S, 69° 34′ W; text-fig. 4): The Lower Jurassic sediments at Cerro Granito were discovered by KEIDEL (1925: 25; also in GROEBER, 1918: 47–48). WEAVER (1931) collected from two different localities, and then the area was mapped by SUERO (1942, 1951). This is an isolated succession that apparently lies unconformably on igneous rocks, and is covered by Quaternary deposits. In 1973 RICCARDI, MANCEÑIDO and DAMBORENEA visited the locality, and a summary of their observations is as follows:

Formation	Age	Thickness	Bed	
"Cuyo"	Domerian?	~ 40 m		Hard calcareous sandstone, medium to coarse-grained.
Group	-Toarcian		167–169	0, 1 and 5 m above the base: *Weyla alata angustecostata* (PHILIPPI), *Myophorella* sp., *Weyla unca* (PHILIPPI), *Posidonotis cancellata* (LEANZA), other bivalves, brachiopods, ammonites and plant débris.
				Base of measured section
		??		Medium-grained sandstones.

The brachiopods were studied by MANCEÑIDO (1978).

Charahuilla-Chacaico Region

WEAVER (1931) made the first serious attempt to describe the Jurassic stratigraphy of the Charahuilla-Chacaico region. The geology of the area was mapped by FERNÁNDEZ (1943), GARCÍA VIZCARRA (1943) and TORREA (1945) and the general stratigraphy was also analyzed by GROEBER (1929: 22), GROEBER et al. (1953: 158), FRENGUELLI (1937 a), LAMBERT (1946), STIPANICIC (1969), WESTERMANN and RICCARDI (1972, 1973, 1979) and RICCARDI & WESTERMANN (1984). The pre-Tithonian sequence comprises lower Jurassic to Callovian sediments. Some sedimentary features were analyzed by ROSENFELD (1978) and ROSENFELD & VOLKHEIMER (1979). For the Lower Jurassic portion of the section VOLKHEIMER (1973) distinguished two formations: Sierra Chacaico and Los Molles.

The lower Jurassic outcrops continue to the north to the point where the Arroyo Los Molles joins the Picún Leufú river. GROEBER collected there part of the bivalves described by A. LEANZA (1943), initially regarded as Pliensbachian in age and nowadays referable to the early Toarcian (see C.19 in text-fig. 4 herein). To the east and on both banks of the Picún Leufú river, the oldest deposits are Aalenian-Bajocian or younger (see WESTERMANN & RICCARDI 1975). Lower Jurassic strata are restricted to some gorges that run parallel to the national road N° 40 (cf. GROEBER et al. 1953: 166; H. LEANZA 1973, fig. 13; see C–18 in text-fig. 4 herein). They yielded the *Otozamites simonatoi* flora described by ORLANDO (1964 a). MANCEÑIDO, DAMBORENEA and BALLENT measured there a stratigraphical section in 1980. There are several beds that contain microfossils studied by BALLENT (1985), but their macrofossil content is very poor.

C.15. Arroyo Lapa (39° 23′ S, 70° 25′ W; text-fig. 4): The stratigraphical section at Arroyo Lapa was illustrated by VOLKHEIMER (1973) and was also measured by RICCARDI, MANCEÑIDO and DAMBORENEA in 1973, on both banks of the Arroyo Lapa. The beds dip 25° to 3° E, forming the eastern slope of the Cerro Charahuilla anticline. Near the base of the section there are some beds with *Fanninoceras* of Pliensbachian age. The next

ammonite assemblage was found 300 m above and indicates an early Toarcian age. From the upper part of this succession came the *Bouleiceras* that HILLEBRANDT (1973 a, Taf. 2, figs. 3–6) described and figured. The palynological content of this section was examined by VOLKHEIMER (1973, 1974) and the brachiopods were studied by MANCEÑIDO (1978). ROSENFELD & VOLKHEIMER (1981, fig. 1) mention two turbiditic events for this section, one during the Pliensbachian and the other during the Toarcian.

Formation	Age	Thickness	Bed	
Los Molles	Early Toarcian	42 m		Very hard calcareous sandstones with interbedded platy siltstones. Fragments or harpoceratid ammonites.
		90 m		Dark siltstones, with fine laminated sandstones towards the top.
			196–197	321 and 348–360 m above the base: several levels with calcareous concretions that yield ammonites and bivalves.
			195	315–321 m above the base: *Posidonotis cancellata* (LEANZA) and other bivalves.
	—?—	18 m		Tuffaceous coarse sandstones, with flow structures and plant remains.
"Sierra	Pliensbachian	143 m		Grey laminated siltstones and medium sandstones. Some dark shales.
Chacaico"			194	252 m above the base: *Entolium* sp. and brachiopods.
			193	109–148 m above the base: *Palaeoneilo patagonidica* (LEANZA), *Parallelodon* sp., other bivalves, brachiopods and ammonites.
			192	109 m above the base: bivalves and brachiopods.
		28 m		Partly covered.
		22 m		Grey siltsones and flagstones with plant débris.
		36 m		Tuffaceous sandstones and tuffs. Also grey laminated siltstones and coarser sediments, in fining upwards sequences. Plant detritus.
		10 m		Partly covered.
		13 m		Greenish grey siltstones and calcareous siltstones.
			190–191	11 and 44 m above the base: Pectinids and *Fanninoceras* sp.
				Base of measured section
		up to 42 m		Volcanic breccia. Clasts become more rounded towards the top.
Lapa	??			Pyroclastic rocks.

C.16. Estancia Charahuilla (39° 25′ S, 70° 25′ W; text-fig. 4): The Arroyo Maihuén cuts the Lower Jurassic sequence about 2 km south of locality C.15, and to the west of Estancia Charahuilla. FERNÁNDEZ (1943) there described his section 1a and part of his fossil collection is housed at the MLP. The same section was mentioned again by GROEBER et al. (1953: 158–161) and some ammonites from this locality were figured by HILLEBRANDT (1973 a, lám. 2, figs. 2, 7).

D. Southern Neuquén Province

Estancia Santa Isabel Region

The geology of this area was first explored by BODENBENDER (1889), but due to a misinterpretation of the fauna by BEHRENDSEN (1892), they referred some outcrops of the Quintuco Formation to the middle Jurassic ("Oolitico medio") (see discussion in ROLLERI et al. 1984). The region was mapped by A. LEANZA between 1943 and 1949 (LEANZA & LEANZA 1979) and by PARKER in 1965 (PARKER 1973). These geological maps differ in some important features concerning the lower Jurassic outcrops. LEANZA & LEANZA sketched a unique subtriangular outcrop of less than 5 km^2 to the south of Estancia Santa Isabel, near Cerro El Bandurrial, but PARKER (1973) represented two outcrops on his map instead. One of them cuts the headwaters of the Arroyo Sañicó, whilst the larger one lies to the east of the Cerro El Carancho. He referred the tuffaceous shales, sandstones and conglomerates to the "Cuyano" Series, whilst LEANZA & LEANZA (1979) assigned them to the Piedra Pintada Formation, within which they recognized a pelitic lower member and a sandy-conglomeratic upper member, together comprising upwards of 400 m in thickness.

D.1. 8 km south of Estancia Santa Isabel (39° 58′ S, 70° 28′ W; text-fig. 5): In 1980 MANCEÑIDO, DAMBORENEA and BALLENT collected early Jurassic invertebrates at about 8 km south of Estancia Santa Isabel, in sediments that overlie porphyritic rocks and dip nearly 25° NE. The observations made there are as follows:

Formation	Age	Thickness	Bed	
Piedra	Late	20 m		Tuffaceous siltstones and shales, partly covered.
Pintada	Pliensbachian (to early Toarcian?) (*Fanninoceras* Zone)	8 m	1055	*Oxytoma inequivalvis* (SOWERBY), *Plicatula (Harpax) rapa* BAYLE & COQUAND, *Frenguelliella* sp., other bivalves, brachiopods and crinoids.
				Fine-grained platy sandstones, very hard. Near the base there is a highly fossiliferous volcanic sandstone.
			1051	*Weyla unca* (PHILIPPI), *Plicatula (Harpax) rapa, Weyla bodenbenderi* (BEHRENDSEN), *Gervillaria ? pallas* (LEANZA), *Isognomon jupiter* (LEANZA), *Pinna* cf. *folium* YOUNG & BIRD, *Myophorella* sp., *Gervillia (Cultriopsis)* sp., *Modiolus gerthi* n. sp., *Parallelodon riccardii* ? n. sp., *Cucullaea* cf. *rothi* LEANZA, other bivalves, brachiopods and corals.
			1050	*Parallelodon groeberi* n. sp., *Lycettia hypertrigona* n. sp., *Pinna* cf. *folium, Weyla unca,* other bivalves, gastropods and brachiopods.
			1049	*Weyla unca, Frenguelliella* sp., other bivalves, gastropods, brachiopods and ammonites.
Choiyoi?	??	?		Grey, purple and green porphyritic rocks.

Piedra Pintada Region

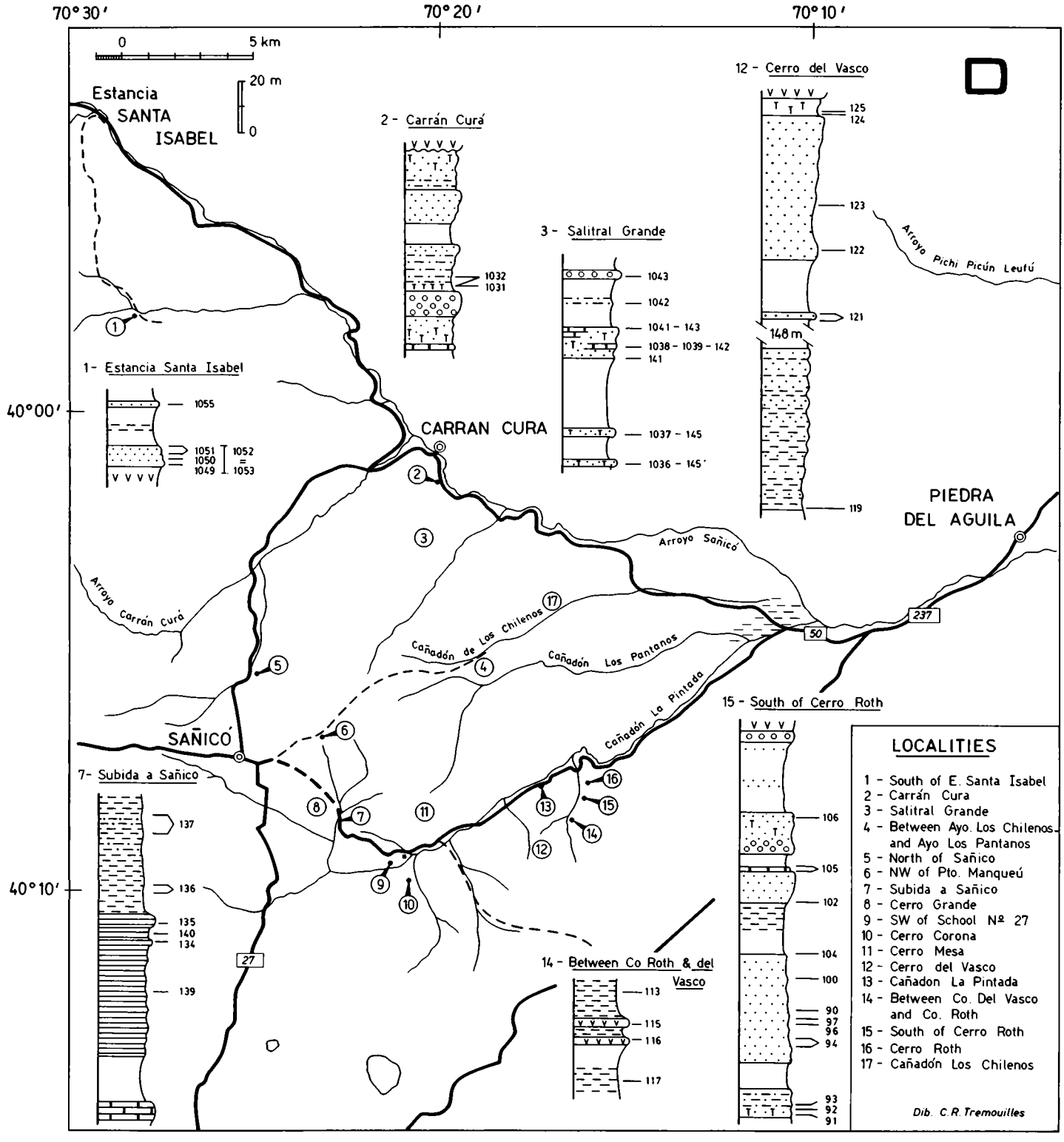
Since ROTH (1899, 1902) discovered the marine Lower Jurassic deposits in the Piedra Pintada region, several authors have contributed to their knowledge: BURCKHARDT (1902), JAWORSKI (1914, 1915, 1925 b), GROEBER (1925), FRENGUELLI (1948), LEANZA (1942 a, 1942 b), GALLI (1954, 1969 b), STIPANICIC et al. (1968), STIPANICIC & BONETTI (1970), PARKER (1973), DAMBORENEA et al. (1975), etc. The fossil flora was described by KURTZ (1902), FRENGUELLI (1937 b, 1941), ORLANDO (1946 b) and HERBST (1966). GERTH (1928) studied some of the corals and MANCEÑIDO (1978, 1981, 1983) dealt with the brachiopods.

The early Jurassic bivalves from this classical locality were described by BURCKHARDT (1902), JAWORSKI (1914, 1915, 1925 b), WEAVER (1931) and A. LEANZA (1940 a, 1940 b, 1942 b). The last-named author proposed a stratigraphical zonation on the base of the bivalve assemblages, and his scheme has been quoted by many authors (GROEBER et al. 1953; STIPANICIC 1969; STIPANICIC & BONETTI 1970). However, DAMBORENEA et al. (1975) demonstrated that the composition of the bivalve associations is more dependent on facies and life conditions than on age differences, and therefore cannot be used for stratigraphic zonation. Their conclusion, that the lower Jurassic marine sequence apparently consists of a continuous succession of sediments of Pliensbachian age, and it is part of a volcanic-sedimentary cicle of greater spatial and chronological range, still holds. More recently GULISANO & PANDO (1981) carried out a lithofacial analysis of these sediments. They recognized seven lithofacies grouped into two main sedimentary events separated by a regional unconformity: an initial pyroclastic filling (Piedra del Aguila + Sañicó Formations) followed by marine sedimentation (Los Molles + Lajas Formations). Nevertheless, the relationships between the different facies are not clear, and the above mentioned regional unconformity was only postulated by GULISANO & PANDO (1981) on the basis of a proposed palaeo-geographical model.

WEAVER (1931) did not visit the area himself, but obtained his fossil material from collections made by G. KLINGAMAN and W. CARY. Therefore, many of WEAVER's localities could not be re-located with certainty.

D.2. Arroyo Sañicó near Carrán Curá (40° 01′ S, 70° 20′ W; text-fig. 5): Immediately to the south of the junction of Arroyo Sañicó and Arroyo Carrán Curá there are some lower Jurassic deposits that were first mentioned by A. LEANZA (1941: 206, fig. 1–2) and then mapped as "Cuyano" by GALLI (1969 b) and PARKER (1973).

MANCEÑIDO, DAMBORENEA and BALLENT measured the following section in 1980 on the right bank of the Arroyo Sañicó, about 1 km south of the school No. 84 (Carrán Curá). The beds dip there about 11° NE.



Text-fig. 5. Locality map of southern Neuquén province (D). Locality numbers and sample numbers as indicated in description of stratigraphic sections. For references see text-fig. 2.

Formation	Age	Thickness	Bed	
Piedra Pintada or Lajas	Pliensbachian	15 m		Siltstones and shales alternating with medium sandstones that bear clay intraclasts.
		13 m		Medium to coarse sandstones, and fine sandstones and shales with plant remains.
		8 m		Partly covered.
Piedra Pintada or Los Molles		18 m		Medium sandstones and dark grey shales. Tuffaceous, fossiliferous bed at the base.
			1031–1032	23–25 m above the base: *Palaeoneilo patagonidica* (LEANZA), *Oxytoma inequivalvis* (SOWERBY), other bivalves, ammonites and plants.
		10 m		Arkosic conglomerate and sandstones with intraclasts and sandy nodules. Very hard light-coloured tuffs and medium to coarse sandstones. Limestone with stromatolitic structures near the base.

D.3. Salitral Grande, Carrán Curá (40° 03′ S, 70° 21′ W; text-fig. 5): Although this area was mapped as "Cuyano" by GALLI (1969 b), he did not mention any fossil locality there, and the first collection at this site was made by DAMBORENEA et al. (1975). The brachiopods were studied by MANCEÑIDO (1978, 1983). The sediments crop out in a low depression about 5 km south of the road between Carrán Curá and Piedra del Aguila and dip about 10° NE. A summary of the observations made by RICCARDI, MANCEÑIDO and DAMBORENEA in 1973, and by MANCEÑIDO, DAMBORENEA and BALLENT in 1980 is as follows:

Formation	Age	Thickness	Bed	
Piedra Pintada or Lajas	Pliensbachian	3 m	1043	Volcanic conglomerate with poorly preserved bivalves and solitary corals.
		?		Partly covered.
		1 m		Very hard tuffaceous grey siltstones, with bivalves preserved as internal moulds.
			1042	*Grammatodon costulatus* (LEANZA), *Falcimytilus? gigantoides* (LEANZA).
		?		Partly covered.
		12 m		Highly fossiliferous tuffaceous sandstones, medium to coarse-grained, calcareous in part.
			1038–1041 & 141–144	*Nuculana* cf. *ovum* (SOWERBY), *Parallelodon groeberi* n. sp., *Parallelodon riccardii*? n. sp., *Cucullaea jaworskii* LEANZA, *Cucullaea rothi* LEANZA, *Falcimytilus gigantoides*, *Pinna* cf. *folium* YOUNG & BIRD, *Gervillella* n. sp. *Isognomon jupiter* (LEANZA), *Weyla bodenbenderi* (BEHRENDSEN), *Weyla unca* (PHILIPPI), *Gervillaria? pallas* (LEANZA), *Frenguelliella* sp., *Myophorella* sp., *Jaworskiella* sp. and other bivalves, *Peristerothyris columbiniformis* MANCEÑIDO and other brachiopods, colonial corals, gastropods, echinoids and *Radstockiceras* sp.
		~ 26 m		Partly covered.
		3 m		Highly fossiliferous very hard, yellowish tuffaceous sandstones.
			145 – 1037	*Parallelodon groeberi* n. sp., *Weyla bodenbenderi*, other bivalves, *Peristerothyris columbiniformis* and other brachiopods.
		? 9 m		Partly covered.
		2.5 m	145′ – 1036	Yellowish tuffaceous sandstones with *Falcimytilus? gigantoides*, *Weyla bodenbenderi*, *Weyla mexicana*?, *Weyla unca*, *Jaworskiella* sp., *Myophorella* sp., other bivalves and brachiopods.

D.4. Ridge between Arroyo de Los Chilenos and Arroyo de Los Pantanos (40° 05′ S, 70° 19′ W; text-fig. 5): Fine tuffs and volcanic breccias crop out at the headwaters of the Cañadón de Los Chilenos and on the ridge between it and Arroyo de Los Pantanos. They are lithologically similar to the topmost beds at Cerro Del Vasco and to those that cover the fossiliferous strata at Salitral Grande. MANCEÑIDO, DAMBORENEA and BALLENT visited the region in 1980 and collected bivalves and plants close to "cota 923" (see map in A. LEANZA 1942 a).

D.5. 4 km north of Sañicó on the way to Carrán Curá (40° 05′ S, 70° 25′ W; text-fig. 5): On both sides of the provincial road No. 23, between 3 and 5 km north of Sañicó, the marine Lower Jurassic is represented by red tuffaceous sandstones. A. LEANZA (1941: 207; 1958, fig. 34) mentioned fossils from this area to the south of Cerro Bayo et the Puertas de Salamanca. This locality has been recorded in GALLI's (1969 b) map. GULISANO & PANDO (1981) included these outcrops in their "purple and grey sandstones and shales facies".

MANCEÑIDO, DAMBORENEA and BALLENT collected bivalves and brachiopods 4 km north of Sañicó, just to the east of a bend of the road between Sañicó and Zapala. Collections made by A. FERNÁNDEZ in 1941 are housed at MLP.

D.6. Northwest of Puesto Manqueú (40° 07′ S, 70° 23′ W, text-fig. 5): There are also outcrops of Lower Jurassic sediments about 1 km east of Sañicó on the road that goes into Cañadón de Los Chilenos, to the SW of Puesto Barra and NW of Puesto Manqueú, where MANCEÑIDO, DAMBORENEA and BALLENT collected marine invertebrates in 1980.

D.7. Subida a Sañicó (40° 09′ S, 70° 22′ W; text-fig. 5): The Lower Jurassic sediments crop out again as part of a monoclinal structure between 5 and 6 km east of Sañicó by the provincial road No. 50, about 2 km NW of the school No. 27 (Piedra Pintada). RICCARDI, MANCEÑIDO and DAMBORENEA measured there a section that was already published in DAMBORENEA et al. (1975, fig. 3). Supplementary observations were made in 1980 by MANCEÑIDO, DAMBORENEA and BALLENT. This locality is probably the same as A. LEANZA's (1942 a, 1942 b) "Subida a Sañicó", and as GULISANO & PANDO's (1981, fig. 1) section 2. Lithological evidence and allochtonous nature of the fossil assemblage suggest either a storm deposit or a turbiditic origin for beds 134 and 135 (see DAMBORENEA et al. 1975: 193).

Formation	Age	Thickness	Bed	
Piedra Pintada = Los Molles	Pliensbachian	44.5 m		Black siltstones and shales, partly covered, with bivalves and ammonites.
			137, 136	63–67 and 85–93 m above the base: *Palaeoneilo patagonidica* (LEANZA), *P. galatea*? (D'ORBIGNY), *Parainoceramus apollo* (LEANZA), *Oxytoma inequivalvis* (SOWERBY), other bivalves and ammonites.
		5 m		Conglomerates with sandy matrix. Volcanic clasts up to 5 cm. Fossils preserved as moulds.
			135	51 m above the base: *Frenguelliella* sp., *Myophorella* sp., *Weyla unca* (PHILIPPI) and other bivalves.
		5 m		Black shales.
			140	48 m above the base: *Parainoceramus apollo*, other bivalves, ammonites and plant débris.
		1 m		Dark green-grey conglomerate, volcanic clasts up to 4 cm.
			134	43 m above the base: *Weyla unca* and *Myophorella* sp.
		43 m		Dark laminated shales, some intercalated tuffaceous sandstones.
			139	23 m above the base: bivalves and plant detritus.
				Base of measured section
		20 m		Partly covered.
		10 m		Limestones with stromatolitic structures.

D.8. Cerro Grande (40° 08′ S, 70° 23′ W; text-fig. 5): There is a collection made by A. LEANZA and deposited at the MLP with the label "Cerro Grande (1035)", that certainly refers to the hill 1035 m high in his map (LEANZA 1942 a).

D.9. Southwest of school No. 27, Piedra Pintada (40° 09′ S, 70° 21′ W; text-fig. 5): Dark shales crop out on the left bank of the Cañadón La Pintada less than 1 km to the SW of the present location of the school No. 27 (Piedra Pintada). RICCARDI, MANCEÑIDO and DAMBORENEA collected there in 1973.

D.10. Eastern slope of Cerro Corona (40° 10′ S, 70° 21′ W; text-fig. 5): This fossiliferous locality was discovered by J. FRENGUELLI, who described it "between Payllalef and Paynakeú", as did also A. LEANZA (1942 a, 1942 b). This last author characterized at this place his "Complejo inferior" or "No. 1". It is placed less than 2 km SW of the school No. 27, on the right bank of the Cañadón La Pintada and on the eastern slope of the Cerro Corona. The relationships of the fauna collected there to other fossil associations was analyzed by DAMBORENEA et al. (1975).

D.11. Cerro Mesa (de La Pintada) (40° 08′ S, 70° 21′ W; text-fig. 5): LEANZA (1942 a) measured a section on the left bank of Cañadón La Pintada that shows similarities to the Cerro Del Vasco section. Fossil invertebrates and plants collected by A. LEANZA and FRENGUELLI at this locality are housed at the MLP. The presence of fossils was corroborated by GALLI (1969 b).

D.12. Cerro Del Vasco (40° 09′ S, 70° 18′ W; text-fig. 5): To the south of the provincial road No. 50, about 12 km east of Sañicó and 4 km west of Cerro Roth, the right bank of Cañadón La Pintada is dominated by the hill named cerro Del Vasco by A. LEANZA (1942 b, fig. 2).

A section that comprises about 400 m of lower Jurassic sediments was described by A. LEANZA (1942 a), DAMBORENEA et al. (1975, fig. 3) and by GULISANO & PANDO (1981, fig. 1). The beds dip about 5° SE. The section measured in 1973 by RICCARDI, MANCEÑIDO and DAMBORENEA is as follows:

Formation	Age	Thickness	Bed	
Piedra	Pliensbachian	40 m		Volcanic conglomerate, clasts up to 40 cm in diameter.
Pintada		7 m		Light-coloured tuffs, variable grain-size.
or Lajas			125	290–294 m above the base: *Frenguelliella* sp., *Jaworskiella* sp., *Myophorella* sp., *Parallelodon groeberi* n. sp., *Lycettia hypertrigona* n. sp., *Modiolus* cf. *thiollierei* (DUMORTIER), *Bakevellia* (*Neobakevellia*?) n. sp., *Gervillella* n. sp., *Gervilleioperna turgida* (LEANZA), *Isognomon jupiter* (LEANZA), *Weyla bodenbenderi* (BEHRENDSEN) and other bivalves.
		56 m		Coarse to conglomeratic sandstones, some cross-bedded beds. Several fossiliferous horizons.
			124	289 m above the base: *Isognomon jupiter*, other bivalves and plant remains.
			123	259 m above the base: *Otozamites* sp.
			122	241 m above the base: *Parallelodon groeberi* n. sp., *Modiolus* cf. *thiollierei* (DUMORTIER), *Isognomon jupiter*, *Weyla bodenbenderi*, other bivalves, gastropods and brachiopods.
		20 m		Partly covered.
		2 m	121	Hard grey sandstones with *Parallelodon groeberi* n. sp., *Modiolus* cf. *thiollierei*, *Isognomon jupiter*, other bivalves and brachiopods.
———		87 m		Partly covered.
Piedra		21 m		White tuffaceous siltstones with plant remains.
Pintada		40 m		Partly covered.
or Los		31 m		Hard fine-grained sandstones and dark shales in alternating beds.
Molles		32 m		Black shales with some thin siltstone and sandstone beds. Ammonites and bivalves throughout.
			119	3 m above the base: *Parainoceramus apollo* (LEANZA), other bivalves and *Fanninoceras* sp.

Base of section

The ammonites found in the lower part of this section indicate a Pliensbachian age, whilst the bivalve and brachiopod assemblages found in the upper portion are equivalent to those of Cerro Roth (see below).

D.13. Cañadón La Pintada between Cerro Del Vasco and Cerro Roth (40° 08′ S, 70° 17′ W; text-fig. 5): Greenish-grey micaceous siltstones that apparently underlie the lowest sediments observed at Cerro Del Vasco and Cerro Roth crop out in a road-cutting on the road No. 50, about 2.5 km west of Cerro Roth. They contain a poor bivalve fauna that includes *Otapiria* n. sp.

D.14. Between Cerro Del Vasco and Cerro Roth on a tributary of the Cañadón La Pintada (40° 09′ S, 70° 17′ W; text-fig. 5): Black fossiliferous shales crop out on both banks of a southern tributary brook of the Cañadón La Pintada, approximately 1 km south of its mouth. Two trachytic sills were sampled and processed for absolute dating by the K-Ar method. The results are in DAMBORENEA et al. (1975: 199). With the corrections indicated by LINARES (1978) the average age is 173 ± 3 Ma (with extremes of 181 and 166 Ma). According to recent geochronologic scales, such an age would correspond with the Pliensbachian (VAN EYSINGA 1971; BRAZIUNAS 1975), the early Aalenian (VAN HINTE 1976), the Bajocian (ODIN 1982) or even the Bathonian (HARLAND et al. 1982; KENT & GRADSTEIN in A. PALMER 1983; WESTERMANN 1984).

The section is a follows:

Formation	Age	Thickness	Bed	
Piedra Pintada or Los Molles	Pliensbachian	4 m	113	Black shales with *Parainoceramus apollo?* (LEANZA), *Fanninoceras* sp. and plant detritus.
		?		Not exposed.
		2 m	115	Trachyte (176 ± 5 Ma).
		3–4 m		Black shales.
		2 m	116	Trachyte (171 ± 5 Ma).
		?		Not exposed.
		2.5 m		Black shales.

D.15. Hill south of Cerro Roth (40° 08′ S, 70° 16′ W; text-fig. 5): This locality is situated directly to the south of Cerro Roth, about 500 m from it. GROEBER (1925) there collected his samples 2075 and 2077. The beds dip about 29° E. DAMBORENEA et al. (1975, fig. 3) there measured a section, as follows:

Formation	Age	Thickness	Bed	
Piedra Pintada or Lajas	Pliensbachian	4 m		Tuffaceous conglomerates, with clasts up to 5 cm in diameter. Hard white tuff at the base.
		27 m		Medium to coarse grey sandstone, partly covered.
		12 m		Medium tuffaceous sandstones, with fine-grained tuffs intercalated. Near the top
			106	there is a fossiliferous horizon with *Nuculana* cf. *ovum* (SOWERBY), *Gervillella* n. sp., other bivalves, gastropods and brachiopods.
		5 m		Fine-grained conglomerates, very hard, with isolated clasts up to 5 cm in diameter. Grey tuffs in this beds and, at the base, a 1.5 m bed of medium-grained tuffaceous sandstones.
		5 m		Partly covered.
		1 m		Limestone formed of solitary and colonial corals.
			105	97 m above the base: *Parallelodon riccardii* n. sp., *Parallelodon groeberi* n. sp., *Cucullaea jaworskii* LEANZA, *Cucullaea rothi* LEANZA, *Lycettia hypertrigona* n. sp., *Gervillella* n. sp., *Gervilleioperna turgida* (LEANZA), *Isognomon jupiter* (LEANZA), *Weyla bodenbenderi* (BEHRENDSEN), other bivalves, gastropods and brachiopods. The corals include species of *Thamnasteria, Collignonastraea?*, *Microphyllia?*, *Oppelismilia?*, *Montlivaltia, Thecosmilia* and others.
		12 m		Coarse white tuffaceous sandstones, very hard, with lenses of fine-grained conglomerates, sabulites and siltstones. Irregular cross-bedding.
		9 m		Light grey shales, with plant remains.
		11 m		Not exposed.
		9 m		Grey laminated sandstones. Fossiliferous bed at the top with a varied fauna of bivalves, gastropods and brachiopods.
			101	66 m above the base: *Weyla bodenbenderi* often observed in life position, *Parallelodon groeberi* n. sp., *Lycettia hypertrigona* n. sp., *Modiolus* cf. *thiollierei* (DUMORTIER), *Falcimytilus? gigantoides* (LEANZA), *Bakevellia (Neobakevellia?)* n. sp., *Gervillaria? pallas* (LEANZA), *Isognomon jupiter, Weyla unca* (PHILIPPI).
		1 m	100	At the top (57 m above the base): fine grey sandstone, hard, with *Nuculana* cf. *ovum, Bakevellia (Neobakevellia?)* n. sp., *Parallelodon groeberi* n. sp., *Cucullaea rothi, Lycettia hypertrigona* n. sp., *Falcimytilus? gigantoides, Gervillia (Cultriopsis)* sp., *Gervillella* n. sp., *Isognomon jupiter, Weyla bodenbenderi, Myophorella* sp., other bivalves, corals, brachiopods and gastropods. At the base: dark grey shales with plant remains and fossiliferous calcareous concretions.
		4 m		Grey medium sandstones, thick-bedded.
		11 m		Massive grey sandstones, with several shell-beds:
			99	41 m above the base: *Parallelodon groeberi* n. sp., *Cucullaea jaworskii, Modiolus* cf. *thiollierei, Gervillaria? pallas, Isognomon jupiter, Weyla bodenbenderi, W. unca, Frenguelliella* sp., other bivalves, brachiopods, corals and gastropods.
			97	38 m above the base: *Isognomon jupiter,* other bivalves and *Montlivaltia* sp.
			96	36 m above the base: *Gervilleioperna turgida.*
		3 m		Black calcareous sandstones, very hard and partially silicified.
			94	27–30 m above the base: *Nuculana* cf. *ovum, Parallelodon groeberi* n. sp.,

	Falcimytilus? *gigantoides, Modiolus* cf. *thiollierei, Aguilerella* n. sp., *Isognomon jupiter, Weyla* sp., *Frenguelliella* sp. and other bivalves.
6 m	Yellowish grey sandstones, very hard, medium to fine-grained, with bivalves.
10 m	Not exposed.
6 m	Grey siltstone with calcareous concretions and grey medium sandstones, partially tuffaceous.
5.5 m	Light coloured sandstones and siltstones with plant remains and vertical burrows.

Base of section

D.16. Cerro Roth (text-fig. 5): The locality where ROTH (1902, lám. 2) found the first invertebrate fossils of the region was called Cerro Roth by LEANZA (1942 b, fig. 3). It stands 19 km SW of Piedra del Aguila and 17 km east of Sañicó, to the south of the provincial road No. 50, 10 km west of the point where it branches off the road No. 237 (see maps in GROEBER 1925; A. LEANZA 1942 a; GALLI 1969 b).

At the MLP there are several collections made there by ROTH, GROEBER, FRENGUELLI and LEANZA, but stratigraphical data are lacking. RICCARDI, MANCEÑIDO and DAMBORENEA visited the locality in 1973 and established the equivalence of the fossiliferous beds to those found at locality D.15 (see above).

D.17. Cañadón de Los Chilenos (text-fig. 5): The MLP collection contains samples by A. LEANZA 1942 a, 1942 b) in light-coloured tuffaceous siltstones with the label "Cañadón de Los Chilenos". The exact locality has not been re-located since then.

Systematic Descriptions

Subclass Palaeotaxodonta KOROBKOV 1954

This group of bivalves has traditionally been considered a very primitive one. Nevertheless, it is not the oldest (JELL 1980; MACKINNON 1982; RUNNEGAR & BENTLEY 1983). Palaeotaxodonts are characterized by their primary taxodont hinge (COX 1959), their protobranchiate ctenidia and their deposit feeding habits. Due to this last mentioned characteristic, they preferably inhabit soft substrata, rich in organic content (MC ALESTER & RHOADS 1967; NICOL 1969: 423; 1972: 13). LEVINTON & BAMBACH (1975) compared Silurian and Recent communities and observed an apparent similarity in their distributions, possibly due to physical factors such as the type of sediment. These bivalves are generally very active shallow burrowers (STANLEY 1970: 53, 58, 85). This activity usually produces a superficial layer that shows intense bioturbation and that is unstable and not easily colonized by suspension-feeders. For this reason it is possible to distinguish between deposit feeder communities and suspension feeder communities that are normally mutually exclusive (RHOADS & YOUNG 1970; RHOADS 1973).

So far, the Lower Jurassic of Argentina has only yielded nuculanaceans, i.e. siphonate protobranchs with a posteriorly elongated shell and siphons that are not related to feeding but only to breathing.

Order Nuculoida DALL 1889

Superfamily Nuculanacea H. ADAMS & A. ADAMS 1858

Family Malletiidae H. ADAMS & A. ADAMS 1858

Genus *Palaeoneilo* HALL & WHITFIELD 1873

Type species: *Nuculites constricta* CONRAD 1842: 249, from the Middle Devonian of New York State; subsequent designation by HALL 1885 (MCALESTER 1968).

