

**Taxonomie und Palökologie der Bivalven im Mittel-
und Oberjura der Keltiberischen Ketten (Spanien)**

63 Abb., 14 Tab., 8 Tafeln

Dissertation

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vorgelegt von

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To my parents

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ZUSAMMENFASSUNG

Taxonomie und Palökologie der Bivalven im Mittel- und Oberjura der Keltiberischen Ketten (Spanien)

Die Bivalvenfauna des Mittel- und Oberjura des Aragonesischen Abschnitts der Keltiberischen Ketten wird nach taxonomischen, stratigraphischen, geographischen und palökologischen Gesichtspunkten analysiert dabei wurden frühere Arbeiten über Bivalven des Jura, insbesondere über Formen aus dem Callov und Oberjura, evaluiert. Es wurden 14 Detailprofile und fünf weitere Profile, die nach der Häufigkeit der Bivalven ausgewählt wurden, aufgenommen und beprobt.

Das bearbeitete Material stammt aus den Formationen Chelva, Yátova, Sot de Chera und Loriguilla des Zeitabschnitts Callov-Kimmeridge. Für jedes Profil wird die stratigraphische Verteilung der Muschel-Taxa angegeben.

Für die taxonomische Analyse wurden mehr als 3000 Individuen herangezogen. Sie repräsentieren 83 Taxa, die zu 46 Gattungen und Untergattungen der Unterklassen Palaeotaxodonta, Pteriomorphia, Isofilibranchia, Palaeoheterodonta, Heterodonta und Anomalodesmata gehören. Eine Art, *Plagiostoma fuersichi* aus dem Callov der Chelva Formation, wird neu beschrieben. Für alle Bivalven wird ihre Autökologie (Ernährungsweise, Lebensweise) diskutiert.

Aus vier Profilen wurden 49 Proben für eine quantitative palökologische Analyse des Bivalvenanteils des Makrobenthos ausgewählt. Mit Hilfe einer Q-mode Clusteranalyse ließen sich fünf Assoziationen und zwei Vergesellschaftungen ausscheiden. Die wichtigsten Umweltfaktoren, welche die Assoziationen beeinflussen, sind Substratbeschaffenheit, Wasserenergie und die Verteilung von organischem Material.

Die Bivalven zeigen ein charakteristisches zeitliches und räumliches Verteilungsmuster innerhalb der Aragonesischen Ketten. Vier Assoziationen treten im Ober-Oxford (Sot de Chera Formation) und eine Assoziation im Unter-Callov auf. In den Formationen Sot de Chera und Loriguilla nimmt die Häufigkeit der Bivalven von NW nach SE, bzw. von den proximalen Bereichen der Plattform zu den distalen Bereichen hin, ab. Die Bivalven der Chelva-Formation treten vermehrt im Gebiet von Ariño auf, das als Hochgebiet interpretiert wird. Die räumliche Verteilung der Bivalven wurde vermutlich zum größten Teil durch die Verfügbarkeit von Nahrung bestimmt.

ABSTRACT

Middle and Upper Jurassic bivalves from the Iberian Range (Spain): taxonomy and palaeoecology

Previous work on Jurassic bivalves from the Iberian Range is reviewed, whereby emphasis is placed on Callovian-Kimmeridgian species.

The taxonomy, distribution pattern, and ecology of the bivalve fauna occurring in Middle and Upper Jurassic rocks of the Aragonian Branch of the Iberian Range have been analysed. For this purpose 14 sections and 5 additional outcrops, selected according to the abundance of bivalves, were measured in detail and sampled. The rocks studied belong to the Chelva, Yátova, Sot de Chera and Loriguilla formations of Callovian-Kimmeridgian age. The distribution of species of bivalves is given for each section.

More than 3000 specimens of bivalves representing 83 species that belong to 46 genera and subgenera of the subclasses Palaeotaxodonta, Pteriomorpha, Isofilibranchia, Palaeoheterodonta, Heterodonta and Anomalodesmata have been used for the taxonomic analysis. One species is new: *Plagiostoma fuersichi* from the Callovian of the Chelva Fm. The autecology (trophic group and life habit) of each bivalve has been discussed.

49 samples of four sections have been selected for a quantitative palaeoecological analysis of the bivalve fraction of the benthic fauna. Five bivalve associations and two assemblages are recognized by a Q-mode hierarchical cluster analysis (Ward method). The main environmental factors controlling bivalve associations are thought to be substrate, water energy and distribution of organic matter.

The bivalves exhibit a distinct spatial and temporal distribution pattern within the Aragonian Branch. Four of the bivalve associations occur in the Upper Oxfordian (Sot de Chera Fm) and one association in the Lower Callovian (Chelva Fm). In the Sot de Chera and Loriguilla formations, the abundance of bivalves decreases from NW to SE i.e., from relatively close to the shore line towards the distal-most part of the carbonate platform. In the Chelva Fm, bivalves are abundant in the Ariño region, interpreted as a palaeogeographic high. The spatial distribution of bivalves might have been largely controlled by the availability of nutrients.

RESUMEN

Los bivalvos del Jurásico Medio y Superior en la Cordillera Ibérica (España): sistemática y paleoecología

Se han revisado las publicaciones previas realizadas sobre los bivalvos del Jurásico en la Cordillera Ibérica. Se han citado las especies mencionadas en los materiales del Calloviense-Kimmeridgiense y las especies del Jurásico Inferior que han sido identificadas en este trabajo.

Se han analizado la taxonomía, el patrón de distribución, y la ecología de los bivalvos de los materiales del Jurásico Medio y Superior de la Rama Aragonesa de la Cordillera Ibérica. Para ello se han estudiado y muestreado 14 secciones detalladas y 5 secciones adicionales, seleccionadas en función de la abundancia de bivalvos. Los materiales estudiados pertenecen a las formaciones Chelva, Yátova, Sot de Chera y Loriguilla de edad Calloviense-Kimmeridgiense. En cada sección se muestra la distribución de las especies de bivalvos.

El análisis taxonómico se ha realizado con más de 3000 ejemplares de bivalvos que representan 83 especies, pertenecientes a 46 géneros y subgéneros de las subclases Palaeotaxodonta, Pteriomorpha, Isofilibranchia, Palaeoheterodonta, Heterodonta y Anomalodesmata. Se ha definido una especie nueva: *Plagiostoma fuersichi* que procede de los materiales del Calloviense de la Fm. Chelva. Se discute la autoecología (grupo trófico y modo de vida) de todos los bivalvos registrados.

Se han seleccionado 49 muestras de cuatro secciones para realizar un análisis paleoecológico cuantitativo de la fracción de bivalvos del macrobentos. Se han reconocido cinco asociaciones y dos "assemblages" mediante un análisis tipo "Q-mode hierarchical cluster" (método de Ward). Los principales factores ambientales que controlan las asociaciones de bivalvos fueron el sustrato, la energía del agua y la distribución de la materia orgánica.

Los bivalvos presentan una distribución temporal y espacial a lo largo de la Rama Aragonesa. Cuatro de las asociaciones se registran en los materiales del Oxfordiense superior (Fm. Sot de Chera) y una asociación en los materiales del Calloviense inferior (Fm. Chelva). En las formaciones Sot de Chera y Loriguilla, la abundancia de bivalvos disminuye desde el NW al SE, es decir, desde áreas más cercanas a la línea de costa hasta las áreas más distales de la plataforma. En los materiales de la Fm. Chelva, los bivalvos son abundantes en el sector de Ariño, interpretado como un alto paleogeográfico. La distribución espacial de los bivalvos parece estar controlada en gran medida por la disponibilidad de nutrientes.

1. INTRODUCTION

1.1. AIM OF STUDY

The present work focuses on the taxonomic study of Callovian-Kimmeridgian (Middle-Upper Jurassic) bivalves of the Aragonian Branch of the Iberian Range. The general aims are as follows:

(a) A detailed stratigraphic record of most relevant Middle-Upper Jurassic sections in the study area. Selected sections have been the subject of a detailed bed-by-bed logging and sampling. The most fossiliferous sections with a comparatively high abundance of bivalves were marked for a palaeoecological analysis.

(b) A taphonomic analysis of the bivalve associations as a prerequisite for subsequent palaeoecological studies. Most important features are: the position in the bed (in growth position or displaced) and the orientation of the fossil. A third relevant factor is the state of preservation of fossils as shells, internal moulds or external casts. This analysis should lead to an understanding of the preservational history of fossil assemblages.

(c) The taxonomic study of bivalve groups is the main purpose of this work. It is justified by the scarcity of previous work on this group in Spain (see Chapter 2). The taxonomic work stands as a necessary, fundamental *sine qua non* condition for the palaeoecological reconstruction of the depositional environment for stratigraphic intervals rich in bivalves.

(d) The palaeoecological study centres on the analysis of palaeobiological features such as life habits, substrate relation, feeding habits, and species interactions. This study focuses, on one hand, on palaeoautecology, i.e. the analysis of the way of life of a certain species in relation to its particular environment and on the other hand, the palaeosynecological analysis. The latter includes the study of relationships between groups within a benthic community and some environmental parameters, such as nature of substrate, food supply, and water energy, among others.

1.2. METHODOLOGY

Prior to the geological field work, a detailed documentary compilation including geological maps and literature was carried out. This includes both “historical” and modern, regional, stratigraphic and palaeontological references. More specific references on bivalves will be analysed in detail further on. The thesis required field work, laboratory work and office work, all of them closely connected.

1.2.1. FIELD WORK

Outcrops in the Aragonian Branch of the Iberian Range have been studied from NW to SE. The scarcity of previous studies and bivalve collections made it advisable to stick, in a first stage of the work, to sections in the Aragonian Branch (Fig. 1). Yet, some *classical* sections in the Castillian Branch of the Iberian Range have also been briefly revised and recorded as a reference. First results showed that the palaeontological content and thus also the bivalve fauna of both areas are entirely comparable. The studied sections include Middle to Upper Jurassic carbonate rocks belonging to the Chelva Fm, Yátova Fm, Sot de Chera Fm and Loriguilla Fm, as defined by GÓMEZ & GOY (1979, 1981). They range from Lower Callovian to Kimmeridgian. In some cases, only selected intervals have been studied within a section, depending mainly on the bivalve content of the units.

Some *classical* sections have been the subject of previous litho- or biostratigraphic (ammonoid) studies since the early 70's of the last century. This has in some way provided a solid biostratigraphic framework for the present palaeontological study. Sections have been studied in detail, bed-by-bed, and levels have been numbered (painted).

The bed-by-bed logging of sections also included intense palaeontological sampling. Fossils were collected quantitatively and marked with their corresponding section code and bed number. A representative sample of other macrofossils, mainly other benthic groups and ammonoids, was also recorded. Ammonoids, identified by members of the ammonoid research group at Zaragoza University, were used for bio-chronostratigraphic purposes. Bivalves have been the subject of intense collecting, in order to get a sound idea of the taxonomic composition within the studied interval as well as on the general and relative abundance. This information served as a basis for analysing their life habits and for further palaeoecological studies. Other benthic groups collected were (1) the remaining groups of benthic molluscs, including scaphopods and gastropods, and (2) brachiopods. A detailed taxonomic determination of these groups has not always been possible; however they have been quite useful for the purpose of palaeoecological reconstructions.

1.2.2. LABORATORY WORK

a) Fossils have been cleaned with water. Chisels and hammers as well as an electrical percutor were used to mechanically prepare the fossils. This part of the work was very tedious and time-consuming.

b) In cases, where fossils occur in argillaceous/marly sediments, hydrogen peroxide was used to separate fossils from their matrix. In particular, this method has been applied to fossiliferous levels of the Yátova Fm which contain small-sized specimens.

c) Microfacies studies and study of shell microstructures of some bivalves were based on thin-sections.

1.2.3. OFFICE WORK

In different universities and museums bivalve material and literature was examined. More precisely, this office work included the following steps:

(a) Reference compilation. This has been the most important step, at the beginning of the work, as only few papers related to bivalves were available in Zaragoza. The compilation of references on Jurassic bivalves have been realized in the following libraries and research centres:

- Library of "Sección Geológicas de la Facultad de Ciencias de la Universidad de Zaragoza".
- Library of "Museo Geominero (IGME)" (Madrid).
- Library of "Real Sociedad Española de Historia Natural" (Madrid).
- Library of " Facultad de Ciencias Geológicas de la Universidad Complutense" (Madrid).
- Bayerische Staatssammlung für Paläontologie und historische Geologie (München, Germany).
- Institut für Paläontologie der Universität Würzburg (Würzburg, Germany).

The Jurassic Library in the Institute of Palaeontology of the University of Würzburg contains a large number of papers on the taxonomy of Jurassic bivalves, as well as papers on other benthic groups of

the same age such a gastropods, brachiopods, echinoids and corals. This Jurassic Laboratory contains a *Catalogue of figured Jurassic bivalve species* of the world. Parts of this catalogue were copied so that a catalogue of bivalve species described from the Aragonian Branch of the Iberian Chain (Middle and Upper Jurassic) and their nearest relatives is now also available at the University of Zaragoza.

(b) Biometric study. Measurements were made on well-preserved bivalves with a calibre using a binocular microscope in case of very small forms. The biometric parameters are described in detail in Chapter 4 (Taxonomy). Correlation and regression analyses have been calculated using statistic programs. The most frequently used parameter is the length/height ratio of shells.

(c) Visits to museums: reference collections.

In the following research centres, collections of bivalves have been studied in order to compare them with those recorded from the Aragonian Branch of the Iberian Chain.

* *Museo Geominero* (Madrid): Middle and Upper Jurassic Bivalves of the Iberian Chain.

* *Museo de Ciencias Naturales* (Madrid): Middle and Upper Jurassic Bivalves of Spain. The material is relatively abundant, but for the greater part identifications are merely at the family level. Therefore, it has not been used as a reference collection. Moreover, in most cases the stratigraphic and geographic origin is uncertain, showing the age as "Jurassic" and the geographic position at the provincial level.

* *Institut für Paläontologie der Universität Würzburg* (Würzburg, Germany): General Invertebrate Collection: Mollusca (bivalves, scaphopods, gastropods) and brachiopods; Middle and Upper Jurassic bivalves from Kachchh (Northwestern India); Middle and Upper Jurassic bivalves of Rajasthan (India); Jurassic bivalves of the Aquitanian Basin (SW France).

* *Bayerische Staatssammlung für Paläontologie und historische Geologie* (München, Germany): Upper Jurassic Bivalves from Portugal; Middle and Upper Jurassic bivalves of South Germany; Jurassic and Cretaceous bivalves of Siberia; The general reference collection of bivalves: This collection is very extensive and contains bivalves from the Palaeozoic up to the Recent. It is organized in taxonomic categories (superfamilies) and contains holotypes and paratypes of many species of Middle and Upper Jurassic defined by German authors of the 19th century, such as Goldfuss, Münster or Böhm.

* *Sedgwick Museum* (Cambridge, Great Britain): Middle and Upper Jurassic bivalves of England.

(d) Taxonomic study. This study refers to the preservation of fossils, the total number of specimens, the list of synonymies, the description and discussion of the material, and its stratigraphic and geographic distribution in the Iberian Range.

(e) Palaeoecological study. The aim of this part of the work is the analysis of the life habits of the recorded bivalves, their feeding mode, their relationship to the substrate and to the remaining benthic groups. Only some levels at some localities were suitable for a quantitative analysis. Prerequisite was that the analysed sample contained at least 30 specimens. For each of these samples, the number of individuals had to be reconstructed, based on the number of articulated specimens and the larger number of either left or right valves. Finally, the relative abundances of the various ecotypes are calculated for each level.

(f) Photography. The photographic work has been carried out by the *Palaeontological Photograph Service of the University of Zaragoza*. Fossils were painted with a solution of graphite and subsequently covered with sublimated Ammonium Chloride.

(g) Text work. All tables and figures have been made by computer programs.

1.3. GEOGRAPHIC AND GEOLOGICAL FRAMEWORK

The study area extends across the northeastern part of the Iberian Peninsula, within the so-called Iberian Range (Fig. 1). This mountain system, generally extending in a NW-SE direction, is traditionally subdivided into two geographical units (branches): the “Aragonian Branch” (NE) and the “Castillian Branch” (SW). These units are separated by Tertiary and Recent (Quaternary) deposits of the so-called Calatayud-Teruel Graben. The southeasternmost area, south from the city of Teruel, down to Valencia and Castellón provinces, was defined as “Sector Levantino” of the Iberian Range by GÓMEZ (1979). The present study focuses on the Callovian-Kimmeridgian interval (Middle to Upper Jurassic), mostly formed by carbonate sequences within the Aragonian Branch (Fig. 1).

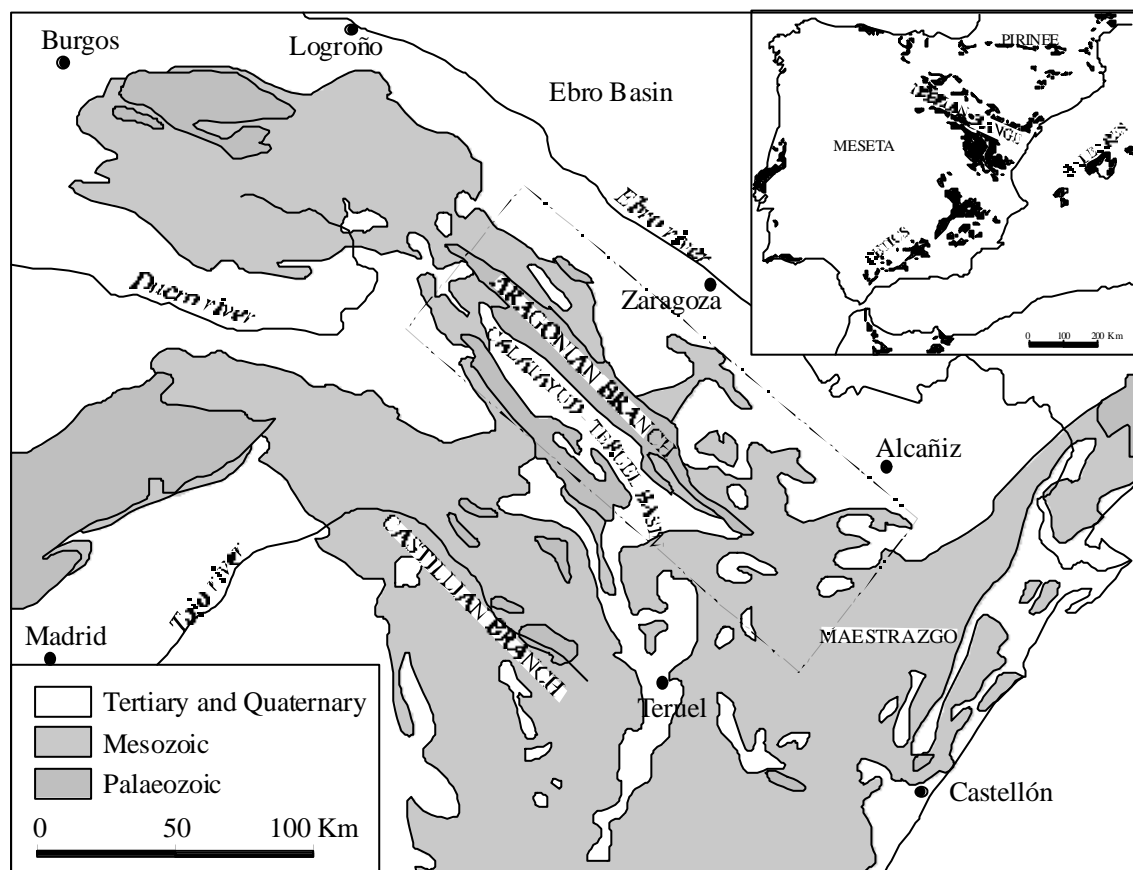


Fig. 1. Geological framework of the study area (Aragonian Branch of the Iberian Range). Modified after BULARD 1972.

The Iberian Range is bounded NNE by Tertiary deposits of the Ebro basin, and SE by Cretaceous rocks of the Maestrazgo (easternmost part of the Iberian Range). The Aragonian Branch extends from the Moncayo Hills (Sierra del Moncayo, Riela area) in the Northwest, to the region of “Bajo Aragón” (lower Aragón) in the Southeast between the localities Calanda and Mas de las Matas. From an

administrative point of view the study area is located in south-central Aragón, extending across the southern part of Zaragoza and north of Teruel. Fig. 2 shows the main outcrops and the main access roads.

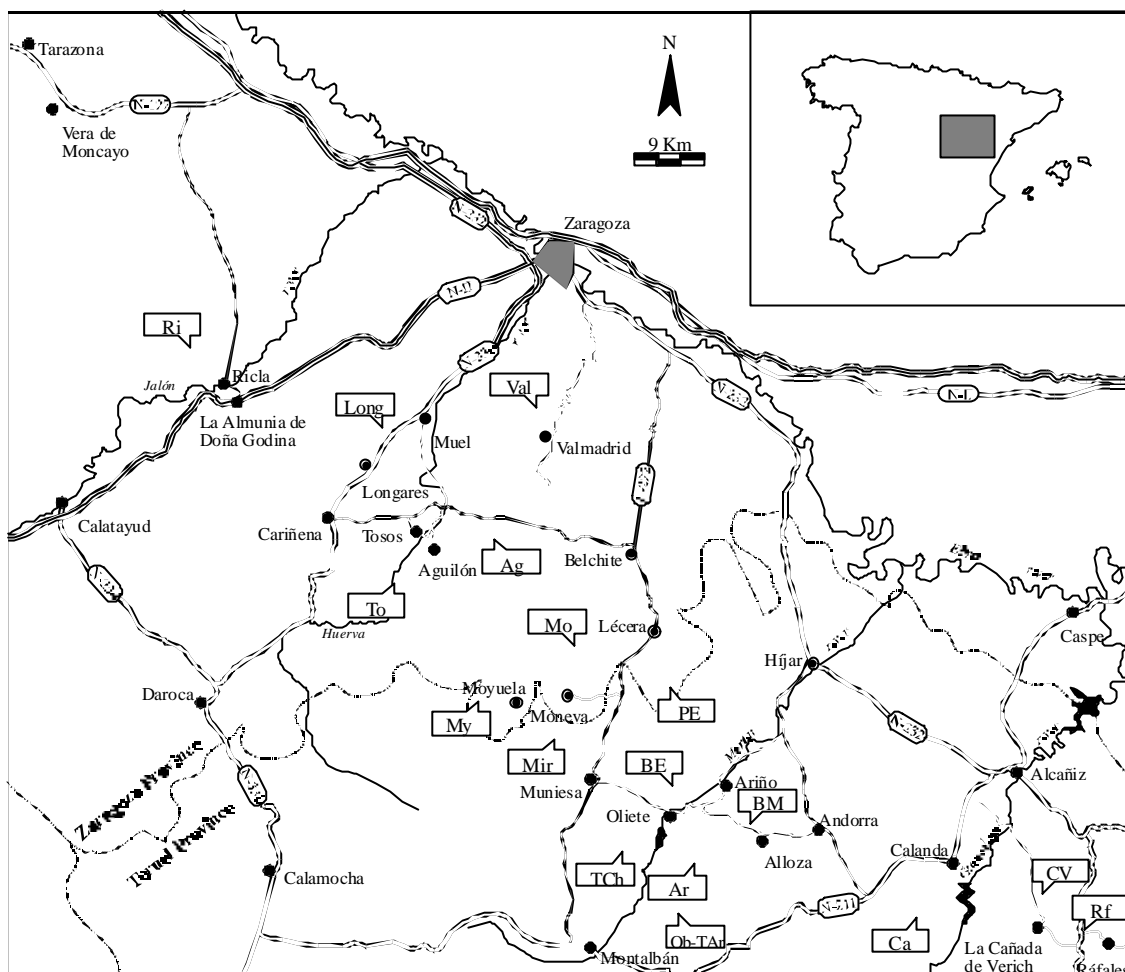


Fig. 2. Geographic framework of the study area, showing the outcrops and main localities. Ri: Ricla, Long: Longares, Val: Valmadrid, To: Tosos, Ag: Aguilón, My: Moyuela, Mo: Barranco de la Librería, Mir: Mirambueno, PE: Barranco de la Peñisquera, BE: Barranco de las Estacas, BM: Barranco del Moro, TCh: Tía Chula, Ar: Ventas de San Pedro, Ob-TAr: Obón-Torre de las Arcas, Ca: Calanda, CV: La Cañada de Verich, Rf: Ráfales.