Synonyms: *Palaeaneilo* [HALL & WHITFIELD], 1869: this is the original spelling, emended later by HALL & WHITFILED (1873) to *Palaeoneilo*. The new name was accepted by ICZN Opinion 215 (see MCALESTER 1968: 41, for more details, as well as references and illustrations of type species listed below).

Synek BARRANDE 1881 (type species: *S. antiquus* BARRANDE 1881)
Filius BARRANDE 1881 (objective synonym of *Synek* BARRANDE)
Goniodon HERRICK 1888 (type species: *G. ohioensis* HERRICK 1888)
Paleoneilo GIRTY 1910 (error pro *Palaeoneilo*)
Anthraconeilo GIRTY 1911 (type species: *A. taffiana* GIRTY 1911)
Olegija CHERNYSHEW 1948 (type species: *O. eugenii* CHERNYSHEV 1948)
Anthraconeilopsis TASCH 1953 (type species: *A. kansana* TASCH 1953).

This genus has a wide geographical and stratigraphical range throughout the Palaeozoic, and is also common in the Triassic of Europe (GOLDFUSS 1833; BITTNER 1895; BROILI 1904; WAAGEN 1907), Bear Island (BÖHM 1903), USSR (BYCHKOV et al. 1976), Mexico (BURCKHARDT & SCALIA 1905), Chile (CECIONI & WESTERMANN 1968), Perú (KÖRNER 1937), New Zealand (TRECHMANN 1918; WILCKENS 1927; MARWICK 1953; FLEMING et al. 1954), China (WEN et al. 1976; ZHANG et al. 1979; Lu 1981), Tonkin (MANSUY 1912) and Japan (ICHIKAWA 1949; 1954a; 1954b; NAKAZAWA 1961).

The presence of *Palaeoneilo* in Jurassic times is not universally acknowledged although it has been found in Switzerland (DE LORIOL 1899), Great Britain (COX 1937a), Sweden (TROEDSSON 1951), USSR (BORISSJAK 1904), Kenya (COX 1965), India (COX 1940) and Japan (HAYAMI 1959a). HALLAM (1976, 1977) includes most of the Jurassic representatives of this genus in *Praesaccella* COX. Similarly DUFF (1978: 27–28) includes some Jurassic species of *Palaeoneilo* in *Mesosaccella* CHAVAN due to the lack of posterior radial sulcus and the presence of a resilifer. Nevertheless, the resilifer is absent in several Mesozoic species (see for instance COX 1937a: 191; TROEDSSON 1951: 148) and these are placed here within *Palaeoneilo* because they are similar to the type species and to other Palaeozoic species. COX (1937a: 193) discussed the relationships between Mesozoic and Palaeozoic species and concluded that there is no reason to separate them, not even at a subgeneric level.

COX (1937a) also distinguished two species-groups within *Palaeoneilo,* with and without a posterior sulcus, each of which has Mesozoic and Palaeozoic members. The type species belongs to the first group, whilst the two species here described correspond to the second one. This difference, according to BURCKHARDT & SCALIA (1905: 11) and COX (1937a: 193), is not enough to segregate them as different genera.

Palaeoneilo patagonidica (A. LEANZA 1942)

Plate 1, fig. 1–3; text-fig. 6

v . 1942a *Nucula patagonidica* n. sp. A. LEANZA, p. 28 (unavailable name)
* ! p v . 1942b *Nucula patagonidica* n. sp. A. LEANZA, p. 151–152; lám. 1, fig. 1, 2, 4 (non fig. 3)
p v . 1975 *Palaeoneilo* – DAMBORENEA et al., cuadro 2, 01.
p v . 1978 *Palaeoneilo patagonidica* (LEANZA) – CAMACHO & RICCARDI, cuadro 1.
? 1980 *Nuculoma patagonídica* (sic) – FRANCHI & PAGE, p. 217.
! v . 1982 *Palaeoneilo patagonidica* (A. LEANZA) – DAMBORENEA, p. 59–62, lám. 35, fig. 1; lám. 52, fig. 1–3.

Type material: Lectotype (here designated): MLP 6251-a, internal mould of a right valve, figured by A. LEANZA (1942b, lám. 1, fig. 1) and here on pl. 1, fig. 1.

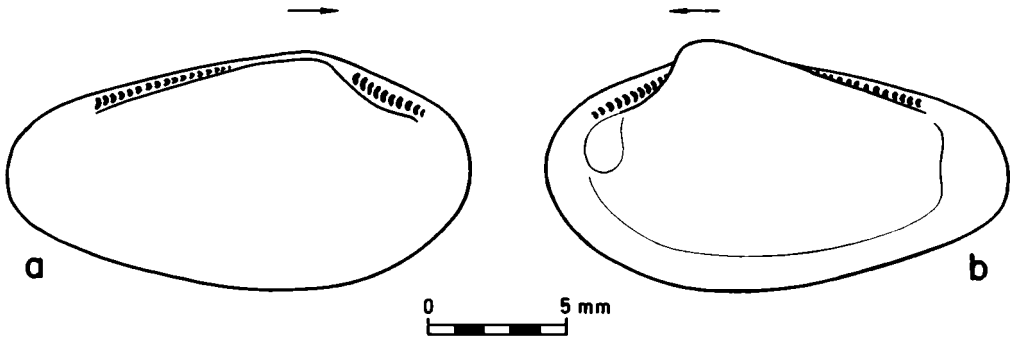
Paralectotypes: MLP 6086, 6087 and 6251-b: five internal moulds and two external moulds of isolated valves, and three incomplete valves. All types come from Subida a Sañicó, Neuquén province (D.7. on text-fig. 5), Pliensbachian, FRENGUELLI's collection.

Other material: MLP 16189 to 16193, 19714 (M 107, 118, 136, 193 and 1031): author's collection, six internal moulds, five external moulds of isolated valves, and one internal mould of both valves, from Subida a Sañicó (D.7), Cerro Roth (D.16), Cañadón La Pintada (D.13), Carrán Curá (D.2) and Arroyo Lapa (C.15), Neuquén province, Pliensbachian. One specimen (MLP 18190) collected by PIATNITZKY in Lower Jurassic sediments at La Carlota, Chubut province.

Doubtfully included in this species: MLP 19675 (M 1336): one internal mould of a left valve from the Late Pliensbachian of Arroyo Serrucho, Mendoza province, author's collection.

Description: Medium-sized, equivalve, inequilateral, elongated-subtrigonal in outline, almost subelliptical, laterally compressed. Dorsal margin gently convex, continuing into a short convex anterior margin without angular deflexion. Ventral and posterior margins gently convex and without any interruption. Length nearly twice the height, the maximum height is situated approximately at mid-length or slightly anteriorly. Prosogyrate umbones not very prominent, placed at about 1/3 of the length from the anterior end of the shell. Taxodont hinge made up of small triangular teeth, parallel to each other in a narrow hinge plate. In the lectotype there are 23 teeth on the posterior part and 11 anteriorly, but the central part of the hinge is not preserved. The first anterior tooth is 1.8 mm from the anterior end, and the last posterior tooth is 3.9 mm from the posterior end. The hinge plate is gently convex throughout and the angle between the two teeth rows is about 136°. The central portion of the hinge is not preserved in any specimen, so the presence or absence of a resilifer and the type of ligament cannot be described.

External surface gently convex, with faint growth lines that become stronger towards the ventral margin. Adductor scars not impressed, the pallial line seems to be posteriorly truncated.



Text-fig. 6. *Palaeoneilo patagonidica* (A. LEANZA), paralectotype, left valve, MLP 6086, Subida a Sañicó, Pliensbachian. a: latex cast; b: internal mould. Arrows point anteriorly.

Measurements:

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Al (mm)
MLP 6251-a, lectotype, pl. 1, fig. 1.	RV IM	22,60	11.70	2.60	1.93	8.10
MLP 6251-b, paralectotype, pl. 1, fig. 2	LV EM	22.40	11.45	2.45	1.96	7.00
MLP 6086, paralectotype, pl. 1, fig. 3	LV IM	15.75	8.10	2.00	1.94	4.85
MLP 6087-a, paralectotype	RV	17.80	9.75	2.10	1.82	5.85
MLP 6087-c, paralectotype	RV	12.20	7.00	1.10	1.74	5.20
MLP 6087-d, paralectotype	RV	13.95	-	2.50	-	4.00
MLP 6087-e, paralectotype	RV	17.60	10.10	1.20	1.74	4.85
MLP 16189	RV IM	9.50	6.70	1.55	1.42	2.45
MLP 16191-b	RV IM	22.15	10.95	2.55	2.02	7.00
MLP 16191-a	RV IM	16.00	8.85	1.70	1.81	5.60
MLP 16192-d	EM	21.85	13.30	-	1.64	7.45
MLP 16192-c	EM	15.80	8.40	-	1.88	5.10

Affinities: *P. patagonidica* has an overall similarity to *P.* cf. *elliptica* (GOLDFUSS) described and figured by CECIONI & WESTERMANN (1968: 70, lám. 3, fig. 2) from the late Triassic of Chile. Chilean specimens are smaller and the comparison is difficult because the figured specimen is distorted (see also FUENZALIDA 1938: 83; and JAWORSKI 1922: 197). *P. elliptica* (GOLDFUSS) figured by ZHANG et al. (1979: 229, pl. 59, fig. 5–6) and LU (1981: 578, pl. 1, fig. 1, 4, 10) from the middle Triassic of China are also similar, but they are more elongated and have the umbones more centrally placed.

The elongate-subtrigonal outline is also found in some Jurassic species from the USSR described by BORISSJAK (1904): *P. amygdala* BOR. is shorter and more regularly oval in shape and *P. choroschowensis* BOR. is larger and strongly inflated. Also very similar are two species, *P. bornholmiensis* (v. SEEBACH) and *P. oviformis* TROEDSSON, described by TROEDSSON (1951) from the Lower Jurassic of Sweden, but in the first one the umbones are anteriorly placed and the second one is less elongated.

P. patagonidica is distinguishable from *P. phillipsi* (MORRIS) and *P. galatea* (D'ORBIGNY) from the European Jurassic because it lacks the posterodorsal angle typical of these species (see TATE 1876, pl. 11; COSSMANN 1916, pl. 8; COX 1937a, pl. 15; TROEDSSON 1951, pl. 16).

Some of the species described by BURCKHARDT & SCALIA (1905) from the late Triassic of Mexico are quite similar to *P. patagonidica* in dimensions. *P. bosei* BURCKHARDT & SCALIA is shorter and more inflated; *P. mexicana* BURCKHARDT & SCALIA has the umbones more anteriorly placed.

Even some Palaeozoic species are similar to *P. patagonidica* in shape, for instance *P. oweni* (MCCHESNEY) figured by MURPHY (1966, pl. 101, fig. 1–8, 10, 12, 17–20) from the Pennsylvanian of the United States, but the muscle scars and hinge are different.

Remarks: The revised species was originally referred to *Nucula* LAMARCK by A. LEANZA (1942b). Although the ligamental characters could not be observed, the generic allocation of this species within *Palaeoneilo* was based upon all other morphological characters, especially the truncated pallial line, the large angle between the two rows

of teeth (see HAYAMI 1959 a: 143) and the posteriorly elongated and laterally compressed shell. HAYAMI (1961: 309) and HALLAM (1977: 71) included this species in the genus *Palaeonucula* QUENSTEDT without additional comments. They were possibly influenced by a mistake in the orientation of the shell on A. LEANZA's (1942 b) figure captions, although his description is correct.

The mention of *"Nuculoma patagonidica"* in FRANCHI & PAGE (1980: 217) is doubtfully included here in the synonymy list. Without access to the specimens it is impossible to determine either if they belong to *P. patagonidica* or if they are true nuculanids as the generic name suggests.

Autecology: This bivalve occurs in great abundance in beds otherwise characterized by the almost total absence of suspension feeders and of any other benthonic fauna. The efficiency of palaeotaxodonts in altering the texture of the superficial layer of sediment and the consequences of this were analyzed by RHOADS (1963), RHOADS & YOUNG (1970) and others. Extant nuculanids live in cold waters (NICOL 1969) down to abyssal depths, but some species, especially large-sized ones, live also in shallow waters (YONGE & THOMPSON 1976). The life habits of *P. patagonidica* can be compared to those of extant *Yoldia* species, such as *Y. limatula* (SAY) that lives on shallow muddy substrates. STANLEY (1970: 117–118) showed that they live completely buried near the surface of the substrate, with the tips of the siphons slightly projecting above the surface, and not as was depicted by other authors (see for instance YONGE & THOMPSON 1976, fig. 86).

Palaeoneilo galatea (D'ORBIGNY 1850)?

Plate 1, fig. 4; text-fig. 7

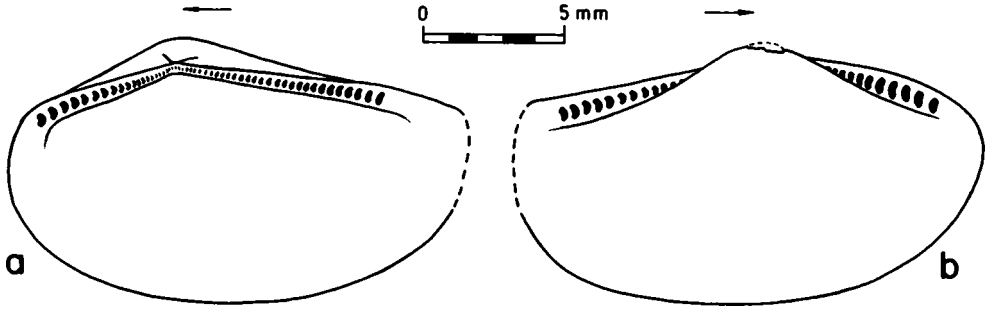
	?	1850	*Leda Galatea* D'ORBIGNY, p. 234, no. 152.
	?	1869	*Leda Galatea* – DUMORTIER, p. 120; pl. 19, fig. 5–6.
p	?	1876	*Leda galathea* (sic) D'ORBIGNY – TATE, p. 383 (non pl. 11, fig. 5).
	?	1916	*Leda (Nuculopsis?) Galatea* D'ORBIGNY – COSSMANN, p. 147; pl. 8, fig. 1–2.
	?	1936 b	*Nuculana (Rollieria ?) galatea* (D'ORBIGNY, DUMORTIER) – COX, p. 465; pl. 34, fig. 11–12.
	?	1937 a	*Palaeoneilo galatea* (DUMORTIER ex D'ORBIGNY) – COX, p. 191–192, pl. 15, fig. 4–7.
	?	1951	*Palaeoneilo galatea* (D'ORBIGNY) – TROEDSSON, p. 149–150; pl. 16, fig. 1, 2, 6 (9–11 ?).
p	v.	1975	*Palaeoneilo* – DAMBORENEA et al., Cuadro 1, 01.
	v.	1982	*Palaeoneilo galatea* (D'ORBIGNY) ? – DAMBORENEA, p. 63–64; lám. 35, fig. 2; lám. 52, fig. 4.

Material: MLP 16194 (M 136), a complete internal mould of a right valve, author's collection, from the Pliensbachian at Subida a Sañicó, southern Neuquén province (locality D.7).

Description: Medium-sized, inequilateral, ovoid in outline. Anterior portion of dorsal margin gently convex, posterior portion straight, forming a right angle at the posterior end. Anterior margin convex, posterior margin appears to be truncated. Ventral margin gently convex and almost parallel to the dorsal one. Length almost equal to double height. Maximum height is somewhat posterior to mid-length. Prominent prosogyrate umbones located at 1/3 of the total length from the anterior end of the shell.

The taxodont hinge is made up of parallel teeth on a fairly wide hinge plate. Teeth are smaller towards the umbones. There is no resilifer. The anterior set of teeth slightly overlaps the posterior set below the umbones (see text-fig. 7 a). The two rows of teeth meet at an angle of 156°. Muscle scars and pallial line not observed. External characters unknown.

Measurements: L = 15.70 mm; H = 8.40 mm; W = 2.15 mm; Al = 5.55 mm; L/H = 1.87.



Text-fig. 7. *Palaeoneilo galatea* (D'ORBIGNY) ?, right valve, MLP 16194, Subida a Sañicó, Pliensbachian. a: latex cast; b: internal mould.

Affinities: *P. galatea* (D'ORBIGNY) is a Pliensbachian European species that was figured by DUMORTIER (1869, pl. 19, fig. 56), COSSMANN (1916, pl. 8, fig. 1–2), COX (1936 b, pl. 34, fig. 11–12; 1937 a, pl. 15, fig. 4–7).

The European specimens differ in their less acute postero-dorsal angle and in having a continuous series of teeth below the umbones. The shell outline of the Piedra Pintada specimen is well within the species' range of variation.

This specimen may be distinguished from *P. patagonidica* (LEANZA) by its more globose shell, more rectangular outline, wider hinge plate and straight posterior portion of the dorsal margin.

? Genus *Malletia* DES MOULINS 1832

Type species: *Malletia chilensis* DES MOULINS 1832: 85, by monotypy, Recent from Chile.
Synonyms: See MCALESTER in COX et al. (1969).

Malletia ? sp. indet.

Plate 1, fig. 5; text-fig. 8

p v. 1942 b *Nucula patagonidica* n. sp. A. LEANZA; lám. 1, fig. 3 (non fig. 1, 2, 4).
v. 1982 *Malletia* ? sp. indet. – DAMBORENEA, p. 64–66; lám. 35, fig. 3; lám. 52, fig. 5.

Material: A. LEANZA's figured specimen (1942 b, lám. 1, fig. 3) is a composite mould of a right valve (MLP 14273) collected by him at Subida a Sañicó, southern Neuquén province (locality D.7), from Pliensbachian beds.

Description: Small to medium-sized, inequilateral, subovate in outline, laterally compressed. Dorsal margin gently convex, forming an obtuse angle with the posterior margin. Dorsal portion of posterior margin straight, then arched towards the evenly convex ventral margin. Anterior margin short, forming an acute angle with the dorsal margin. Prosogyrate umbones located in the anterior third of the shell. The length is about 1.5 the height and the maximum height is situated near the posterior end of the shell.

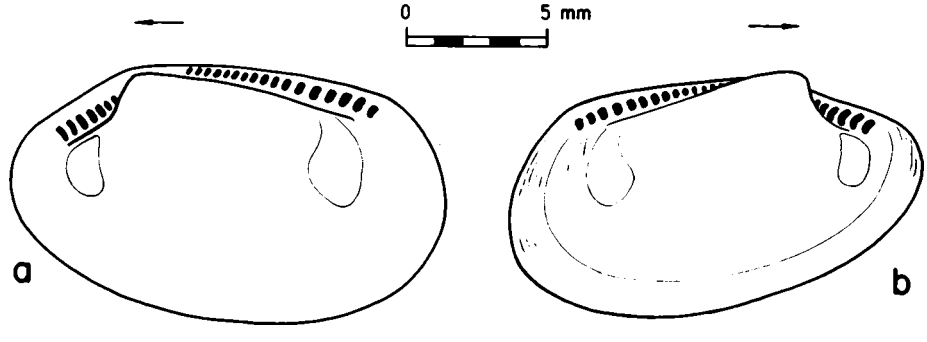
Hinge made up of two sets of taxodont teeth meeting at an angle of 133° on a wide hinge-plate. There are 16 posterior and 7 anterior teeth, the umbonal portion of the hinge is not preserved. The first anterior tooth is at 1,8 mm from the anterior end of the hinge plate and the last posterior tooth is at 1.6 mm from the posterior end (see text-fig. 8).

The posterior muscle scar is slightly larger than the anterior one. The characters of the pallial line have not been observed.

External surface with regularly spaced and prominent growth lines that are equally impressed over the whole surface. These external characters were observed on the composite mould, as no external mould was available.

Measurements: L = 14.80 mm; H = 9.50 mm; W = 2.20 mm; Al = 3.90 mm; L/H 1.56.

Affinities: This species can be distinguished from *P. patagonidica* (LEANZA) by its oval rather than subtriangular outline, by being shorter, by the number and appearance of its teeth and the hinge plate and by its more regular and impressed growth lines. The posterior end is narrow in *P. patagonidica* and very wide in *Malletia* ? sp. indet.



Text-fig. 8. *Malletia* ? sp. indet., right valve, MLP 14273, Subida a Sañicó, Pliensbachian. a: latex cast; b: composite mould.

P. galatea (D'ORBIGNY) ?, found in the same beds as *Malletia* ? sp. differs in the position of the umbones and in its general outline and inflation.

Some affinities to *Palaeoneilo rectangularis* BURCKHARDT & SCALIA (1905) from the late Triassic of Mexico are also apparent, but *Malletia* ? sp. has a larger length / height ratio and a different hinge and outer surface.

The wide and flat posterior end and the low inflation of the shell are similar to those of Mesozoic and Cenozoic species of *Malletia,* but the generic position of this species will remain doubtful until more and better preserved material is found.

Remarks: This specimen was considered by A. LEANZA (1942b) as part of his original set of *Nucula patagonidica.* As shown above, it does not belong to that species.

Autecology: Extant species of *Malletia* that inhabit the Norwegian fjords, live buried with their anterior-posterior axis parallel to the substrate surface, bending their siphons upwards (YONGE & THOMPSON 1976). They are also very active burrowers and have a cosmopolitan range (BERNARD 1979: 12).

Malletiidae gen. et sp. indet.

Plate 1, fig. 6

v. 1982 Malletiidae gen. et sp. indet. – DAMBORENEA, p. 66–67; lám. 52, fig. 6.

Material: MLP 16195 (M 136), one incomplete internal mould of a left valve from the Pliensbachian of Subida a Sañicó, southern Neuquén province (locality D.7), author's collection.

Description: Medium to large-sized shell, inequilateral, outline subelliptical, very inflated in anterior view. Anterior portion of dorsal margin slightly convex merging into the convex anterior margin without any interruption. Ventral margin evenly convex and posterior margin unknown. A very low umbonal ridge extends from the umbones to the postero-ventral end. Umbones located somewhat anteriorly of the mid-length but broken in the only available specimen.

Only the anterior set of taxodont teeth is preserved. They are 12 in number, short, parallel to each other but oblique to the dorsal margin. The first teeth of the posterior row seem to overlap the last ones of the anterior row just below the umbones. The angle between both sets of teeth cannot be measured directly, but from the general outline of the shell it seems to approach 180°.

Ligamental characters unknown. The anterior adductor muscle scar is located at about the anterior third of the anterior row of teeth. It is a subcircular, well-marked impression. The posterior adductor muscle scar is less impressed but larger than the anterior one. External characters unknown.

Measurements: L = 31.00 mm; H = 17.20 mm; W = 5.15 mm; L/H = 1.80.

Remarks: This specimen, found at the same locality as all the other malletids here described, is regarded as a different species due to its larger size, different hinge and the presence of an umbonal ridge.

Family Nuculanidae H. ADAMS & A. ADAMS 1858

Genus *Nuculana* LINK 1807

Type species: *Arca rostrata* CHEMNITZ, 1784 (= *Arca pernula* MÜLLER 1771). Recent from northern Europe and America, by original designation. SPEDEN (1970) assigns the authorship of *Arca rostrata* to GMELIN 1791, because he considers that CHEMNITZ' name is not valid.

Synonyms: See PURI in COX et al. 1969.

Nuculana is a cosmopolitan genus, very common in Mesozoic and Cenozoic deposits, that has some extant species. It includes posteriorly rostrate forms, with internal and sometimes also external, ligaments.

A group of Mesozoic species, named *Phaenodesmia* by BITTNER (1895) and characterized by an uninterrupted series of taxodont teeth without a chondrophore, is indistinguishable from *Nuculana* on external characters alone (see for instance BITTNER 1895; BORISSJAK 1904). As the hinge of many species is poorly known, it is possible that many Mesozoic species, traditionally referred to *Nuculana,* belong to *Phaenodesmia* instead.

Nuculana cf. *ovum* (J. DE C. SOWERBY 1824)

Plate 1, fig. 7–9; text-fig. 9

cf. 1824 *Leda ovum* SOWERBY, p. 176; pl. 376, fig. 1.
cf. 1876 *Leda ovum,* SOWERBY – TATE, p. 384.
? 1891 *Leda acuminata* QUENST. (non ZIETEN) – BEHRENDSEN, p. 372, 388.
? 1892 *Leda acuminata* v. BUCH – BEHRENDSEN, p. 32.
cf. 1909 *Nuculana ovum* SOW. – COUNILLON, p. 531; pl. 11, fig. 9.
? 1922 *Leda acuminata* QUENST. (non ZIETEN) – BEHRENDSEN, p. 161–173, 224.
? 1925 *Leda acuminata* BUCH – GERTH, p. 18.
cf. 1948 *Nuculana ovum* (J. de C. SOWERBY) – WILSON, fig. 7–B.
cf. 1962 *Nuculana ovum* (J. de C. SOWERBY) – CASTELL, pl. 12, fig. 4.
v . 1975 *Nuculana* – DAMBORENEA et al., Cuadro 1, 02.
?v 1978 a *Nuculana* sp. – DAMBORENEA in VOLKHEIMER et al., Tab. 2.
v . 1982 *Nuculana* cf. *ovum* (J. de C. SOWERBY) – DAMBORENEA, p. 68–72; lám. 35, fig. 4–7; lám. 52, fig. 7–9.

Material: MLP 16196 to 16202 (M 94, 104, 109 and 142): six right valves, three left valves and some internal and external moulds, author's collection from the Pliensbachian of Salitral Grande (D.3), hills south of Cerro Roth (D.15) and Cerro Roth (D.16), southern Neuquén province. MLP 16203: one specimen collected by GULISANO from the lower Toarcian deposits at Arroyo Ñiraico (C.4), northern Neuquén.

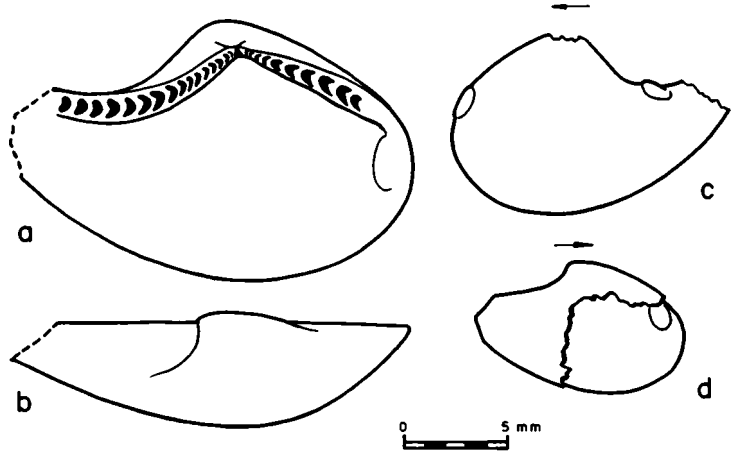
Some doubtful specimens, MLP 16249 (M 429) were collected by the author from upper Pliensbachian deposits at Arroyo La Laguna, southern San Juan province (locality A.2).

Description: Medium-sized shells, equivalve, inequilateral, nuculaniform, well-inflated, length greater than height, and posteriorly elongated into a short rostrum. Umbones opistogyrate, prominent, located approximately at mid-length. Anterior portion of dorsal margin, anterior and ventral margins evenly convex. Posterior dorsal margin slightly concave. Posterior margin short and straight. The posterior end of the rostrum is located at about mid-height. The posterodorsal area of the shell surface is concave and a low umbonal ridge extends from the umbones to the end of the rostrum.

The anterior adductor muscle scar in medium-sized and is only slightly impressed in the antero-dorsal portion of the shell. The posterior adductor muscle scar is equal in size but it is deeply impressed on the shell's inner surface. Pallial line not observed.

The hinge is made up of two sets of parallel triangular teeth with a narrow oblique resilifer between them. The anterior row is a straight line of about 9 teeth, whilst the posterior row is a dorsally concave line of about 15 teeth. The teeth are oblique to the hinge line.

The shell surface is smooth with very low commarginal regular growth lines.



Text-fig. 9. *Nuculana* cf. *ovum* (J. de C. SOWERBY). a: latex cast of an internal mould of a left valve, MLP 16203, Arroyo Ñiraico, lower Toarcian (?); b: dorsal view of a right valve, MLP 16196, hill south of Cerro Roth, Pliensbachian. c: internal mould of a left valve, MLP 16201-a, Cerro Roth, Pliensbachian; d: right valve, MLP 16198, hill south of Cerro Roth, Pliensbachian.

Measurements:

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Al (mm)
MLP 16196, pl. 1, fig. 7	RV S	19.10	13.30	5.70	1.44	9.25
MLP 16197, pl. 1, fig. 8	RV S	11.60	7.65	3.00	1.52	5.90

MLP 16198, text-fig. 9-d	RV S	10.30	6.60	2.25	1.56	4.60
MLP 16199-c	RV S	-	7.20	3.30	-	5.35
MLP 16199-d	LV S	12.90	8.95	3.60	1.44	6.10
MLP 16199-e	LV S	14.65	9.60	3.85	1.53	6.35
MLP 16201-a, text-fig. 9-c	LV IM	13.30	9.40	4.10	1.41	5.25
MLP 16201-b	LV IM	11.00	-	2.15	-	4.55
MLP 16202	RV S	10.10	6.60	3.35	1.53	4.90
MLP 16203, pl. 1, fig. 9	LV IM	11.40	-	-	-	5.20

Affinities: This species shows its greatest affinities to *Nuculana ovum* (J. DE C. SOWERBY) from the European Toarcian and the earliest Jurassic of Indochina (see figures in DAVIDSON 1876, pl. 10, fig. 3, COUNILLON 1909: 531, pl. 11, fig. 9; WILSON 1948, fig. 7B; CASTELL 1962, pl. 12, fig. 4).

The species here described belongs to a group of nuculanid species generally referred either to *Nuculana* (s.l.) or to *N. (Praesaccella),* recognizable on external similarities. Such are, for instance, *N. (Dacryomya) thompsoni* COX (1965: 26, pl. 1) from the Toarcian of northeast Kenya, and *N. (Praesaccella) juriana* COX (1940: 33–34; WEN 1982: 230, pl. 1, fig. 21) from the Indian and Chinese Jurassic, from which *N.* cf. *ovum* differs in having a larger overall size and a less prominent external ornamentation. Also *N. zieteni* (BRAUNS, 1871, non *Leda Zietenii* D'ORBIGNY 1837 = *Palaeoneilo galatea* D'ORBIGNY) as was figured by GOLDFUSS (1837, Taf. 125, fig. 7) and TROEDSSON (1951, pl. 16) from the lower Jurassic of Germany and Sweden, has stronger and more regular growth lines. *N. vendaensis* (COSSMANN 1904: 518, pl. 17, fig. 8–10) from the French Lower Jurassic is smaller, has fewer teeth and an elongated anterior region.

Some species of the USSR Jurassic also belong to this group: "*Leda*" *subjacutica* POLUBOTKO (1968: 31, tabl. 59, fig. 3–5) from the Aalenian-Toarcian has a more triangular outline than that of the species here described. "*L.*" cf. *argoviensis* MOESCH (BORISSJAK 1904, pl. 3, fig. 7) from the Oxfordian, has a shallow sulcus anterior and parallel to the umbonal ridge.

N. cf. *ovum* can be distinguished from *Nuculana scarburgensis* COX & ARKELL, figured as "*Leda anglica* D'ORB." by LYCETT (1863, pl. 39, fig. 7), from the middle Jurassic of Great Britain, by a more elongated and less subtriangular outline. *N.* cf. *ovum* is very similar also to *N. willetti* MARWICK (1953: 88) from the Oxfordian of New Zealand, which has a shorter and wider rostrum. "*Leda*" *australis* MOORE (1870) from the Australian late Jurassic has a similar outline but the figured specimens are incomplete.

N. (*Dacryomya*) *silicea* COX (1949: 17–18, pl. 1, fig. 2; also in KÖRNER 1937, pl. 12, fig.1 as *Leda* (?) aff. *sulcellata* MÜNSTER) from the Peruvian late Triassic, and *N.* (*D.*) *toriyamai* HAYAMI (1959b: 41; pl. 5, fig. 2–3) from the Japanese Sinemurian, have a more acute rostrum. "*Leda*" *aequilatera* KOCH & DUNKER as figured by TATE (1876, pl. 11, fig. 10) lacks an umbonal ridge and the rostrum is shorter and wider.

The taxon described by BEHRENDSEN (1891: 388 = 1922: 173) as "*Leda acuminata* QUENST. (non ZIETEN)" from the Lower Jurassic of the upper Rio Salado, Mendoza province, is probably conspecific with the species described here, but this cannot be confirmed because no specimen from the same locality was available, and BEHRENDSEN's description is very short and uninformative.

JAWORSKI (1925a: 175–176; 1926: 396) also described a nuculanid under the name "*Leda* (*Dacryomya*) *acuta* MER." from the Aalenian-Bajocian of Cañada Colorada and Bardas Blancas (Mendoza province), and so did WEAVER (1931: 184–185) from the Middle Jurassic of Cerro Lotena (Neuquén province). The specimens may be distinguished from the species here described by their elongated shape (according to the measurements provided by those authors) and by the presence of a strong ridge and posterior sulcus. No material from those localities was available for comparison.

N. cf. *ovum* (J. DE C. SOWERBY) is quite different from the specimens figured by GOTTSCHE (1878 = 1925) as "*Leda*" *striatissima* from the Middle Jurassic of Paso del Espinacito, San Juan province.

Remarks: The affinities of this species to those grouped in the subgenus *Praesaccella* COX (see COX 1940: 32–33) lie in general external appearance and the few hinge teeth. Lack of well-preserved pallial line prevents the inclusion of *N.* cf. *ovum* in *Praesaccella.* The lack of sharp postero-dorsal ridges precludes its reference to *Dacryomya* AGASSIZ. The statement made by BRADSHAW & BRADSHAW (1971) that taxodonts with internal ligament have nearly equal anterior and posterior series of teeth is confirmed on this species.

Autecology: The extant species of this genus are more abundant in Boreal and cold-temperate regions and, although they have a wide water-depth range, they are more common in medium-depth waters (BERNARD 1979: 13) below the surf-line (MERKLIN 1949: 241). *N. minuta* (MÜLLER), for instance, lives in sandy or muddy gravel bottoms between 10 and 180 m deep, being locally abundant at some places (TEBBLE 1966). MERKLIN (1949) provided further examples, concluding that the shallow burrower *Nuculana* prefers sheltered waters of normal salinity and soft bottoms rich in organic content.

The Argentine material consists of rare findings in rich and diverse faunas. In the Chilean Lower Pliensbachian, on the other hand, HILLEBRANDT & SCHMIDT-EFFING (1981: 23) mention green marls with abundant *Nuculana* sp. with both valves preserved together.

Subclass Pteriomorphia BEURLEN 1944

Order Arcoida STOLICZKA 1871

Superfamily Arcacea LAMARCK 1809

Several arcacean species have been already described or mentioned in the Argentinian Lower Jurassic, and most of them are dealt with here. Some of these taxa were originally erroneously assigned to late Jurassic or even to Cretaceous species, such as JAWORSKI's (1915) mention of *Arca nobilis* CONTEJ. and *Cucullaea gabrielis* LEYM. from Piedra Pintada.

This group of bivalves has a special significance in the South American Lower Jurassic. Several of these species have intermediate (or even apparently inconsistent) characters if traditional criteria for the delimitation of genera in post-Liassic deposits are considered alone. Some of the species here described have transitional characters between those of different arcacean groups. This is consistent with the fact that several of these groups, such as the Arcidae and Cucullaeidae, began their differentiation in early Jurassic times (COX 1959; THOMAS 1978a, 1978b).