Outcrops have been selected, on one hand, among *classical* well known sections for their wealth in fossils and good exposure. On the other hand, new outcrops have been selected because of their richness in bivalves. Altogether, fourteen sections have been recorded in detail, following a NW-SE direction: Ricla, Valmadrid, Tosos, Moneva, Lécera (province of Zaragoza), and Muniesa, Ariño, Oliete, Foz Calanda, La Cañada de Verich (province of Teruel). Some additional outcrops in the localities of Longares, Aguilón, Moyuela (province of Zaragoza), and Obón-Torre de las Arcas, Ráfales (province of Teruel) have been recorded. However, due to their low fossil content, they were not treated in that detail as the above mentioned sections.

A general plate tectonics evolutionary model for the Iberian Range was proposed by ÁLVARO *et al.* (1979). The Iberian Range is interpreted as an aulacogene where several evolutionary stages are recognized: an early Graben-stage (Lower to Middle Triassic), a transitional, stage (from Middle to Upper Triassic) and a later flexure stage (Jurassic and Cretaceous).

The Middle Jurassic was an unstable interval during which a wide carbonate platform developed, structured in uplifted and subsiding blocks. This block tectonic activity was accompanied by volcanic eruptions from Late Toarcian to Bathonian times (GÓMEZ *et al.* 1976). A homogeneous carbonate ramp subsequently developed during the Upper Jurassic (Oxfordian to Kimmeridgian). This interval was also characterized by a decreasing tectonic activity and the widespread development of marine conditions throughout the basin. At the end of the Jurassic (Late Tithonian) tectonic reactivation at the basin margins led to a final regression stage, evidenced by the development of continental facies in the internal part of the basin.

2. PREVIOUS WORK

The aim of this chapter is, on the one hand, to provide a review of regional studies on the geology and palaeontology of the Iberian Chain since the 19th century. On the other hand, it is a detailed review of previous studies on Jurassic bivalves in Spain. The authors will be treated exclusively in chronological order.

2.1 REGIONAL STUDIES

Only the most important regional stratigraphic studies are mentioned here. For a more comprehensive review of previous studies see GÓMEZ (1979: 34-81).

In the middle part of the 19th century, DE VERNEUIL & COLLOMB (1852) studied several Jurassic outcrops in the East of Spain. Some years later, VILANOVA Y PIERA (1863) carried out a geological study in the province of Teruel recognizing all stages of the Jurassic system.

The Jurassic rocks of the province of Zaragoza were treated by DONAYRE (1873) and PALACIOS (1893). The latter author also studied the stratigraphy of Jurassic rocks of the Ricla area (province of Zaragoza).

The geological-palaeontological studies of CORTÁZAR (1885) and MALLADA (1885) enhanced the knowledge of the palaeontology of the Iberian Chain considerably. They paid special attention to the ammonites providing a biostratigraphic framework of the Jurassic rocks. At the same time, they offered a general idea of the main fossil groups recorded.

DEREIMS (1898) accomplished a detailed geological study of southern Aragón, with a "modern" approach to litho- and biostratigraphy.

NAVÁS (1903) studied Lower Jurassic rocks of La Almunia area (province of Zaragoza) and JOLY (1923) Upper Jurassic outcrops of the same area. The latter author also carried out some geological studies in the "Sierra de Albarracín" (province of Teruel).

Several doctoral theses were carried out on Jurassic rocks of the Iberian Range since the 1950's. Of those, the study by RIBA (1959) greatly increased the knowledge of for the litho- and biostratigraphic subdivision of the Jurassic of the Sierra de Albarracín.

At the same time that Spanish authors started to study Jurassic rocks extensively, a large number of studies were produced by German authors. GEYER (1965) studied the biostratigraphy and palaeontology (corals) of the Upper Jurassic of the "Montes Universales de Albarracín". The works of GEYER and others on the Jurassic stratigraphy were numerous in the Castillian Branch of the Iberian Chain during these years.

Since 1966, BULARD started to publish on the Middle and Upper Jurassic rocks of the Aragonian Branch of the Iberian Chain. In his PhD thesis (BULARD 1972), he studied Middle and Upper Jurassic rocks of the southern margin of the Ebro Basin. He described several outcrops in detail and analysed the Callovian-Oxfordian boundary. His work proved to be one of the most important studies in the Aragonian Branch of the Iberian Chain and formed the base for subsequent palaeontologic, stratigraphic and biostratigraphic studies by other authors.

MARÍN & TOULOUSE (1972) treated the Callovian-Oxfordian boundary (Dogger-Malm) of the Ariño-Oliete area (Aragonian Branch of the Iberian Chain).

GÓMEZ (1979), in his doctoral thesis, studied the Jurassic carbonate facies of the "Sector Levantino" of the Iberian Chain. An exhaustive review of previous work was given, the Middle and Upper Jurassic lithostratigraphic units of the Iberian Chain were defined, and the Dogger-Malm boundary was discussed. GÓMEZ & GOY (1979, 1981) defined formally the Middle and Upper Jurassic lithostratigraphic units of the "Sector Levantino" and their lateral equivalents in the entire Iberian Chain.

The lithostratigraphic units include the Chelva Fm, Sot de Chera Fm, Loriguilla Fm and Higuieruelas Fm. The uppermost part of the Chelva Fm, formed by limestone with sponges (Oxfordian in age), was separated as a member within this formation (Yátova Mb). Later, other authors (GÍNER 1980, SALAS 1987 and AURELL 1990) recognized this unit as an independent formation defined as Yátova Fm.

The biostratigraphy and taxonomy of the Oxfordian ammonoids of the Iberian Chain was studied by MELÉNDEZ (1989).

AURELL (1988) studied the stratigraphy and sedimentology of the Upper Jurassic between the rivers Aguasvivas and Guadalope. He informally erected some new lithostratigraphic units. Later on, MELÉNDEZ *et al.* (1990) defined two new units the *Calanda Member* and the *Alacón Member* of the Loriguilla Fm.

FEZER & GEYER (1988) developed a stratigraphic and palaeontological (ammonoids) study of the Oxfordian-Kimmeridgian outcrops in "Bajo Aragón".

SALAS (1987) and AURELL (1990) defined the stratigraphic sequences, the evolution of the carbonate platform during the Upper Jurassic and characterized the sedimentary environments.

The Dogger-Malm boundary was studied repeatedly from a biostratigraphic, sedimentologic, taphonomic and palaeogeographic point of view, especially in the Ariño-Oliete area. Apart from MARÍN & TOULOUSE (1972), the most recent studies were by AURELL *et al.* (1994) and MELÉNDEZ *et al.* (1997 and references therein), and provided an updated review of the geological problems in this interval and some biostratigraphic precisions.

Callovian ammonoids were studied by various authors: LARDIÉS (1988, 1990) and SEQUEIROS (1984) (oppelids and perisphinctids). SEQUEIROS & CARIU (1984) presented a biostratigraphic synthesis of the Callovian of Ricla; SEQUEIROS & MELÉNDEZ (1987) and LARDIÉS *et al.* (1988) clarified the biostratigraphy of the Callovian in the central sector of the Iberian Chain.

The Oxfordian ammonoids, in particular the perisphinctids, were treated in various monographs (MELÉNDEZ 1989; FONTANA 1990; MELÉNDEZ & FONTANA 1993; BELLO 1995, 1996). The Upper Oxfordian ataxioceratids were described by PÉREZ-URRESTI (1995, 1996).

Work on the Middle and Upper Jurassic bivalves of the Iberian Chain was carried out by DELVENE (1997a,b, 1998 and 1999). DELVENE *et al.* (1998) offered new biostratigraphic data on the Oxfordian-Kimmeridgian boundary in the Ricla area and showed the most abundant bivalve species and their life habits.

BÁDENAS (1997) redefined the lithostratigraphic units and improved the sedimentologic pattern of the Ricla-Calatorao area. Finally, BÁDENAS (1999), in her doctoral thesis, discussed the sedimentation

history on carbonate ramps during the Kimmeridgian in several basins of the eastern Iberian Plate, her object of study being the Kimmeridgian sediments of the Ricla-Calatorao area.

The most modern syntheses on the Upper Jurassic of the Iberian Chain deal with the Oxfordian of the Iberian Chain and its transition to the Catalan Chain (RAMAJO *et al.* 1999) and with the Callovian-Kimmeridgian interval in the "Sierra de Arcos" (Andorra-Moneva) and "Bajo Aragón" (Calanda-Mas de las Matas) (AURELL *et al.* 1999a).

2.2. STUDIES ON JURASSIC BIVALVES OF THE IBERIAN RANGE

The work of TORRUBIA 1754: "*Aparato para la Historia Natural*" constituted the first palaeontological reference on the Iberian Chain in Spain (PELAYO 1994), and contains the first data and drawings of bivalves (his plates: 1-2, 48 and 10). Its repercussion in Europe led to its translation into German in 1773. Recently, it was re-edited in Madrid by UEI de Paleontología e Instituto de Geología Económica de Madrid (1994) in connection with the 10th *Jornadas de Paleontología*. The Spanish bivalve material studied by TORRUBIA comes from the Lower Jurassic of the Molina de Aragon area (see BERNAD 1999a).

In their work *Coup d'oeil sur la constitution géologique de quelques provinces de l'Espagne*, DE VERNEUIL & COLLOMB (1852) treated rocks from all geological ages. For the Jurassic material (1852: 104-115), the most representative outcrops were given. A list of fossils with the name of the Jurassic genera and species of eastern and southeastern Spain was given and supplemented with the locality and stratigraphical level where these species occurred in France. The exact stratigraphical level where these species were found was not mentioned by the authors. They showed that they fit in the standard chronostratigraphic zonation in Europe. In their list, 26 species belong to bivalves, four of them were figured on their plate 3, figs. 4-7. The species assigned a Callovian-Kimmeridgian age in their work are listed in Table 1.

TABLE 1. Callovian-Kimmeridgian bivalves discussed by DE VERNEUIL & COLLOMB (1852).			
SPECIES	LOCALITY	STRATA IN WHICH THE SAME SPECIES OCCURS IN FRANCE	REFERENCE
<i>Mytilus bipartitus</i> Goldfuss	Frías	"Kelloway"	p. 112
<i>Pecten subspinosus</i> Schlotheim	Between Alustante and Prados Redondos	"Oxfordien"	p. 112
<i>Pecten textorius</i> Goldfuss	Anchuela	"Lias Supérieur"	p. 112
<i>Pholadomya trapezina</i> Buvignier	Between Frías and Villar del Cobo	"Oxfordien" (In Spain, Oxfordian in age)	p. 112, pl. 3, fig. 7
<i>Ostrea gregarea</i> Sowerby	Guadalaviar, Griegos, Anchuela, Albarracín, Villar del Cobo, Checa, Carrascosa, Torremocha, Barahona	"Kelloway y Oxfordien" (In Spain, Lower Jurassic in age)	p. 112, pl. 3, fig. 6

EZQUERRA (1850, 1854, 1857) reviewed the contemporary studies, in particular DE VERNEUIL & COLLOMB (1852). He described all geological ages in detail, the most important minerals and compiled a catalogue of species of all fossil groups mentioned. In “terrenos jurásicos and oolíticos, con agregación de los liásicos”, he mentioned 36 species of bivalves that he included in the class Acephala and in the orders Ortoconquia and Pleuroconquia (Table 2).

TABLE 2. Jurassic bivalves listed by EZQUERRA (1854). •Species identified in this work.		
SPECIES	LOCALITY	REFERENCE (page)
<i>Astarte elegans</i> Sowerby	Torres	178
<i>Gryphaea incurva</i> Sowerby	Albarracín, Calomarde	179
<i>Lima elea</i> d'Orbigny	Brieva, Anchuela	178
<i>Lima gigantea</i> Deshayes	Ablanque, Anchuela	178
<i>Lima obscura</i> Deshayes	Albarracín	178
• <i>Lima proboscidea</i> Sowerby	Ablanque, Alcolea del Pinar, Canales (prov. of Logroño), Mansilla de la Sierra	178
<i>Lithodomus prolongus</i> d'Orbigny	Calomarde	178
<i>Lutraria rotundata</i> Goldfuss	Anchuela, Monterde	178
<i>Lyonsia unioides</i> Goldfuss	Anchuela, Villar del Cobo	178
<i>Mactromya liasina</i> Agassiz	Maranchón, Albarracín, Villar del Cobo	178
• <i>Mytilus bipartitus</i> Goldfuss	Frías	178
<i>Mytilus plicatus</i> ? Sowerby	Las Majadas, Albarracín	178
<i>Opis sarthacensis</i> d'Orbigny	Anchuela	178
<i>Ostrea erina</i> d'Orbigny	Anchuela	179
<i>Ostrea colubrina</i> Goldfuss	Albarracín, Villar del Cobo	179
<i>Ostrea costata</i> Sowerby	Ablanque	179
<i>Ostrea cymbium</i> Lamk.	Brieva de Juaros	179
• <i>Ostrea gregarea</i> Sowerby	Guadalaviar, Anchuela, Villar del Cobo, Torremocha, etc.	179
<i>Ostrea marshii</i> Sowerby	Calomarde	179
• <i>Ostrea solitaria</i> Sowerby	Ablanque	179
<i>Pecten acuticosta</i> Lamk.	Maranchón, Albarracín, Villar del Cobo	178
<i>Pecten disciformis</i> Schub.	Barahona	179
<i>Pecten equivalvis</i> Goldfuss	Mansilla de la Sierra, Brieva	179
<i>Pecten pradoanus</i> Verneuil	Anchuela, Guadalajara, Las Majadas	179

TABLE 2 (cont.)		
• <i>Pecten subspinosus</i> Schlotheim	Alustante and Prados	179
• <i>Pecten textorius</i> Goldfuss	Anchuela	179
<i>Pholadomya acuticosta</i> Sowerby	Between Orihuela and Monterde	178
<i>Pholadomya decorata</i> Ziet.	Ablanque	178
<i>Pholadomya hausmanni</i> Goldfuss	Anchuela	178
• <i>Pholadomya trapecina</i> Buvignier	Frías, Villar del Cobo	178
<i>Pholadomya paucicosta</i> Roem.	Albarracín	178
<i>Plicatula spinosa</i> Sowerby	Anchuela, Torremocha	179
<i>Posidonia minuta</i> Goldfuss	Monterde	178
<i>Tracia chanviniana</i> d'Orbigny	Frías	178
<i>Trigonia costata</i> Park.	Anchuela	178

VILANOVA Y PIERA (1863) described the province of Teruel from several points of view. He treated Jurassic rocks (1863: 46-72) and studied the localities with the best outcrops. In the “*Catálogo provisional de los principales fósiles jurásicos de la provincia de Teruel*” (1863: 65), 48 species of bivalves were mentioned. In his plates of Jurassic fossils (pls. 9-10), he figured species of brachiopods and ammonites but no bivalves. He referred to the study of DE VERNEUIL & COLLOMB (1852) and marked with an asterisk the fossils collected by DE VERNEUIL. 48 species of bivalves were mentioned in this work, 21 of them belonging to the Callovian-Kimmeridgian and are listed in Table 3.

TABLE 3. Callovian-Kimmeridgian bivalves listed by VILANOVA Y PIERA (1863). * Fossils collected by DE VERNEUIL. ** Fossils collected by DE VERNEUIL and VILANOVA Y PIERA. Fossils without asterisk belong to VILANOVA Y PIERA. • Species identified in this work.			
SPECIES	LOCALITY	STRATA	REFERENCE (page)
• <i>Arca concinna</i> Goldfuss	Torrevelilla	"Oxfórdico, Portlándico"	66, 71
• <i>Ceromya excentrica</i> Agassiz	Between Josa and Obón	"Kimmeridgico"	66
<i>Ceromya inflata</i> Agassiz	Torrevelilla y Obón	"Oxfórdico, Kimmeridgico, Portlándico"	66, 70-71
<i>Lima pectiniformis</i> Brongniart	Obón, Ariño	"Grande Oolita"	67
• <i>Lima proboscidea</i> Sowerby	Obón, Ariño	"Grande Oolita"	67
<i>Lima substriata</i> ? Münster	Obón, Ariño	"Grande Oolita"	67
<i>Modiola acinaces</i> Leymerie	Ariño	"Coralrag"	67
<i>Mya rugosa</i> Roemer	Torrevelilla, Torres	"Portlándico"	66, 71

TABLE 3 (cont.)			
•** <i>Mytilus bipartitus</i> Goldfuss	Albarracín, Frías	"Oxfórdico"	67
<i>Mytilus pectinatus</i> Sowerby	Albarracín	"Oxfórdico"	67
<i>Mytilus sublaevis</i> Sowerby	Albarracín	"Oxfórdico"	67
* <i>Ostrea colubrina</i> Goldfuss	Guadalaviar, Obón, Griegos, Albarracín, Villar	"Calóvico"	67
•** <i>Ostrea gregarea</i> Sowerby	Guadalaviar, Obón, Griegos, Albarracín, Villar, etc.	"Oxfórdico"	67
<i>Pecten barbatus</i> ? Sowerby	Obón	"Oxfórdico"	67
<i>Pecten lens</i> Sowerby	Albarracín	"Oolita inferior and Oxfórdico"	67
<i>Pecten lugdunensis</i> Sowerby	Torrevelilla	"Oolita inferior and Portlándico"	67, 71
** <i>Pholadomya paucicosta</i> Roemer	Albarracín	"Coralrag"	66
•* <i>Pholadomya trapezina</i> Buvignier	Between Frías and Villar	"Oxfórdico"	66
<i>Pleuromya helena</i> Chapuis & Dewalque	Torres	"Grande Oolita"	66
* <i>Thracia chauviniana</i> d'Orbigny	Frías	"Oxfórdico"	66
* <i>Trigonia clathrata</i> ? Agassiz	Albarracín	"Oxfórdico"	66

Of the other species mentioned from older stratigraphic intervals, only *Pecten velatus* GOLDFUSS, included in genus *Eopecten* now, from the Lower Jurassic of Abejuela (province of Teruel), is also recorded in this study.

DONAYRE (1873) carried out a geological study of the province of Zaragoza. He dedicated a part of his work to the Jurassic System (1873: 72-78) where he described the rocks and the fossils in the different localities of the province. In an annex, the "*Catálogo de los fósiles recogidos en la provincia de Zaragoza*", he gives the name of the species, strata and locality, among them, eight species of bivalves. Those found in the context of this study are given in Table 4.

TABLE 4. Jurassic bivalves listed by DONAYRE (1873). • Species identified in this work.			
SPECIES	LOCALITY	STRATA	REFERENCE (page)
• <i>Ceromya excentrica</i> d'Orbigny	Aguilón	Jurassic ("grupo oolítico o Lías Superior")	118
<i>Lima punctata</i> Deshayes	Aguilón	Jurassic ("grupo oolítico o Lías Superior")	118

TABLE 4 (cont.)			
<i>Pecten heblii</i> d'Orbigny	Aguilón	Jurassic ("grupo oolítico o Lías Superior")	118
• <i>Pholadomya trapecina</i> ?Buvignier	Aguilón	Jurassic ("grupo oolítico o Lías Superior")	118

MALLADA (1879-1885) mentioned more than 100 species of Jurassic bivalves from Spain, and figured 31 of them. He figured species of all Jurassic fossil groups referred to in *Boletín de la Comisión del Mapa Geológico de España* (RÁBANO & GUTIÉRREZ MARCO 1999). Of his 59 plates, eight of them contain figures of bivalves. They were published in the following chronological order:

TABLE 5a. Chronological order of published plates by MALLADA (1879-1884) that contain bivalve figures.				
Number of plates	1879	1881	1883	1884
30				
30A-B				
30C				
31-32				
33				
43				

In 1885, the volume II of his *Sinopsis de las especies fósiles encontradas en España* was published, and a compilation of the Triassic and Jurassic systems was included; parts published between 1879 and 1884 were reprinted. The plates of bivalves were not modified. Finally, in 1892, the *Catálogo de las especies fósiles encontradas en España*, a list of most species mentioned in the previous studies and their localities, was published. It included localities mentioned in his compilation of 1885 and new Spanish localities. Furthermore, 39 species of bivalves were mentioned without figures.

In this last study, some erroneous information in his previous publications was rectified, such as the wrong authorship of several species.

From the species (MALLADA 1885, 1892) included in the Lower Jurassic or "Sistema Liásico" and between the "Oolita Inferior" and the "Gran Oolita" (Bajocian-Bathonian), the eight following were found in the Callovian and the Kimmeridgian of the Aragonian Branch of the Iberian Chain: *Mactromya aequalis* AGASSIZ, *Pecten cingulatus* GOLDFUSS, *Pecten textorius* SCHLOTHEIM, *Hinnites velatus* (GOLDFUSS), *Ostrea gregarea* SOWERBY, *Arca (Cucullaea) concinna* PHILLIPS, *Lima duplicata* SOWERBY and *Pleuromya alduini* (BRONGNIART).

Lima proboscidea SOWERBY (MALLADA 1879, 1885: pl. 31, figs. 1-2), now included in the genus *Ctenostreon*, was figured by MALLADA, but he did not give the locality and the age. This species is relatively abundant in the Callovian-Oxfordian of the northeastern sector of the Aragonian Branch of the Iberian Chain.

From the stratigraphic interval treated in this study, 49 species were mentioned by MALLADA. The information is provided in Table 5b.