Most extant epibyssate arcaceans live in periodically unstable litoral environments. Infaunal taxa, instead, cannot survive in permanently unstable substrates because, as a consequence of their ligamental weakness, they are slow and unefficient burrowers (THOMAS 1978a, 1978b). Arcaceans are very rare in deep seas (OLIVER & ALLEN 1980).

Family Parallelodontidae DALL 1898

Subfamily Parallelodontinae DALL 1898

Genus *Parallelodon* MEEK & WORTHEN 1866

Type species: *Macrodon rugosus* BUCKMAN 1845 (p. 99) from the Middle Jurassic of Great Britain.

Synonyms: *Macrodon* (LYCETT MS) BUCKMAN 1845 (objective synonym) (non SCHINZ 1822, Pisces; nec MÜLLER 1842, Pisces).
? *Glyptarca* HICKS 1873 (type species: *G. primaeva* HICKS 1873).
Prorhynchus HALL 1885 (type species: *Palaeanatina quadratum* HALL 1883) (non SCHULTZE 1851, Vermes).
Macrodus BEUSHAUSEN 1895 (objective synonym) (non GRAY 1864, Carnivora).
Beushausenia COSSMANN 1897 (objective synonym) (non MAILLEUX 1913, Bivalvia; nec sensu ARKELL 1930, Bivalvia).
Gilbertwhitea CRICKMAY 1930 (type species: *Arca* (*Nemodon*) *simillima* WHITEAVES 1900).
? *Palaeocucullaea* TOKUYAMA 1960 (type species *Parallelodon monobensis* NAKAYAMA 1956).

MEEK & WORTHEN proposed the generic name *Parallelodon* to replace *Macrodon* BUCKMAN, since that was preoccupied by two fish genera. From that moment several authors wrote about the validity and scope of this generic name. Several nomenclatural problems (see synonym list above) and other matters, such as the almost complete independence of the work on Mesozoic and Palaeozoic faunas, complicated the picture. ARKELL (1930a), BRANSON (1942) and DRISCOLL (1961) gave a detailed discussion of the question.

WOODS (1899) and GILLET (1924) considered that the hinge characters of *Parallelodon* MEEK & WORTHEN 1866 and those of *Grammatodon* MEEK & HAYDEN 1860 are sufficiently similar to each other to consider both names as synonyms. ARKELL (1930a) included all Palaeozoic and Mesozoic taxa into one genus, which he preferred to call *Parallelodon* (by priority of concept) and which he subdivided into three subgenera: *P* (*P.*), *P.* (*Grammatodon*) and *P.* (*Beushausenia*). He did not realize that *Beushausenia* is an objective synonym of *Parallelodon*, as both names were originally proposed as replacement names for *Macrodon*. On the other hand COX (1940: 41) considered that there are enough arguments to consider *Grammatodon* and *Parallelodon* as separate genera. BRANSON (1942) recognized three subgenera: *Grammatodon (G.)*, *G.* (*Parallelodon*) and *G.* (*Cosmetodon*).

As a thorough revision of the Parallelodontidae is beyond the scope of this work, the approach of most contemporaneous authors (Cox 1937b; Kobayashi & Ichikawa 1950b; Dickins 1963; Newell in Cox et al. 1969; etc), that consider *Parallelodon* and *Grammatodon* as different genera is followed here (see also Manceñido et al. 1976: 70–74).

Parallelodon has not been mentioned as such for the South American Jurassic. Nevertheless, several early Jurassic species from Argentina belong to it. On the other hand Jaworski's record of "*Arca nobilis* Contej." from Piedra Pintada corresponds, as shown below, to a *Parallelodon* species. Other species referred to "*Arca*" seem to belong to *Grammatodon* (see below).

The first species described here shows peculiar hinge characters that differentiates it from most other species of this genus, and that could justify its separation into a distinct subgeneric taxon, for which the name *Gilbertwhitea* Crickmay, typified by *Arca* (*Nemodon*) *simillima* Whiteaves (s. s.) as recently revised by Poulton (1981: 67–69), would be available. The other two species here included have the typical generic hinge characters.

Parallelodon groeberi n. sp.

Plate 2, fig. 1–8; text-fig. 10, 11, 13 c

? 1864 An undetermined bivalve – Meek, pl. 7, fig. 3.
. 1915 *Arca nobilis* Contejean – Jaworski, p. 420.
. 1925b *Arca nobilis* Contejean – Jaworski, p. 70.
v. 1925 *Arca nobilis* Contejean – Groeber, p. 460, 462.
v. 1953 *Arca nobilis* Contejean – Groeber et al., p. 154, 155.
v. 1975 *Parallelodon* – Damborenea et al., Cuadro 1, 03.
! v. 1982 *Parallelodon groeberi* n. sp. Damborenea, p. 75–80; lám. 36, fig. 2, 3, 6; lám. 53, fig. 1–9 (unavailable name).

Derivation of name: After the late Dr. Pablo Groeber, who collected part of the material here described, and who made fundamental contributions to the knowledge of the Andean Jurassic.

Material: Holotype: MLP 16210 (M 100), figured in pl. 2, fig. 1 a–b, an almost complete specimen with the valves slightly displaced relative to one another, from the Pliensbachian of the hills south of Cerro Roth, southern Neuquén Province (locality D.15 on text-fig. 5), author's collection.

Paratypes: MLP 8868 and 8874, four right valves and two left valves, collected by Roth and Groeber at Cerro Roth, Neuquén (D.16) in Pliensbachian sediments. Also 54 right valves and 66 left valves, most of them complete, 11 of them with both valves together: MLP 16204 to 16248, 16250, 16254, 16676 and 19719 (M 94, 99, 100, 101, 103, 104, 105, 108, 121, 122, 125, 144, 145, 1038, 1040, 1041, 1050 and 1383) collected by the author from Pliensbachian beds at the hills south of Cerro Roth (D.15), Cerro Roth (D.16), Cerro Del Vasco (D.12), Salitral Grande (D.3) and 8 km south of Estancia Santa Isabel (D.1), all of them southern Neuquén province.

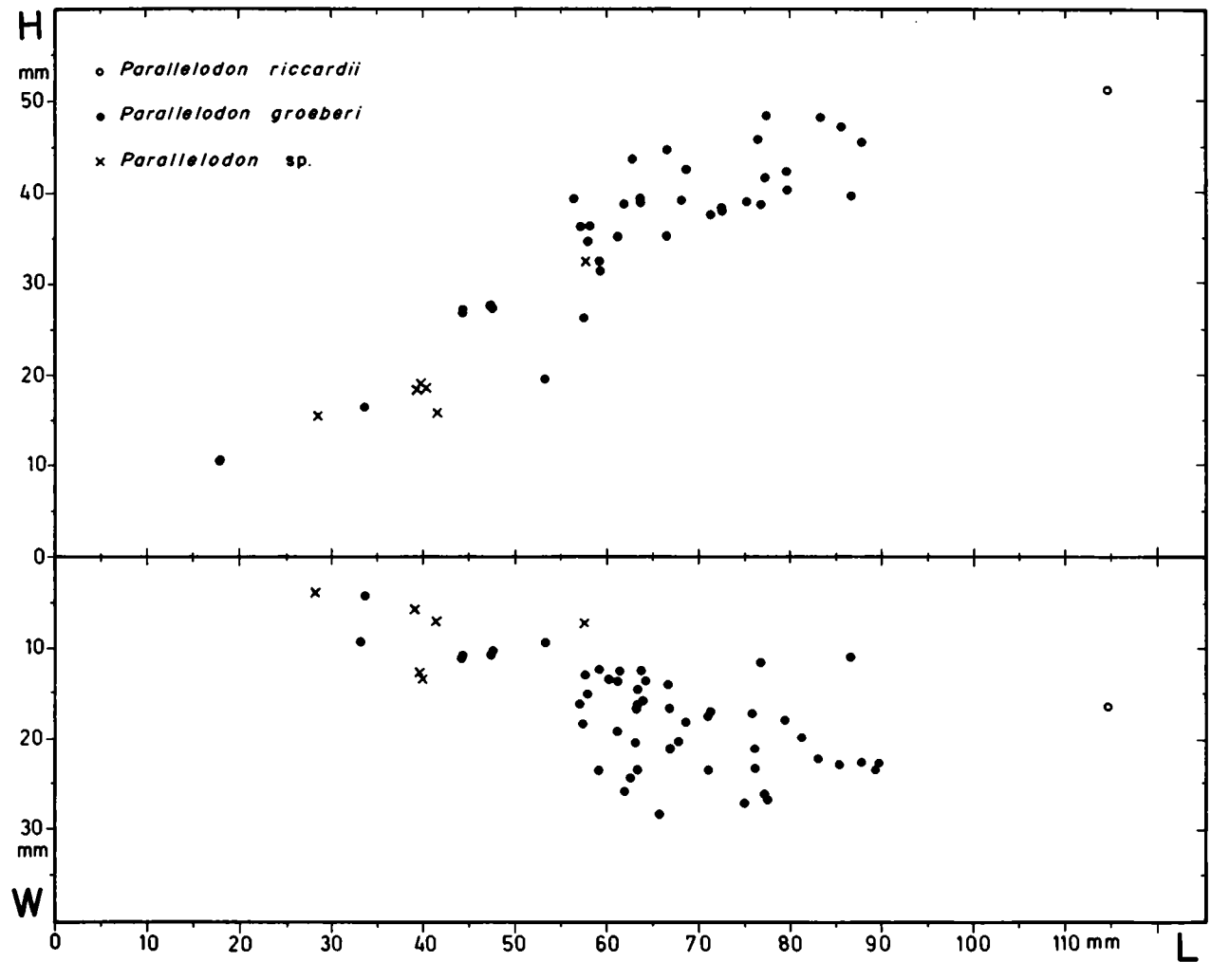
Doubtfully included in this species: one external mould of a right valve from Arroyo Serrucho, Mendoza province (locality B.8), late Pliensbachian, author's collection (MLP 19641, M 1314).

Diagnosis: Large *Parallelodon,* inflated and sub-rectangular in outline. Umbonal ridge low. With byssal sinus and ventral byssal gape. Ligamental area wide and triangular in shape, umbones distant to each other. Hinge platform very narrow, crenulated teeth that converge to a point above and in front of the umbones. Anterior and posterior teeth long, central teeth very short. Anterior muscle scar on a myophoric platform. Outer surface with irregular growth striae and very faint radial riblets.

Description: Shell equivalve, very inequilateral, inflated, large, and sub-rectangular, elongated in outline. The shell shape reminds that one of species of *Arca* s. s. Shell of medium thickness. Hinge-line straight and corresponding to the maximum shell length. The anterior margin meets the dorsal margin at an angle of about 90°. It is dorsally straight but then it bends to join the ventral margin. The ventral margin is parallel to the hinge-line anteriorly and oblique to it in its posterior half. It merges into the posterior margin without any interruption. The anterior margin is sinuous and meets the dorsal margin at a variable angle close to 90°.

The shell surface has a shallow and wide oblique sulcus from the umbones to the middle of the ventral margin. At the margin, the end of the sulcus corresponds to the byssal gape, which is elongated and deeper on the left valve. The sulcus is parallel to a low umbonal ridge that ends at the postero-ventral corner of the shell.

The umbones are wide, low and prosogyrous. They are located at about 1/5 of the total length from the anterior end of the shell.



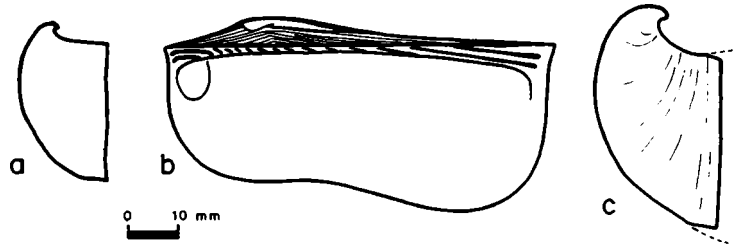
Text-fig. 10. Scatter diagrams showing the length / height (L / H) ratio and length / width (L / W) ratio of *Parallelodon groeberi* n. sp., *Parallelodon riccardii* n. sp, and *Parallelodon* sp.

The ligamental area is triangular, flat and wide, and it has numerous chevron-shaped ligamental grooves radiating from beneath the umbones. The growth of the ligamental area is allometric relative to shell size and in large specimens the umbones are placed very far apart as a result of the width of the ligamental area. A small ridge bounds the anterior and posterior margins of the ligamental area. The V-shaped grooves are replaced by straight grooves parallel to the hinge-line in fully grown specimens, where the width of the ligamental area is larger than 12–15 mm. This generally coincides with a sudden increment in the slope of the ligamental surface and with an abrupt increase in shell thickness instead of following the normal logaritmic growth (see text-fig. 11 c). The shell keeps the same perimeter instead of increasing it as a result of the combined effect of these characters.

The hinge-plate is very narrow along almost all its length and only widens near the anterior and posterior ends. The teeth converge to a point above the umbones and in front of the anterior end of the shell. The hinge has two anterior teeth on each valve, which are straight and parallel to the dorsal margin and bend downwards at both ends, especially posteriorly. There are a variable number of very short oblique medium teeth and two or three long oblique posterior teeth that reach the dorsal margin of the hinge-plate at their anterior ends. All the teeth have crenulated sides.

The anterior adductor muscle scar is oval in outline and is located on a low platform at the antero-dorsal corner of the shell. The posterior adductor muscle scar is hardly noticeable at the postero-dorsal corner. The pallial line is entire and the inner margin of the shell is smooth.

The outer surface has irregularly spaced growth lines that become more prominent near the ventral margin. Some specimens show faint radial riblets, that cover the whole surface in young specimens but are only seen on the posterior portion of the shell of large specimens.



Text-fig. 11. *Parallelodon groeberi* n. sp. a–b: schematic drawings based on several adult specimens. a: anterior view of right valve; b: interior view of a right valve; c: posterior view of a very large left valve (MLP 16234-a), showing the abrupt change in the normal growth logaritmic curve to maintain the same shell outline despite the size increase.

Measurements: The following table contains the measurements of the holotype and some of the figured paratypes. Brackets indicate that the shell is not complete. See also scatter diagram in text-fig. 10.

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Al (mm)	Hu (mm)	Ud (mm)	Wh (mm)
MLP 16210, pl. 2, fig. 1	LV	(63.40)	39.60	14.90	(1.60)	13.05	28.50	4,60	-
MLP 8874-a, pl. 2, fig. 7	LV	79.65	40.15	18.15	1.98	16.45	31.45	7.70	-
MLP 16224, pl. 2, fig. 8	RV	(76.55)	(45.90)	23.55	(1.67)	18.55	41.75	6.10	1.25
MLP 16226, pl. 2, fig. 6	LV	(62.90)	(43.60)	24.80	(1.44)	14.70	39.30	9.15	2.60
MLP 16227, pl. 2, fig. 5	LV	(57.30)	(36.25)	16.40	(1.58)	12.90	28.65	(7.30)	1.05

Affinities: The very narrow hinge-plate and the wide ligamental platform distinguish *P. groeberi* from most Mesozoic species. SKWARKO (1974: 13) described some specimens from the Bajocian Newmarracarra Limestone as "Parallelodontidae spp." which have a striking similarity to the species here considered. The Australian material and *P. groeberi* could certainly be considered as belonging to the same species-group. The narrow hinge-plate also causes the central teeth to be numerous and almost vertical (see THOMAS 1978a: 187). The hinge differences observed in the three *Parallelodon* species here considered are mostly due to the dissimilar widths of their hinge-plates (see text-fig. 13).

These hinge characters are also present in the type species of *Gilbertwhitea* CRICKMAY, *Parallelodon simillima* (WHITEAVES), which was originally thought to come from Cretaceous sediments (WHITEAVES 1884: 234, pl. 31, fig. 5, as *Nemodon fischeri* D'ORB.; REINHART 1937: 173–174, pl. 27, fig. 7a, b), but later proved to be of Mid Jurassic age (see POULTON 1981: 67, pl. 9.1, fig. 20–23). This Canadian species has a parallelodontid hinge with a narrow hinge-plate and obsolescent central teeth, inflated shells, and a deep byssal sulcus, which resemble *P. groeberi,* but differs from the Argentine species in its smaller size and trapezoidal outline. The hinge was incorrectly illustrated by CRICKMAY (1930, pl. 3, fig. d), and this led to different opinions about the status of his new name *Gilbertwhitea,* until recently POULTON (1981) re-illustrated WHITEAVES' material showing the parallelodontid teeth.

Also *P. dejanira* (D'ORBIGNY), from the Bajocian of France and Israel, has a narrow hinge-plate, but the specimens are smaller, have an excavated posterior margin and an acute antero-dorsal angle (PARNES 1981: 27–28, pl. 4, fig. 2–4). From *Parallelodon* sp. here described, this species can be distinguished by its larger size, its narrower hinge-plate and its smaller postero-dorsal angle.

Remarks: JAWORSKI (1915) described several specimens from Piedra Pintada as "*Arca nobilis* CONTEJEAN". As this species was known from the French Kimmeridgian, he considered that the Argentine material was also of late Jurassic age. In the Spanish translation of JAWORSKI's paper GROEBER (in JAWORSKI 1925b) added a footnote to make it clear that this age determination was wrong, "as the fossil comes from the Liassic beds with *Vola Bodenbenderi* and other abundant and characteristic forms, and two specimens from this locality were found by GROEBER". JAWORSKI's specimens are probably housed at Bonn (Germany).

A. LEANZA (1942a) stated that this species does not occur at Piedra Pintada and, "if determinations are correct, they come from somewhere else in Neuquén". GROEBER (1925), on the other hand, had already rejected this possibility.

JAWORSKI's identifications are included here in the synonymy list of *P. groeberi* as they match the available material quite well. The old collection of the MLP house some specimens collected by ROTH and GROEBER and labelled "*Arca nobilis* CONTEJ.". These probably are the samples mentioned by GROEBER (1925 and in GROEBER et al. 1953).

This species is relatively common in the Lower Jurassic outcrops of southern Neuquén.

Autecology: This species probably lived attached to hard substrates by a strong byssus (see KAUFFMAN in COX et al. 1969) like extant species of *Arca* do, living on exposed surfaces of rock or coral, sometimes partially filling shallow cavities (see STANLEY 1970: 121). Almost every specimen of *P. groeberi* has epizoic organisms on the outer surface, mostly on the posterior portion of the shell. They include small coiled serpulids, different kinds of borings, some of them made by sponges, and even small corals.

Parallelodon riccardii n. sp.

Plate 1, fig. 14 a–c; text-fig. 10, 12, 13 a

! v . 1982 *Parallelodon riccardii* n. sp. DAMBORENEA, p. 80–84; lám. 36, fig. 1, 4; lám. 52, fig. 13–15 (unavailable name).

Derivation of name: After Dr. A. C. RICCARDI, of the MLP, collector of the holotype, who made important contributions to the knowledge of the Jurassic stratigraphy of South America.

Material: Holotype: MLP 16251 (M 105) an incomplete right valve, figured in pl. 1, fig. 14, from the Pliensbachian of the hills south of Cerro Roth, southern Neuquén province (locality D.15 on text-fig. 5), RICCARDI's collection.

Other specimens doubtfully included in this species: MLP 16252 and 16253 (M 1038 and 1051), Pliensbachian of 8 km south of Estancia Santa Isabel (D.1) and Salitral Grande (D.3), southern Neuquén province, author's collection.

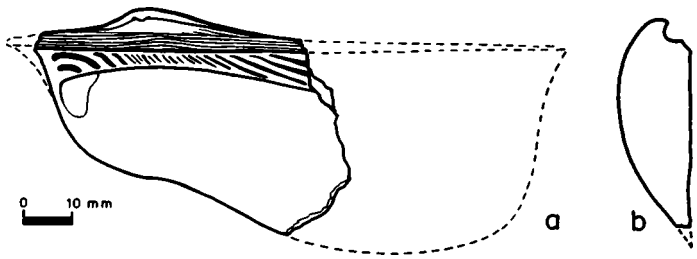
Diagnosis: Shell of trapezoidal outline, laterally very compressed, with the maximum height of the shell located posteriorly and an acute antero-dorsal angle. Byssal sinus and byssal gape present but without posterior ridge. Ligamental area narrow. External surface with growth lines and thin and faint radial riblets. Numerous teeth, three anterior, about 12 central and at least four posterior ones, placed on a very wide hinge-plate. Anterior adductor muscle scar on a high myophoric platform.

Description: Large thick shells, elongated, very inequilateral, trapezoidal in outline, laterally compressed. Length about twice the height. Hinge line straight and probably corresponding to the maximum length. Anterior margin nearly straight that meets the dorsal one at an acute angle (about 45°). Ventral margin long and sinuous, joining the anterior and posterior margins without interruptions. The ventral margin is oblique to the dorsal one along its entire length and the maximum shell height is placed posteriorly. The posterior margin is not preserved but it can be reconstructed from the growth lines. It was probably slightly sinuated and met the dorsal margin at an acute angle. The ventral margin shows a long narrow byssal gape that corresponds to the end of a very shallow sulcus that extends from the umbones to the ventral margin. There is no umbonal ridge.

Prosogyrate and low umbones, located near the anterior end of the shell. Ligamental area narrow, long and triangular in shape. Its surface is divided into two portions: a rectangular strip parallel to the hinge line that dips towards the commissure plane and corresponding to the functional portion of the ligament, and a triangular, concave area nearest the umbones which is subhorizontal in anterior view (see text-fig. 12b). This sudden change increases the functional surface of the ligamental area but at the same time does not separate the umbones very much. The ligamental grooves are deep, almost straight, parallel to each other and to the hinge line on the area nearest to the hinge, whilst they are chevron-shaped and faint on the triangular umbonal region. The ligamental area is bordered by a sharp posterior ridge and a low anterior one.

The hinge-plate is very wide. It narrows slightly just behind the umbones, but then it widens towards the posterior portion of the shell. The teeth converge towards a point above the umbones and in front of the anterior end of the shell. There are three strong anterior teeth that have their anterior ends curved downwards and their medium portions parallel to the hinge line. The central part of the hinge-plate is occupied by about 12 short, narrow and oblique teeth. Behind them at least four long, oblique, strong posterior teeth appear, with their anterior ends reaching the hinge line.

The anterior adductor muscle scar is placed on a strong myophoric platform of sub-triangular outline. Pallial line and posterior adductor muscle scars are unknown. The inner margin of the shell is smooth.



Text-fig. 12. *Parallelodon riccardii* n. sp. Reconstruction based on the holotype, a right valve, MLP 16251, showing hinge and ligamental characters. a: interior view; b: anterior view showing abrupt change in the slope of the ligamental area.

The outer surface of the shell is covered by irregular thin growth lines that become somewhat lamellose and more irregular on the byssal sinus. They are crossed by thin low radial riblets that become stronger on the posterior portion of the shell.

Measurements: MLP 16251 (holotype): L = 64.10 mm preserved; H = 42.95 mm preserved; W = 16.70 mm; Al = 22.75 mm preserved; Wh = 4.75 mm; LAA = 8.55 mm; HAA = 8.60 mm; number of radial riblets on the posterior portion of the shell: 12 to 15 in 10 mm.

Affinities: *P. riccardii* differs from the type species of the genus, *P. rugosus* (BUCKMAN) (1845: 99, pl. 5, fig. 5a–b; MORRIS & LYCETT 1853, pl. 5, fig. 1, 1a, 1b; ARKELL 1930a, fig. 1, pl. 14, fig. 1–4), from the British Bathonian, by its acute antero-dorsal angle and by being more compressed laterally. Also *P. riccardii* has more numerous teeth, the anterior ones bending downwards.

The antero-dorsal projection and the laterally compressed shells are the main characters that distinguish this taxon from other Mesozoic *Parallelodon* species. From the Bathonian European species *P. ? hirsonensis* (D'ARCHIAC) (1842: 374, pl. 27, fig. 5, 5a; MORRIS & LYCETT 1853, pl. 5, fig. 1; FISCHER 1964: 32, fig. 3a–b) differs by a dissimilar arrangement of teeth (see figure in FISCHER 1969, pl. 9, fig. 3). *P. azzouzi* FRENEIX (1965: 52, pl. 1, fig. 1) from the Middle Jurassic of Tunisia shares with *P. riccardii* the alate posterior part of the shell, but its anterior extremity is less pointed and the posterior wing is distinctly separated from the remaining part of the shell. *P. trapezium* COX (1928, 1936b), from the Lower Jurassic of Great Britain, is smaller and its maximum length does not correspond to the hinge line.

Parallelodon simillima (WHITEAVES), from the Middle Jurassic of British Columbia (WHITEAVES 1884: 234, pl. 31, fig. 5, as *Nemodon fischeri* D'ORB.; REINHART 1937: 173–174, pl. 27, fig. 7a, b; POULTON 1981: 67–69, pl. 9.1, fig. 20–23) has a similar shell outline, but is more inflated and has a narrow hinge-plate.

P. riccardii n. sp. and *P. groeberi* n. sp. are associated in the same beds. They differ in many important characters: *P. groeberi* has a sub-rectangular outline, is more inflated and its shell is thinner. The antero-dorsal and postero-dorsal angles are about 90° in *P. groeberi* and acute in *P. riccardii;* the hinge-plate is very wide in *P. riccardii* whilst it is very narrow in *P. groeberi.*

On the other hand, strong affinities can be found with *P.* sp. which is described below. *P.* sp. has, however, a smaller and more inflated shell, its maximum length does not coincide with the hinge line and its ligamental area is wider.

Autecology: This is an epibyssate form (cf. STANLEY 1970: 23, and THOMAS 1978a: 183) that had a strong byssus. The laterally compressed, elongated shell and the fact that the ventral margin is clearly divergent from the dorsal one suggest a nestling habit within natural cavities on a hard substratum (see THOMAS 1978a: 183; STANLEY 1970). According to THOMAS (1978a: 189) the faint radial riblets increase the friction between the shell and the cavity walls.

P. riccardii is associated with hermatypic corals, that could have provided the cavities and hard substrate for this species. It has a striking similarity to coral-associated species of *Barbatia* figured by ARKELL (1928).

Parallelodon sp.

Plate 1, fig. 10–12; text-fig. 10, 13b

? 1925a *Arca* sp. indet. cf. *liasina* DUM. non ROEMER – JAWORSKI, p. 179.
v 1978a *Parallelodon* sp. – DAMBORENEA in VOLKHEIMER et al., Tab. 2.
v 1982 *Parallelodon* sp. – DAMBORENEA, p. 84–87; lám. 36, fig. 5; lám. 52, fig. 10–12.

Material: From author's collection: MLP 16255 to 16262, 19024 and 19655 (M 193, 309, 311, 313, 317, 320, 336, 431, 437, 1285, 1322 and 1329), six internal moulds of left valves, five internal moulds of right valves, one external mould of left valve, one steinkern and one composite mould, most of them from lower to upper Pliensbachian beds of Cerro Puchenque (B.9), Rio Atuel (B.1), Paso del Portezuelo Ancho (B.4) and Arroyo Serrucho (B.8), Mendoza province; and also from upper Pliensbachian beds at Arroyo Lapa (C.15), Neuquén province. This species ranges into the early Toarcian at Arroyo La Laguna (A.2), San Juan Province, and Cerro Puchenque (B.9), Mendoza province.

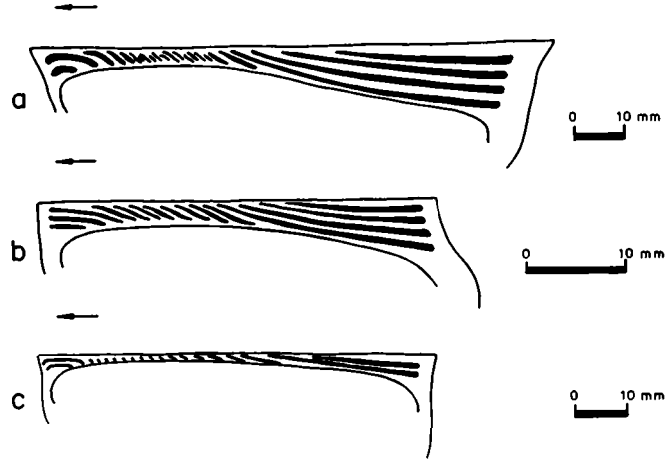
There is also one specimen (MLP 16263) collected by KEIDEL at Arroyo Blanco, Rio Atuel, Mendoza.

Description: Medium-sized shells, equivalve, very inequilateral, globose, sub-rectangular in outline. Length nearly equal to twice the height. The hinge line is straight and does not correspond to the maximum length of the shell. The anterior margin is short and convex and meets the dorsal margin at a slightly acute angle. The middle portion of the ventral margin is interrupted by a narrow byssal gape that corresponds to a slight sinus on the shell surface. This ventral margin is nearly parallel to the dorsal one, only diverging slightly behind the byssal gape. The posterior margin is wide and convex, and meets the dorsal margin at an acute angle. The shell lacks an umbonal ridge and the posterior wing is not clearly distinguished from the remaining part of the shell.

The umbones are prosogyrate, wide and low; they are placed about $^1/_5$ of the total length from the anterior end of the shell. The ligamental area is an elongated triangle that bears several chevron-shaped ligamental grooves.

The hinge-plate is wide and the teeth converge to a point above the umbones, and to the front of the anterior end of the shell. The three or four posterior teeth are strong and parallel to each other, and their anterior ends reach the hinge line. The two or three anterior teeth are short and oblique, and their anterior ends are almost parallel to the hinge line. The middle part of the hinge-plate has a variable number of oblique narrow teeth that become almost perpendicular to the hinge line below the umbones.

The anterior adductor muscle scar is only slightly impressed on the internal moulds. The pallial line is commarginal and becomes fainter near the byssal gape. The outer surface of the shell is ornamented with thin growth lines and very faint radial riblets very close to each other. The inner margin of the shell is smooth.



Text-fig. 13. Reconstruction of the right hinge characters of the three species of *Parallelodon* described here, based on several specimens. a: *Parallelodon riccardii* n. sp.; b: *Parallelodon* sp.; c: *Parallelodon groeberi* n. sp. Sockets shown in black.

Measurements: Brackets indicate incomplete specimens.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	Al (mm)	Hu (mm)	Ud (mm)
MLP 16255, pl. 1, fig. 12	LV	EM	28.45	(15.40)	(3.70)	(1.85)	(6.30)	(12.65)	-
MLP 16256	LV	IM	57.80	(32.15)	7.25	(1.80)	11.05	(22.30)	-
MLP 16259, pl. 1, fig. 11	RV	IM	(39.20)	(18.40)	5.75	(2.13)	(9.80)	15.00	(4.10)
MLP 16260, pl. 1, fig. 10	LV	IM	-	(16.50)	3.40	-	9.30	13.15	-
MLP 16261-a	RV	IM	(39.90)	19.00	13.40	(2.10)	9.90	12.65	7.25

Affinities: *P.* sp. has affinities with several species described for the Lower and Middle Jurassic of different localities. As the available material is rare and incomplete, an open nomenclature is used.

P. rugosus (BUCKMAN) differs from *P.* sp. in its narrow hinge-plate, smaller number of central teeth and in having its maximum length corresponding to the hinge line (see figures in BUCKMAN 1845: 99, pl. 5, fig. 5a–b; MORRIS & LYCETT 1853, pl. 5, fig. 1, 1a, 1b; ARKELL 1930a, fig. 1, pl. 14, fig. 1–4).

The species here described has striking similarities to *P. niranohamensis* HAYAMI (1958: 100, pl. 7, fig. 1–4) from the Japanese Hettangian; it can be distinguished from this species by its less prominent and wider umbo, a deeper byssal sinus and a more compressed shell. *P. infraliassicus* HAYAMI (1959 b: 42, pl. 5, fig. 4–6), also from the Lower Jurassic of Japan, has a similar byssal sinus but the umbones are more posteriorly placed and the dorsal and ventral margins are parallel to each other. The Japanese species has a *Grammatodon*-type hinge and probably belongs to *Grammatodon* (*Cosmetodon*). Another similar species is *Arca pulla* TERQUEM (1855: 307, pl. 21, fig. 1) from the Lower Jurassic of Holland, but it is smaller and has stronger radial ribs.

P. pindiroensis COX (1965: 29, pl. 1, fig. 7–8), from the Bajocian of Tanzania, is less elongated and has a narrower hinge-plate. *P. azzouzi* FRENEIX (1965: 52, pl. 1, fig. 1), from the Tunisian Middle Jurassic, has a very well developed posterior wing and a longer postero-ventral projection.

P. sp. is also similar to "*Macrodon*" cf. *curionii* BITTNER as figured by TRECHMANN (1918: 191, pl. 21, fig. 12–13) from the Triassic of New Zealand, from which it can be distinguished by its lower umbones and stronger anterior teeth. "*Macrodon*" *buchi* BÖHM (1903: 39, pl. 4, fig. 11–14), from the Triassic of Bear Island, has an analogous but shorter shell outline.

Remarks: This species is relatively common in the Lower Jurassic deposits of southern Mendoza. One specimen probably referable to this species from the Chachil area (Neuquén province) is housed at the FCENBA, labelled as "*Cucullaea lamberti* n. sp.", a nomen nudum.

Subfamily Grammatodontinae BRANSON 1942

Genus *Grammatodon* MEEK & HAYDEN 1860

Type species: *Arca* (*Cucullaea*) *inornata* MEEK & HAYDEN 1859, from the early Oxfordian (see IMLAY 1967: 76) of the United States, original designation.

Some species described by A. LEANZA (1942b) are here referred to the genus *Grammatodon*. JAWORSKI (1925a) mentioned *Arca rhomboidalis* CONTEJ. in the late Early Jurassic of Cerro Puchenque. His material seems to belong to *Grammatodon* and is here questionably included in *G. costulatus* (LEANZA).

Grammatodon (*Grammatodon*) cf. *toyorensis* HAYAMI 1959

Plate 1, fig. 13; text-fig. 16c

v . 1942a *Cucullaea* sp. – A. LEANZA, p. 29.
v . 1942b *Cucullaea* sp. indet. – A. LEANZA, p. 153; lám. 1, fig. 9.
cf. 1959b *Grammatodon toyorensis* HAYAMI, new species; p. 45–46; pl. 5, fig. 9–12.
vp . 1975 *Grammatodon* – DAMBORENEA et al., Cuadro 1, 03 (sample 133 only).
v . 1978 *Cucullaea* sp. indet. – CAMACHO & RICCARDI, cuadro 1.
v . 1982 *Grammatodon* (*Grammatodon*) cf. *toyorensis* HAYAMI – DAMBORENEA, p. 87–90; lám. 36, fig. 8; lám. 54, fig. 9.

Material: MLP 6098: an internal mould of a right valve, collected by FRENGUELLI at Cerro Grande (D.8), southern Neuquén, Pliensbachian. MLP 15484: one internal mould of a left valve collected by GULISANO from the late Pliensbachian of Cordillera del Viento (C.1), Neuquén; and MLP 16264 (M 133): one internal mould of a left valve collected by the author from Pliensbachian beds of Piedra Pintada (D.9), Neuquén.

Description: Shell small, inequilateral, sub-trapezoidal in outline and slightly longer than high. Hinge margin nearly straight and scarcely shorter than the shell maximum length. The anterior margin meets the dorsal one at a slightly acute angle, and is evenly convex. The ventral margin is convex and the posterior margin is straight and joins the dorsal margin at an obtuse angle. The postero-ventral end of the shell is projected. Length/height ratio is about 1.40.

Umbones prosogyrous, prominent and located a little more than $^1/_3$ of the total length from the anterior end of the shell. An oblique low umbonal ridge extends from the umbones to the postero-ventral corner of the shell.

The hinge is typically *Grammatodon*-like and has three anterior teeth and three posterior teeth that converge to a point just below the umbones. The central teeth are not preserved in the available material. The inner

margin of the shell is smooth. Other internal characters are unknown. As the material consists only of internal moulds, no external characters can be seen apart from a few faint growth lines.