TABLE 5b. Callovian-Kimmeridgian taxa mentioned by MALLADA (1885, 1892). • Species identified in this work.			
SPECIES	LOCALITY	STRATIGRAPHICAL LEVEL	REFERENCE
<i>Anisocardia tyrolensis</i> , Zitt.	Fuente de los Frailes de Cabra	Tithonian	1892: 101
<i>Arca (Cucullaea) texta</i> Roemer	Arcos River	Kimmeridgian- Portlandian-	1885: 89; 1892: 101
<i>Astarte bulla</i>	Peña Escorxada de Castelldefels	Kimmeridgian	1892: 101
<i>Aucella carinata</i> Paronna sp.	Fuente de los Frailes de Cabra	Tithonian	1892: 100
<i>Aucella zitteli</i> , Neum.	Segura de la Sierra	Kimmeridgian	1892: 101
? <i>Cardium dissimile</i> Sowerby	Between Chinchilla and Almansa?	Callovian Kimmeridgian	1885: 84; 1892: 101
• <i>Ceromya excentrica</i> Voltz.sp.	Between Josa and Obón, Río Arcos, Anchuela, Aguilón ?, El Pobo, Alcublas, Jérica, between Chinchilla and Almansa	Lower levels from Jurassic, Oxfordian	1885: 82; 1892: 101
<i>Ceromya inflata</i> Voltz.sp.	Obón, Torrelvilla, Albarracín, between Anguela and Hombrados, between Chinchilla and Almansa	Oxfordian - Portlandian	1885:81, pl. 30B, figs. 2-3; 1892: 101
<i>Corbula pichleri</i> Zitt.	Fuente de los Frailes de Cabra?	Kimmeridgian	1892: 101
<i>Eligmus polytypus</i> Desl	El Chorro	Kimmeridgian	1892: 99
• <i>Goniomya trapezina</i> (Buvignier)	Between Frías and Villar del Cobo	Oxfordian	1885: 76, pl. 30B, fig. 1; 1892: 102
<i>Hinnites paniscus</i> d'Orbigny	Albarracín	?Middle and Upper Jurassic	1892: 99
<i>Hinnites tenuistriatus</i> d'Orbigny	Sarrión	? Middle and Upper Jurassic	1892: 100
<i>Lima rigida</i> Sowerby	Between Clarés and Mochales	Oxfordian	1885: 96; 1892: 100
<i>Lucina rugosa</i> Roemer sp.	Torres?, Torrelvilla?, Alcublas?	Kimmeridgian	1892: 101
<i>Lyonsia sulcosa</i> Agassiz	Ligüerzana	Oxfordian	1885: 83
<i>Mactromya rugosa</i> Roemer sp.	Torres?Torrelvilla?	Portlandian and Kimmeridgian	1885: 76
<i>Mytilus acinaces</i> Leym.sp.	Ariño?	"Coralino"	1885: 91; 1892: 100

TABLE 5b (cont.)			
• <i>Mytilus bipartitus</i> Sowerby	Albarracín, Frías, Griegos	Oxfordian	1885: 90, pl. 43, fig. 7; 1892: 100
<i>Mytilus pectinatus</i> Sowerby	Albarracín	Oxfordian	1885: 91, pl. 43, fig. 5
<i>Mytilus sowerbyanus</i> d'Orbigny	Albarracín, Javalambre, Majadas, La Cierva, Tragacete, Ricla, Calomarde, Guadalaviar, Tramacastilla, Anchuela del Campo	Bathonian, Oxfordian "Gran Oolita"	1885: 91, pl. 43, fig. 3; 1892: 100
<i>Mytilus subpectinatus</i> Sowerby	Albarracín, Guadalaviar, Torremocha	Oxfordian	1892: 100
<i>Neoera lorioli</i> Nem.	Cabra	Tithonian	1892: 101
<i>Neoera mosensis</i> Buvignier	Between Salsadella and Sierra de Valdanche	Kimmeridgian, Portlandian	1885: 83; 1892: 101
<i>Ostrea amata</i> , d'Orbigny	Frías, Calomarde	Oxfordian	1892: 99
<i>Ostrea bruntrutana</i> Thurmann	Between Salsadella and Sierra de Valdanche, between Castell de Cabres and Morella	Upper Jurassic, Oxfordian	1885: 105; 1892: 99
<i>Ostrea colubrina</i> Lamarck	Villar del Cobo, Albarracín	"Coralino"	1885: 105; 1892: 99
<i>Ostrea deltoidea</i> Lamarck	Reocín?, Udías?, Comillas?, Torcal de Antequera	Oxfordian, "Coralino"	1885: 104; 1892: 99
• <i>Ostrea solitaria</i> Sowerby	Ablanque	"Coralino"	1885: 105
<i>Ostrea virgula</i> Defrance	Between Salsadella and Sierra de Valdanche, Jérica?, Torcal de Antequera	"Coralino", Kimmeridgian Upper Jurassic	1885: 105; 1892: 99
? <i>Pecten inaequicostatus</i> Phillips	Albarracín?	Oxfordian	1892: 100
<i>Pecten lens</i> Sowerby	Albarracín, between Frías and Calomarde	Bajocian, Callovian, Oxfordian	1885: 100; 1892: 100
<i>Pecten lugdunensis</i> Sowerby	Torrevelilla?	Oxfordian	1885: 101; 1892: 100
<i>Pecten sub-fibrosus</i> d'Orbigny	Venta de los Baños Ventas de Buñol	Oxfordian	1885: 100; 1892: 100
• <i>Pecten sub-spinosus</i> Schlotheim	Alustante, Prados Redondos	Callovian, Oxfordian	1885: 99-100; 1892: 100
<i>Pholadomya (Homomya)</i> <i>hortulana</i> Agassiz	Between Chinchilla and Almansa	Oxfordian	1892: 102

TABLE 5b (cont.)			
• <i>Pholadomya acuminata</i> Hartmann	Frías, Albarracín	Oxfordian	1885: 80, pl. 30A, figs. 6-7; 1892: 102
<i>Pholadomya escheri</i> Agassiz	Foz de Calanda	Callovian	1892: 102
<i>Pholadomya exaltata</i> Agassiz	Becerril?	Callovian, Oxfordian, Kimmeridgian	1885: 80; 1892:102
<i>Pholadomya lineata</i> Goldfuss	Between Campalbo and Manzanaruelo	Oxfordian	1885: 81; 1892:102
<i>Pholadomya purchisoni</i> Sowerby	Torremocha de los Arrieros, Pradilla, Montorio, Caramillo de la Fuente, Mochales, Anguela, Torremochuela?, Albarracín, Paracense, Sarrión, between Josa and Hoz de la Vieja	"Oolita inferior- Caloviense"	1885: 78, pl. 30, figs.3- 5, pl. 30A, figs. 1-2; 1892: 102
<i>Pholadomya paucicosta</i> Roemer	Albarracín, Arcos River, Ablanque	Oxfordian	1892: 102
<i>Pholadomya pectinata</i> Agassiz	Alcublas	Portlandian and Kimmeridgian	1885: 81; 1892: 102
• <i>Pholadomya protei</i> Defrance	Arcos River	Oxfordian	1892: 102
<i>Pinna ampla</i> Sowerby	Villel de Mesa	"Gran Oolita" and Lower Oxfordian	1885: 92
<i>Posidonomya alpina</i> Gras.	Las Hoyas de Loja	Kimmeridgian	1892: 100
<i>Thracia chauviniana</i> d'Orbigny	Frías	Oxfordian	1885: 83; 1892: 101
<i>Trigonia clavellata</i> Sowerby	Lastres?	Oxfordian	1885: 88 ; 1892: 101
<i>Trigonia gibbosa</i> Sowerby	Alcublas, El Toro	Oxfordian	1885: 89; 1892: 101
<i>Pholadomya purchisoni</i> Sowerby	Torremocha de los Arrieros, Pradilla, Montorio, Caramillo de la Fuente, Mochales, Anguela, Torremochuela?, Albarracín, Paracense, Sarrión, between Josa and Hoz de la Vieja	"Oolita inferior- Caloviense"	1885: 78, pl. 30, figs.3- 5, pl. 30A, figs. 1-2; 1892: 102

CORTÁZAR (1885) reported more than 200 species of Jurassic fossils from the province of Teruel, many of which were collected by DE VERNEUIL, COLLOMB, VILANOVA Y PIERA and other geologists in those years. Jurassic rocks were separated in "Liassic" and "Grupo oolítico" stratigraphically and the geology of the province of Teruel was reviewed, Jurassic species being for mentioned each locality (without figures). Of the Jurassic species, 90 belong to bivalves, 46 of them are from the Callovian-Kimmeridgian interval. From the Lower Jurassic species mentioned in that paper, the following were found in this study: *Ostrea gregarea* SOWERBY, *Pecten velatus* GOLDFUSS *Pecten textorius* SCHLOTHEIM and *Lima proboscidea* SOWERBY.

CORTÁZAR's (1885) list of species includes the species collected by him, and species mentioned by previous authors. He indicated with an asterisk species the occurrence of which he did not checked, but mentioned by other authors. His "Grupo Oolítico" (Callovian and Oxfordian) bivalve species are listed in Table 6:

TABLE 6. Callovian-Oxfordian bivalves reported by CORTÁZAR (1885). • Species identified in this work. ♦Species mentioned by others authors but not checked by CORTÁZAR.			
SPECIES	LOCALITY	STRATIGRAPHICAL LEVEL	REFERENCE (page)
♦ <i>Astarte burgomontana</i> Verneuil	Teruel?	"Grupo Oolítico"	226
♦ <i>Lima pectiniformis</i> Brongniart	Teruel?	"Grupo Oolítico"	226
♦ <i>Lima substriata</i> Münster	Teruel?	"Grupo Oolítico"	226
•♦ <i>Mactromya aequalis</i> Agassiz	Royuela	"Grupo Oolítico"	128, 225
♦ <i>Modiola acinaces</i> Leym.	Teruel?	"Grupo Oolítico"	226
♦ <i>Mya rugosa</i> Roem.	Teruel?	"Grupo Oolítico"	226
♦ <i>Mytilus sublevis</i> Sowerby	Teruel?	"Grupo Oolítico"	226
♦ <i>Pecten lugdunensis</i> Sowerby	Teruel?	"Grupo Oolítico"	226
♦ <i>Pholadomya bucardium</i> Agassiz	Teruel?	"Grupo Oolítico"	225
♦ <i>Pleuromya helesia</i> Chapuis et Dur.	Teruel?	"Grupo Oolítico"	225
♦ <i>Pholadomya paucicosta</i> Roem.	Teruel?	"Grupo Oolítico"	226
•♦ <i>Pholadomya trapezina</i> Buvignier	Teruel?	"Grupo Oolítico"	226
♦ <i>Thracia chauviniana</i> d'Orbigny	Teruel?	"Grupo Oolítico"	226
♦ <i>Trigonia clathrata</i> Agassiz	Teruel?	"Grupo Oolítico"	226
♦ <i>Trigonia costata</i> Park.	Teruel?	"Grupo Oolítico"	226
• <i>Arca concinna?</i> Phillips	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín Cuesta de la Cerroja, del Pozuelo, Guadalaviar	"Grupo Oolítico"	129, 226
<i>Arca texta</i> d'Orbigny	Arcos River	"Grupo Oolítico"	132, 226

TABLE 6 (cont.)			
• <i>Ceromya excentrica</i> Agassiz	Pobo, Arcos River	"Grupo Oolítico"	130, 132, 226
<i>Ceromya inflata</i> Voltz.	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín Cuesta de la Cerroja, del Pozuelo, Guadalaviar	"Grupo Oolítico"	129, 226
<i>Hinnites tenuistriatus</i> d'Orbigny	Sarrión to Javalambre, Hoya de la Caridad	"Grupo Oolítico"	131, 226
• <i>Hinnites velatus</i> Goldfuss	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	129, 226
<i>Lima</i> nov. sp. "vecina de <i>lanotata</i> "	Calomarde	"Grupo Oolítico"	127
<i>Lima obscura</i> Sowerby	Hoya de la Caridad	"Grupo Oolítico"	131, 226
• <i>Lima proboscidea</i> Sowerby	Cuesta de la Cerroja, del Pozuelo and Guadalaviar	"Grupo Oolítico" "Liásico"	128, 222, 226
<i>Lima tenuistriata</i> Münster	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	129, 226
<i>Mactromya aequalis</i> Agassiz	Royuela	"Grupo Oolítico"	128, 225
<i>Mytilus asper</i> Sowerby	Cuesta de la Cerroja, del Pozuelo and Guadalaviar	"Grupo Oolítico"	128, 226
• <i>Mytilus bipartitus</i> Sowerby	Teruel	"Grupo Oolítico"	226
<i>Mytilus pectinatus</i> Sowerby	Cuesta de la Cerroja, del Pozuelo, Guadalaviar Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	128-129, 226
<i>Mytilus plicatus</i> Sowerby	Cuesta de la Cerroja, del Pozuelo and Guadalaviar	"Grupo Oolítico"	128, 226
<i>Mytilus sowerbyanus</i> d'Orbigny	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	128-129, 226

TABLE 6 (cont.)			
<i>Ostrea amata</i> d'Orbigny	Between Frías and Calomarde	Oxfordian	127
<i>Ostrea arcata</i> d'Orbigny	Teruel?	"Grupo Oolítico"	226
<i>Ostrea colubrina</i> Lamk.	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	129, 226
<i>Hinnites tenuistriatus</i> d'Orbigny	Sarrión to Javalambre, Hoya de la Caridad	"Grupo Oolítico"	131, 226
<i>Pecten inaequicostatus</i> Phillips	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín Teruel	"Grupo Oolítico"	129, 226
<i>Pecten barbatus</i> Sowerby	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín Teruel	"Grupo Oolítico"	129, 226
<i>Pecten lens</i> Sowerby	Between Frías and Calomarde	Oxfordian	127, 226
<i>Pholadomya acuticosta</i> Sowerby	Monterde	"Grupo Oolítico"	129, 225
<i>Pleuromya arenacea</i> Agassiz	Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín	"Grupo Oolítico"	129, 225
<i>Pholadomya decussata</i> Agassiz	Between Frías and Calomarde	Oxfordian	127
<i>Pholadomya mariae</i> d'Orbigny	Villar del Cobo	"Grupo Oolítico"	128, 225

<i>Pholadomya purchisoni</i> Sowerby	Royuela, Valdecomadres, Virgen del Carmen, Bco. Hondo, Bco. Argudo, Pajares, Valdemarín, Entrambasaguas, Albarracín Cuesta de la Cerroja, del Pozuelo, Guadalaviar, Royuela, between Peracense and Villafranca del Campo, Hoya de la Caridad, Sarión to Javalambre, Sierra de Camarena, Josa to Hoz de la Vieja	"Grupo Oolítico"	128-131, 134, 225
<i>Pholadomya uralensis</i> d'Orbigny	Between Frías and Calomarde	Oxfordian	127, 226
• <i>Pholadomya protei</i> DeFrance	Arcos River	"Grupo Oolítico"	132, 226
<i>Pinnigena saussurei</i> d'Orbigny	Pobo	"Grupo Oolítico"	130, 226

PALACIOS (1893) described the geology of the province of Zaragoza and separated rocks in the "terreno Liásico" and "terreno Jurásico". This palaeontological data were scarce and focused mainly of ammonites. Of his species, six belong to Lower Jurassic bivalves that were not recorded in this study. No bivalves were mentioned from the "terreno Jurásico".

DEREIMS (1898) studied the stratigraphy of southern Aragon in detail and divided the Jurassic system in Lower, Middle and Upper. He described the most representative outcrops and mentioned in detail the previous and contemporary authors who studied the same material. Numerous fossil species were mentioned but not figured. Special attention was paid to ammonoids, which were used to establish a biostratigraphic correlation with the "rest" of Europe. Four genera and 49 species of bivalves were mentioned and a decrease in diversity from Lower to Upper Jurassic was noted. Of the Lower Jurassic species mentioned, the following were found in the present study: *Pleuromya alduini* (BRONGNIART) and *Pecten textorius* SCHLOTHEIM. 14 from the Upper Jurassic species are listed in Table 7:

SPECIES	LOCALITY	STRATIGRAPHICAL LEVEL	REFERENCE (page)
• <i>Ceromya excentrica</i> Agassiz	Sierra de Javalambre	Upper Jurassic	144
<i>Cucullaea concinna</i> Quenstedt	Sierra de Albarracín	Upper Jurassic	132
<i>Lima quenstedti</i> Moesch	Sierra de Albarracín	Upper Jurassic	133
<i>Mactromya rugosa</i> Agassiz	Sierra de Albarracín	Upper Jurassic	133
<i>Mytilus subpectinatus</i>	Herrera-Villar de los Navarros	Upper Jurassic	146

<i>Ostrea bruntrutana</i>	Castellón	Kimmeridgian	150
<i>Ostrea cf. matronensis</i> de Loriol	Sierra de Albarracín	Upper Jurassic	134
<i>Ostrea flabellata</i>	Sierra de Albarracín, Sierra Palomera, Sima de San Pedro	Upper Jurassic	134, 138, 141, 144-145
<i>Ostrea virgula</i>	Castellón	Kimmeridgian	150
<i>Ostrea cf. bruntrutana</i> Thurmann	Sierra de Albarracín	Upper Jurassic	134
• <i>Pholadomya acuminata</i> Hartmann	Jabaloyas-Griegos	Lower Oxfordian	141
<i>Pholadomya cf. protei</i> Brongniart	Sierra de Albarracín	Upper Jurassic	133
• <i>Pholadomya protei</i> Defrance	Sierra de Javalambre	Upper Jurassic	144
<i>Pinnigena saussurei</i> d'Orbigny	Sierra de Javalambre	Upper Jurassic	144

NAVÁS (1903) described a visit to the cave of the Sima in Ricla (province of Zaragoza). He mentioned the fauna, flora and minerals and nine species of bivalves in the *barranco de las conchas*, which came from the Lower Jurassic.

BATALLER (1954) mentioned, without figures, Triassic and Jurassic species of Spain. The reference of the original diagnosis, the age and locality were given. All of the eight species of Jurassic bivalves mentioned are from the Lower Jurassic of Soria, Mallorca, Guadalajara, Lérida and Asturias.

None of the species mentioned by the last two authors were identified in this study.

ALMELA & SANZ (1958) described the geological history of Spain and in this context also the Jurassic System (1958: 95-102). After discussing general aspects of the Jurassic of the world they focussed their study on "*las manchas jurásicas en España*". In a table, they listed the characteristic fossils of the Jurassic, without referring to their origin. Eight of the fossils they mentioned were bivalves and all of them were figured (pls. 24-27, 31, 34). Of them, the only species mentioned from the studied stratigraphic interval was *Exogyra virgula* D'ORBIGNY from the Kimmeridgian (pl. 34, fig. 2). The other species belong to the Lower and Middle Jurassic. Among them, only *Ctenostreon proboscideum* (J. SOWERBY) (pl. 26, fig. 2) is identified in this study.

RIBA (1959) in his *Estudio geológico de la Sierra de Albarracín* dedicated some chapters to the Jurassic (1959: 135 -171). He exhaustively reviewed previous work on the Sierra de Albarracín and described some stratigraphic outcrops in detail. For each one of them, fossils were mentioned, without figures. Among the bivalves, nine genera and 25 species were listed. Taxa belonging to the Middle and Upper Jurassic are listed in Table 8.

TABLE 8. Jurassic bivalves listed by RIBA (1959). • Species identified in this work.			
SPECIES	LOCALITY	STRATIGRAPHIC LEVEL	REFERENCE (page)
<i>Alectryonia</i> sp.	Sierra de Albarracín Villar del Cobo	"Lias Superior" Middle and Upper Jurassic	153, 155
<i>Arctostrea eruca</i> Rollier	Griegos	Middle and Upper Jurassic	159
• <i>Ctenostreon proboscideum</i> (?) Sowerby	Griegos	Middle and Upper Jurassic	159
<i>Ctenostreon</i> sp.	Villar del Cobo, Frías de Albarracín	"Lías superior" Middle and Upper Jurassic	146, 153, 162
<i>Goniomya v-scripta</i> Sowerby	Frías de Albarracín	Middle and Upper Jurassic	161
• <i>Hinnites velatus</i> d'Orbigny	Jabaloyas	Middle and Upper Jurassic	164
<i>Homomya</i> sp.	Jabaloyas	Middle and Upper Jurassic	164
<i>Ostrea</i> cf. <i>bruntrutrana</i> Thurmann	Jabaloyas	Kimmeridgian (?)	169
<i>Ostrea</i> cf. <i>matronensis</i> de Loriol	Jabaloyas	Kimmeridgian (?)	169
<i>Alectryonia</i> sp.	Sierra de Albarracín Villar del Cobo	"Lías superior" Middle and Upper Jurassic	153, 155
<i>Ostrea</i> sp.	Villar del Cobo, Albarracín- Gea, Frías de Albarracín, Jabaloyas	"Liásico" Middle and Upper Jurassic	146, 147, 150, 153, 162, 164
<i>Pecten</i> sp.	Villar del Cobo, Albarracín-Gea, Portillo de Tramacastilla, Frías de Albarracín, Jabaloyas	"Liásico" Middle and Upper Jurassic	138, 146, 150, 153, 162, 164
<i>Pholadomya</i> sp.	Albarracín, Albarracín-Gea	"Liásico"	143, 146
<i>Plagiostoma</i> sp.	Entrambasaguas, Albarracín-Gea, Frías de Albarracín	"Liásico" Middle and Upper Jurassic	141, 145, 162

BATALLER (1963) studied some Callovian outcrops located in Abejuela (Teruel) and mentioned ammonites, belemnites, brachiopods, nautilids, gastropods and bivalves. The two last groups were considered to be very rare. Among the bivalves *Ostrea* sp. was mentioned (1963: 142), described (1963: 171), and compared with *Plicatula peregrina* and *Exogyra nana*. In the same study, BATALLER compared outcrops of Abejuela with some outcrops of eastern Spain. At Port of Tortosa and Cap of Salou,

Posidonomya alpina A. GRASS was found and in the region of Vandellós, *Pholadomya reticulata* AGASSIZ, *Posidonomya alpina* A. GRASS and *Trancredia cossmanni*.

BEHMEL & GEYER (1966) carried out a stratigraphic and palaeontological study of the Lower Jurassic of the Sierra de Albarracín. Among the figured material, they presented seven species of bivalves (pls. 4 and 5). Of these, two were found in the stratigraphic interval studied in this work. The specimen figured as *Arcostrea* sp. (pl. 4, fig. 4) could be assigned to *Actinostreon gregareum* (J. SOWERBY) and *Velata tumida* (ZIETEN) (pl. 5, fig. 3) could be assigned to *Eopecten velatus* (GOLDFUSS). These determinations are in agreement with M. GAHR (*personal comm.* 1999).

VIALARD (1973: 135) noted large pteriids, *Modiolus* and *Myophorella* (*Jaworskiella*) *kobyi* (CHOFFAT) in the Kimmeridgian of La Yesa (province of Valencia). *Nucula inconstans* ROEDER and *Astarte percrassa* ÉTALLON (1973: 135) were mentioned in the Middle Oxfordian of Talayuelas (province of Cuenca). In Lower Kimmeridgian marls and calcareous clays of the Montes Universales (Hoya del Peral, Valencia), (1973: 146-147), several species of bivalves were found: *Leda? roederi* DE LORIO, *Nucula inconstans* ROEDER, *Plicatula quenstedti* DE LORIO, *Astarte contejeani* DE LORIO, *Astarte percrassa* ETALLON and *Lucina berlieri* DE LORIO. *Leda? roederi* DE LORIO has been included in the genus *Dacryomya*: *Dacryomya roederi* (DE LORIO) was identified in the Sot de Chera Fm (Upper Oxfordian-Lower Kimmeridgian) of Ricla in this study. Within Aalenian rocks of the Huérguina-Paravientos area (province of Cuenca), *Camptonectes* cf. *lens* SOWERBY and *Chlamys dewalqui* OPPEL were noted by LE JONCOUR (1965).

Among the most recent studies on bivalves two studies must be mentioned that treat this group from a palaeoecologic point view. MAYORAL & SEQUEIROS (1979) studied epizoans and boring organisms in organic substrates provided by bivalves (Table 3, p. 125), and other molluscs (gastropods, ammonites, nautilids and belemnites), crinoids and brachiopods, occurring in the Lower and Middle Jurassic of Belchite (province of Zaragoza). In a subsequent study, the same authors (SEQUEIROS & MAYORAL 1980) studied epizoans on shells of *Plagiostoma gigantea* (SOWERBY) from the Toarcian of Belchite (province of Zaragoza).

GOY & SUÁREZ VEGA (1983) produced a stratigraphic and palaeogeographic synthesis of the Jurassic of Spain and mentioned the main groups of fossils, especially ammonoids. They pointed out some levels characterized by bivalves within the upper part of the Cortes de Tajuña Fm (some specimens of *Gryphaea*). At the upper boundary of the Cuevas Labradas Fm, some ferruginized surfaces with ostreids are present. Finally, in the Moscardón area, some disarticulated valves of *Bositra buchi* were found in the Upper Bathonian

MELÉNDEZ *et al.* (1983), in a biostratigraphic study of the Upper Oxfordian of Moscardón (Teruel), dealt with ammonoids and provided a general review of other groups of molluscs (belemnites, gastropods and bivalves). They mentioned the occurrence of small-sized bivalves similar to *Nicaniella* (*Trautscholdia*). From their description (1983: 39), it becomes quite clear that they referred to *Nicaniella* (*Trautscholdia*) *carinata* (PHILLIPS), a very abundant species in the Sot de Chera Fm (Upper Oxfordian-Lower Kimmeridgian) of the Aragonian Branch of the Iberian Chain. The bivalves with compressed valves which they assigned to *Astarte prismatica* ÉTALLON, could belong to the genera *Astarte* or

Nicaniella (*Nicaniella*). The authors mentioned, with some doubts, the presence of some moulds assigned to the genus *Placunopsis* (1983: 39, 42).