Measurements: All measurements were taken with an eye-piece micrometer.

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Al (mm)	Lh (mm)
MLP 6098, pl. 1, fig. 13	RV IM	9.66	7.28	2.25	1.33	3.64	8.75
MLP 16264	LV IM	10.25	6.87	1.55	1.49	3.75	8.50

Affinities: This species can be compared to *G. toyorensis* HAYAMI (1959b, pl. 5, fig. 9–12), from the Hettangian of the Higashinagano Formation of western Japan. Nevertheless, the Argentine specimens are smaller and have a straight posterior margin, whilst the Japanese species has a concave one. The external ornamentation of the shells cannot be compared because only internal moulds are available.

It can be distinguished from *G. kenyanus* COX (1965, pl. 2, fig. 1–2) from the Toarcian of Kenya, by the presence of an umbonal ridge, the absence of a median sinus and the projected postero-ventral end in *G.* cf. *toyorensis.*

There is a Middle Jurassic group of species, informally known as the *G. concinnus* (PHILLIPS) group (see for instance DUFF 1978: 36–37), that has similar characters to the species here described. They differ by having a characteristic radial ornamentation that can be seen even on internal moulds. *G. haguei* (MEEK) from the Bajocian of western United States (MEEK 1877: 134–137, pl. 12, fig. 1; IMLAY 1967: 75–76, pl. 1, fig. 2–6) fits also in this group.

The type species of *Grammatodon, G. inornatus* (MEEK & HAYDEN), from the Oxfordian of western United States (USNM 201; MEEK & HAYDEN 1865: 90, pl. 3, fig. 9; WHITFIELD 1880, pl. 5, fig. 16–18) is similar in outline to the species here described as observed on plastotypes of the figured specimens (USNM 201), but they have a lower umbonal ridge. *G. chartroni* (COSSMANN 1904: 515, pl. 17, fig. 5–7) from the Lower Jurassic of France lacks an umbonal ridge. The same can be said of *G. lineatus* (GOLDFUSS) (1835: 141, pl. 121, fig. 9a–c) from the Lower Jurassic of Württemberg, Germany, which also has a less pointed postero-ventral extremity.

The Argentine material is more equant and acuminate postero-ventrally, but otherwise resembles the Canadian *Grammatodon cumshewensis* (WHITEAVES). This was originally illustrated by WHITEAVES (1884, pl. 31, fig. 8–8b) as *G. inornatus,* and thought to belong to the Cretaceous "Queen Charlotte Islands" Group, but comes in fact from the upper part of the Middle Jurassic Yakoun Formation (cf. POULTON 1979, 1981).

G. sonninianus CRICKMAY (1930), from the Canadian Middle Jurassic, is also similar to the species here described, but it is larger and more elongated.

Among the boreal Middle and Late Jurassic species the greatest affinities can be found with *G. schowrovskii* (ROUILL. & VOSS.) as figured by BORISSJAK (1905, pl. 2, fig. 10–12), ARKELL (1930a, pl. 15, fig. 7) and KELLY (1984: 18, pl. 1, fig. 11–21, 23), but this has a longer shell; and *G. minimus* (LECKENBY) (DUFF 1978, pl. 2, fig. 1–6, 8–10), but this has a cancellate ornamentation.

G. cf. *toyorensis* differs from *G. costulatus* (LEANZA) from the Lower Jurassic of Argentina because it lacks radial ornamentation and has a less elongated and differently shaped shell.

Remarks: The hinge characters and other features of this species are those of *Grammatodon* MEEK & HAYDEN, although the possibility that the specimens could be juveniles of *Cucullaea* cannot be completely disregarded. Inclusion in *Grammatodon* (*G.*) is based on the well developed umbonal ridge, a feature that prevents possible reference to *Indogrammatodon* COX (1937b).

Autecology: This species, with its short and dorsally inflated shell, could have been a superficial burrower with a weak or no byssus (see STANLEY 1970; DUFF 1978). The life position was probably with the posterior margin of the shell parallel to the substrate surface.

Grammatodon costulatus (A. LEANZA 1942)

Plate 2, fig. 16–17; text-fig. 14, 16b

? 1925a *Arca rhomboidalis* CONTEJEAN – JAWORSKI, p. 177; lám. 4, fig. 13.
v. 1942a *Cucullaea costulata* n. sp. A. LEANZA, p. 29 (unavailable name).

*! v 1942b *Cucullaea costulata* n. sp. A. LEANZA, p. 152; lám. 1, fig. 5-6.
v. 1978 *Grammatodon costulatus* (LEANZA) - CAMACHO & RICCARDI, Cuadro 1.
! v. 1982 *Grammatodon costulatus* (A. LEANZA) - DAMBORENEA, p. 90-93; lám. 36, fig. 12; lám. 55, fig. 11-14.

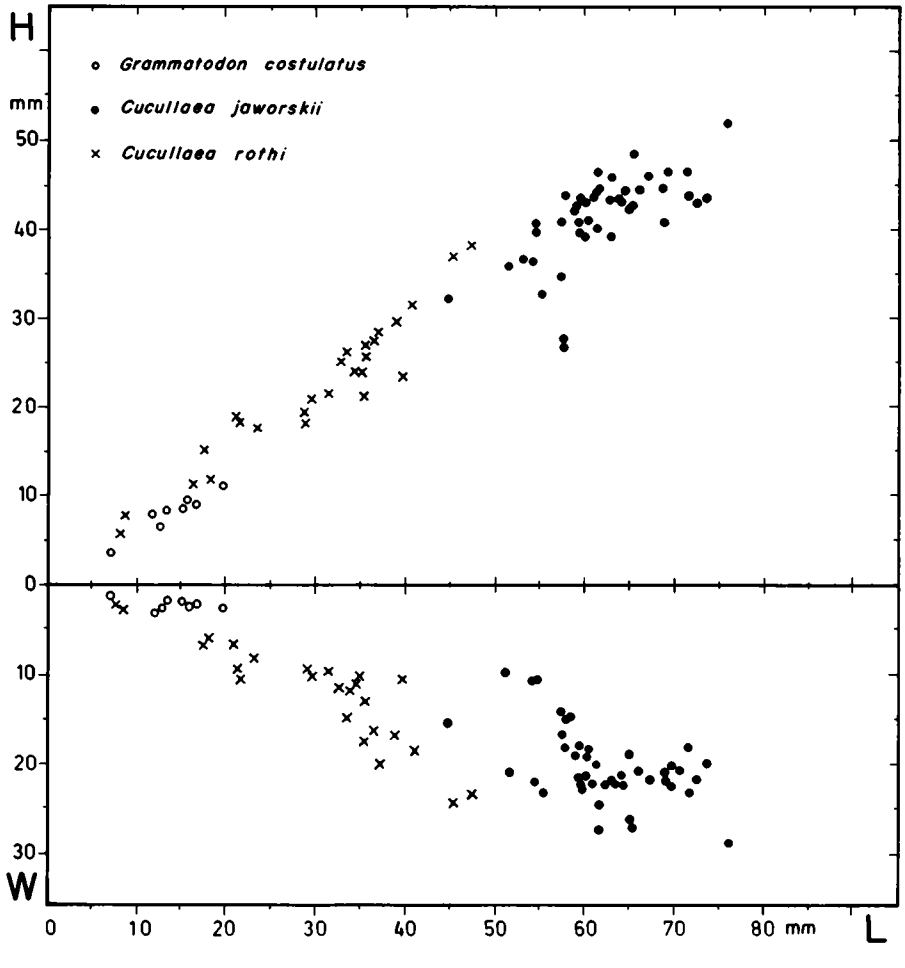
Material: LEANZA's original set: MLP 6074, two composite moulds of right valves, one external mould of left valve and two fragmentary moulds, collected by FRENGUELLI from Pliensbachian beds at Subida a Sañicó (locality D.7), southern Neuquén province. Lectotype (here designated): MLP 6074-a, a right valve internal mould, figured by A. LEANZA (1942b, lám. 1, fig. 6) and here in pl. 2, fig.16. Paralectotypes: all other specimens under MLP catalogue number 6074.

Additional material: MLP 16265, 16266 (M 301 and 320): author's collection, two external moulds of right valves from Pliensbachian beds at Cerro Puchenque (B.9), Mendoza province.

Doubtfully included in this species: MLP 16267 (M 1042), four internal moulds of left valves, three of right valves, and several fragments, from author's collection at Salitral Grande (D.3), southern Neuquén, Pliensbachian (see pl. 2, fig. 14-15 here).

Description: Small inequilateral shell, sub-trapezoidal in outline, length greater than height. The dorsal margin is straight and slightly shorter than the maximum length. The anterior margin meets the dorsal at a right angle and is convex. The ventral margin is also convex and the posterior margin is slightly convex and meets the dorsal one at an obtuse angle. The postero-ventral corner of the shell is rounded and of about 90°. The prosogyrate and low umbones are placed at $^1/_3$ of the total length from the anterior end of the shell. A sharp umbonal ridge extends from the umbones, and becomes lower and wider towards the postero-ventral corner of the shell.

The anterior and posterior teeth are clearly seen on the internal moulds, but the central ones were not preserved. The anterior teeth are three on the right valve, the uppermost one is nearly parallel to the hinge line, the others converge to a point below the umbones. On the lectotype the anterior end of the anterior teeth is at 1.26 mm from the anterior end of the hinge-plate. The posterior teeth are also three on the right valve, the longest



Text-fig. 14. Scatter diagrams showing the length / heigth (L / H) and length / width (L / W) ratios of *Grammatodon* (*G.*) *costulatus* (LEANZA), *Cucullaea jaworskii* LEANZA and *Cucullaea rothi* LEANZA.

being the uppermost one. The posterior end of the tooth is at 1.12 mm from the posterior end of the hinge-plate on the lectotype. The longest posterior tooth is parallel to the hinge line. Other internal features unknown.

The outer surface has growth lines and thin regular radial riblets that are even seen on composite moulds. The space between two ribs is twice as wide as the ribs. Although all specimens are incomplete, it appears that this ornamentation has the same features on both valves.

Measurements: Brackets indicate incomplete specimens. See also scatter diagram on text-fig. 14.

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Lh (mm)	Al (mm)	α	β
MLP 6074-a, lectotype	RV CM	19.70	11.10	2.45	1.78	16.95	6.50	91°	119°
MLP 6074-b, paralectotype	RV CM	16.90	9.05	2.05	1.86	14.25	6.00	96°	110°
MLP 6074-c, paralectotype	LV EM	13.50	8.15	1.45	1.65	11.40	(4.20)	-	-
MLP 16267-a, pl. 2, fig. 14	LV IM	12.80	6.65	2.40	1.92	9.85	4.55	-	-
MLP 16267-b, pl. 2, fig. 15	LV IM	7.10	3.45	1.50	2.05	6.20	2.35	-	-
JAWORSKI 1925a, lám. 4, fig. 13	LV S	12.00	8.00	3.00	1.50	-	-	-	-

Affinities: *G. kindopeensis* (COX 1965: 33, pl. 3, fig. 3–4) from the Late Kimmeridgian of Tanzania, differs from *G. costulatus* in its stronger radial ribs, although it has a similar outline and size.

The length/height ratio is comparable to that of *G. micromorpha* (CRICKMAY 1930, pl. 3, fig. e–f) from the Canadian Bajocian, but that species has a median sinus. *Parallelodon* (*Grammatodon*) *montanayensis* LORIOL figured by ALENCASTER DE CSERNA & BUITRÓN (1965: 17, lám. 5, fig. 9) from the Upper Jurassic of Petlalcingo, Mexico, has a similar shape but is more inflated and has more convex and oblique ventral margin.

The species of the *G. concinnus* group mentioned in the comparison of *G.* cf. *toyorensis,* have all a smaller length/height ratio.

Remarks: A. LEANZA (1942b) provided a detailed description of this species, which he included in *Cucullaea* LAMARCK but he did not mention the hinge characters that are of great importance in establishing the generic affinities.

The specimen figured by JAWORSKI (1925a) as *Arca rhomboidalis* CONTEJ. from Cerro Puchenque is included questionably in *G. costulatus.* The collection from this locality available to the present author includes material referable to this species, but not so well preserved as JAWORSKI's specimen. If conspecific, this specimen could add information in order to establish the generic affinities of the species. The unequal ornamentation on both valves and the nature of the posterior umbonal ridge as seen on JAWORSKI's figure are similar to those found in different species of *Indogrammatodon.* Unfortunately JAWORSKI's specimen was not available.

Autecology: The elongated shape of *G. costulatus* shells could indicate an epifaunal habit, on the basis of the analysis made on extant arcacean species (STANLEY 1970). The lack of byssal gape and the posterior truncation of the shell suggest, however, a shallow burrower. This type of inconsistency, also found by DUFF (1978) in British Callovian species, stresses the difficulties awaiting autecological interpretations based on the functional morphology of just a few features of the shell.

Grammatodon ? sp.

v. 1978a *Grammatodon* ? sp. - DAMBORENEA in VOLKHEIMER et al., Tab. 2.
v. 1982 *Grammatodon* ? sp. - DAMBORENEA, p. 93–94.

Material: MLP 16268 (M 438), a poorly preserved left valve from the early Toarcian of Arroyo La Laguna, southern San Juan (locality A.2), author's collection.

Description: Medium-sized shell, inequilateral, trapezoidal elongated in outline, globose, with the maximum width in the anterior portion of the shell. The dorsal margin is long and straight; it meets the posterior margin at an obtuse angle and the anterior margin at an acute angle. The posterior margin is straight to slightly sinuous and the shell has a pointed and rounded postero-ventral corner. The ventral and anterior margins are evenly convex. The umbones are placed within the anterior half of the shell and are very wide but do not protrude above the hinge line. The posterior umbonal carina is low. The triangular ligamental area is very wide and is

bounded by anterior and posterior ridges. Hinge characters unknown. The available specimen is eroded in such a way that the external characters are not seen.

Measurements: L = 34.00 mm; H = 15.80 mm; W = 7.40 mm; L/H = 2.15; Al = 9.75 mm; Lh = 25.45 mm.

Remarks: The poor preservation of this specimen prevents one from establishing its affinities and from making proper comparisons with other species. It cannot be included within any of the previously described species, from which it differs by its pointed anterior end. The greatest affinities are found with an undescribed Bajocian species from Neuquén.

Family Cucullaeidae STEWART 1930

Genus *Cucullaea* LAMARCK 1801

Type species: *Cucullaea auriculifera* LAMARCK 1801 (= *Arca cucullata* RÖDING 1798; *Arca cucullus* GMELIN 1791; ? *Arca labiata* SOLANDER 1786), Recent, Indopacific, subsequent designation by CHILDREN 1823.

Synonyms: *Cucullana* LICHTENSTEIN 1818 (type species: *Arca cucullus* GMELIN 1791).
? *Latiarca* CONRAD 1862 (type species: *Cucullaea gigantea* CONRAD 1830).
Archaeodon CRICKMAY 1930 (type species: *A phylarchus* CRICKMAY 1930).
Cucullastis FINLAY & MARWICK 1937 (type species: *Cucullaea* (*Cucullastis*) *barbara* FINLAY & MARWICK 1937).
Cucullona FINLAY & MARWICK 1937 (type species: *Cucullaea* (*Cucullona*) *inarata* FINLAY & MARWICK 1937).

The genus *Cucullaea,* which includes some living species, is widely represented throughout the Mesozoic from the early Jurassic onwards. It attained its greatest diversity during the Cretaceous. Many of the early Jurassic species originally described as *Cucullaea* belong to *Grammatodon.*

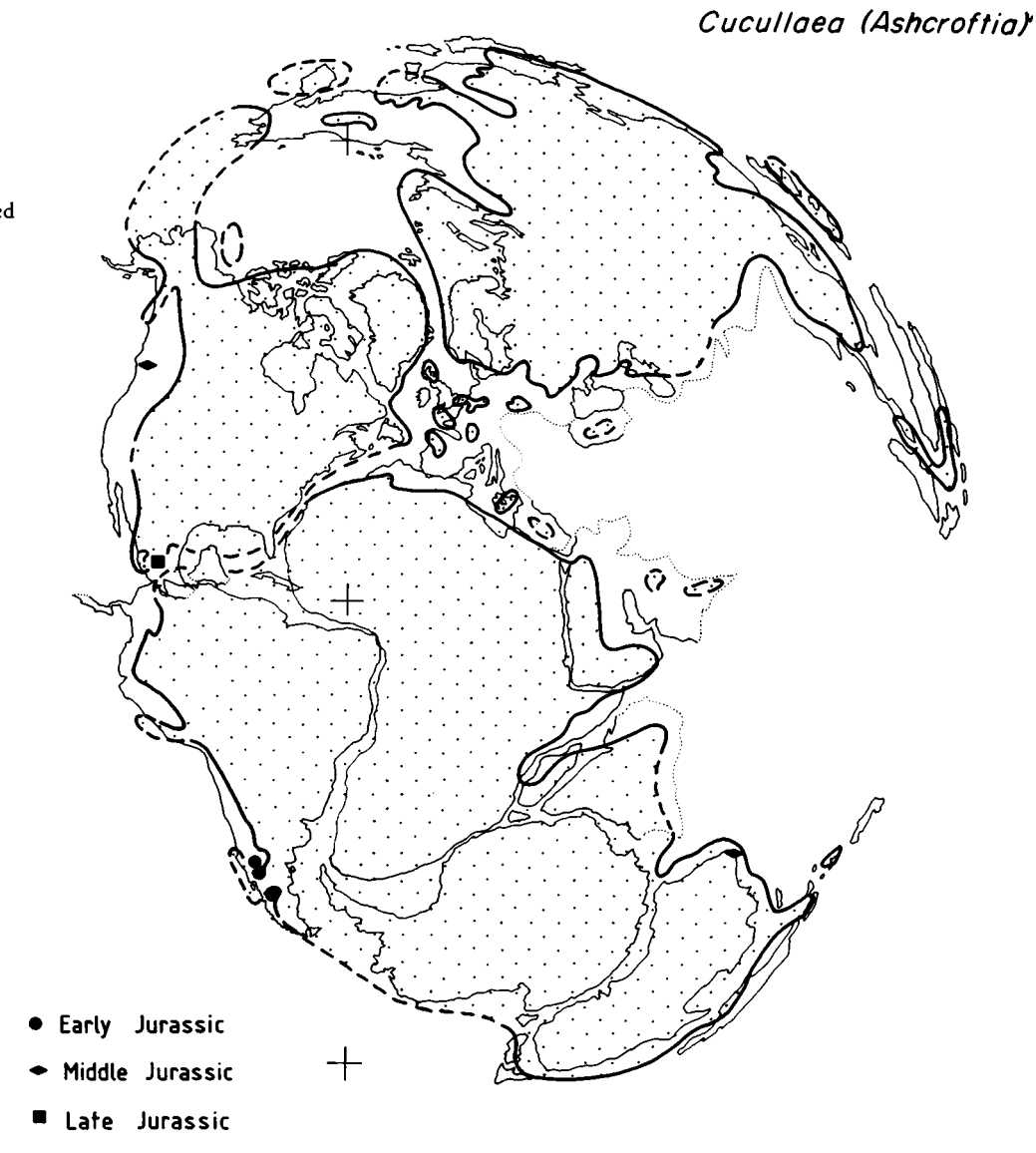
In the early Jurassic of Argentina this genus is represented by several species, but only two of them will be discussed here. Other species are not included due to lack of material and enough data to make critical revisions; they are: (a) *Cucullaea* sp. in BEHRENDSEN 1891 (p. 387; 1922: 172) from the Lower Jurassic of Portezuelo Ancho (Mendoza province). The description is incomplete and there is no illustration. (b) *Cucullaea* sp. in JAWORSKI, 1925a (p. 177), not figured either, from the "upper lower Jurassic" (Aalenian ?) of Cañada Colorada (Mendoza province); it probably does not belong to any of the species described here according to the short description available.

? Subgenus *Ashcroftia* CRICKMAY 1930

Type species: *Ashcroftia inversidentata* CRICKMAY 1930, from the Bajocian of British Columbia, Canada, by original designation.

CRICKMAY (1930: 43) described his new genus *Ashcroftia* to include cucullaeid species with the following characters: "Tumid, with broad ligamental area, faintly striate surface, smooth internally except for a weak ridge bordering the posterior muscle scar. Central tooth an inverted V, on both sides of which come first oblique teeth, then elongate hooked teeth of the *Latiarca* type. Similar in shell contour to the *Cucullaea* group. Nearest to *Latiarca* CONRAD 1862 which it resembles in lacking muscle-scar laminae. It differs in the smaller number and peculiar attitude of the central teeth on the hinge plate. Probably many of the Jurassic species referred to *Cucullaea* belong to *Ashcroftia. Cucullaea,* sensu stricto, is confined to later Cenozoic and recent faunas of the warmer regions of the earth".

Some authors, such as SKWARKO (1967: 93) considered that the hinge characters allow the separation of this taxon from *Cucullaea* at the generic level. Others, like NEWELL (in COX et al. 1969) place *Ashcroftia* as synonym of *Cucullaea.* His idea that the phylogenetic significance of the form and distribution of the lateral teeth is uncertain is not shared here and *Ashcroftia* is recognized as a distinct subgenus of *Cucullaea* and a useful taxon for grouping species with parallelodontid posterior teeth, that are not curved downwards, and without a strong posterior myophoric buttress. These characters are commonly present in lower and middle Jurassic *Cucullaea* species. This subgenus differs from *Dicranodonta* WOODS by its smooth ventral margin. *Ashcroftia,* as here understood, ranges from the Pliensbachian (*C. jaworskii* LEANZA) to the lower Cretaceous (*A. distorta* (GLAESSNER)) and is mostly circumpacific in palaeogeographical distribution (see text-fig. 15).



Text-fig. 15. Palaeogeographic distribution of the subgenus *Cucullaea* (*Ashcroftia* ?) as understood here (see text). Palaeocontinental reconstructions from SMITH & BRIDEN (1977) for the Early Jurassic, hypothetic coast-lines compiled from various sources.

Cucullaea (*Ashcroftia* ?) *jaworskii* A. LEANZA 1940

Plate 2, fig. 9–13; text-fig. 16a

. 1934 *Cucullaea* sp. – FERUGLIO, p. 40–41; tav. 4, fig. 12a–b.
? 1936 *Cucullaea* sp. – PIATNITZKY, p. 88.
! * v. 1940b *Cucullaea jaworskii* A. LEANZA, p. 209–212; lám. 1, fig. 1–3.
v. 1942a *Cucullaea jaworskii* LEANZA – A. LEANZA, p. 30–32.
v. 1942b *Cucullaea jaworskii* LEANZA – A. LEANZA, p. 153; lám. 1, fig. 8.
. 1942b *Cucullaea* cf. *jaworskii* LEANZA – A. LEANZA, p. 200 (reference to FERUGLIO's, 1934, material).
p v. 1975 *Cucullaea* – DAMBORENEA et al., cuadro 1, 05.
v. 1978 *Cucullaea jaworskii* LEANZA – CAMACHO & RICCARDI, cuadro 1.
! v. 1982 *Cucullaea* (*Ashcroftia* ?) *jaworskii* A. LEANZA – DAMBORENEA, p. 95–99; lám. 36, fig. 7; lám. 54, fig. 1–8.

Type material: Holotype: MLP 3724, figured by A. LEANZA (1940b, lám. 1, fig. 1–2) and here in pl. 2, fig. 11, a bivalved specimen collected by LEANZA at Cerro Roth, southern Neuquén (locality D.16), Pliensbachian. Paratypes: MLP 3725, two complete specimens, two right valves and two left valves, and MLP 14304, same collector and locality.

Other material: The examined material consists of 23 complete shells, 20 left valves and 15 right valves, all of them preserved as recrystalized shells: MLP 6096 collected by FRENGUELLI at Cerro Roth (D.16); MLP 6106 collected by A. LEANZA at Cerro Roth; MLP 14423

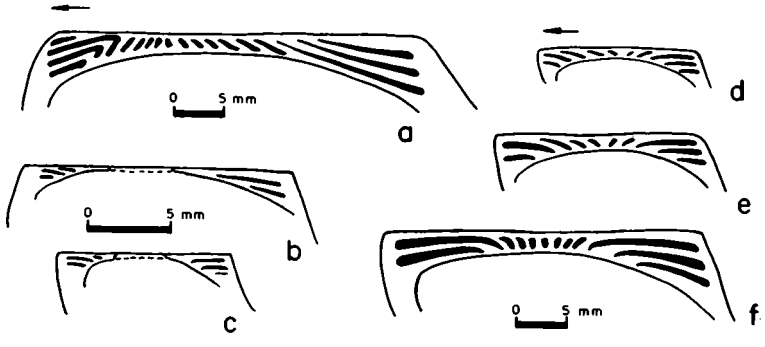
collected by GASPARINI & DELLAPÉ at Picún Leufú; MLP 16270 to 16286, 19720 (M 99, 105, 108, 143 and 1383) collected by the author at Cerro Roth, hills south of Cerro Roth (D.15), Salitral Grande (D.3), all of them from southern Neuquén province and of Pliensbachian age. Also MLP 16269 from Cerro Roth, old MLP collection. There is also some material from the Lower Jurassic beds of Chubut province: the right valve figured by FERUGLIO (1934, tav. 4, fig. 12a-b) from Rio Genoa, and one specimen collected by PIATNITZKY (MLP 18130) at Mulanguiñeo.

Doubtfully referred to this species: MLP 16287 (M 1005) and MLP 18125, a couple of valves, the first one from Arroyo Los Toldos, central Neuquén province (locality C.5), author's collection; the other one from Mulanguiñeo, Chubut province, PIATNITZKY's collection.

Description: A detailed description was provided by A. LEANZA (1940b, 1942b). Nevertheless, the large collection of well preserved specimens permited the observation of several morphologic features which were not included in the original description.

The shell outline, length/height ratio and general shape is remarkably variable within this species. Unfortunately, the observation of the ontogenetic development of the hinge was not possible, but a detailed description of the adult shell will be given (see text-fig. 16a). The teeth converge to a point above the umbones. The numerous central teeth are very thin. The posterior teeth are two or three on each valve, they are long, and their anterior ends reach the dorsal margin of the shell. The posterior ends of the anterior teeth bend sharply downwards and become parallel to the central teeth. The anterior teeth are two to four on each valve. Both the anterior and posterior teeth are very strong and transversely crenulated.

The triangular ligamental area is wide and slightly concave and is covered by V-shaped ligamental grooves. On the anterior portion of the ligamental area, there are some intercalated grooves that do not continue on the posterior part. The arrangement of the ligamental grooves is a variable character that can be related to the shell's general shape. For instance, very inflated shells have a long ligamental area that is very broad anteriorly and they bear many intercalated grooves on this portion.



Text-fig. 16. Schematic right hinge characters, based on several specimens, sockets shown in black. a: *Cucullaea* (*Ashcroftia* ?) *jaworskii* A. LEANZA; b: *Grammatodon costulatus* (A. LEANZA); c: *Grammatodon* (*G.*) cf. *toyorensis* HAYAMI; d-e-f: ontogenetic series in *Cucullaea* (*Idonearca*) *rothi* A. LEANZA.

Only the anterior adductor muscle scar is placed on a strong myophoric buttress. The shell is ornamented with closely set radial riblets and irregularly distributed commarginal growth lines. The radial ornamentation disappears on slightly weathered specimens and is always stronger on the posterior portion of the shell.

Measurements: See also scatter diagram on text-fig. 14.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	Al (mm)	Lh (mm)	Ud (mm)
MLP 3724, holotype	LV	S	64.05	43.10	21.20	1.49	16.70	43.50	2.40
MLP 3725-b, paratype	LV	S	58.85	42.50	19.30	1.38	17.15	41.60	3.00
MLP 3725-d, paratype	LV	S	61.35	44.35	20.15	1.38	19.90	39.40	3.35
MLP 3725-f, paratype	RV	S	71.65	46.60	23.50	1.54	18.45	50.10	4.00
MLP 3725-g, paratype	LV	S	44.75	32.15	15.35	1.39	13.40	29.65	2.25

Affinities: *Cucullaea* (*Ashcroftia* ?) *jaworskii* has strong affinities to *C. semistriata* Moore from the Australian Bajocian (MOORE 1870, pl. 14, fig. 3; SKWARKO 1974, pl. 12, fig. 1-7), which is shorter posteriorly, has a stronger radial ornamentation that persists on the anterior portion of the shell, lacks the anterior myophoric platform and has more central teeth on a narrower hinge plate.

The hinge of the species here described is similar to that of *Ashcroftia inversidentata* CRICKMAY (1930, pl. 2, fig. d) from the Bajocian of British Columbia, Canada, but they can be distinguished by a different shell outline and by the presence of an anterior myophoric buttress in *C.* (*A.*?) *jaworskii.*

ALENCASTER de CSERNA & BUITRÓN (1965: 16–17, lám. 5, fig. 1–2) described as *Cucullaea* sp. a specimen from the Late Jurassic of Petlalcingo, Mexico, which is "strikingly similar to *C. jaworskii* LEANZA" (op. cit., p. 17). The external resemblance of these taxa is remarkable indeed, but a closer comparison is not possible because the internal characters of the Mexican specimen are unknown.

C. (*A.*?) *jaworskii* is superficially similar to *Protarca* ? *tramitensis* (CRAGIN) from the Cenomanian of Texas, as figured by STEPHENSON (1952, pl. 11, fig. 17–22), but the posterior teeth dip in the opposite direction.

A. LEANZA (1940b: 211) has already observed the differences from *C. meridionalis* TORNQUIST (1898: 164, Taf. 7, fig. 10) from the Bajocian of Espinacito Pass (San Juan).

Remarks: LEANZA's species is only doubtfully included in the subgenus *Cucullaea* (*Ashcroftia*) due to the presence on an anterior myophoric buttress, which is apparently absent in the type species and has not been observed in other species of this subgenus.

FERUGLIO (1934: 40–41) described and figured a specimen from the Lower Jurassic of Rio Genoa (Chubut province) as *Cucullaea* sp., which is certainly conspecific with *C. jaworskii* LEANZA. A. LEANZA (1940b) did not include this specimen in his new species, but later (1942b: 200) referred it as *C.* cf. *jaworskii.* PIATNITZKY's collections from Mulanguiñeo, Chubut, include some specimens which cannot be distinguished from the types of this species. Nevertheless, PIATNITZKY's record of a *Cucullaea* sp. (1936: 88) is only doubtfully included in the synonymy because his collections also contain *C. rothi* LEANZA. At the DNGM there is a steinkern that could possibly belong to this species and which was collected by KEIDEL at Nueva Lubecka, Chubut (DNGM 9661).

Autecology: The length/height ratio of this species is close to the boundary line established by STANLEY (1970: 23) for epifaunal vs. infaunal recent arcaceans. Some of the shells show a slight ventral depression that could correspond to a byssus, although it is not a proper byssal gape. Taking into account all the morphologic features and comparing them with those of extant species, it is thought that *C. jaworskii* was a semi-infaunal burrower, such as *Anadara notabilis* (RÖDING) (cf. STANLEY 1970: 22, 125). This interpretation is supported by the almost complete absence of epizoic organisms on shells of this species found in beds where epifaunal shells are covered by a wide variety of them.

In southern Neuquén province this species is normally preserved as complete shells with both valves together, at the most only slightly disarticulated. Single valves are rare.

Subgenus *Idonearca* CONRAD 1862

Type species: *Cucullaea tippana* CONRAD 1858 (= *C. capax* CONRAD 1858; = ? *C. vulgaris* MORTON 1830) from the Cretaceous of the United States, subsequent designation by DALL 1898 (fide NICOL 1954).

GILLET (1924) regarded this taxon as a subgenus of *Arca* and recognized several species within it. The Argentine material described here is characterized by the absence of a median fold on the postero-dorsal area.

Some authors consider that *Idonearca* is a synonym of *Cucullaea* (COX 1940: 55–56), but others regard it as a separate taxon of subgeneric rank (for instance NEWELL in COX et al. 1969; HAYAMI 1975; FRENEIX 1980), or even a separate genus (STEPHENSON 1941; KELLY 1984).

Cucullaea (*Idonearca*) *rothi* A. LEANZA 1940

Plate 1, fig. 15–16; text-fig. 1 a–c; 16 d–f

? 1915 *Cucullaea Gabrielis* LEYM. = *dilatata* D'ORB. – JAWORSKI, p. 444.
? 1925b *Cucullaea Gabrielis* LEYM. (= *dilatata* D'ORB.) – JAWORSKI, p. 71.
? 1936 *Cucullaea* sp. – PIATNITZKY, p. 88.
! * v 1940b *Cucullaea rothi* LEANZA – A. LEANZA, p. 212–214; lám. 2, fig. 1–6.
v 1942a *Cucullaea rothi* LEANZA – A. LEANZA, p. 30, 32.
v 1942b *Cucullaea rothi* LEANZA – A. LEANZA, p. 153; lám. 1, fig. 7.
v p 1975 *Grammatodon* – DAMBORENEA et al., Cuadro 1, 04.
v p 1975 *Cucullaea* – DAMBORENEA et al., Cuadro 1, 05.
v 1978 *Cucullaea rothi* LEANZA – CAMACHO & RICCARDI, Cuadro 1.

v 1978a *Cucullaea* cf. *rothi* LEANZA - DAMBORENEA in VOLKHEIMER et al., Tab. 2.
! v 1982 *Cucullaea* (*Idonearca*) *rothi* A. LEANZA - DAMBORENEA, p. 100–104; lám. 34, fig. 1–3; lám. 36, fig. 9–11; lám 55, fig. 1–6.

Type material: Holotype: MLP 3726, a complete shell figured by A. LEANZA (1940b, lám. 2, fig. 1–6) and here on pl. 1, fig. 16 a–c, collected by FRENGUELLI at Cerro Roth, southern Neuquén province (locality D.16), Pliensbachian. Paratype: MLP 3727, an internal mould of a left valve, same locality and collector.

Other material: The examined material consists of four complete shells, six isolated valves, 46 internal and three external moulds. This species is common at Pliensbachian localities from southern Neuquén province: MLP 6097 collected by FRENGUELLI at Cerro Roth; MLP 16288 to 16298, 16302, 16303 and 16386 (M 100, 104, 105, 108, 141, 143, 144, 1038 and 1040), collected by the author at Cerro Roth (D.16), hills south of Cerro Roth (D.15) and Salitral Grande (D.3). It also occurs in early Toarcian beds of southern San Juan province (locality A.2): MLP 16299 to 16301 (M 431, 437, 438), author's collection. PIATNITZKY collected one specimen from Lower Jurassic beds at Mulanguiñeo, Chubut province (MLP 18112). Another specimen from Chubut collected by RICCARDI at Cañadón Chapingo, 3 km SE of Cerro Carnerero (MLP 16304) is doubtfully included in this species (pl. 1, fig. 18 here).

At the FCENBA there are some specimens from the lower Jurassic of Espinazo del Zorro, central Neuquén.

Description: The holotype, a fully-grown weathered specimen, was described by A. LEANZA (1940b: 212–213), but the amount of available additional material allows a description of the ontogenetic development and details of the hinge and external ornamentation.

The shell is slightly inequivalve, the left valve is larger than the right one, overlapping it along the anterior, posterior and ventral margins. This character is more evident in young specimens (see text-fig. 1 a–c).

The ontogenetic changes of the hinge are sketched on text-fig. 16 d–f. Young specimens have a *Grammatodon*-like hinge, i. e. the teeth converge on a point below the umbones and their distal ends reach the hinge line. As the shell grew, the anterior and posterior teeth became parallel to the hinge-line and the distinction in anterior, central and posterior teeth became clearer. In adult shells the anterior and posterior teeth have an almost equal length and their distal ends tend to curve downwards. Central teeth are numerous and almost vertical.

The umbonal ridge is low and rounded in adult specimens but very sharp in young ones, in the latter it is associated with a concave posterior portion of the shell.