In the last years Lower Jurassic bivalves have been the object of several studies. BERNAD & CALVO (1995) and BERNAD (1999b) carried out a taxonomic and statistical study of *Plicatula spinosa* SOWERBY from the Lower Toarcian of Turmiel (province of Guadalajara). He concluded that this species was an opportunist in a low-energy environment.

BERNAD (1996a,b) gave an account of the bivalves in the notes of the fieldtrip to the Iberian Chain during the 1st Toarcian and 4th Aalenian working groups Meeting. He described two well exposed sections in the Pliensbachian-Toarcian of La Almunia de Doña Godina and Ricla (province of Zaragoza), (1996a: 14, figs. 1.5, 1.6). In the first section, from the Upper Pliensbachian up to the Mirabile Subzone (Tenuicostatum Zone) of the Lower Toarcian, the abundance and diversity of bivalves (Pholadomyoidea, Pteroida and Veneroidea) was relatively high. In the second section that covered the rest of the Toarcian, the abundance and diversity of bivalves, was notably reduced, only scarce representatives of the Superfamily Pectinacea being present. Some of the species noted by the author were found in the present study: *Pseudolimea duplicata* (SOWERBY), *Chlamys textoria* (SCHLOTHEIM) and *Pleuromya alduini* (BRONGNIART). The Toarcian of the Rambla del Salto (Sierra Palomera, province of Teruel) is characterized by the distinct increase in the abundance and diversity of bivalves in all biozones (1996b: 36, figs. 2.6-2.8). Representatives of the orders Pteroida, Arcoidea, Mytiloidea, Trigonoidea, Nuculoida, Veneroidea and Pholadomyoidea are represented. The following species were found in the stratigraphic interval of this study: *Chlamys textoria* (SCHLOTHEIM), *Pseudolimea duplicata* (SOWERBY), *Pleuromya alduini* (BRONGNIART), *Pleuromya uniformis* (SOWERBY) and *Lopha* [= *Actinostreon*] *gregarea* (SOWERBY). Finally, in the Toarcian-Aalenian of Fuentelsaz (province of Guadalajara), BERNAD (1996c: 62, fig. 3.5; 1999c) found the maximum in abundance and diversity of bivalves in the Mactra Subzone, a decrease in the Aalensis Subzone, and again an increase during the Buckmani Subzone (all of them belonging to the Upper Toarcian, Aalensis Zone). In the Opalinum Zone (Aalenian) the diversity and abundance of bivalves decreased, the orders Pteroida, Trigonoidea, Arcoidea, Mytiloidea, Veneroidea and Pholadomyoidea being still present. BERNAD (1996c) mentioned numerous species; however, only *Pseudolimea duplicata* (SOWERBY) was found in this study.

BERNAD (1997a) studied the taxonomy of Lower Jurassic bivalves from Spain deposited in the Museo Geominero (IGME), Madrid. The collection consists of 462 specimens; the author revised the taxonomic determinations and indicated the localities of the specimens. Furthermore, 32 of the species were figured. The following bivalve species from this collection were also reported in the present study: *Pleuromya alduini* (BRONGNIART), *Modiolus bipartitus* SOWERBY, *Gryphaea bilobata* SOWERBY, *Pseudolimea duplicata* (SOWERBY), *Eopecten velatus* (GOLDFUSS), *Chlamys textoria* (SCHLOTHEIM) and *Lopha gregarea* (SOWERBY).

BERNAD (1997b) reviewed of the species of *Plagiostoma* from the Toarcian of the Iberian Chain, none of them found in this study.

BERNAD (1999a) reviewed the bivalves figured by TORRUBIA (1754) from Molina of Aragón. He identified the bivalves, reproduced the original figures and compared them with some bivalves

collected in Iberian Chain (provinces of Guadalajara and Teruel). Of the mentioned species, *Lopha* [= *Actinostreon*] *gregarea* (J. SOWERBY) was identified in the present study.

Middle and Upper Jurassic bivalves were hardly ever treated by previous authors, due to their scarcity and poor preservation compared with Lower Jurassic taxa. Callovian-Kimmeridgian bivalves were studied by DELVENE in the last four years. Many of her data were incorporated in regional studies together with Jurassic specialists of the University of Zaragoza, and many of the data will be referenced in the next chapters. Among taxonomic and palaeoecological studies, the following are the most important: DELVENE (1997a) identified bivalves belonging to the orders Pholadomyoidea, Veneroidea, Mytiloidea, Pteroida (suborders Pteriina and Ostreina) from the Callovian-Oxfordian of the northeastern part of the Iberian Chain (provinces of Zaragoza and Teruel). All taxa were grouped according to their life habits indicating the proportions of these groups in the most fossiliferous levels.

Bivalves are especially abundant in the Sot de Chera Fm of the Ricla area (province of Zaragoza) (DELVENE 1997b). Three of the most abundant species are: *Nicaniella* (*Trautscholdia*) *carinata* (PHILLIPS), *Gervillella aviculoides* (J. SOWERBY) and *Nanogyra nana* (J. SOWERBY). The taxonomy of the bivalves, their stratigraphic ranges and some palaeoecologic aspects of the Sot de Chera Fm of Ricla were discussed by DELVENE *et al.* (1998).

DELVENE (1998) reviewed the data presented in 1997a, updating the names of some taxa, incorporating new material, and adding some interpretation of the life habits of the bivalves in that area.

Finally, DELVENE (1999) mentioned the common bivalves species in the Callovian and Oxfordian of the eastern area of the Aragonian Branch of the Iberian Chain. A taphonomic analysis of the Callovian bivalves led to the conclusion that during the Lower Callovian (Gracilis/Bullatus Zone) the bivalves were the most abundant benthic group and can be interpreted as a representing a palaeocommunity.

3. STRATIGRAPHY

3.1. LITHOSTRATIGRAPHIC UNITS

The studied rocks belong to the *Turia Group*, according to the classification scheme of GÓMEZ (1979) in the "sector Levantino" of the Iberian Range. The lithostratigraphic units of the Middle and Upper Jurassic of the "sector Levantino" were defined formally by GÓMEZ & GOY (1979), and later on extended to the rest of the Iberian Range by GÓMEZ & GOY (1981).

The studied rocks belong to the following lithostratigraphic units: Chelva Fm, Yátova Fm, Sot de Chera Fm and Loriguilla Fm (Fig. 3).

AUC	GÓMEZ (1979) GÓMEZ & GOY (1979, 1981)		GINER (1980) SALAS (1987) AURELL (1990)		MELÉNDEZ <i>et al.</i> (1990)		AURELL (1990)	BÁDENAS (1997) BÁDENAS <i>et al.</i> (1999)
					Calanda Area	Alacón Area	Ricla Area	Ricla Area
Kimmeridgiense / Kimmeridgiense	Loriguilla Fm	Loriguilla Fm	Loriguilla Fm	Loriguilla Fm		Alacón Mb	Ricla Mb	Loriguilla Fm
								Torrecilla Fm (Ricla Mb)
					Calanda Mb		Loriguilla Fm	Loriguilla Fm
Oxfordiano / Oxfordiano	Sot de Chera Fm	Sot de Chera Fm	Sot de Chera Fm	Sot de Chera Fm	Sot de Chera Fm	Sot de Chera Fm	Sot de Chera Fm	Upper section
								Middle section
C. Levantino / C. Levantino	Yátova Mb	Yátova Fm	Yátova Fm	Yátova Fm	Yátova Fm	Yátova Fm	Yátova Fm	Lower section
	"Capa de Arroyofrío"	"Capa de Arroyofrío"	"Capa de Arroyofrío"	"Capa de Arroyofrío"	"Capa de Arroyofrío"	"Capa de Arroyofrío"	"Capa de Arroyofrío"	
	"Parte media informal"							

Fig. 3. Upper and Middle Jurassic lithostratigraphic units of the Iberian Range and later modifications of the original scheme. This figure refers only to units studied in this work.

Subsequently, some authors modified the original scheme (Fig. 3). The main modifications are:

(1) Upgrading of the Yátova Mb to formation rank. The upper part of the *Chelva Formation*, Oxfordian in age, consists of sponge-bearing limestone. It was distinguished as a member of this formation (*Calizas con esponjas de Yátova Member*) in the original definition. Later on, several authors (GINER 1980; SALAS 1987 and AURELL 1990) recognized this unit as an independent formation.

(2) The formal definition of two units as members within the Loriguilla Fm: the Calanda Mb and Alacón Mb (MELÉNDEZ *et al.* 1990). The *Calizas y Margas de Calanda Member*, consisting of "una alternancia de calizas blancas (*wackestone* de fósiles) y margas, con un abundante contenido en ammonites y de edad Kimmeridgiense Inferior". The *Calizas blancas de Alacón Member* consisting of "calizas masivas blancas, cretosas, con una textura de *packstone* de bioclastos, peloides, y oncolitos, fácilmente reconocible y que muestra una distribución geográfica restringida en el sector occidental del área estudiada. Su edad es Kimmeridgiense superior a Tithónico inferior".

(3) The recognition of a siliciclastic unit with member rank in the northwestern part (Ricla region) called *Areniscas y Calizas de Ricla Member* (AURELL 1990). It is part of the Torrecilla Fm, the lateral equivalent of the Loriguilla Fm in Cameros.

During the last years, the initially defined units for the Upper Jurassic have been broadly subdivided, not only in the Aragonian Branch but also in the Castillian Branch. In this work, only the subdivisions of the Aragonian Branch are considered. A brief characterization of the lithostratigraphic units treated in this study is given:

**Chelva Formation ("Formación Carbonatada de Chelva")*. Limestone embraced between a marly unit (*Turmiel Fm*) and a limestone unit (*Yátova Fm*). The studied material of this paper is from the uppermost Chelva Fm, above the *Calizas Nodulosas de Casinos Member* ("parte media informal"). In the northeastern region of the Iberian Range, this interval consists of approximately 1 m of beige bioclastic limestone, usually of Early Callovian (*Bullatus Zone*) age. The limestone is well-bedded, alternating with thin marly intervals. The top is a hardground. The bed just below the hardground is highly fossiliferous, dominating taxa are bivalves and ammonites.

-*"Capa de oolitos ferruginosos de Arroyofrío"*. This unit occurs at the top of Chelva Fm. It consists of iron-oolithic limestone, usually varying between some decimetres up to 1.5 m. Commonly, it is divided into one or several irregular beds forming the Middle-Upper Jurassic boundary. The age of this unit varies between Early Callovian and Late Oxfordian. Where two levels are developed, one of them commonly belongs to the Callovian and the other one to the Oxfordian; Upper Callovian and Lower Oxfordian may be represented in some localities. Among fossils, ammonoids predominate, bivalves are rare. The equivalent of the "Capa de Arroyofrío" in Riela the region is a succession of micritic or bioclastic black limestone whose uppermost boundary is an irregular surface interpreted as a karstification surface (RAMAJO & MELÉNDEZ 1996).

* *Yátova Fm ("Calizas con esponjas de Yátova")*. This formation consists of 10 to 15 m of grey to yellow bioclastic wackestone with sponges. The lower boundary is the "Capa de oolitos ferruginosos de Arroyofrío". The uppermost one is usually a discontinuity surface followed by the marly Sot de Chera Fm. The lower levels of the Yátova Fm may contain scarce dispersed iron-oids.