The shell outer surface has commarginal, regularly-spaced growth lines and thin radial ribs. This results in a reticulate pattern in young specimens, which even exhibit lamellose ornamentation on the shell's anterior portion. On fully-grown specimens the radial ribs are only seen on the anterior and posterior parts of the shell, the central part has only regular growth lines, which become wider and more separated towards the ventral margin. The radial ornamentation differs on the two valves, as seen on well-preserved young specimens: the ribs are thinner and more crowded on the right than on the left valve. This difference is a common feature on some cucullaeids and also in some parallelodontids.

The inner margin of the shell is smooth but it is thickened in a strip parallel to the ventral margin. This thickened strip is somewhat wider on the left than on the right valve. The posterior adductor muscle scar is placed on a low myophoric platform, whilst the anterior adductor muscle scar does not have any shell thickening. The shell inner surface is smooth. The byssal features are unavailable. The width and crowding of the ligamental grooves are quite variable. On specimens of equal size the number of ligamental grooves varies from six to 13.

Measurements: See also scatter diagram on text-fig. 14. The specimens marked with an asterisk in the following table were measured using an ocular micrometer.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	Lh (mm)	Al (mm)
MLP 3726-a, holotype	RV	S	38.80	29.65	17.10	1.31	31.10	18.35
MLP 3726-b, holotype	LV	S	40.65	31.25	18.70	1.30	31.15	18.10
MLP 3727, paratype	LV	S	35.35	25.55	17.75	1.38	27.10	-
MLP 16291-v, text-fig. 1 (*)	RV	S	7.93	5.87	2.00	1.35	5.87	3.87
MLP 16291-w, text-fig. 1 (*)	LV	S	8.50	8.00	2.37	1.06	5.87	4.25

Affinities: A group of morphologically related species appears in the Argentine Jurassic from the Pliensbachian to the Bajocian. It includes *C. rothi* LEANZA in the early Jurassic and *C. sparsicosta* GOTTSCHE and *C. quadrata* TORNQUIST (possibly synonyms) in the Aalenian and Bajocian.

C. quadrata TORNQUIST (1898: 165, Taf. 7, Fig. 8) from the Bajocian of Paso del Espinacito (San Juan province) has strong similarities to *C. rothi*. They may be distinguished by the more posteriorly placed umbones in *C. rothi*

and by details of external ornamentation. Comparison with *C. sparsicosta* GOTTSCHE was already made by A. LEANZA (1940b).

There are several Mesozoic species with which *C. rothi* can be compared. *C.* cf. *subdecussata* MÜNST. as figured by SCHMIDTILL (1927) from the German Middle Jurassic is quite similar, especially specimens in figs. 8, 13a and 13b. The umbones seem to be more posteriorly placed in *C. rothi,* and the external ornamentation is also different.

C. inversidentata (CRICKMAY 1930), from the Canadian Bajocian, has a similar shape, but it is larger and has a smaller length/height ratio, and the hinge characters are different. The shell outline resembles that of *C. elatmensis* BORISSJAK (1905: 23, pl. 3, fig. 8–10), from the Middle Callovian of central USSR; *C. minchinhamptonensis* COX & ARKELL (1948), from the Middle Jurassic of Europe (cf. MORRIS & LYCETT 1853, pl. 5, fig. 4; FISCHER 1969, pl. 9, fig. 5); and *C.* (*I.*) cf. *minchinhamptonensis* COX & ARKELL from the Middle Jurassic of southern China (WEN et al. 1976, pl. 18, fig. 9). *C. rothi* can be distinguished from them all by a less elongated postero-ventral portion of the shell and the more convex ventral margin.

C. mabuchii HAYAMI (1958: 102, pl. 7, fig. 7–10), from the Japanese Hettangian, is also similar, but has the anterior margin shorter than the posterior one. *C. aalensis* QUENSTEDT (1856: 359, Taf. 48, Fig. 22; FANTINI-SESTINI 1966, tav. 56, fig. 1) from the Toarcian-Aalenian of Germany and Iran, is shorter and more laterally compressed. *C. inflata* MOORE (MOORE 1870, pl. 14, fig. 1–2), from the Bajocian of Australia, has a similar shape but is smaller and shorter (see also SKWARKO 1974, pl. 22, fig. 6–8).

Young specimens of *C.* (*I.*) *rothi* resemble several *Grammatodon* species, such as *G. concinnus* (PHILLIPS) from the European Callovian (GREPPIN 1899, pl. 9, fig. 3; DUFF 1978, pl. 2, fig. 7, 11–17, 19), which is more elongated; and *G. hersilius* (D'ORB.) from the Oxfordian of Europe (DUFF 1978, pl. 2, fig. 18, 20, 24), that has a longer hinge line and a smaller shell. *G. cypriniformis* (LUNDGREN), from the Upper Sinemurian – Lower Pliensbachian of Sweden (TROEDSSON 1951: 154–157, pl. 17, fig. 1–15, pl. 18, fig. 1) is hardly distinguished from young specimens of *C.* (*I.*) *rothi.*

Also *G. haguei* (MEEK) from the Middle Jurassic of the United States (USNM 12546; IMLAY 1967: 75, pl. 1, fig. 2–6) is similar to young specimens of *C. rothi,* but it can be distinguished by its longer hinge line and fewer radial ribs. It is interesting to note here that in the same beds as *C. haguei* (MEEK) occur larger specimens that were considered by all authors as belonging to a different species, *Idonearca haguei* (STANTON) (see IMLAY 1967: 76, pl. 1, fig. 11–13, 15). This species resembles adult specimens of *C. rothi.* Considering the ontogenetic development of *C. rothi,* the possibility that *G. haguei* (MEEK) and *I. haguei* (STANTON) represent two different growth stages of the same species cannot be disregarded. If a complete ontogenetic series had not been available at Piedra Pintada, adult and young specimens of *C. rothi* could have been regarded as belonging to different species, one of them referable to *Grammatodon* and the other to *Cucullaea* (*Idonearca*). Similarly STEPHENSON (1941: 92–94, pl. 11, fig. 1–4; pl. 12, fig. 3) regarded *I. tippana* (CONRAD) as a young stage of *I. capax* (CONRAD), both from the Late Cretaceous of Mississippi, and thus he considered both names as synonyms.

The Chilean species "*Arca*" *santiaguensis* HUPÉ (1854: 300, pl. C5, fig. 10, on the explanation of the plate as *Arca Huidobrii* nob; R. PHILIPPI 1899, lám. 27, fig. 3) is based on internal moulds and as such is difficult to assign to a definite arcacean genus. Its shape is similar to that of *C. rothi* but it has stronger radial ribs.

Remarks: The generic affinities of this species were difficult to establish. As already mentioned, young individuals are totally referable to *Grammatodon,* but adult specimens show transitional hinge characters between *Grammatodon* and *Cucullaea* (*Idonearca*).

Autecology: *C.* (*I.*) *rothi* was probably a shallow burrower that lived with its posterior truncation parallel to the sediment surface. Only one specimen (a single valve) shows epizoic organisms and, as they are only on the inner surface of the shell, they surely lived there after the bivalve's death.

Although *C. rothi* and *C. jaworskii* are occasionally found together, they seem to be mutually exclusive. The local abundance of one or the other could either indicate slight ecological differences or a discontinuous distribution, which is very common in burrowing bivalves.

Cucullaea (*Idonearca*) cf. *rothi* A. LEANZA 1940

Plate 1, fig. 17

v. 1982 *Cucullaea* (*Idonearca*) cf. *rothi* A. LEANZA – DAMBORENEA, p. 104–105; lám. 55, fig. 10.

Material: The examined material consists of one steinkern, 27 deformed compound moulds of left valves and 15 of right valves and four external moulds of left valves. This taxon occurs in late Pliensbachian to early Toarcian beds of Mendoza province: MLP 15830, 16305, 19014, 19018, 19025, 19030, 19682, 19686, 19688, 19696 and 19705 (M 316, 336, 1283, 1284, 1285, 1286, 1335, 1347, 1348, 1349, 1351 and 1352), author's collection, at Cerro Puchenque (locality B.9), Paso del Portezuelo Ancho (B.4) and Arroyo Serrucho (B.8). It was also collected by GULISANO at Arroyo Ñiraico, northern Neuquén province (C.4): MLP 15540, 15547, and by the author at 8 km south of Estancia Santa Isabel (D.1): MLP 16306 (M 1051).

Description: Medium-sized shell, inequilateral. The available specimens are distorted but they seem to have a sub-quadrangular form. The inner margin of the shell is smooth and has a strong internal thickening.

The shell outer surface is covered by commarginal growth-lines and thin, crowded radial riblets on the anterior and posterior portion of the shell. The umbonal ridge is prominent but not sharp. Other characters are unknown.

Measurements: MLP 16305 (figured specimen): L = 32.35 mm; H = 21.90 mm.

Remarks: The specimens here considered are similar to *C. rothi* but they could not be referred undoubtedly to this species because they are badly preserved and could also be compared to *C. meridionalis* TORNQUIST, from the Bajocian of Paso del Espinacito, San Juan province (TORNQUIST 1898: 165, Taf. 7, Fig. 10) and from Arroyo Negro, Mendoza province (JAWORSKI 1925a: 176). JAWORSKI's material occurs at the same locality as the specimen figured here, but at a higher stratigraphical level. More well-preserved material is needed to establish the affinities of these specimens. Whilst *C. rothi* occurs mostly in Pliensbachian beds of southern Neuquén and Chubut provinces, *C.* cf. *rothi* is found mostly in early Toarcian deposits of Mendoza and northern Neuquén.

Cucullaea ? sp.

Plate 1, fig. 19 a–b

Material: MLP 16307 (M 800), an almost complete steinkern from the Toarcian of Arroyo Poti Malal (locality B.12) and MLP 19056 (M 1292), a left valve from the Pliensbachian of Arroyo del Portezuelo Ancho (B.5), southern Mendoza province, author's collection.

Description: Shell of medium size, trapezoidal, the length is larger than the height. The dorsal margin is straight and meets the posterior margin at an obtuse angle. The posterior margin is straight to feebly sinuous. The umbones are high and are placed at ⅓ of the total length from the anterior end. A low umbonal ridge extends from the umbones to the postero-ventral corner of the shell. The hinge characters are unknown, only the central teeth below the umbones are seen and are perpendicular to the hinge-line. The ligamental area is very wide and triangular, judging from the internal mould.

The anterior adductor muscle scar is placed on the antero-dorsal corner of the shell. Both adductor scars are only slightly raised above the inner shell surface. Below the umbones there are several radially arranged muscle scars that could belong to the pedal retractor muscles. The pallial line is entire and the inner margin is smooth. Other characters are unknown.

Measurements: MLP 16307 (figured specimen): L = 61.30 mm; H = 43.60 mm; Dl = Lh = 46.70 mm; Ud = 7.30 mm; W = 22.30 mm.

Remarks: These specimens cannot be referred to any of the previously described species. The generic affinities are uncertain as the hinge and ligamental characters are poorly known. Although the posterior myophoric buttress is not well developed, the specimens are doubtfully referred to *Cucullaea,* but they could also belong to *Grammatodon.*

Order Mytiloida FÉRUSSAC 1822

Subfamily Mytilacea RAFINESQUE 1815

Family Mytilidae RAFINESQUE 1815

The family Mytilidae is known since at least Devonian times. The group includes byssally attached (epifaunal and infaunal) nestling and boring bivalves. The intraspecific morphologic variability has been studied by several authors (see for instance BOETTGER 1930; SOOT-RYEN 1955; LOWENSTAM 1967).

There are several mytiloid species in the south American Jurassic which were traditionally referred to *Mytilus, Modiolus, Volsella* (= *Modiolus*), *Brachidontes* and *Lithodomus* (= *Lithophaga*), but there is no up-date revision of this group. The nomenclature of the early Jurassic species has remained unclear since the publication of R. PHILIPPI (1899) paper.

The presence of *Lithodomus* (?) mentioned by BEHRENDSEN (1891: 386; 1922: 171) from Portezuelo Ancho, Mendoza, could not be verified in collections from the same locality. If this reference corresponds to a mytilid, according to BEHRENDSEN's short description it probably refers to a member of the Lithophaginae.

Measurements of specimens were taken according the indications given by KAUFFMAN (1973).

Subfamily Mytilinae RAFINESQUE 1815

Genus *Lycettia* COX 1937

Type species: *Mytilus lunularis* LYCETT, 1857, from the Middle Jurassic of England, by original designation.
Synonym: *Cuneolus* STEPHENSON 1941 (type species: *Dreissena tippana* CONRAD 1858).

The generic name *Lycettia* was proposed by Cox (1937c) to include several species from the Jurassic of Great Britain that can be distinguished not only by their shape but also by peculiar hinge and ligamental characters (see Cox 1940: 83–85). The generic diagnosis is as follows: "Shell smooth, sickle-shaped, with acutely pointed, terminal umbones and a very sharp carina which runs from the umbo to the postero-ventral corner. Antero-ventral region not at all expanded. Umbonal angle occupied by a septum which is not at all, or very little, depressed below the plane of the valve margins and bears a weak, sub-median, radially disposed tooth. Dorsal margin bordered by a flattened ligamental area, which (except near the umbo) in inclined outwards to a slight extent so as to be subexternal, and bears one or more longitudinal ridges, the most conspicuous of which originates at the umbo, where the area tapers to a point. Location of anterior adductor scar unknown" (COX 1940: 83).

This genus is homoeomorphic with the Dreissenidae (Veneroida, Dreissenacea), but the nacreous structure of the shell indicates affinities to the Mytilidae (see Cox 1937c and in Cox et al. 1969: N273). Cox (1937c) pointed out the external similarities between *Lycettia* species and a widely distributed group of Cretaceous species, such as *Dreissena tippana* CONRAD. A few years later this last species was chosen as type of *Cuneolus* STEPHENSON (1941: 156–157), a name that nowadays is considered a synonym of *Lycettia* by NEWELL (in Cox et al. 1969). If true, the range of *Lycettia* is early Jurassic – late Cretaceous. Jurassic species were nevertheless more abundant, especially during the early Jurassic. According to Cox (1940: 62) *Lycettia* could be a direct descendant from the Myalinidae (with terminal umbones and external ligament) unlike the rest of the mytilids.

This genus has been found in the Jurassic of Europe, India and east Africa. DAMBORENEA et al. (1975) mentioned it for the first time for South America. Its palaeogeographical distribution during Jurassic times is shown on text-fig. 17. An early Jurassic species is described here, and the genus ranges into the Middle Jurassic of western Argentina, including specimens of *Lycettia* cf. *lunularis* (LYCETT), figured here in text-fig. 19.

Lycettia hypertrigona n. sp.

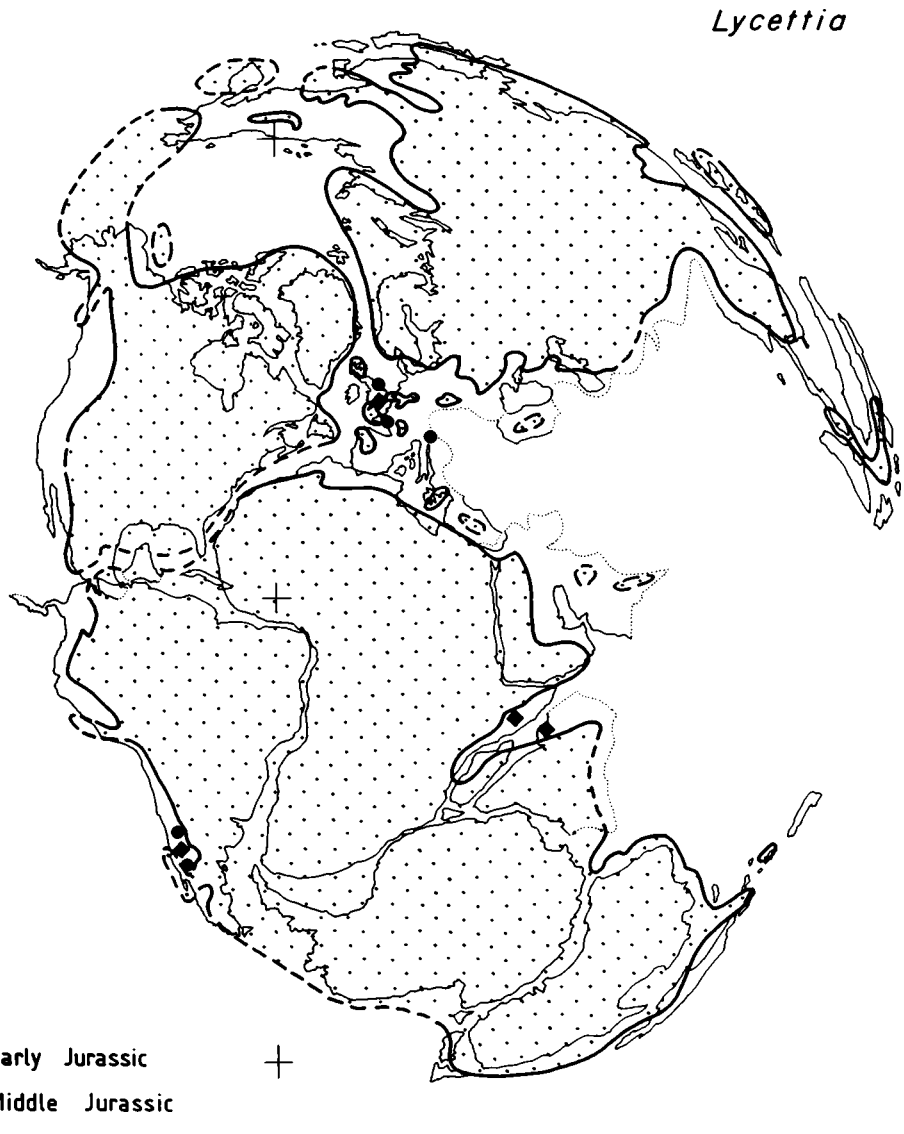
Plate 3, fig. 1–4; text-fig. 18 a–d; 21

v. 1975 *Lycettia* sp. – DAMBORENEA et al., Cuadro 1.
v. 1980 *Lycettia* sp. – DAMBORENEA, p. 8–9.
! v 1982 *Lycettia hipertrigona* n. sp. DAMBORENEA, p. 108–112; lám. 37, fig. 1–4; lám. 56, fig. 1–7 (unavailable name).

Derivation of name: The specific name refers to the triangular shape in lateral view and also in transversal section.

Material: Holotype: MLP 16308 (M 100) figured in pl. 3, fig. 2 a–b, an almost complete shell with slightly disarticulated valves, collected by the author from Pliensbachian beds at the hill south of Cerro Roth, southern Neuquén province (locality D.15).

Paratypes: from Neuquén province: MLP 16309 to 16313 (M 100, 103, 105, 125 and 1050), one almost complete shell, three right valves and two left valves, four internal moulds, some external moulds and fragments, Pliensbachian, author's collection at the following localities: Cerro Roth (D.16), hill south of Cerro Roth (D.15), Cerro Del Vasco (D.12) and 8 km south of Estancia Santa Isabel (D.1). From



Text-fig. 17. Palaeogeographic distribution of the mytilid genus *Lycettia* during the Jurassic. Palaeocontinental reconstruction from SMITH & BRIDEN (1977) for the Early Jurassic, hypothetic coast-lines compiled from various sources.

southern Mendoza province (Arroyo Serrucho, B.8): MLP 19689, 19697 to 19700 and 19706 (M 1349, 1351 and 1352), four almost complete shells, three right valves, one left valve and one external mould of a left valve, Toarcian, author's collection.

Doubtfully included here is an internal mould of a left valve, MLP 16314 (M 437) from the early Toarcian of Arroyo La Laguna, San Juan province (A.2).

Diagnosis: Triangular shell, height equal to length, with terminal umbones and an acute, almost straight ventral carina. Transversal section triangular. Dorsal and posterior margins meet at an angle of slightly more than 90°. Outer surface smooth.

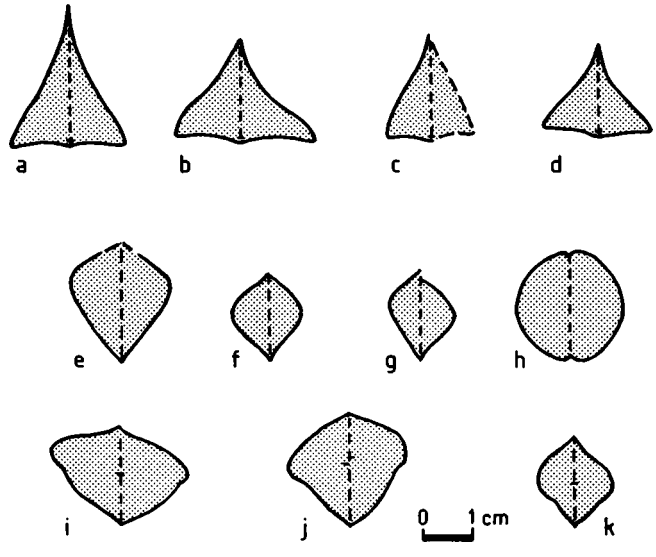
Description: Medium-sized shell, triangular in lateral view, height almost equal to length. The dorsal margin is very long and straight, to feebly convex and meets the posterior margin at a slightly obtuse angle. The posterior margin is also straight to slightly convex in some specimens. The ventral margin is weakly concave and meets the posterior one at a rounded postero-ventral corner.

The prosogyrate umbones are small and are placed at the anterior end of the dorsal margin. A strong and sharp carina extends from the umbones to the postero-ventral corner. It is straight to slightly concave and divides the valve surface in two portions that meet each other at an acute angle. The dorsal part has a convex surface that becomes flat on the postero-dorsal region; the ventral part has a weakly concave surface. The shell's maximum

width is located on the carina at a third of the length from the anterior end. The shell lacks an antero-ventral expansion. In anterior view the shell has a triangular section (see text-fig. 18 a–d).

The presence of dorsal thickening was observed on the internal mould of a right valve. This probably corresponds to the ligamental area. There is one tooth-like structure in the umbonal region of the left valve. Other internal characters are unknown.

The outer surface of the shell is smooth, only some weak irregularly spaced growth lines are present. These growth lines are stronger on the ventral surface of the shell. The shell is thin, becoming thicker only near the dorsal margin and at the carina.



Text-fig. 18. Mytilacean profiles as seen in anterior view, oriented with the carina in a horizontal position. a–d: *Lycettia hypertrigona* n. sp.; a: holotype, MLP 16308; b: paratype, MLP 16309-ab; c: paratype, MLP 16309-f; d: paratype, MLP 16313; a–c from hill south of Cerro Roth, Pliensbachian, d: from 8 km south of Estancia Santa Isabel, Late Pliensbachian (?). e: *Inoperna* sp., MLP 16315, Arroyo La Laguna, Late Pliensbachian. f: *Inoperna* sp. MLP 15837, Aalenian of Lérida, Spain. g: *Inoperna sowerbyana* (D'ORB.), MLP 2809, Mid Jurassic of Great Britain. h: "*Modiola plicata* SOW." from Chile, according to R. PHILIPPI, 1899, lám. 24, fig. 7. i: *Modiolus* (*Gibbomodiola*) *gerthi* n. sp., MLP 16335-ab, 8 km south of Estancia Santa Isabel, late Pliensbachian (?). j–k: *Modiolus* cf. *bipartitus* J. SOWERBY, MLP Bajocian of Chacaico, Neuquén province.

Measurements: Measurements of incomplete specimens are given between brackets. See also scatter diagram on text-fig. 21.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	L/W	Dl (mm)
MLP 16308, holotype	LV	S	(41.65)	(38.60)	13.00	(1.07)	(3.20)	36.45
MLP 16309-b, paratype	LV	S	(44.45)	(38.85)	14.30	(1.14)	(3.10)	–
MLP 16311, paratype	RV	IM	28.85	26.15	8.75	1.10	3.29	(21.40)
MLP 16313, paratype	LV	IM	(37.50)	(26.80)	10.30	(1.39)	3.64	25.00

Affinities: One of the characters that is common to all species of *Lycettia* is their great intraspecific variation in shell outline. This is clearly evident in the species described here; comparison with poorly known species is therefore difficult.

In its triangular shape, with the height nearly equal to the length, this species resembles the early Jurassic "*Mytilus*" *bittneri* TAUSCH (1890: 15, pl. 7, fig. 17 a–d) from the Italian Tyrol. But *L. hypertrigona* can be distinguished by its more acute postero-dorsal angle and by having its maximum width more anteriorly placed. This Italian species was regarded by Cox (1937c: 343) as a *Falcimytilus,* together with other mytilid species described by TAUSCH in that paper. Nevertheless, it is thought that it could be a *Lycettia* species.

L. hypertrigona differs from *L. aviothensis* (BUV.) from the middle Early Jurassic of France and England (TATE 1876: 376–377; COX 1937c: 347–348, pl. 17, fig. 1); *L. lunularis* (LYCETT) from the Aalenian–Bajocian of England (LYCETT 1857: 128; COX 1937c: 346, pl. 17, fig. 4–6). *L.* cf. *lunularis* (LYCETT) from the Middle Jurassic of Argentina (text-fig. 19 here) and *L. indica* COX (1940: 85–86, pl. 5, fig. 19–20) from the Jurassic of India, by its more triangular outline and its more acute postero-dorsal and postero-ventral angles.

An unidentified specimen from Kenya housed at the BMNH probably belonging to *L. dalpiazi* VENZO shows a rounded postero-dorsal angle of the shell.

Autecology: Following STANLEY's (1972) arguments, this species represents an extreme of epifaunal adaptation within the Mytilidae. The shell is triangular in lateral view, the ventral margin is flat or even slightly concave and there is no anterior expansion of the shell. As shown by SEILACHER (1984) all these features provide stability either to byssally attached bivalves that live on hard substrates in very high

energy environments, or to edgewise recliners on soft substrates. The best preserved specimens of the two Argentine species were found within thicker and larger shells of other bivalves: the early Jurassic ones within *Myoconcha* shells and the middle Jurassic ones within astartid shells. These large shells were possibly the hard substrate to the *Lycettia* species. The shell of the Argentine *Lycettia* species is not thickened ventrally, as in other secondary soft bottom dwelling mytiloids (see *Falcimytilus*).

A common feature to all *Lycettia* species is that they are generally represented by very few specimens, which also points to a high energy habitat.

Text-fig. 19. *Lycettia* cf. *lunularis* (LYCETT), MLP 19091, early Bajocian of Paso del Carro Quebrado, Neuquén province. a: left valve; b: dorsal view; c: ventral view. Natural size.

Subfamily Lithophaginae ADAMS & ADAMS 1857

Genus *Inoperna* CONRAD in KERR 1875

Type species: *Modiolus* (*Inoperna*) *carolinensis* CONRAD 1875, from the Late Cretaceous of Texas (United States), subsequent designation by STEPHENSON 1923.

Synonym: *Pharomytilus* ROLLIER 1914 (type species: *Mytilus plicatus* J. SOWERBY 1819) (fide COX 1940).

This genus, ranging from the early Jurassic to the late Cretaceous, is characterized by an ensiform shape, elongate and slightly curved outline, with the ventral margin almost parallel to the hinge line. The anterior margin projects in front of the umbones. A diagonal ridge divides the shell surface in two regions, the dorsal one with oblique folds parallel to the growth lines and the ventral one smooth, only covered by faint growth lines.

The affinities of *Inoperna* with other bivalve groups are not well established. CONRAD originally related it to *Inoceramus* (fide COX 1940), whilst WADE (1926), POPENOE (1937), DAY (1967) and others, regarded it as a quite separate genus. Nowadays it is considered a member of the Lithophaginae (SOOT-RYEN in COX et al. 1969).

The scope of the genus has also changed considerably according to different authors. Some, like FRENEIX (1965) and PALMER (1973) interpreted it broadly to include species such as *M. scalprum* SOW. Others prefer to restrict it to species with dorsal folds and a diagonal ridge. The palaeogeographical distribution of this genus during the Jurassic is depicted on text-fig. 20.

The origin of this peculiar bivalve could possibly be found among some elongated and narrow species of *Modiolus* that have a diagonal ridge, such as *Modiolus* n. sp. (in TRAUTH 1909: 105, Taf. 3, Fig. 20 a–b) from the Hettangian – Pliensbachian of the Austrian pre-Alps, instead of *Modiolus scalprum* J. SOW. as was traditionally considered up to now (COX 1940; FRENEIX 1965: 95).

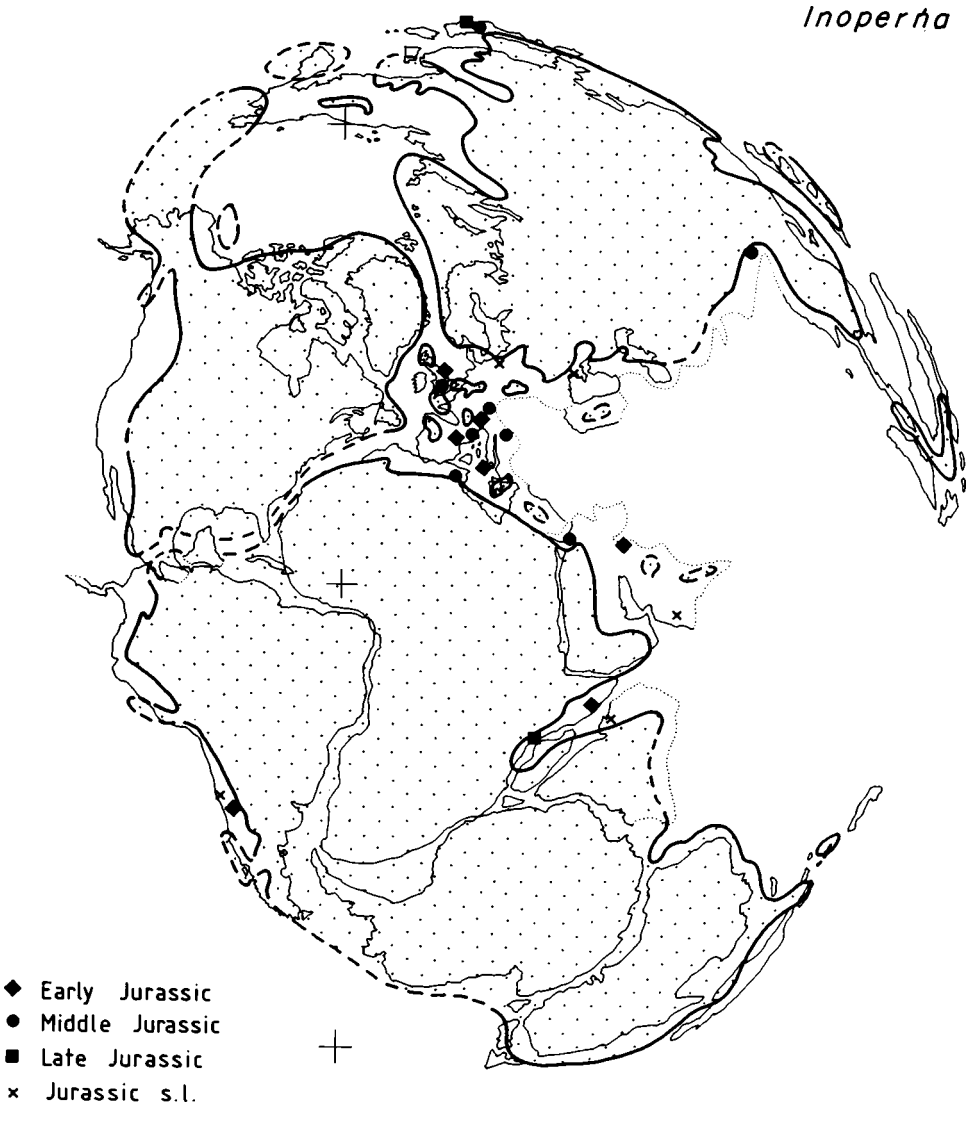
The following description is the first one of an Argentine *Inoperna.* This record is one of the oldest for the genus.

Inoperna sp.

Plate 4, fig. 1; text-fig. 18e

v 1978a *Inoperna* sp. – DAMBORENEA in VOLKHEIMER et al., Tab. 2.
v 1982 *Inoperna* sp. – DAMBORENEA, p. 113–116; lám. 37, fig. 5; lám. 57, fig. 12.

Material: MLP 16315 (M 429), one incomplete left valve and its external mould, author's collection from the late Pliensbachian of southern San Juan province (Arroyo La Laguna, locality A.2).



Text-fig. 20. Palaeogeographic distribution of the genus *Inoperna* during the Jurassic. Palaeocontinental reconstruction from SMITH & BRIDEN (1977) for the early Jurassic, hypothetic coast-lines compiled from various sources.

Description: Medium to large shell, long and narrow, slightly arched and sub-rectangular in outline. The available specimen is not complete, lacking the anterior end and part of the dorsal region. The dorsal and ventral margins appear to be subparallel. The maximum shell width is located dorsally (see text-fig. 18–e) on the posterior half of the shell.

The umbones are anteriorly placed but not terminal. A low, curved carina extends from the umbones to the postero-ventral region of the shell and divides the shell surface in two parts. The dorsal one has very regular folds, parallel to the growth-lines, with slightly wider interspaces. The folds become weaker towards the carina. On the carina and on the ventral region of the shell the folds disappear and the shell is covered by commarginal growth-lines, somewhat irregularly spaced with thin vertical striae similar to those of *Lithophaga* RÖDING and of some *Inoperna* specimens, for instance *I. perplicata* (ET.) in COX (1965: 39, pl. 3, fig. 14).

Measurements: Of the incomplete specimen: L = 90 mm; H = 22.6 mm; W = 11 mm.

Affinities: The comparison with other species is difficult because the only available specimen is not complete. Nevertheless it shows strong affinities to the Toarcian to Callovian species *I. sowerbyana* (D'ORBIGNY) (= *Modiola plicata* J. SOWERBY 1819, non *Mytilus plicatus* GMELIN 1791). This is a widely distributed and very variable species needing revision. Forms referable to *I. sowerbyana* (D'ORBIGNY) are known to occur in the Toarcian to

Callovian of Great Britain (Morris & Lycett 1853; Phillips 1871; Richardson 1904; Cox & Arkell 1948; Pojeta & Palmer 1976; and others), in the Toarcian to Bathonian of France (Dumortier 1874; Cossmann 1900; Dubar 1925; Lanquine 1929; Charles 1948; Freneix et al. 1956; Fischer 1964, 1969), in the late Bajocian of Switzerland (Greppin 1899); in the Aalenian of Lérida, Spain (Dalloni 1930), in the Aalenian of southeast Germany (Quenstedt 1858), in the Bathonian of Hungary (Vörös 1971), in the Toarcian to Callovian of east Africa (Fütterer 1897; Cox 1965), in the early to middle Callovian of Tunisia (Freneix 1965), in the Bajocian of Israel (Parnes 1981), in the Toarcian (Fantini-Sestini 1966) and Bajocian (Cox 1936a) of Iran, in the Bathonian to Callovian of Kutch, India (Cox 1940) and in the Middle Jurassic of China (Zhang et al. 1979, Chen 1982) and Japan (Hayami 1975). Figures of early Jurassic specimens are few and the Argentine specimen differs from the fragments figured by Cox (1965, pl. 3, fig. 10, 11) from the Toarcian of Didimtu Hills, Kenya, in its different arrangement of the dorsal folds near the carina. It can also be distinguished from the specimen figured by Fantini-Sestini (1966, pl. 56, fig. 10 a–b) from the Toarcian of northern Iran by its lower carina. The strongest affinities of the specimen here described lie with Dumortier's (1874, pl. 40, fig. 12) material from the late Early Jurassic of the Rhone basin, although the last one has fewer dorsal folds.

The general outline and size of the specimens here described are similar to the following figured specimens of *I. sowerbyana*: Fischer's (1969, pl. 10, fig. 7) from the Bathonian of Rumigny, France; and Pojeta & Palmer's (1976, fig. 3 E–F) and Richardson's (1904, pl. 18, fig. 6) from the early Bajocian of Cheltenham, England. It is also similar to specimen MLP 2809 from the English Middle Jurassic.

The Chilean specimen figured by R. Philippi (1899, lám. 24, fig. 7; text-fig. 18–h herein) as *Modiola plicata* Sow. has a different transversal section and type of commarginal ornamentation.

Greco's (1894) species "*Modiola elegans*" from the early Jurassic of Calabria, Italy, has a smaller, shorter and more curved shell than the Argentine specimen.

Remarks: The only previous record of a South American *Inoperna* could be the fragment of unknown geographic or stratigraphic occurrence figured by R. Philippi (1899, lám. 24, fig. 7) as "*Modiola plicata* Sow.". Nevertheless, his drawing does not allow a definite opinion about this specimen. It could also belong to another mytiloid species (such as, for instance, *Modiolus* cf. *thiollierei* here described).

Autecology: *Inoperna* is now regarded as a member of the Lithophaginae, a subfamily that includes boring mytilids. Palmer (in Pojeta & Palmer 1976) observed specimens of *Inoperna* in semi-infaunal life position in calcareous mudstones (biomicrites). The Argentine specimen was also found in calcareous mudstones, but not in life position. These organisms could have been adapted to bore in fine-grained, semi-consolidated rocks, such as some pholadid species and some lithophagines like *Adula* (Soot-Ryen 1955; Yonge 1955) do nowadays. A feature in common with extant boring species is the vertical striation of the shell (see for instance Soot-Ryen 1955, pl. 89, pl. 9, fig. 49). The function of the striae, which are only found in some lithophagines, is not yet known, and it would be important to find possible relationships to the boring mechanism used by these bivalves (see Yonge 1955). It is thought that the boring habit of some lithophagines was probably preceded by a "nestling" stage and that the posterior elongation of the shell allowed the development of proper boring mechanisms, as the bivalve could then penetrate the rock with its anterior end forward (see also Pojeta & Palmer 1976).

Subfamily Modiolinae Keen 1958

? Genus *Falcimytilus* Cox 1937

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

Cox (1937c: 343) applied the name *Falcimytilus* to a group of Jurassic mytilid species characterized by a smooth, sickle-shaped shell, with terminal and pointed beaks and a curved carina. The antero-ventral region of the shell is expanded; the ligament extends along about $^4/_5$ of the dorsal margin and is supported by a shell thickening; the hinge is without teeth. Cox (1937c) discussed the affinities of this taxon, which he originally regarded as a subgenus of *Mytilus* on the basis of beak position and ligamental characters. Cox maintained this opinion in all subsequent papers, but Soot-Ryen (1955: 6; and in Cox et al. 1969) argued that the edentulous hinge is an important character and he gave *Falcimytilus* a generic status within the Modiolinae. Several Jurassic species were ascribed to this genus, which also has a wide geographic range. Kobayashi & Ichikawa (1950a) included in *Falcimytilus* some late Triassic mytilids from Japan.

Falcimytilus ? gigantoides (A. LEANZA 1942)

Plate 3, fig. 5-7; text-fig. 21, 22

*! v 1942b *Modiolus gigantoides* n. sp. A. LEANZA, p. 182-183; lám. 11, fig. 3.
v p 1975 *Modiolus* - DAMBORENEA et al., Cuadro 1.
v 1975 *Modiolus gigantoides* LEANZA - CAMACHO & RICCARDI, Cuadro 1.
v 1982 *Falcimytilus ? gigantoides* (A. LEANZA) - DAMBORENEA, p. 116-120; lám. 37, fig. 9-15; lám. 38, fig. A, B1-8; lám. 56, fig. 11-15.

Type material: Lectotype (here designated): MLP 6092, A. LEANZA's only figured specimen. Paralectotypes: MLP 6091 and 6093, two almost complete shells. LEANZA's original set was collected by FRENGUELLI from Pliensbachian beds at Cerro Roth, southern Neuquén province (locality D.16).

Additional material: This species was only found in Pliensbachian deposits of the Piedra Pintada region, southern Neuquén, at the following localities: Salitral Grande (D.3), north of Sañicó (D.5), Cerro Roth (D.16) and hill south of Cerro Roth (D.15). The material collected by the author consists of 21 complete shells, 17 right valves and 19 left valves: MLP 16316 to 16332 (M 94, 100, 101, 103, 104, 143, 1036 and 1042). One specimen (MLP 16333) was collected by FERNÁNDEZ.

Description: Medium-sized shell, sub-triangular to sickle-shaped, very variable outline, height almost equal to length, equivalve. The shell is very thick in full-grown specimens. The dorsal margin is straight to slightly convex; it extends more than half the total shell length and merges into the evenly convex posterior margin. The ventral margin is straight to concave. The anterior margin is very short and convex, the anterior portion of the shell is very small. A curved low ridge extends from the umbones to the postero-ventral corner. The angle between the hinge axis and the tangent to the umbonal ridge at the valve margin (δ) varies between 66° and 98°; the shell is prosocline to exceptionally opistocline. In front of the umbonal ridge there is a slight sulcus parallel to it that reaches the ventral margin at the point of its greatest concavity. The umbones are terminal, prosogyrous and low. In large specimens the beaks curve forwards and outwards, further away from the commissure plane. The anterior region of the shell is very small and only develops on fully-grown specimens. The shell's maximum width is ventrally placed (see text-fig. 22b) on the anterior half of the shell.

The hinge is edentulous. The internal ligament is placed on a sulcus parallel to the dorsal margin. This sulcus is supported by a thin ridge that extends from the umbones almost to the end of the dorsal margin, where it curves upwards. The shell has another oblique dorsal internal ridge, very clear on all internal moulds (see pl. 3, fig. 6b). Other internal characters are unknown.

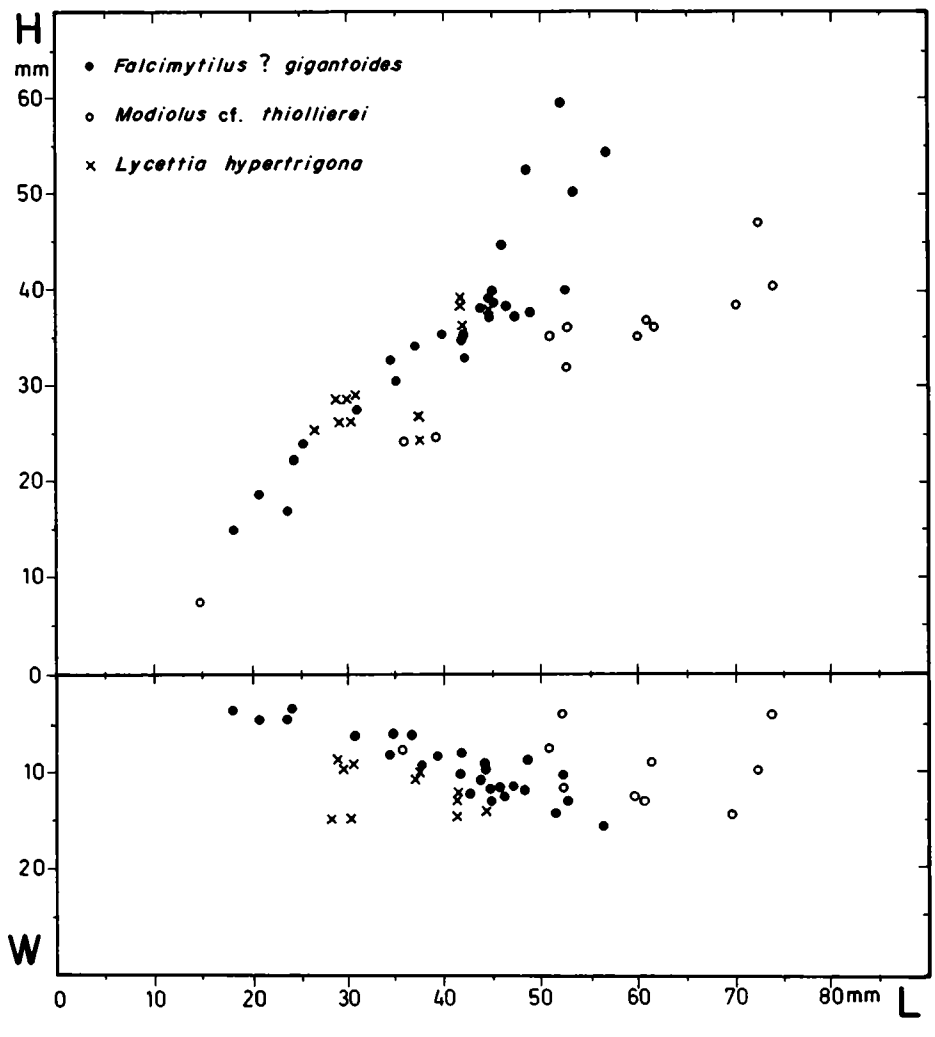
The outer surface of the shell has irregularly spaced growth-lines, which locally become crowded causing the development of low steps on the shell surface. Although there is no byssal gape, the point of greatest concavity along the ventral margin probably corresponds to the place where the byssus emerged from the shell.

Allometric variations comprise the increase of the angle δ, the change from prosocline to acline or even opistocline shells, the increase in ridge and ventral margin concavities, the increase in shell thickness and the already mentioned separation of the umbones from the commissure plane. The first two mentioned tendencies were already exemplified by NEWELL (1942, fig. 17) and quoted by STANLEY (1972, fig. 13) and by NEWELL & BOYD (1978, fig. 2) in a Palaeozoic myalinid species.

Measurements: When both valves are preserved, only the measurements of the most complete valve are given. See also scatter diagram on text-fig. 21.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	Dl (mm)	δ
MLP 6092, lectotype	LV	S	56.65	54.45	16.00	1.04	36.60	89°
MLP 6091, paralectotype	LV	S	44.65	37.40	13.00	1.19	32.40	-
MLP 16319, pl. 3, fig. 7	LV	S	44.80	38.95	12.30	1.15	32.40	-
MLP 16323, pl. 3, fig. 5	LV	S	51.85	59.90	14.40	0.86	36.05	98°
MLP 16325, text-fig. 22-4	LV	S	44.45	39.25	10.00	1.13	28.05	70°
MLP 16327, text-fig. 22-6	LV	S	53.20	50.50	13.60	1.05	35.70	81°
MLP 16331-ab, text-fig. 22-3	LV	S	38.50	32.50	9.70	1.17	29.55	68°

Affinities: As pointed out by A. LEANZA (1942b), *Modiolus giganteus* QUENSTEDT, from the late Bajocian of Germany (QUENSTEDT 1858: 439), Switzerland (see GREPPIN 1899: 105, pl. 11, fig. 4; 1900, pl. 14, fig. 1-2) and Israel (PARNES 1981: 29, pl. 3, fig. 36) has a great superficial resemblance to *F. ? gigantoides,* but in the European species



Text-fig. 21 Scatter diagrams showing the length / height (L / H) and length / width (L / W) ratios of *Lycettia hypertrigona* n. sp., *Falcimytilus* ? *gigantoides* (A. LEANZA) and *Modiolus* cf. *thiollierei* (DUMORTIER).

the anterior portion of the shell is better developed and the umbones are therefore not terminal. MÖRICKE (1894: 42) referred Chilean Mid Jurassic specimens to QUENSTEDT's species.

F. mirabilis (LEPSIUS 1878) (non *Mytilus mirabilis* TRECHMANN 1918) from the Lower Jurassic of the Italian Alps is similar to the species here described. As can be judged from TAUSCH's figures (1890, pl. 7, fig. 15–16) of LEPSIUS' original material, this species differs from *F.* ? *gigantoides* in having a sharper carina and a more inflated shell. KRUMBECK (1923: 82–87, pl. 174, fig. 1–13) described *F. mirabilis timorensis* and recognized seven morphologic variants of this subspecies in the Lower Jurassic of Timor. Undoubtedly this subspecies shows the greatest affinities to the Argentine material and they could even be conspecific, although the anterior region seems to be less developed in the Indopacific specimens. HOFFET (1933: 99) also mentioned this species from the Lower Jurassic of Indochina.

Mytiloids with a sickle-shaped shell and an acute umbonal ridge are already known in the late Triassic, for instance *Modiolus speciosus* MERLA (HUDSON & JEFFERIES 1961, text-fig. 4 b–c), that can be distinguished from *F.* ? *gigantoides* by its more elongated shell and non-terminal umbones.

The Chilean species *Mytilus lepidus* PHILIPPI from Doña Ana (R. PHILIPPI 1899: 46, lám. 24, fig. 2), probably a *Falcimytilus,* is very similar to young specimens of *F.* ? *gigantoides,* but differs in its better defined postero-dorsal angle and by the maximum width being placed at the middle of the shell length.

The type species, *F. suprajurensis* (COX) (COX 1937 c: 344, pl. 17, fig. 1–3; KELLY 1984: 34, pl. 4, fig. 11–14) from the Kimmeridgian and Portlandian of Great Britain, Greenland and the USSR, has an acute umbonal ridge and a smaller antero-ventral expansion. Also *F. whitei* (WHITFIELD 1880: 360, pl. 5, fig. 10–12; USNM 12312) from

the Middle Jurassic of the United States, has a smaller antero-ventral expansion but is nevertheless similar to young specimens of *F.* ? *gigantoides.*

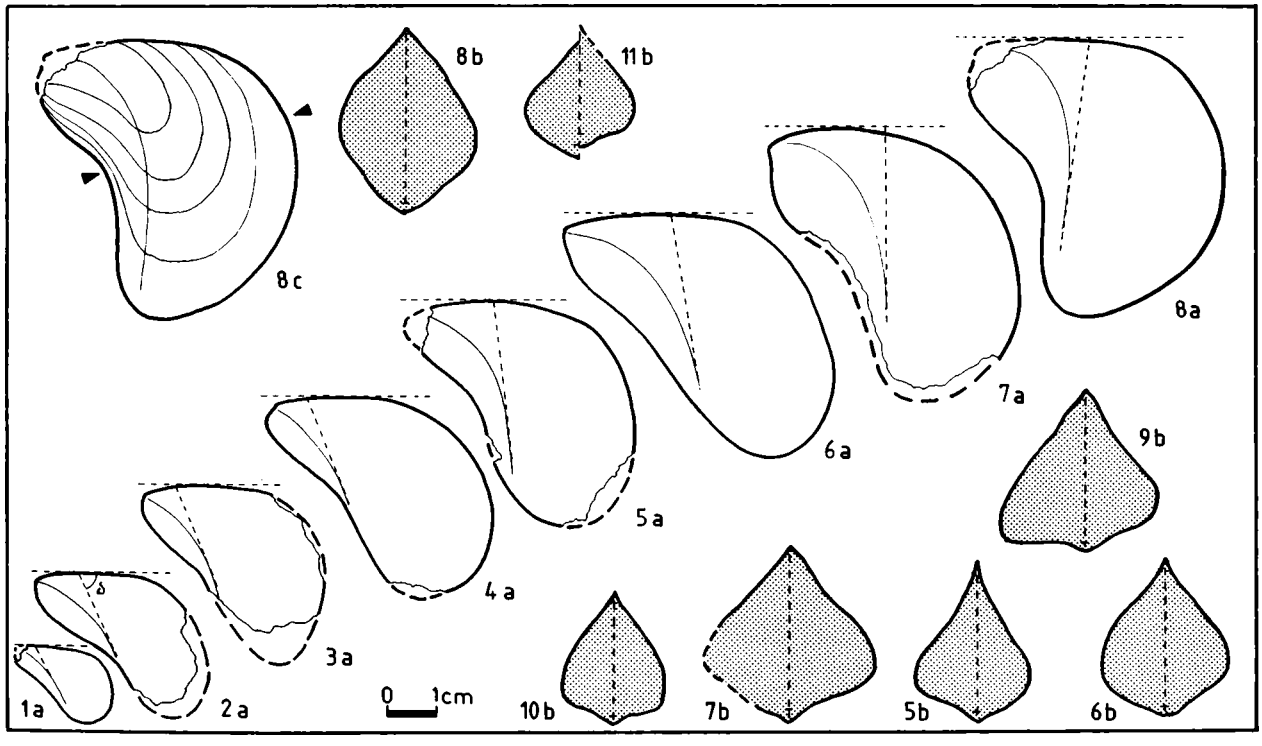
F. cf. *stricapillatus* (HAYAMI) figured by ALENCASTER DE CSERNA (1963: 19–20, lám. 1, fig. 7–9) from the Middle Jurassic of Mexico, has a straight ventral margin, lacks the anterior expansion of the shell and has radial striae on the outer shell surface.

In lateral view *F.* ? *gigantoides* is also similar to *F. tumidus* (MORRIS & LYCETT) (1853: 37, pl. 4, fig. 5; COX & ARKELL 1948: 5) from the British Bathonian, but this has a more inflated shell; and to *M. chartroni* COSSMANN (1904: 512, pl. 17, fig. 3–4) from the lowest Jurassic of Vendée, France, but this species has a narrower anterior region of the shell and lacks umbonal carinae.

Other *Falcimytilus* species, such as *F. tifoensis* (COX) and *F. dietrichi* (COX) from the Late Jurassic of east Africa (COX 1965) and Germany (YAMANI 1982); *F. jurensis* (ROEM.) from the Late Jurassic of Europe and Africa (COX 1935, pl. 15, fig. 15–17; FRENEIX 1965: 48); *F.* cf. *dietrichi* (COX) from the Middle Jurassic of China (ZHANG et al. 1979) and *F.* sp. from the Bajocian of Australia (SKWARKO 1974: 20) do not have an anterior expansion.

F. ? *gigantoides* differs from *Modiolus* cf. *thiollierei* (DUM.), which will be described below, because the latter is more elongated and subrectangular in outline, with a δ angle always below 60° and no terminal beaks. *Modiolus gerthi* n. sp., also from the Argentine Early Jurassic, has a short shell clearly divided in two regions by an umbonal ridge and a parallel sulcus.

Remarks: This species, as is characteristic of all epifaunal mytilids, has a great deal of morphological variation in shell outline and general shape. Some of these variations can be correlated with allometric changes but others cannot be explained in this way. Several morphotypes could be distinguished and, with more material, an analysis of their geographical and stratigraphical distribution could probably throw some light on the interpretation of the causes of this enormous variability.



Text-fig. 22. *Falcimytilus* ? *gigantoides* (A. LEANZA). 1a–8a: inferred ontogenetic series, all specimens from Piedra Pintada area, Neuquén province, showing an increase in the value of the angle δ, in the curvature of the umbonal ridge and in the concavity of the ventral margin with the size increase. 8c: an almost complete specimen showing the trace of some of the growth-lines. 1: MLP 16330-z; 2: MLP 16333-ab; 3: MLP 16331-ab; 4: MLP 16325; 5: MLP 16321-ab; 6: MLP 16327; 7: MLP 6092, lectotype; 8: MLP 16323; 9: MLP 6093, paralectotype; 10: MLP 16319; 11: MLP 6091, paralectotype.

Autecology: All observed morphological characters indicate a byssally attached epifaunal mode of life for this species, on hard or semi-hard substrates (cf. STANLEY 1970, 1972). The arched shape would help, in STANLEY's opinion, for attachment to curved surfaces, including also other mytilid shells, as was observed in several extant species that live in tightly crowded groups, such as *Brachidontes recurvus* RAFINESQUE (STANLEY 1970: 27; 1972: 171) and *Mytilus galloprovincialis* L. (BOETTGER 1930; LOWENSTAM 1967). An alternative hypothesis was recently proposed by SEILACHER (1984), who considers *"Mytilus" mirabilis,* here referred to *Falcimytilus,* as a secondary soft-bottom dweller, stabilized by differential shell-thickening and its triangular cross-section. However, in the Argentine specimen the shell is thinner and the cross-section is rhombic.

Genus *Modiolus* LAMARCK 1799

Type species: *Mytilus modiolus* LINNÉ 1758, Recent of Europe; subsequent designation by GRAY 1847, by absolute tautonymy.

Synonyms: *Volsella* SCOPOLI 1777 (rejected by ICZN Opinion 325, 1955).
Modiola LAMARCK 1881 (unjustified emendation of *Modiolus).*
Perna ADAMS & ADAMS 1858, non PHILIPPSON [RETZIUS] 1788 (see Vokes 1967: 156) (Bivalvia, Mytilidae) nec BRUGUIÈRE 1972, (Bivalvia, Isognomonidae), nec OKEN 1815 (Bivalvia, Mytilidae, rejected by ICZN Opinion 417).
Eumodiolus IHERING 1900 (objective synonym).
Nudiola MONTEROSATO 1917 (type species: *Modiola adriatica* LAMARCK, 1819).

Species referred to *Modiolus* are known since the Devonian and they are the oldest mytilids recorded. Several subgeneric taxa have only been recognized among Tertiary and Recent *Modiolus,* but this has not yet been attempted for older species, although there are important morphologic variations and several species-groups can be distinguished. COX (1937c: 341, and 1940: 63) discussed the affinities between *Modiolus* and other mytilids.

The nomenclature of South American early Jurassic bivalves referred to *Modiolus* is complex and deserves a detailed analysis. BAYLE & COQUAND (1851) described and figured a mytilid from Tres Cruces (Chile) as *Mytilus scalprum* GOLDFUSS (p. 15–16, pl. 7, fig. 3–4), a homonym of *Modiolus scalprum* SOWERBY. Later MÖRICKE (1894: 89) recorded this species in a table as "*Mytilus* cf. *scalprum* GOLD.". BAYLE & COQUAND's illustration was later copied by R. PHILIPPI (1899, lám. 24, fig. 8), who also reproduced on his own lám. 24, fig. 14, GOLDFUSS' (1837, Taf. 30, Fig. 9) figure of *Modiolus scalprum,* concluding that the specimens were not conspecific. He then named BAYLE & COQUAND's material *Modiola baylei* PHILIPPI, although he also included it in the synonymy list of *Modiola andina* PHILIPPI. Furthermore, *M. baylei* as figured by BAYLE & COQUAND (1851, pl. 7, fig. 3–4) and PHILIPPI (1899, lám. 24, fig. 8) is very similar to *M. andina* (see PHILIPPI, 1899, lám. 24, fig. 3) and *M. coquandi* PHILIPPI (1899, lám. 24, fig. 5) said (PHILIPPI 1899: 45) to be identical to *M. andina* differs from this species as figured by him on his lám. 24, fig. 3 and resembles *M. andina* var. (PHILIPPI 1899, lám. 24, fig. 12). As the stratigraphic location of PHILIPPI's material is not precise, the confusion surrounding the definition of several of his species could only be settled after a detailed study of the original and topotypic material. Chilean authors use the names "*Modiola*" *baylei,* "*M.*" *andina* and "*M.*" *scalprum* as three different species that coexisted in the early Jurassic of Cordillera de Doña Ana (see for instance THIELE 1964; PÉREZ & REYES 1977).

The first description and illustration of an Argentine, early Jurassic mytilid was made of a specimen from Piedra Pintada identified by BURCKHARDT (1902: 245, pl. 4, fig. 9) as "*Mytilus scalprum* BAYLE & COQUAND". Later JAWORSKI (1915: 419 = 1925 b: 66–67) described "*Modiola hillana* SOW." from an undetermined level at Arroyo Blanco, rio Atuel (probably early Jurassic ?). WEAVER (1931: 299) and LEANZA (1942b: 181–182, lám. 12, fig. 4) record again *Modiolus scalprum* SOW. from Piedra Pintada, but they do not include BAYLE & COQUAND's or BURCKHARDT's records in their synonymy lists.

This matter was further complicated by nomenclatorial problems surrounding *M. scalprum* in Europe. J. SOWERBY (1818) described a new species from the Middle Jurassic of Great Britain as *Modiola cuneata* (J. SOWERBY 1818: 19, pl. 211, fig. 1). In the same work but in a part that was published a year later, this author described as *Modiola cuneata* other species from the early Jurassic of England (J. SOWERBY 1819: 87, pl. 248, fig. 2), but he noticed the homonymy and in the errata of the same volume (1821) replaced the junior name by *Modiola scalpra* J. SOWERBY. Some years later GOLDFUSS, describing another Hettangian to Sinemurian species from central Europe, chose the name *Mytilus scalprum* GOLDFUSS (1837: 165, Taf. 130, fig. 9). As SOWERBY's name had been combined with *Mytilus* by TERQUEM (1855: 310), OPPEL proposed the name *Mytilus morrisi* OPPEL (1856: 99) to replace the secondary homonym *M. scalprum* GOLDFUSS 1837 non SOWERBY 1821 (fide TRAUTH 1909). Unfortunately the name *Mytilus morrisii* had already been used by SHARPE (1850: 187, pl. 22, fig. 5) for an *Arcomytilus* from the late Jurassic

of Portugal and a new homonymy was thus produced. This was noticed by TIETZE in 1872 who proposed the name, *Modiola neumayri* to replace *M. morrisi* OPPEL 1856 (= *M. scalprum* GOLDFUSS) non *M. morrisii* SHARPE 1850 (fide NEUMAYR 1879; TRAUTH 1909 and JEKELIUS 1915). In view of this situation it is possible that BAYLE & COQUAND and also BURCKHARDT, referred to GOLDFUSS' species, whilst WEAVER and LEANZA alluded to SOWERBY's.

From the analysis of the available material and a careful study of the references, all previous records are included here in three different species, namely *Modiolus baylei* R. PHILIPPI, *Modiolus* cf. *thiollierei* (DUM.) and a new species.

Modiolus cf. *thiollierei* (DUMORTIER 1869)

Plate 3, fig. 8–13; text-fig. 21, 23

cf.	1869	*Mytilus Thiollierei* (nov. spec.) DUMORTIER, p. 284–285; pl. 34, fig. 5–6.
?	1876	*Modiola Thiollierei* DUMORTIER – TATE, p. 378.
?	1899	*Modiola plicata* SOW. – R. PHILIPPI, lám. 24, fig. 7.
v.	1915	*Modiola hillana* SOW. – JAWORSKI, p. 419.
v.	1925 b	*Modiola hillana* SOW. – JAWORSKI, p. 66–67.
cf.	1929	*Modiola Thiollierei* DUM. – LANQUINE, p. 130; pl. 3, fig. 1.
?	1931	*Modiola scalpra* SOWERBY – WEAVER, p. 299.
?	1942 a	*Vulsella* (?) sp. – A. LEANZA, p. 29.
v.	1942 b	*Modiolus scalprus* SOW. – A. LEANZA, p. 181–182; lám. 12, fig. 4.
v p.	1975	*Modiolus* – DAMBORENEA et al., Cuadro 1.
v.	1978	*Modiolus scalprus* SOWERBY – CAMACHO & RICCARDI, cuadro 1.
?	1981	*Modiolus* cf. *scalprus* (SOW.) – HILLEBRANDT & SCHMIDT-EFFING, p. 10.
v.	1982	*Modiolus* cf. *thiollierei* (DUMORTIER) – DAMBORENEA, p. 126–129; lám. 37, fig. 16–20; lám. 39, fig. A, B 1–7; lám. 57, fig. 1–11.

Material: MLP 6090: an internal mould of a left valve described by A. LEANZA (1942 b) from the Pliensbachian of Cañadón de Los Chilenos (locality D.4), southern Neuquén province. MLP 6128, two specimens collected by A. LEANZA at Cerro Roth (D.16) but not included in his description.

The author's collection consists of eight complete shells, four right valves, six left valves, three steinkerns and some external moulds of isolated valves, from Pliensbachian beds of southern Neuquén (Cerro Del Vasco, hill south of Cerro Roth and Cerro Roth) and Mendoza (Arroyo Serrucho, Cerro Puchenque) and also lower Toarcian beds of southern Mendoza (Cerro Puchenque, Cerro Tricolor): MLP 15834, 16336 to 16348, 19631, 19671, 19674, 19676, 19678, 19721 (M 94, 99, 101, 121, 122, 125?, 324, 325, 331, 332, 806, 1310, 1334, 1335, 1336, 1342, 1343, 1383). Also one internal mould (MLP 16349) collected by GULISANO from the Toarcian of Arroyo Ñiraico, northern Neuquén (C.4) and one right valve (MLP 19090 = DNGM 8450) collected by KEIDEL and described by JAWORSKI (1925 b: 66–67) from the Pliensbachian of Rio Atuel, Mendoza province (B.1).

Description: Shell medium to large, equivalve, very elongated and trapezoidal in outline. The dorsal margin is straight and as long as half of the total shell length. The posterior margin is evenly convex and meets the dorsal margin at a very obtuse angle and the ventral one without interruption. The ventral margin is straight to slightly concave and the anterior margin is short and convex.

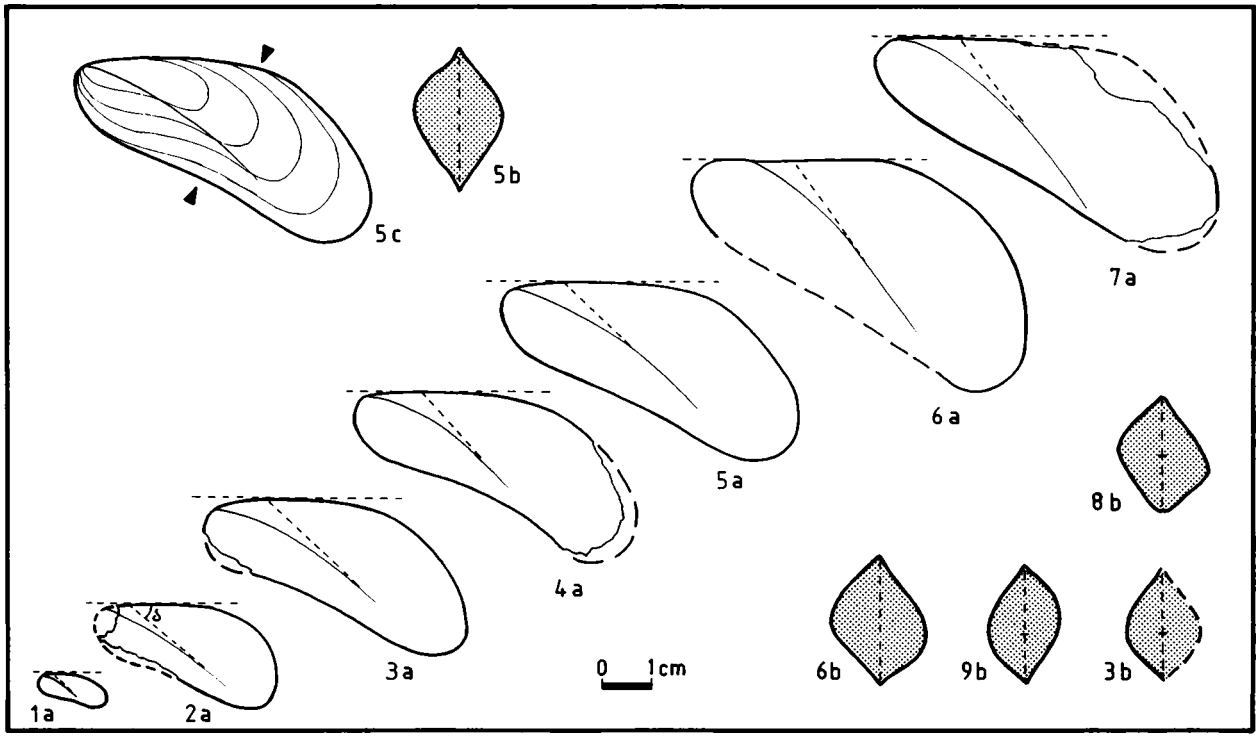
The umbones are very low and prosogyrous but not terminal. The shell is laterally compressed, with the maximum width placed at mid-length. In anterior view the shell outline is rhombic (see text-fig. 23 b), with the maximum width located at approximately mid-height.

From the umbones to the postero-ventral end, a low curved ridge divides the shell surface in two regions. The angle δ between the hinge axis and the tangent to the umbonal ridge at the valve margin varies from 34° to 54°. The muscle scar and ligamental characters are unknown. The shell has an internal dorsal elongated thickening that runs approximately parallel to the dorsal margin and is slightly shorter than it. The outer surface of the shell has regularly spaced growth lines, somewhat stronger on the dorsal region of the shell and imbricated towards the dorsal region.

This species shows an increase in the δ angle as the shell grows (see text-fig. 23), but it never reaches 60°.

Measurements: In bivalved specimens only the measurements of the best preserved valve are given. See also scatter diagram on text-fig. 21.

Specimen	Material	L (mm)	H (mm)	W (mm)	L/H	Dl (mm)	δ
MLP 6090, pl. 3, fig. 11	LV IM	51.15	35.05	7.85	1.45	40.80	–
MLP 16340, pl. 3, fig. 9	BV S	59.75	35.20	12.85	1.69	39.65	–
MLP 16341, pl. 3, fig. 13	BV S	61.60	36.15	9.00	1.70	40.20	44°
MLP 16344-a, pl. 3, fig. 10	RV IM	52.05	31.95	11.70	1.62	33.30	–



Text-fig. 23. *Modiolus* cf. *thiollierei* (DUMORTIER). a: lateral views of left valves; b: profiles as seen in anterior view, oriented with the carina in a horizontal position; 5c: complete specimen showing the trace of some of the growth-lines. 1a–7a: inferred ontogenetic series, specimens from several localities, showing an increase in the value of δ with the size increase. 1: MLP 16348; 2: MLP 16343-c; 3: MLP 16344; 4: MLP 16340; 5: MLP 16341; 6: MLP 16337; 7: MLP 16339-a; 8: MLP 16343; 9: MLP 16346.

Affinities: There is a European Jurassic group of species that shows affinities with the Argentine material. The specimens can be compared to *Modiolus thiollierei* (DUMORTIER), a species that is known from the late Pliensbachian of France (DUMORTIER 1869; LANQUINE 1929; CHARLES 1948) and England (TATE 1876). Nevertheless, due to some minor differences the use of open nomenclature is preferred to the precise assignment of this species. The Argentine specimens are smaller than those figured by DUMORTIER (1869) but have the maximum shell width located at about mid-length as the specimens figured by LANQUINE (1929). In some Argentine specimens the angle δ is slightly larger than in the European figured material and the angle between the dorsal and posterior margins is more acute. Another very similar species is *M. scalprum* J. SOWERBY from the Sinemurian to Pliensbachian of Europe (PHILLIPS 1871, pl. 8, fig. 22; RICHARDSON 1904, pl. 15, fig. 6; COSSMANN 1908, pl. 3, fig. 1; TRAUTH 1909, pl. 3, fig. 17; TROEDSSON 1951, pl. 14, figs. 9–10) but this has a more elongated and evenly arched shell and its δ angle is smaller.

M. scalprus SOW. figured by PÉREZ (1982, lám 14, fig. 14), from the Pliensbachian of Chile, has a more rectangular shape and a smaller δ angle, *M. maitlandi* ETHERIDGE, from the Bajocian of Western Australia (SKWARKO 1974: 20, pl. 24, fig. 14) is also similar, but the shell outline is more arched with a very concave ventral margin and the shell is larger.

Modiolus numismalis OPPEL in DUMORTIER (1869: 126, pl. 29, fig. 8–9) from the early Pliensbachian of France, has the same characteristic fasciculate growth lines, but is wider anteriorly. *Modiolus hillanus* J. de C. SOWERBY, from the Hettangian to Sinemurian of Europe, has a very similar shape, but its length/height ratio is smaller (JOLY 1936: 112–113; TROEDSSON 1951, pl. 4, fig. 9–11; FRENEIX & CUBAYNES 1984, pl. 1, fig. 3–4). The same features are present in *Modiolus hoffmanni* NILSSON from the Portuguese Lower Jurassic (BÖHM 1901: 232, Taf. 9, fig. 14–15) which has also a more triangular shape. *M. productus* (TERQUEM 1855: 311, pl. 21, fig. 7), from the early Lower Jurassic of France, has a more arched and elongated shell.

Some species that can be compared with this group lived since late Triassic (Norian–Rhaetian) times, for instance *Modiolus minutus* GOLDFUSS from northwest USSR (see KIPARISOVA et al. 1966: 162, tabl. 29, fig. 3–5; BYCHKOV et al. 1976, tabl. 72, fig. 8). This differs from *M.* cf. *thiollierei* in its smaller size and shorter shell.

The Argentine material is also similar to *Modiolus isonemus* (MEEK) from the Middle Jurassic of the United States (USNM 12545; see IMLAY 1964, pl. 1, fig. 22) but this lacks the dorsal imbrication of the growth lines, its dorsal margin is shorter and meets the posterior one without interruption.

The growth-line pattern of the Argentine specimens is also observed in *Modiolus imbricatus* J. SOWERBY, a Toarcian to Middle Jurassic species from Europe and Africa (MORRIS & LYCETT 1853, pl. 4, fig. 2; COX 1935, pl. 16, fig. 3–5; DESIO et al. 1960, taf. 10, fig. 15–18; ABBATE et al. 1974, tav. 40, fig. 3; ZHANG et al. 1979, pl. 92, fig. 1, 2, 4, 5, 12, 13, 16, 21), but this species has a thinner shell, an always concave ventral margin and a different shape in anterior view.

M. baylei PHILIPPI ?, which is also described here, is shorter, its shell outline is sub-triangular, the angle δ is larger and the posterior end of the shell is more rounded than in *M.* cf. *thiollierei.*

Remarks: R. PHILIPPI's figured specimen (1899, lám. 24, fig. 7) identified as *"Modiola plicata* Sow," probably belongs to the species here described. *"Modiola scalpra* Sow." in WEAVER (1931) was also included in the synonymy list but some doubts about its identity still remain because it was not figured. On the other hand the right valve identified by JAWORSKI (1915 = 1925 b) as *"Modiola hillana* Sow." is housed at the DNGM (DNGM 8450 = MLP 19090) and clearly belongs to the species here described (see pl. 3, fig. 8).

A. LEANZA's specimen of this species (1942 b, lám. 12, fig. 4) is re-illustrated here to show its shape in lateral view, as his photograph was taken tangentially when the specimen was not completely cleaned.

Autecology: The life habits of this species could be compared to those of the extant *Modiolus modiolus* (LINNÉ) that prefers a sandy or pebbly substrate and lives semi-infaunally attached to large pebbles by its byssus (see STANLEY 1970). A similar life position was observed by FÜRSICH (1980: 293) in an Oxfordian species from Greenland which has a shell shape similar to that of *M.* cf. *thiollierei.* Such species are considered by SEILACHER (1984) as adapted to what he calls "mud-sticking".

Modiolus baylei R. PHILIPPI 1899 ?

Plate 4, figs. 2–5

?	1851	*Mytilus scalprum* GOLDF. – BAYLE & COQUAND, p. 15–16; pl. 7, figs. 3–4.
?	1854	*Mytilus scalprum* GOLDF. – HUPÉ, p. 313.
?	1867	*Mytilus scalprum* SOW. – RÉMOND DE CORBINEAU, p. 119.
?	1899	*Modiola andina* PH., R. PHILIPPI, p. 47; lám, 24, fig. 3 (only).
?	1899	*Modiola baylei* PH., R. PHILIPPI, p. 48; lám. 24, fig. 8 (= BAYLE & COQUAND, 1851, pl. 7, figs. 3–4)
v	1902	*Mytilus scalprum* BAYLE Y COQUAND – BURCKHARDT, p. 245; lám. 4, fig. 9.
?	1936	*Mytilus scalprum* BAYLE et COQUAND – PIATNITZKY, p. 89.
v ?	1978 a	*Modiolus* sp. – DAMBORENEA in VOLKHEIMER et al., tab. 2.
v .	1978	*Mytilus scalprum* BAYLE y COQUAND – CAMACHO & RICCARDI, cuadro 1.
? cf.	1981	*Modiolus* cf. *baylei* (PHIL.) – HILLEBRANDT & SCHMIDT-EFFING, p. 10, 29.
v	1982	*Modiolus baylei* R. PHILIPPI ? – DAMBORENEA, p., 129–132, lám. 57, figs. 13–15.

Material: NHMB G 16640 (= MLP 18154), original of BURCKHARDT (1902, lám. 4, fig. 9), collected by ROTH at Piedra Pintada, southern Neuquén province, Pliensbachian. MLP 13957 and 15482, two specimens collected by GULISANO from the early Toarcian of Arroyo Serrucho, Mendoza province (B.8) and southern Cordillera del Viento, Neuquén province (C.1). MLP 16351 to 16353, 19644, 19659 and 19713 (M 313, 331, 431, 1291, 1317 and 1324), seven specimens and some fragments collected by the author from the Pliensbachian of Arroyo La Laguna, San Juan province (A.2), Arroyo Serrucho (B.8), Cerro Puchenque (B.9) and Arroyo del Portezuelo Ancho (B.5), Mendoza province.

This species is probably present in Chile (R. PHILIPPI 1899, see also HILLEBRANDT & SCHMIDT-EFFING 1981) in early Toarcian and early Pliensbachian strata, and in Mulanguiñeo, Chubut province, Argentina (PIATNITZKY 1936).

Description: Medium-sized shell, sub-triangular in outline, equivalve, laterally compressed. The dorsal margin is straight and extends more than half the total shell length. The posterior and anterior margins are evenly convex and the ventral one is slightly concave. The umbones are low and prosogyrous and almost terminal. The umbonal ridge is low and arched, and the angle δ between the hinge axis and the tangent to the umbonal ridge at

the valve margin varies between 50° and 55°. The dorsal margin is thickened by a ridge that bears a longitudinal groove. Other internal characters are unknown.

The outer surface of the shell is covered by commarginal growth-lines, irregularly spaced.

Measurements:

Specimen	Material		L (mm)	H (mm)	W (mm)	L/H	Dl (mm)
NHMBG 16640, pl. 4, fig. 2	LV	S	40.45	26.60	-	1.52	25.00
MLP 13957, pl. 4, fig. 4	RV	IM	9.70	6.65	-	1.45	6.45
MLP 16352, pl. 4, fig. 3	BV	IM	40.10	31.90	7.00	1.25	29.45
BAYLE & COQUAND 1851, lám. 7, figs. 3–4			37.25	25.80	7.80	1.44	-

Affinities: *Modiolus subimbricatus* (MEEK) in IMLAY (1964, pl. 1, figs. 16–20), from the Bajocian to Callovian of western United States, is very similar to this species, but has a less developed anterior lobe. Also *M. mandanaense* LEES, from the lowest Jurassic of Canada (FREBOLD 1964, pl. 3, fig. 7) can be compared to it but has a more acute postero-ventral angle.

Modiolus neumayri TIETZE (= *M. scalprum* GOLDFUSS non SOWERBY) from several localities of the Hettangian – Sinemurian of continental Europe (TRAUTH 1909, Taf. 3, fig. 16; see also NEUMAYR 1879; JEKELIUS 1915) can be distinguished by a more rectangular outline.

The shell shape is similar to that of "*Modiola*" *mariae* GEMMELLARO (DAL PIAZ 1909, tav. 35, fig. 4) from the lowest Jurassic of Italy but this has a ventral sulcus and a conspicuous ventral byssal gape. LENTINI (1974, tav. 13, fig. 4) figured a *Modiolus* cf. *glabratus* DUNKER from the Sicilian lowest Jurassic that has a less triangular shape and more posteriorly placed umbones.

Two species described by NEWTON (1895) from the Middle Jurassic of Madagascar are similar to *M. baylei* ? in general outline: *Mytilus madagascariensis* NEWTON (1895, pl. 3, fig. 3) and *Modiola angustissima* NEWTON (1895, pl. 3, fig. 4), but the specimens are incomplete and it is difficult to establish their affinities. *M. tschernyschewi* BORISSJAK (1906, Taf. 4, Fig. 14) from the Jurassic of the USSR is shorter and sub-quadrate, and *Mytilus aequiplicatus* ETALLON (in DE LORIOL & PELLAT 1875, pl. 18, fig. 21) from the French Upper Jurassic has a similar shape but its dorsal margin is longer.

Remarks: BURCKHARDT's (1902, lám. 4, fig. 9) specimen from Piedra Pintada, referred to "*Mytilus scalprum* BAYLE & COQUAND", is here included in this species (see pl. 4, fig. 2 herein). The other material is only doubtfully identified because it is poorly preserved.

In 1924 GROEBER (p. 89) mentioned "*Modiola* cf. *Paronai* BITTNER" in the supposedly Triassic sediments of the headwaters of the Catán Lil River, Neuquén province. The associated fauna was later referred to early Jurassic species. As judged by the appearance of BITTNER's figures (1895: 48, pl. 5, figs. 19–20), the Catán Lil material could also belong to *Modiolus baylei* ? as interpreted here.

? Subgenus *Gibbomodiola* SACCO 1898

Type species: *Modiola* (*Gibbomodiola*) *taurarcuata* SACCO 1898, from the Oligocene of Italy, by original designation.

The subgenus *Gibbomodiola* was erected by SACCO (1898: 41) when be described one Tertiary species from Italy, but he also included in his new taxon some extant species. The original diagnosis is as follows: "Group of elongate-ovate shaped shells, transversely and arcuately gibbous in the dorsal region, originating a sort of smooth carina that in the anterior part of the shell produces a rounded step on the shell surface."

Besides the Tertiary and Recent species mentioned by SACCO (1898), there is a group of Mesozoic species characterized by a sulcus that is ventral and parallel to the umbonal carina, by the prominent and rounded carina, almost straight in lateral view, and by the shell surface divided in two regions, both of them convex, one dorsal and the other one ventral to the sulcus. The dorsal area sometimes bears faint radial striae. This group of species could perhaps be separated as a new subgenus of *Modiolus,* but it may also be accomodated within *Gibbomodiola* on account of their external morphological similarity. In the last case the vertical range of *Modiolus* (*Gibbomodiola*) is considerably extended back to the early Jurassic at least.

Modiolus (*Gibbomodiola* ?) *gerthi* n. sp.

Plate 4, figs. 7–10, 15; text-fig. 18 i

? 1982 *Modiolus* sp. A. – PÉREZ, lám. 18, figs. 9–10.
v. 1982 *Modiolus* cf. *lonsdalei* (MORRIS y LYCETT) – DAMBORENEA, p. 123–125; lám. 37, fig. 21; lám. 55, figs. 15–17.

Derivation of name: The specific name refers to the late E. GERTH, who studied the geology and stratigraphy of southern Mendoza.

Material: This species occurs in early Toarcian beds of southern Mendoza province (Cerro Puchenque and Arroyo Serrucho, localities B.8 and B.9 on text-fig. 3). The material is mostly preserved as composite moulds. The holotype is a complete left valve, MLP 19702 (M 1351) figured on pl. 4, fig. 7, from Arroyo Serrucho. Paratypes: MLP 15833, 15835, 19683, 19690 to 19694, 19701 to 19704 and 19707 (M 332, 336, 1347, 1349, 1351 and 1352): 16 left valves, seven right valves, five complete shells and some fragments. Also included in this species is a complete shell, MLP 16335 (M 1051) from late Pliensbachian (or early Toarcian) beds at 8 km south of Estancia Santa Isabel, southern Neuquén province (D. 1). All specimens were collected by the author.

If PÉREZ' (1982) record of *Modiolus* sp. A is proved conspecific, this species could be also present in Chile.

Diagnosis: Medium-sized, short rectangular-oval shells, very inflated. The shell is divided in two areas by a well-developed rounded umbonal carina and a deep ventral sulcus parallel to it. The anterior expansion of the shell is large and inflated. The umbones are low and almost terminal. The postero-dorsal area of the shell bears faint radial striae more conspicuous near the margin. Hinge edentulous, other internal characters unknown.

Description: Shell of medium-size, rectangular-oval in outline, short. The dorsal margin is straight to slightly convex, the posterior and anterior margins are convex and the ventral margin is nearly straight. The shell is very inflated, the maximum width is placed slightly dorsal to mid-height (see text-fig. 18 i) at about the middle of the total shell length. The prosogyrate umbones are low and almost terminal. From the beaks to the postero-ventral corner of the shell there is a conspicuous rounded carina, almost straight in lateral view, with a deep ventral sulcus parallel to it. This sulcus divides the shell surface in two areas, both of them with convex surface. The anterior expansion of the shell, in front of the sulcus, is large and inflated.

The outer surface of the shell is covered by thin commarginal growth lines. In addition to these, some specimens show faint regular radial striae around the dorsal and posterior margins of the shell. In front of the umbonal carina the shell is smooth. As all the specimens that show this radial striation are preserved as composite moulds, it is difficult to determine whether this character corresponds to external ornamentation or is an internal feature.

The hinge is edentulous. The ligamental characters are unknown, and muscle scars were not observed in the available material.

Measurements: In specimens with both valves preserved, only the measurements of the left valve are given.

Specimen	Material		L (mm)	H (mm)	W (mm)	L/W	Dl (mm)
MLP 19702, holotype, pl. 4, fig. 7	LV	CM	23.70	21.70	4.65	1.09	14.30
MLP 15833, paratype	LV	CM	25.05	17.80	4.70	1.40	15.00
MLP 15835-ab, paratype	BV	CM	27.75	16.85	7.55	1.64	14.40
MLP 15835-c, paratype	LV	CM	24.10	20.90	5.00	1.15	11.45
MLP 16335, paratype, pl. 4, fig. 8	BV	CM	36.10	23.55	13.40	1.53	18.80
MLP 19690, paratype, pl. 4, fig. 15	BV	CM	34.40	(16.20)	10.15	–	19.00
MLP 19701, paratype	BV	CM	26.10	19.00	4.50	1.37	16.45
MLP 19707, paratype	LV	CM	25.60	17.95	3.50	1.42	–

Affinities: The closest affinities of *Modiolus* (*Gibbomodiola* ?) *gerthi* can be established with *Modiolus saurini* HAYAMI (1964: 165–166, pl. 7, figs. 3–4), from the Lower Jurassic of south Viet-Nam, which also has radial striae, but it has a more prominent anterior lobe and a less-developed umbonal carina.

The Argentine species can be also compared to *M. lonsdalei* (MORRIS & LYCETT) from the Middle Jurassic of Great Britain, France and the USSR (MORRIS & LYCETT 1853: 40, pl. 4, fig. 3; PIRYATINSKII et al. 1962: 47, pl. 7, fig. 3; COSSMANN 1908, pl. 2, figs. 3–4), but *M. gerthi* has more inflated shells with radial striae. The most complete specimens also resemble *M.* cf. *lonsdalei* figured by FANTINI-SESTINI (1966, pl. 56, fig. 7) from the early Jurassic of northern Iran, but it is wider in dorsal view.

Another similar species that has a less developed carina is "*Modiola*" *subaequiplicata* RÖM. as was figured by BORISSJAK (1906, pl. 1, fig. 16a–b) from the Middle Jurassic of central USSR.

Modiolus bipartitus J. SOWERBY, a very common Bathonian to Oxfordian species from Europe, India and Africa (cf. for instance BORISSJAK 1906, pl. 1, figs. 3–6 as *Modiola tulipaea* LAM.; ARKELL 1929: 55, pl. 2, figs. 1–4; COX 1940: 67–69, pl. 5, figs. 11–12; COX & ARKELL 1948: 4; COX 1965: 37, pl. 3, fig. 9; DUFF 1978: 41–42, pl. 2, figs. 28–33) has a more trapezoidal outline in lateral view and is obliquely elongated. Another similar species, that differs from the Argentine specimens by its more trapezoidal outline, is *Modiolus anatinus* (SMITH) from the Bajocian to Callovian of Europe and Africa (see for instance LYCETT 1863, pl. 33, fig. 11 as *Modiola gibbosa* SOW.; COX 1930, 1965: 37, pl. 3, fig. 7; VÖRÖS 1971: 174, pl. 1, fig. 2). *Modiolus vicinalis* D'ORBIGNY (in KELLY 1984: 33, pl. 4, figs. 9, 15) from the latest Jurassic – early Cretaceous of Great Britain and the USSR, has a superficial resemblance to *M. gerthi* but its carina is arcuate and it lacks the radial striation.

From the Middle Jurassic of Argentina (Barda Blanca and Cañada Colorada, Mendoza) JAWORSKI (1925a: 174–175, lám. 1, fig. 8) described a *Modiolus* under the name *M. cuneatus* Sow. This name is now considered (see COX 1965) as a junior synonym of *M. anatinus* (SMITH), but JAWORSKI's specimen does not seem to belong to this species, and is not comparable to the material here described.

Modiola glendayi (WEIR) in COX (1940: 69, pl. 5, figs. 8–10) from the Bathonian and Callovian of India, has the whole area dorsal to the sulcus covered by concentric regular folds. *Modiola contracta* R. PHILIPPI (1899: 47, lám. 24, fig. 4) from Peñon de Atacama, Chile, has a more sinuous ventral margin, a more triangular outline and a less developed anterior expansion. The stratigraphical location of this species is unknown.

Autecology: The morphological characters suggest a semi-infaunal mode of life for this species, with a dorsally placed maximum width (STANLEY 1970, 1972) and a strong umbonal ridge that probably indicates the substrate surface when the animal was in life position.

Order Pterioida NEWELL 1965

Suborder Pinnina WALLER 1978

Superfamily Pinnacea LEACH 1819

Family Pinnidae LEACH 1819

The family Pinnidae, that includes the largest known heteromyarian bivalves, has only few genera and has persisted since the early Carboniferous. The Pinnidae have some unique morphological features and life habits among bivalves: the mantle is not attached near the ventral margin by pallial muscles, but is free and only fixed by a pair of pallial retractor muscles (YONGE 1953: 347), allowing the quick contraction of the mantle within the shell when this is damaged. The valves are not articulated and the ligament does not open the valves, which have a large posterior gape that can be opened or closed by the posterior adductor muscle. The portion of the shell behind the posterior adductor is made up of the outer prismatic layer alone, which is very flexible, very rich in conquioline, and can be quickly repaired after damage. An analysis of the adaptations and evolution of the Pinnacea, as well as the detailed anatomy of the extant species *Pinna carnea* GMELIN was provided by YONGE (1953).

Genus *Pinna* LINNÉ 1758

Type species: *Pinna rudis* LINNÉ 1758, from tropical seas, subsequent designation by CHILDREN 1823.
Synonyms: See COX & HERTLEIN in COX et al. 1969: N283.

Pinna s. s. is very common in almost all Jurassic faunas. At that time it had a cosmopolitan distribution, but extant members of this genus are restricted to tropical and subtropical seas. Most of the nominal species described are only known very superficially, and it is therefore possible that the proposed names greatly surpass the number of real taxa, as is the case with most long-ranging and easily recognizable genera. As already pointed out by DECHASEAUX (1941) the Pinnidae are not useful for biostratigraphy, except in restricted areas, but they are good facies indicators.

The presence of *Pinna* in Argentine early Jurassic sediments has been mentioned several times, but this is the first time material has been figured (see also DAMBORENEA 1982, lám. 58). All the available specimens can be easily included in one species.

Pinna (*Pinna*) cf. *folium* YOUNG & BIRD 1822

Plate 4, fig. 6, 11-14; text-fig. 24

v.	1915	*Pinna Buchii* KOCH & DUNK.	- JAWORSKI, p. 414.
v.	1915	*Pinna* sp.	- JAWORSKI, p. 415.
?	1925a	*Pinna* sp.	- JAWORSKI, p. 157.
v.	1925b	*Pinna Buchii* KOCH & DUNK.	- JAWORSKI, p. 39-40.
v.	1925b	*Pinna* sp.	- JAWORSKI, p. 40, 41.
?	1925	*Pinna Buchii* KOCH & DUNKER	- GERTH, p. 14.
?	1934	*Pinna* sp.	- FERUGLIO, p. 44.
?	1936	*Pinna* sp.	- PIATNITZKY, p. 88, 102.
non	1975	*Pinna*	- DAMBORENEA et al., Cuadro 1.
.	1980	*Pinna* sp.	- BLASCO et al., p. 191.
v.	1982	*Pinna* (*Pinna*) cf. *folium* YOUNG and BIRD	- DAMBORENEA, p. 140-146, lám. 40, figs. 1-7; lám. 58, figs. 1-6.

Material: One specimen collected by FERNÁNDEZ (MLP 5606) from Pliensbachian beds 3 km north of Sañicó (locality D.5), southern Neuquén province. The material collected by KEIDEL at Rio Atuel, Mendoza province (B.1) and described by JAWORSKY (1915 = 1925 b) as *P. buchii* (one external mould) and as *P.* sp. (four internal moulds) was seen at the DNGM. Two specimens from Loncopán, Chubut province, were collected by ARBE (MLP 15970), and some specimens from Cordillera del Viento, Neuquén province (C.1 and C.4), early Toarcian, were collected by GULISANO (MLP 15483 and 15545).

From author's collection: 35 specimens and some fragments, mostly internal moulds of the anterior half of the shell: MLP 16354 to 16367, 19011, 19019, 19029, 19062, 19069, 19647, 19650, 19680, 19681, 19684, 19695, 19708 and 19709 (M 298, 313, 315, 320, 322, 351, 365, 437 ?, 818, 1040, 1051, 1053, 1121 ?, 1192, 1193, 1283, 1285, 1286, 1287, 1303, 1318, 1321, 1344, 1346, 1347, 1349, 1352 and 1353). This species was found in Pliensbachian to Toarcian sediments of Neuquén (southern Cordillera del Viento, Arroyo Lonqueo, 8 km south of Estancia Santa Isabel and Salitral Grande), Mendoza (Rio Atuel, Paso del Portezuelo Ancho, Arroyo del Portezuelo Ancho, Arroyo Serrucho, Cerro Puchenque and Arroyo Poti Malal) and also probably San Juan (Arroyo La Laguna). It is possible that this species ranges into younger sediments in western Argentina.

In addition to the material here described, FERUGLIO (1934: 44), PIATNITZKY (1936: 88) and BLASCO et al. (1980) mention *Pinna* sp. from several localities in Chubut province.

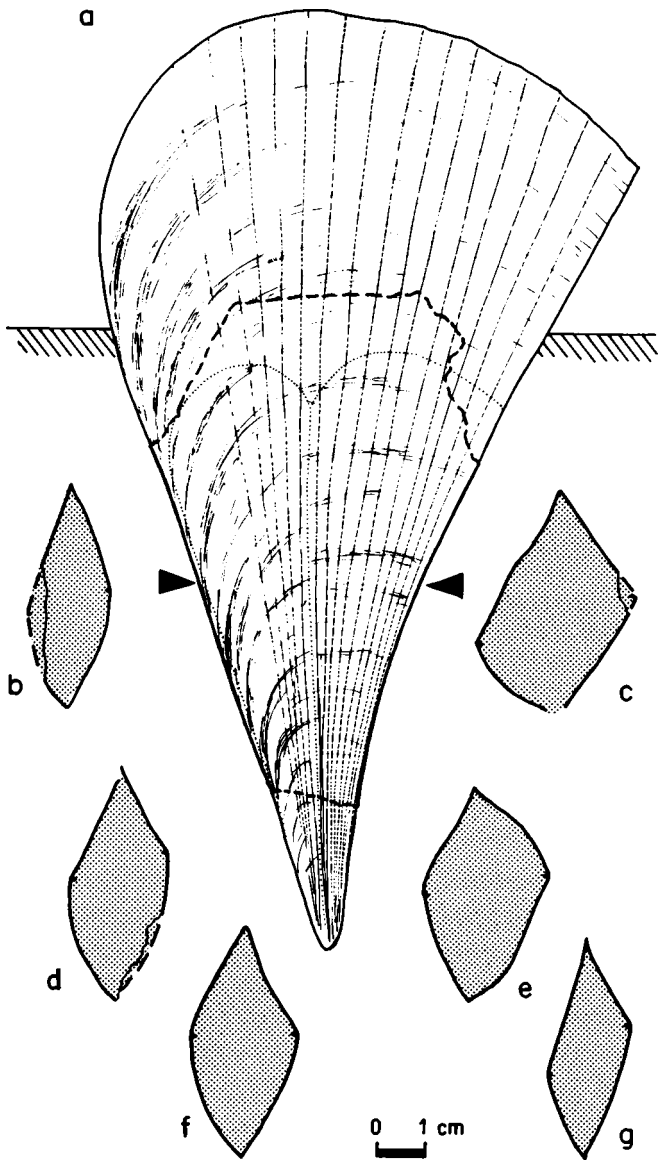
Description: Medium-sized shell, triangular in outline, the posterior margin is unknown. The dorsal and ventral margins are both straight to slightly concave and meet at an angle of 28° to 34°. The angle between the dorsal and posterior margins could be measured in only one specimen, and is 113°. The medium carina is strong, straight, and is split by a well-developed groove that probably corresponds to the scar of the progressive growth migration of the posterior pallial retractor muscle. Inner nacreous layer of the shell divided in two lobes, the ventral one slightly shorter than the dorsal one. Whilst the dorsal lobe extends to the dorsal margin, the ventral lobe does not reach the ventral margin, being subparallel and close to it. Adductor muscle scars unknown. The thick exterior prismatic layer of the shell is preserved in just a few specimens.

The shell exterior is ornamented by regularly spaced radial ribs that cover all the area dorsal to the carina and the dorsal half ot the area ventral to the carina. The ribs are thin, low and straight; they do not multiply, so that the space between them increases towards the posterior end of the shell. There are nine or ten ribs on the dorsal region and five to six on the ventral area; the space between them is flat and equally wide on both regions of the shell. This radial ornamentation is transversely crossed by faint, irregularly-spaced, growth lines, and numerous commarginal folds that can even be seen on internal moulds. These are irregular on the dorsal region of the shell, but more regular on the ventral portion, where they become asymptotic to the ventral margin of the shell. Some specimens show scars where injured shell was repaired.

The transverse section is rhombic, but the relative dimensions of the shell are difficult to establish as all the specimens are deformed. In all the specimens the carina on the right valve is placed more dorsally than that on the left valve (see text-fig. 24). This could also be due to post-depositional deformation, but it could indicate that the shell was originally slightly inequivalve.

Some specimens were more than 30 cm long, but as most of them are incomplete, a table of measurements is not included here.

Affinities: This *Pinna* belongs to a group of species that are characterized by almost straight dorsal and ventral margins, an acute apical angle, few (but more than 20) radial ribs equally spaced over all the shell surface but absent towards the ventral margin and commarginal folds stronger in the ventral part of the shell. They are



Text-fig. 24. *Pinna* (*Pinna*) cf. *folium* YOUNG & BIRD. a: Reconstruction of a complete shell in life position, right lateral view, based on MLP 16356. b–g: transversal sections, seen from the posterior end, dorsal side uppermost. b: MLP 16356, Cerro Puchenque, Pliensbachian.; c: MLP 16358, same locality; d: MLP 16363, Estancia Santa Isabel, late Pliensbachian (?); e: MLP 16359, Rio Atuel, Pliensbachian; f: MLP 16357, Cerro Puchenque, Pliensbachian; g: MLP 16364-f, Estancia Santa Isabel.

common throughout the Mesozoic and have received several specific names according to their geographic and/or stratigraphic position. These nominal species are generally distinguished from each other by minor morphological details that are variable even within each population. The analysis of their relationships is further hindered by a poor knowledge of intra-specific variability and by the lack of suitable illustrations.

The Argentine specimens are closely comparable to *Pinna folium* YOUNG & BIRD, that is known from the Hettangian to Sinemurian of Europe (TATE 1876; ROLLIER 1914; LANQUINE 1929; DECHASEAUX 1941; CHARLES 1948). Some authors, such as DECHASEAUX (1941) and CHARLES (1948) include *P. inflata* CHAPUIS & DEWALQUE 1851, from the early Jurassic of continental Europe, as a synonym of this species. As can be seen from COSSMANN's figures (1916: 143–144, pl. 6, figs. 8–9) and TRAUTH's description (1909: 80–81), the Argentine material is very similar to this species in size, shape and ornamentation, but the apical angle of COSSMANN's figured specimen is slightly smaller and the radial ribs are fewer. DUMORTIER (1869: 280, pl. 33, figs. 3–6) included in *P. inflata* specimens that are also similar to the material here described. DUMORTIER's specimens were later named *P. dumortieri* by ROLLIER (1914: 382).

ROLLIER (1914: 381) also named *P. zieteni* the Sinemurian material from the area of Stuttgart figured by ZIETEN (1833, Taf. 55, Fig. 6 a–b) as *P. diluviana* SCHL. (which is in fact a Cretaceous species). JOLY (1936: 114) described *P. zieteni* from the earliest Jurassic of Belgium and DECHASEAUX (1941) from the Charmouthian and Aalenian of Lorraine, France. The Argentine specimens differ from ZIETEN's material in minor ornamentation details.

The Aalenian to Bathonian European species *P. cuneta* PHILLIPS (MORRIS & LYCETT 1853: 32, pl. 6, fig. 11; QUENSTEDT 1857, Taf. 60, Fig. 2; DECHASEAUX 1941: 42) has more radial ribs. MÖRICKE (1894: 43–44, Taf. 6, Fig. 11) described and figured one specimen as *P.* cf. *cuneata* PHIL. from the Bajocian of Tarapacá, Chile, that has a more acute apical angle and more radial ribs than the species here described.

P. buchii KOCH & DUNKER is widely known from the Middle Jurassic of Europe and Africa, as figured by GREPPIN (1899: 99; 1900, pl. 13, figs. 3–4), PIRYATINSKII et al. (1962: 36, tabl. 7, figs. 1–2), COX (1965, pl. 4, fig. 9). This species also has a more acute apical angle and more radial ribs, characters that are also present in the Argentine Callovian specimens referred to *P. buchii* (MLP 4596, see also WEAVER 1931: 196). JAWORSKI (1915: 114 and 1925 b: 39–40) and GERTH (1925: 14) referred to this specimen early Jurassic material from Rio Atuel that is here included in the synonymy of *P.* cf. *folium.*

P. lanceolata J. SOWERBY is more common in the Callovian and Oxfordian of Europe (PHILLIPS 1871; ARKELL 1933: 219, pl. 28, fig. 5, pl. 29, fig. 1–2; DUFF 1978: 45, pl. 3, figs. 14, 16, 19, 20, text-fig. 12 a) and although it has similar size and ornamentation, it can be distinguished by its smaller apical angle.

P. kawhiana MARWICK (1953: 97, pl. 13, fig. 14) from the Heterian (Oxfordian) of New Zealand is also similar, but has only eight radial ribs on the dorsal region and four on the ventral.

R. PHILIPPI (1899) described three *Pinna* species from the Chilean Mesozoic without further stratigraphical data. *P. angusta* PHIL. and *P. andina* PHIL., both based on probably weathered and very incomplete specimens, have a smaller apical angle. *P. tumida* PHIL. has a reticulate ornamentation on the ventral portion of the shell that distinguishes it from the specimens here described.

Another early Jurassic species, *P. semistriata* TERQUEM (1855: 309 pl. 22, fig. 1; DECHASEAUX 1941: 37; KONCHANOVÁ 1967: 40, Taf. 5, fig. 3; LENTINI 1974, tav. 13, fig. 9), from the Hettangian and Sinemurian of Europe, lacks radial ribs on the ventral region of the shell. *P. hartmanni* ZIETEN (1833, Taf. 55, Fig. 5 a–b; TATE 1876: 376; GRECO 1894: 147; TRAUTH 1909: 80; JEKELIUS 1915: 56; JOLY 1936: 115; DECHASEAUX 1941: 38; KOCHANOVÁ 1967: 41, tabl. 5, fig. 4; LENTINI 1974, tav. 13, fig. 10) has a clear cancellate ornamentation quite different from that of *P.* cf. *folium.*

Remarks: *Pinna* sp. described by JAWORSKI (1915, 1925 b) from Piedra Pintada apparently belongs to the species under discussion here. *Pinna* sp. I from Arroyo Negro, Cerro Puchenque (JAWORSKI 1925 b: 157) is included here on the basis of extensive collections from that locality. On the other hand there is no material available from the localities in Chubut from which FERUGLIO (1934: 44) and PIATNITZKY (1936: 88, 102) mention *Pinna* sp.

Autecology: YONGE (1953) discussed in detail the life habits of *Pinna carnea* GMELIN and remarked that all *Pinna* species have the same semi-infaunal habit in soft substrates, attached to coarse debris by a strong and long byssus ("mud sticker" in SEILACHER's 1984, sense). All the posterior part of the shell behind the posterior adductor muscle is exposed. This has the advantage of raising the inhalant current above the substrate surface, but with the drawback of exposing that part of the organism to injuries produced by predators or other causes. Nevertheless, the projecting valves can be rapidly repaired since they are made exclusively of the outer calcareous layer (YONGE 1953). Due to this peculiar mode of life, most fossil specimens are incomplete, with only the anterior (i.e. buried) part of the shell preserved.

Pinna carnea GMELIN lives in calcareous sandy mud of sheltered litoral grass flats (YONGE 1953; STANLEY 1970). SEILACHER (1954), YONGE & THOMPSON (1976) and STANLEY (1970) made similar observations on other Pinnidae species. STANLEY (1970) found that *P. carnea* can exceptionally live on a hard substrate, attached by its byssus.

The reports of fossil *Pinna* resting in life position are numerous, see for instance HALLAM (1960: 31), BRAMER & KEMPER (1966), HEMINGWAY et al. (1968: 26) HUDSON & PALFRAMAN (1969: 391) SELLWOOD (1972, pl. 28, fig. 3), KŘÍŽ & SOUKUP (1975), FÜRSICH (1980: 292). The author also observed almost completely vertical specimens in the Sinemurian of South Wales and in the early Jurassic of Arroyo Serrucho, Argentina. Re-deposited *Pinna,* with the valves lying parallel to bedding, as most of the specimens here described were found, are far more common. KŘÍŽ & SOUKUP (1975) found specimens in life position in several silty limestone facies and concluded that *P. decussata* GOLDFUSS, from the late Cretaceous of Bohemia, is a good depth indicator that only appears in life position in low energy environments several meters deep, but less that 100 m according to DECHASEAUX (1941).

? Genus *Trichites* Voltz in Thurmann 1833

Type species: *Trichites saussuri* Thurmann, from the late Jurassic of Europe, by monotypy.

This genus is common in Middle Jurassic to Lower Cretaceous strata all over the world. Some specimens from early Jurassic times are also known, such as the Chilean material figured by Pérez (1982) and the Argentine material here described.

A detailed discussion of the validity of this generic name and its distinctive characters and distribution was provided by Cox (1940: 136–138).

Trichites ? sp.

Material: One incomplete shell with both valves, MLP 16368 (M 352), collected by the author from lower Pliensbachian beds of Rio Atuel, southern Mendoza province (locality B.1).

Description: the specimen is incomplete, the umbonal region of the shell is missing. The shell is very big, subtrapezoidal in outline and the valves are very thick, biconvex and laterally compressed, probably of equal length and height. The outer surface is very uneven and apparently has only irregular folds that are parallel to the growth-lines. The inner surface is smooth, slightly wavy, and some muscle scars can be seen, probably those of the adductor muscle.

The shell structure is clearly prismatic. The fragment is about 12 cm long, but the whole length of the specimen probably was at least 24 cm.

Remarks: The prismatic structure of the shell is similar to that figured for other *Trichites* species (see for instance Cox & Hertlein in Cox et al. 1969, fig. C.24–16; Fürsich 1980, fig. 6).

It is difficult to establish the affinities of this shell as it is very incomplete. *Trichites* ? sp., from the Pliensbachian of Chile (Pérez 1982, lám. 12, fig. 12) has ribs and nodes on the outer surface of the shell which were not seen in the Argentine specimen. *T. nodosus* Lycett (Morris & Lycett 1853, pl. 3, fig. 11) and *T. saussuri* Thurmann (see Cox & Hertlein in Cox et al. 1969) are also nodose shells, both from the Middle and Late Jurassic of Europe. *T. indicus* Cox (1940, pl. 10, fig. 13) has an overall similarity but is has an incipient radial ornamentation.

Autecology: Fürsich (1980) described *T. saussuri* in life position in Late Jurassic sediments at Cabo Espichel, Portugal. He suggested that this was a semi-infaunal species that lived with the anterior region of the shell buried in the sediment. The byssus could be atrophied in adults, since the thick umbonal region of the shell would ensure the stability of the shell in that position. Fürsich & Schmidt-Kittler (1980), in an analysis of the same Portuguese fauna, added that they were found in small groups and that their shells were the substrate for a varied fauna of epizoic and boring organisms (see also Fürsich 1981).

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Explanation of Plates

(All specimens are coated with amonium chloride. Figures natural size except where otherwise indicated. Specimens from author's collection except where otherwise indicated)

Plate 1

Figs. 1–3. *Palaeoneilo patagonidica* (A. LEANZA). x 2. Subida a Sañicó, Pliensbachian. FRENGUELLI's collection. Specimens already figured by A. LEANZA (1924b, lám. 1, figs. 1–2).

1. Lectotype, MLP 6251-a, internal mould of a right valve.
2. Paralectotype, MLP 6251-b, external mould of a left valve.
3. Paralectotype, MLP 6086, internal mould of a left valve.

Fig. 4. *Palaeoneilo galatea* (D'ORBIGNY) ?. MLP 16194, internal mould of a right valve, x 2. Subida a Sañicó, Pliensbachian.

Fig. 5. *Malletia* ? sp. MLP 14273, composite mould of a right valve, x 2. Subida a Sañicó. Pliensbachian. A. LEANZA's collection. Figured by A. LEANZA (1942b, lám. 1, fig. 3) as *Nucula patagonidica.*

Fig. 6. Malletiidae gen. et sp. indet. MLP 16195, internal mould of a left valve, x 2. Subida a Sañicó, Pliensbachian.

Figs. 7–9. *Nuculana* cf. *ovum* (J. DE C. SOWERBY), x 2.

7. MLP 16196, right valve, hill south of Cerro Roth, Pliensbachian.
8. MLP 16197, right valve, hill south of Cerro Roth, Pliensbachian.
9. MLP 16203, internal mould of a right valve, Arroyo Ñiraico, early Toarcian, GULISANO's collection.

Figs. 10–12. *Parallelodon* sp. x 2.

10. MLP 16260, internal mould of a left valve. Cerro Puchenque, Pliensbachian.
11. MLP 16259, latex cast from internal mould of a right valve. Cerro Puchenque, Pliensbachian.
12. MLP 16255, latex cast from external mould of a left valve. Arroyo Lapa, Pliensbachian.

Fig. 13. *Grammatodon* (*Grammatodon*) cf. *toyorensis* HAYAMI. MLP 6098, internal mould of a right valve, x 2. Cerro Grande, Pliensbachian. FRENGUELLI's collection, figured by A. LEANZA (1942b, lám. 1, fig. 9) as *Cucullaea* sp. indet.

Fig. 14. *Parallelodon riccardii* n. sp. Holotype, MLP 16251, right valve. Hill south of Cerro Roth, Pliensbachian. RICCARDI's collection. 14a: dorsal view; 14b: external view; 14c: internal view.

Figs. 15–16 *Cucullaea* (*Idonearca*) *rothi* A. LEANZA.

15. MLP 16293, left valve. Hill south of Cerro Roth, Pliensbachian. 15a: internal view; 15b: dorsal view; 15c: external view.
16. Holotype, MLP 3726, bivalved specimen. Cerro Roth, Pliensbachian. FRENGUELLI's collection. Figured by A. LEANZA (1940b, lám. 2, figs. 1–6). 16a: dorsal view; 16b: posterior view; 16c: left valve exterior.

Fig. 17. *Cucullaea* (*Idonearca*) cf. *rothi* A. LEANZA. MLP 16305, left valve exterior, Cerro Puchenque, Pliensbachian.

Fig. 18. *Cucullaea* (*Idonearca*) *rothi* A. LEANZA ?. MLP 16304, composite mould of a left valve, x 2. Cañadón Chapingo, 3 km SE of Cerro Carnerero, Chubut, early Toarcian. RICCARDI's collection.

Fig. 19. *Cucullaea* ? sp. MLP 16307, steinkern. Arroyo Poti Malal, Toarcian. 19a: right valve; 19b: dorsal view.

Plate 2

Figs. 1–8. *Parallelodon groeberi* n. sp. Hill south of Cerro Roth, Pliensbachian, except where otherwise indicated.

1. Holotype, MLP 16210, bivalved specimen. 1a: left valve exterior; 1b: ventral view.
2. Paratype, MLP 16213, dorsal view of a left valve showing borings and epizoans.
3. Paratype, MLP 16211, dorsal view of a bivalved specimen.
4. Paratype, MLP 16228, right valve hinge.
5. Paratype, MLP 16227, left valve interior.
6. Paratype, MLP 16226, left valve hinge.
7. Paratype, MLP 8874-a, left valve exterior. Cerro Roth, Pliensbachian. ROTH's collection.
8. Paratype, MLP 16224, dorsal view of left valve.

Figs. 9–13. *Cucullaea* (*Ashcroftia* ?) *jaworskii* A. LEANZA. Cerro Roth, Pliensbachian, A. LEANZA's collection, except where otherwise indicated.

9. MLP 16279, right valve hinge. Hill south of Cerro Roth, Pliensbachian.
10. Paratype, MLP 3725-g, left valve interior.
11. Holotype, MLP 3724, complete specimen. Figured by A. LEANZA (1940b, lám. 1, figs. 1–2). 11a: right valve exterior;,11b: dorsal view.
12. Paratype, MLP 3725-ab, complete specimen. 12a: right valve exterior; 12b: dorsal view.
13. Paratype, MLP 3725-e, right valve interior.

Figs. 14–15. *Grammatodon costulatus* (A. LEANZA) ?, x 2.
14. MLP 16267-a, internal mould of a left valve. Salitral Grande de Carrán Curá, Pliensbachian.
15. MLP 16267-b, internal mould of a left valve. Salitral Grande de Carrán Curá, Pliensbachian.

Figs. 16–17. *Grammatodon costulatus* (A. LEANZA) x 2.
16. Lectotype, MLP 6074-a, composite mould of a right valve, Subida a Sañicó, Pliensbachian. Figured by A. LEANZA (1924b, lám. 1, fig. 6). FRENGUELLI's collection.
17. Paralectotype, MLP 6074-b, composite mould of a right valve. Subida a Sañicó, Pliensbachian. Figured by A. LEANZA (1942b, lám. 1, fig. 5).

Plate 3

Figs. 1–4. *Lycettia hypertrigona* n. sp.
1. Paratype, MLP 16313, steinkern. 8 km south of Estancia Santa Isabel, upper Pliensbachian ?. 3a: right valve; 36b: anterior view; 3c: dorsal view; 3d: ventral view.
2. Holotype, MLP 16308, nearly complete specimen with valves displaced by rotation. Hill south of Cerro Roth, Pliensbachian. 2a: ventral view; 2b: left side view.
3. Paratype, MLP 19706, steinkern. Arroyo Serrucho, early Toarcian. 3a: right valve; 3b: anterior view.
4. Paratype, MLP 16311, internal mould of a right valve. Cerro del Vasco, Pliensbachian.

Figs. 5–7. *Falcimytilus* ? *gigantoides* (A. LEANZA)
5. MLP 16323, left view of specimen with both valves, Cerro Roth, Pliensbachian.
6. MLP 16333-ab, steinkern. North of Sañicó, Pliensbachian. FERNÁNDEZ' collection. 6a: left valves; 6b: dorsal view.
7. MLP 16319, specimen with both valves. Hill south of Cerro Roth, Pliensbachian. 7a: dorsal view; 7b: left valve; 7c: anterior view.

Figs. 8–13. *Modiolus* cf. *thiollierei* (DUMORTIER)
8. DNGM 8450 (= MLP 19090), right valve. Arroyo Blanco, Rio Atuel, Pliensbachian. KEIDEL's collection.
9. MLP 16340, specimen with both valves. Cerro del Vasco, Pliensbachian. 9a: dorsal view; 9b: anterior view; 9c: left valve; 9d: ventral view.
10. MLP 16344-a, composite mould of a right valve, x 1.5. Cerro Puchenque, Pliensbachian.
11. MLP 6090, internal mould of a left valve. Cañadón de Los Chilenos, Pliensbachian. Figured by A. LEANZA (1942b, lám. 12, fig. 4) as *Modiolus scalprus* Sow. 11a: left valve; 11b: dorsal view.
12. MLP 19674, composite mould of a left valve, Arroyo Serrucho, Pliensbachian.
13. MLP 16341, specimen with both valves. Cerro Del Vasco, Pliensbachian. 13a: anterior view; 13b: left valve.

Plate 4

Fig. 1. *Inoperna* sp. MLP 16315, latex cast from an incomplete external mould of a left vale. Arroyo La Laguna, late Pliensbachian.

Figs. 2–5. *Modiolus baylei* R. PHILIPPI ?.
2. NHMB G 16640 (= MLP 18154), left valve. Piedra Pintada, Pliensbachian, ROTH's collection, figured by BURCKHARDT (1902, lám. 4, fig. 9).
3. MLP 16352, steinkern. Cerro Puchenque, Pliensbachian. 3a: dorsal view; 3b: right valve.
4. MLP 13957, right valve of young specimen, x 2. Arroyo Serrucho, early Toarcian. GULISANO's collection.
5. MLP 19644, right valve. Arroyo Serrucho, Pliensbachian.

Figs. 6, 11–14. *Pinna* (*Pinna*) cf. *folium* YOUNG & BIRD.
6. MLP 19680, composite mould, right valve. Arroyo Serrucho, early Toarcian.
11. MLP 16358, composite mould. Cerro Puchenque, Pliensbachian. 1a: right valve; 1b: left valve.
12. MLP 16359, composite mould. Rio Atuel, early Pliensbachian. 2a: left valve; 2b: dorsal view.
13. MLP 19011, external mould, left valve. Paso del Portezuelo Ancho, Pliensbachian.
14. MLP 16363, composite mould, left valve. 8 km south of Estancia Santa Isabel, late Pliensbachian ?.

Figs. 7–10, 15. *Modiolus* (*Gibbomodiola* ?) *gerthi* n. sp.
7. MLP 19702, holotype, composite mould, left valve. Arroyo Serrucho, early Toarcian.
8. MLP 16335, paratype, steinkern. Estancia Santa Isabel, late Pliensbachian ?. 8a: view of left valve; 8b: dorsal view; 8 anterior view.
9. MLP 19694-b, paratype, external mould of left valve. Arroyo Serrucho, early Toarcian.
10. MLP 19701, paratype, steinkern, view of right valve. Arroyo Serrucho, early Toarcian.
15. MLP 19690, paratype, steinkern. Arroyo Serrucho, early Toarcian. 15a: dorsal view; 15b: ventral view.

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Explanation of Plates

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Plate 1

Figs. 1-3. *Palaeoneilo patagonidica* (A. LEANZA). x 2. Subida a Sañicó, Pliensbachian. FRENGUELLI's collection. Specimens already figured by A. LEANZA (1924b, lám. 1, figs. 1-2).

1. Lectotype, MLP 6251-a, internal mould of a right valve.
2. Paralectotype, MLP 6251-b, external mould of a left valve.
3. Paralectotype, MLP 6086, internal mould of a left valve.

Fig. 4. *Palaeoneilo galatea* (D'ORBIGNY) ?. MLP 16194, internal mould of a right valve, x 2. Subida a Sañicó, Pliensbachian.

Fig. 5. *Malletia* ? sp. MLP 14273, composite mould of a right valve, x 2. Subida a Sañicó. Pliensbachian. A. LEANZA's collection. Figured by A. LEANZA (1942b, lám. 1, fig. 3) as *Nucula patagonidica.*

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7. MLP 16196, right valve, hill south of Cerro Roth, Pliensbachian.
8. MLP 16197, right valve, hill south of Cerro Roth, Pliensbachian.
9. MLP 16203, internal mould of a right valve, Arroyo Ñiraico, early Toarcian, GULISANO's collection.

Figs. 10-12. *Parallelodon* sp. x 2.

10. MLP 16260, internal mould of a left valve. Cerro Puchenque, Pliensbachian.
11. MLP 16259, latex cast from internal mould of a right valve. Cerro Puchenque, Pliensbachian.
12. MLP 16255, latex cast from external mould of a left valve. Arroyo Lapa, Pliensbachian.

Fig. 13. *Grammatodon* (*Grammatodon*) cf. *toyorensis* HAYAMI. MLP 6098, internal mould of a right valve, x 2. Cerro Grande, Pliensbachian. FRENGUELLI's collection, figured by A. LEANZA (1942b, lám. 1, fig. 9) as *Cucullaea* sp. indet.

Fig. 14. *Parallelodon riccardii* n. sp. Holotype, MLP 16251, right valve. Hill south of Cerro Roth, Pliensbachian. RICCARDI's collection. 14a: dorsal view; 14b: external view; 14c: internal view.

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16. Holotype, MLP 3726, bivalved specimen. Cerro Roth, Pliensbachian. FRENGUELLI's collection. Figured by A. LEANZA (1940b, lám. 2, figs. 1-6). 16a: dorsal view; 16b: posterior view; 16c: left valve exterior.

Fig. 17. *Cucullaea* (*Idonearca*) cf. *rothi* A. LEANZA. MLP 16305, left valve exterior, Cerro Puchenque, Pliensbachian.

Fig. 18. *Cucullaea* (*Idonearca*) *rothi* A. LEANZA ?. MLP 16304, composite mould of a left valve, x 2. Cañadón Chapingo, 3 km SE of Cerro Carnerero, Chubut, early Toarcian. RICCARDI's collection.

Fig. 19. *Cucullaea* ? sp. MLP 16307, steinkern. Arroyo Poti Malal, Toarcian. 19a: right valve; 19b: dorsal view.

Plate 2

Figs. 1-8. *Parallelodon groeberi* n. sp. Hill south of Cerro Roth, Pliensbachian, except where otherwise indicated.

1. Holotype, MLP 16210, bivalved specimen. 1a: left valve exterior; 1b: ventral view.
2. Paratype, MLP 16213, dorsal view of a left valve showing borings and epizoans.
3. Paratype, MLP 16211, dorsal view of a bivalved specimen.
4. Paratype, MLP 16228, right valve hinge.
5. Paratype, MLP 16227, left valve interior.
6. Paratype, MLP 16226, left valve hinge.
7. Paratype, MLP 8874-a, left valve exterior. Cerro Roth, Pliensbachian. ROTH's collection.
8. Paratype, MLP 16224, dorsal view of left valve.

Figs. 9-13. *Cucullaea* (*Ashcroftia* ?) *jaworskii* A. LEANZA. Cerro Roth, Pliensbachian, A. LEANZA's collection, except where otherwise indicated.

9. MLP 16279, right valve hinge. Hill south of Cerro Roth, Pliensbachian.
10. Paratype, MLP 3725-g, left valve interior.
11. Holotype, MLP 3724, complete specimen. Figured by A. LEANZA (1940b, lám. 1, figs. 1–2). 11a: right valve exterior; 11b: dorsal view.
12. Paratype, MLP 3725-ab, complete specimen. 12a: right valve exterior; 12b: dorsal view.
13. Paratype, MLP 3725-e, right valve interior.

Figs. 14–15. *Grammatodon costulatus* (A. LEANZA) ?, x 2.
14. MLP 16267-a, internal mould of a left valve. Salitral Grande de Carrán Curá, Pliensbachian.
15. MLP 16267-b, internal mould of a left valve. Salitral Grande de Carrán Curá, Pliensbachian.

Figs. 16–17. *Grammatodon costulatus* (A. LEANZA) x 2.
16. Lectotype, MLP 6074-a, composite mould of a right valve, Subida a Sañicó, Pliensbachian. Figured by A. LEANZA (1924b, lám. 1, fig. 6). FRENGUELLI's collection.
17. Paralectotype, MLP 6074-b, composite mould of a right valve. Subida a Sañicó, Pliensbachian. Figured by A. LEANZA (1942b, lám. 1, fig. 5).

Plate 3

Figs. 1–4. *Lycettia hypertrigona* n. sp.
1. Paratype, MLP 16313, steinkern. 8 km south of Estancia Santa Isabel, upper Pliensbachian ?. 3a: right valve; 36b: anterior view; 3c: dorsal view; 3d: ventral view.
2. Holotype, MLP 16308, nearly complete specimen with valves displaced by rotation. Hill south of Cerro Roth, Pliensbachian. 2a: ventral view; 2b: left side view.
3. Paratype, MLP 19706, steinkern. Arroyo Serrucho, early Toarcian. 3a: right valve; 3b: anterior view.
4. Paratype, MLP 16311, internal mould of a right valve. Cerro del Vasco, Pliensbachian.

Figs. 5–7. *Falcimytilus* ? *gigantoides* (A. LEANZA)
5. MLP 16323, left view of specimen with both valves, Cerro Roth, Pliensbachian.
6. MLP 16333-ab, steinkern. North of Sañicó, Pliensbachian. FERNÁNDEZ' collection. 6a: left valves; 6b: dorsal view.
7. MLP 16319, specimen with both valves. Hill south of Cerro Roth, Pliensbachian. 7a: dorsal view; 7b: left valve; 7c: anterior view.

Figs. 8–13. *Modiolus* cf. *thiollierei* (DUMORTIER)
8. DNGM 8450 (= MLP 19090), right valve. Arroyo Blanco, Rio Atuel, Pliensbachian. KEIDEL's collection.
9. MLP 16340, specimen with both valves. Cerro del Vasco, Pliensbachian. 9a: dorsal view; 9b: anterior view; 9c: left valve; 9d: ventral view.
10. MLP 16344-a, composite mould of a right valve, x 1.5. Cerro Puchenque, Pliensbachian.
11. MLP 6090, internal mould of a left valve. Cañadón de Los Chilenos, Pliensbachian. Figured by A. LEANZA (1942b, lám. 12, fig. 4) as *Modiolus scalprus* Sow. 11a: left valve; 11b: dorsal view.
12. MLP 19674, composite mould of a left valve, Arroyo Serrucho, Pliensbachian.
13. MLP 16341, specimen with both valves. Cerro Del Vasco, Pliensbachian. 13a: anterior view; 13b: left valve.

Plate 4

Fig. 1. *Inoperna* sp. MLP 16315, latex cast from an incomplete external mould of a left vale. Arroyo La Laguna, late Pliensbachian.

Figs. 2–5. *Modiolus baylei* R. PHILIPPI ?.
2. NHMB G 16640 (= MLP 18154), left valve. Piedra Pintada, Pliensbachian, ROTH's collection, figured by BURCKHARDT (1902, lám. 4, fig. 9).
3. MLP 16352, steinkern. Cerro Puchenque, Pliensbachian. 3a: dorsal view; 3b: right valve.
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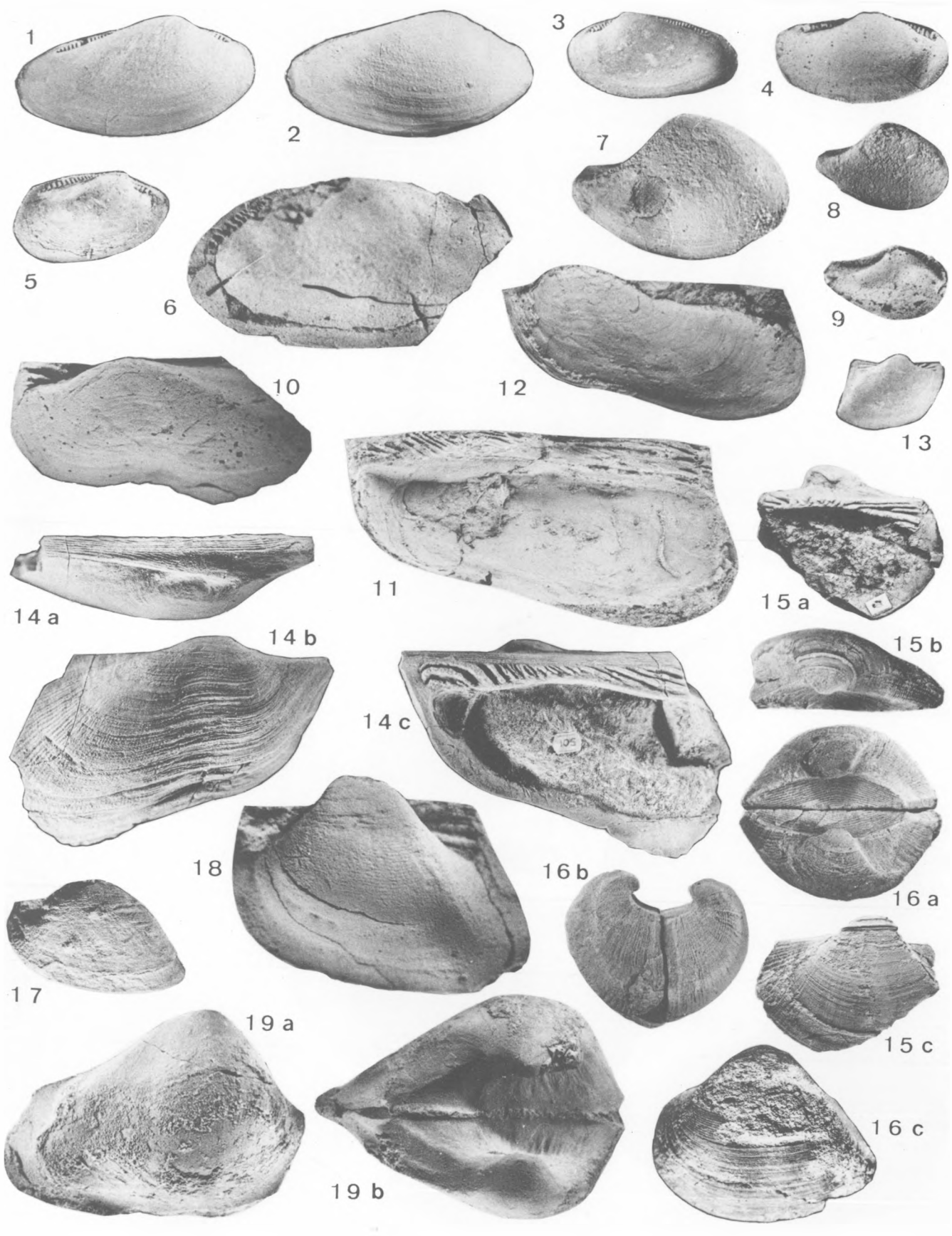
6. MLP 19680, composite mould, right valve. Arroyo Serrucho, early Toarcian.
11. MLP 16358, composite mould. Cerro Puchenque, Pliensbachian. 1a: right valve; 1b: left valve.
12. MLP 16359, composite mould. Rio Atuel, early Pliensbachian. 2a: left valve; 2b: dorsal view.
13. MLP 19011, external mould, left valve. Paso del Portezuelo Ancho, Pliensbachian.
14. MLP 16363, composite mould, left valve. 8 km south of Estancia Santa Isabel, late Pliensbachian ?.

Figs. 7–10, 15. *Modiolus* (*Gibbomodiola* ?) *gerthi* n. sp.
7. MLP 19702, holotype, composite mould, left valve. Arroyo Serrucho, early Toarcian.
8. MLP 16335, paratype, steinkern. Estancia Santa Isabel, late Pliensbachian ?. 8a: view of left valve; 8b: dorsal view; 8c: anterior view.
9. MLP 19694-b, paratype, external mould of left valve. Arroyo Serrucho, early Toarcian.
10. MLP 19701, paratype, steinkern, view of right valve. Arroyo Serrucho, early Toarcian.
15. MLP 19690, paratype, steinkern. Arroyo Serrucho, early Toarcian. 15a: dorsal view; 15b: ventral view.


1
2
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4
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10
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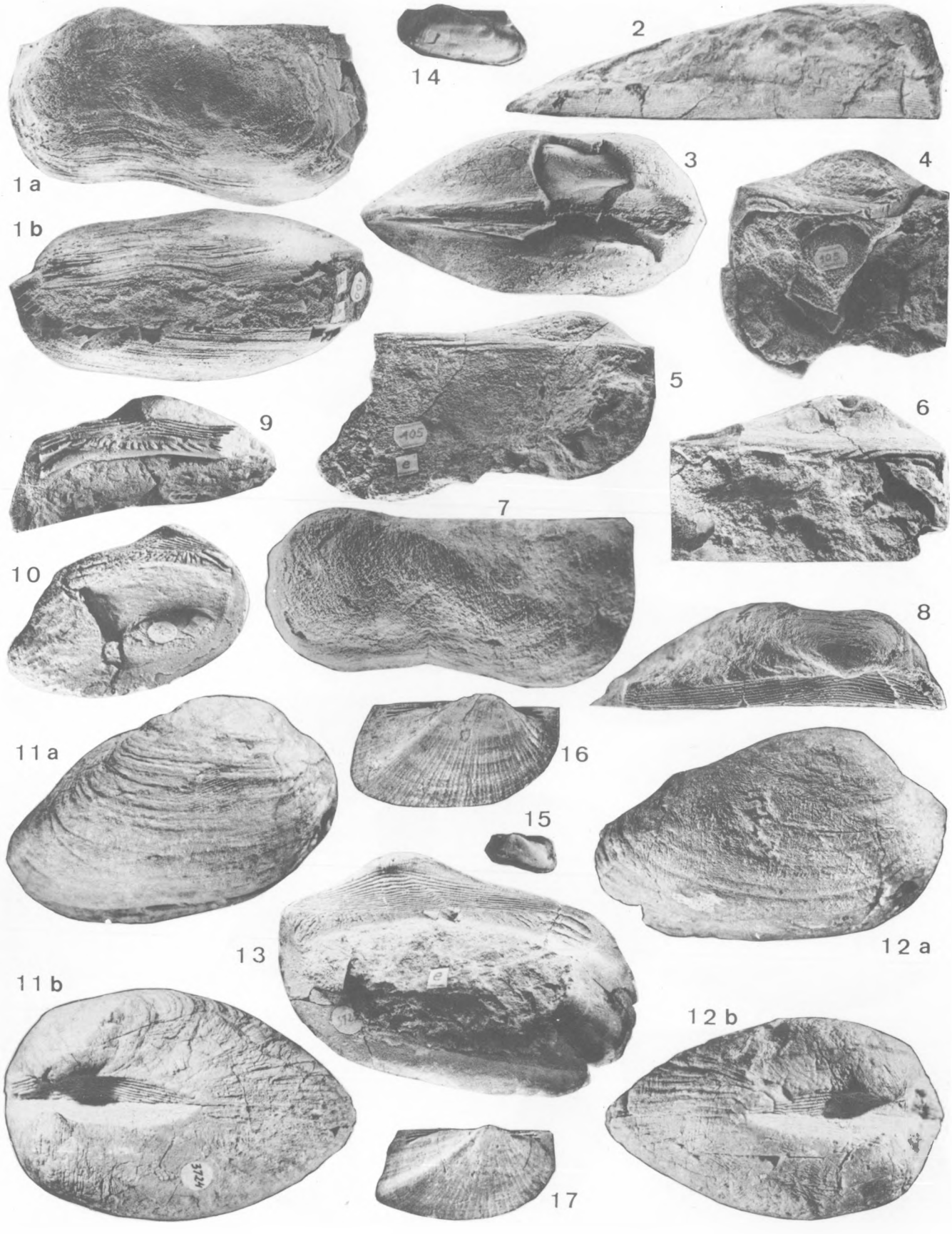
12
13
14 a
14 b
14 c
15 a
15 b
16 a
16 b
16 c
17
18
19 a
19 b
15 c


14
2
1a
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11a
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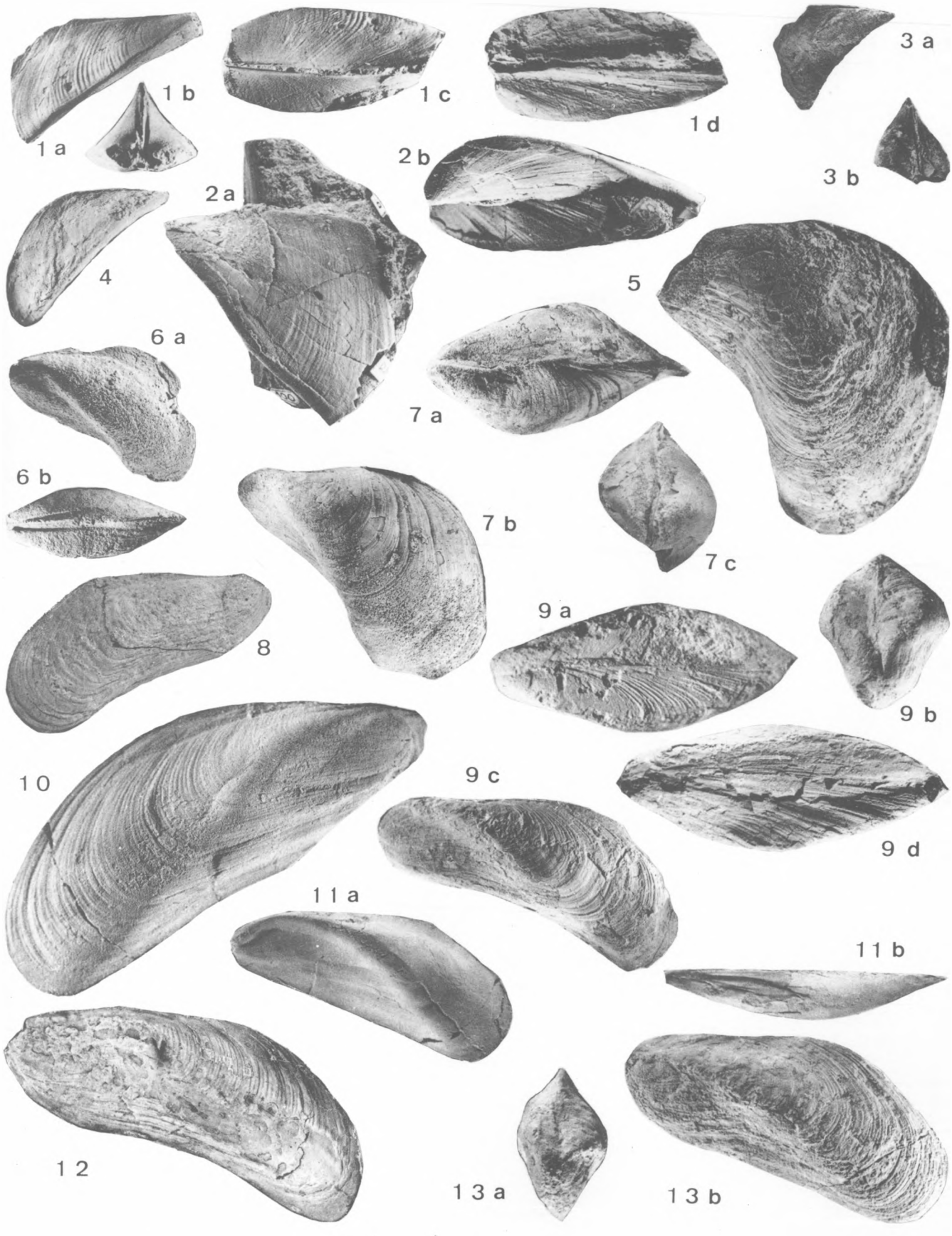
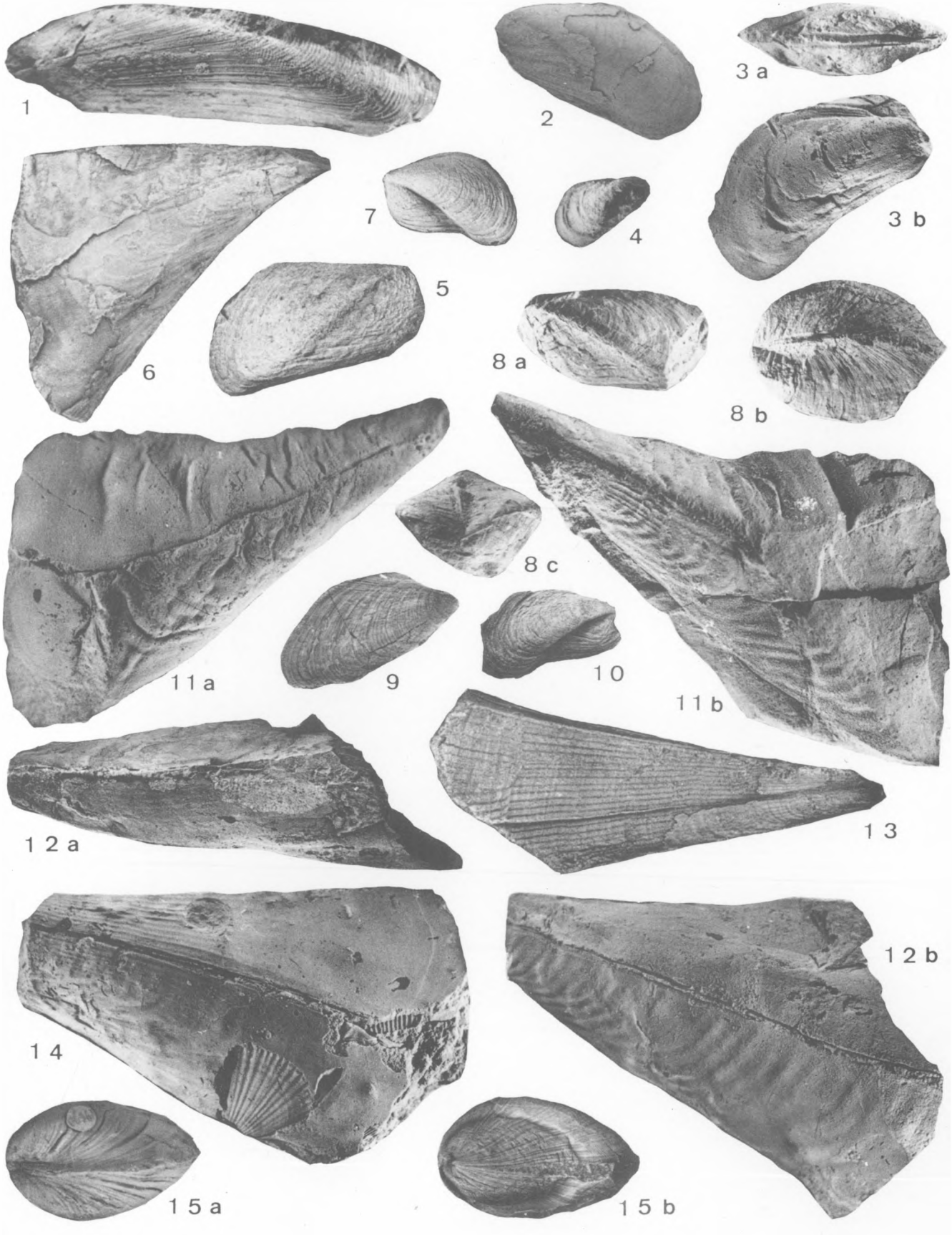
17


1 a
1 b
1 c
1 d
2 a
2 b
3 a
3 b
4
5
6 a
6 b
7 a
7 b
7 c
8
9 a
9 b
9 c
9 d
10
11 a
11 b
12
13 a
13 b



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