Two intervals are distinguished in this unit: The lower interval consists of 2 to 4 m of regularly bedded limestone with sponges being the main component forming small bioherms in the Riela area. The upper interval consists of 8 to 10 m of limestone with intercalated marl. Sponges, ammonites, belemnites, crinoids and brachiopods are common; bivalves, serpulids and gastropods are rare.

The age of the formation is Middle and Late Oxfordian.

In the eastern area (Sierra de Arcos, Sierra de los Moros and Bajo Aragón), the upper interval is distinctly glauconitic and the abundance of sponges decreases until they disappear.

**Sot de Chera Fm ("Margas de Sot de Chera")*. The formation is predominantly marly, with calcareous marl and intercalated marly limestone. The lower boundary is the upper discontinuity surface of the Yátova Fm. The upper boundary is the base of the upper unit (*Loriguilla Fm*). There is a gradual transition between the two formations, characterized by an increase in carbonate content, and the boundary is drawn where limestone predominates over marl.

The thickness of this formation is very variable and is progressively decreasing from NW to SE in the study area. The maximum values are more than 150 m in northwestern region of the Aragonian Branch (Riela sections, Figs. 7, 9). In the southeastern region (sections of La Cañada de Verich and Ráfales, Fig. 39), the thickness is 3 to 4 m.

In the Ricla region, three intervals can be distinguished (BÁDENAS 1997; BÁDENAS *et al.* 1999). In the lower interval silty limestone predominate and fossils are scarce. In the middle interval, marly sediments predominate with intercalations of limestone, and the third interval consists of an alternation of limestone and marl with the proportion of limestone increasing towards the top of the section.

The age of the formation is Late Oxfordian, the boundary to the Early Kimmeridgian being close to its top. The fossil content is low, although at some levels rare ammonites, brachiopods and bivalves occur. In the Ricla region, bivalves are the most abundant and diverse group. Other groups at these levels are molluscs (ammonites, belemnites, scaphopods, gastropods), brachiopods, and rare echinoderms.

* *Loriguilla Fm* ("*Ritmita calcárea de Loriguilla*"). The formation consists of regular limestone-marl alternations with limestone predominating. Its appearance is regular and monotonous, and its thickness varies considerably in the Aragonian Branch. In the Ricla region, its maximum thickness is between 35 and 45 m, and in the La Cañada de Verich region, between 60 and 75 m. The lower boundary coincides with the dominance of limestone-marl alternations. Where the Sot de Chera Fm is not present, the Loriguilla Fm directly rests on the Yátova Fm. In the Ricla area, the base is the first level of sandy limestone with solitary corals.

The upper boundary of this formation coincides with the base of *Higueruelas Fm* (belonging to the *Turia Group*, GÓMEZ & GOY 1979). The contact is usually sharp, for example in the Aguilón-Tosos region, where yellow and grey marly sediments are overlain by compact white limestone. However, the contact can also be diffuse such as in Valmadrid section, where the boundary between the Loriguilla Fm and Higueruelas Fm is gradual, here, the contact is placed where the limestone beds are thick and massive. Fossils are rare and consist mainly of ammonites which several authors used to establish the biostratigraphy. Bivalves are more abundant in the northwestern region (Valmadrid, province of Zaragoza) than in the southeastern area (La Cañada de Verich, province of Teruel). The age of the Loriguilla Fm has been discussed by several authors based on ammonites, which, in the different areas, characterize zones from the Lower Kimmeridgian to Lower Tithonian. In the Ricla area the unit is Late Kimmeridgian in age (AURELL *et al.*, 1989). In Bajo Aragón and Maestrazgo areas, all zones of the Kimmeridgian to the base of Tithonian have been recognized (ATROPS & MELÉNDEZ 1985).

3.2. OUTCROPS IN THE ARAGONIAN BRANCH OF THE IBERIAN RANGE

Fig. 4 shows the studied stratigraphic interval for each geographic region from NW to SE, the lithostratigraphic units as well as the age. The outcrops were selected according to the abundance of bivalves. In this study, the Oxfordian-Kimmeridgian boundary is drawn between the Planula and Platynota zones.

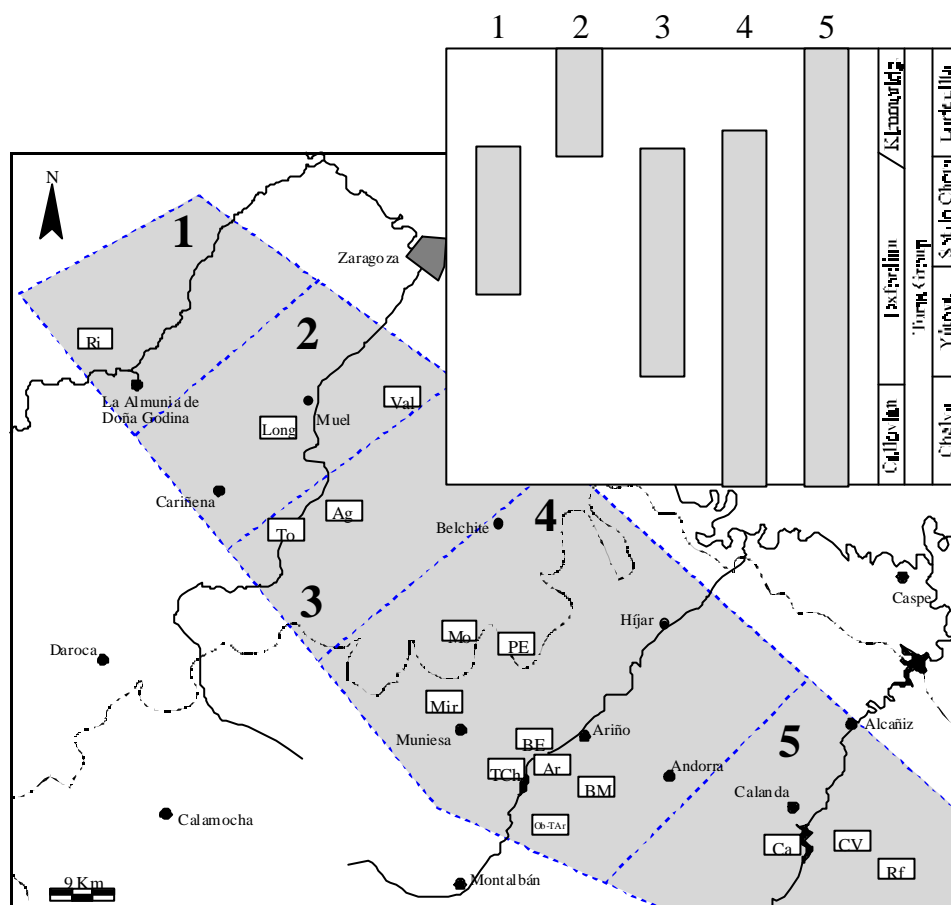


Fig. 4. Range of sections in each geographical region. Ri: Ricla, Long: Longares, Val: Valmadrid, To: Tosos, Ag: Aguilón, Mo: Barranco de la Librería, Mir: Mirambueno, PE: Barranco de la Peñisquera, BE: Barranco de las Estacas, BM: Barranco del Moro, TCh: Tía Chula, Ar: Ventas de San Pedro, Ob-TAr: Obón-Torre de las Arcas, Ca: Calanda, CV: La Cañada de Verich, Rf: Ráfales.

3.2.1. NORTHWESTERN AREA

(a) Section of "Los Picarros" (Ricla, province of Zaragoza): Ri₄ and Ri₈

The northwestern area of the Aragonian Branch of the Iberian Range is well represented by studied outcrops around Ricla (province of Zaragoza). The abundance and diversity of bivalves in the Sot de Chera Fm in this region is noteworthy.

Upper Jurassic rocks in this area have been studied by several authors. BULARD (1972) studied Upper Oxfordian limestone with sponges (Bimammatum Zone), and recognized an overlying marly facies of Late Oxfordian age. Upsection, the ammonite *Progeronia* sp. in the first sandy beds indicates a Kimmeridgian age. The Ricla-Tarazona area was studied by NIEVA (1986), NIEVA *et al.* (1986) and ALONSO *et al.* (1989), who correlated this region with the westernmost area. AURELL (1990) defined a new lithostratigraphic unit (*Areniscas y Calizas de Ricla Member*) in the Ricla area. This sandy unit is

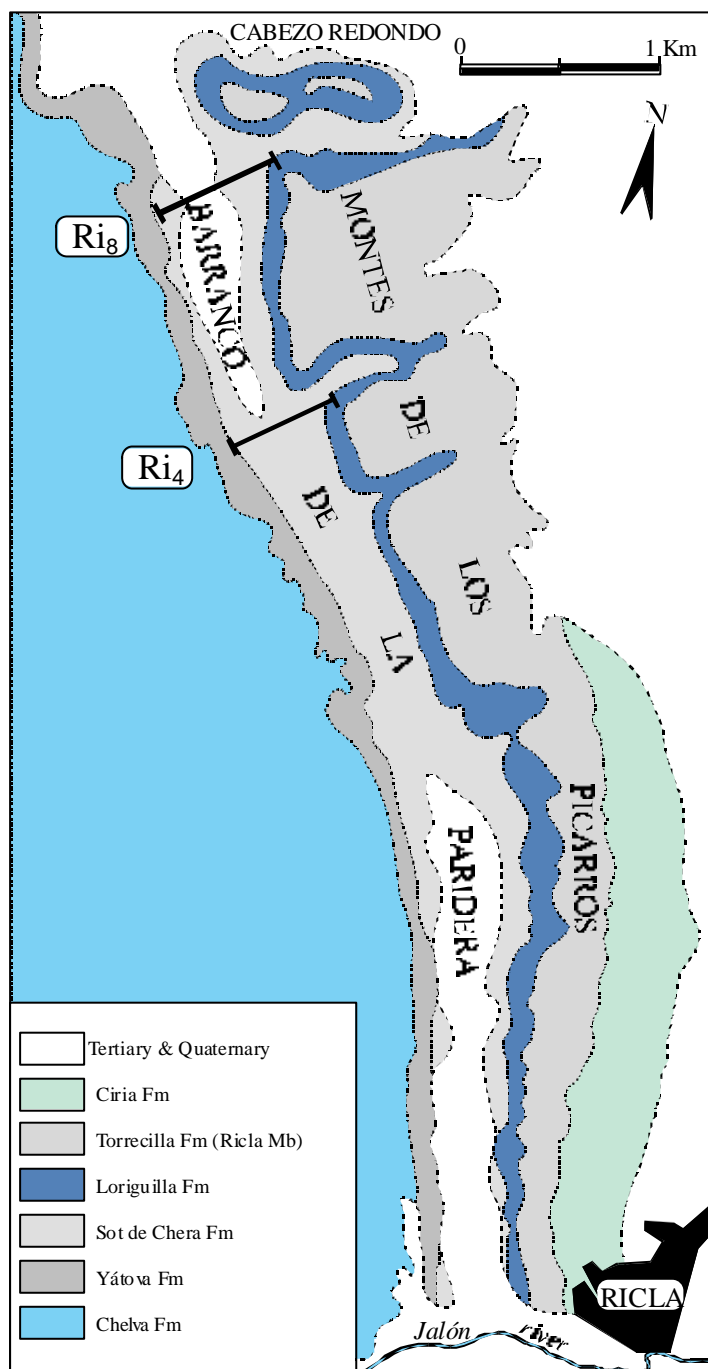


Fig. 5. Geological sketch map of the Ricla region (province of Zaragoza) with position of sections Ri₄ and Ri₈. (Modified after AURELL 1990).

included in the Torrecilla Fm which is the lateral equivalent of the Loriguilla Fm in the Sierra de Cameros. BÁDENAS *et al.* (1999) provided further details about the lithostratigraphy and sedimentology in the Ricla-Calatorao area. DELVENE (1997) reported the more abundant species of bivalves in the Sot de Chera Fm (Montes de los Picarros). Most recent papers on this studied area were mentioned before: DELVENE *et al.* (1998) and BÁDENAS (1999).

The sections Ri₄ and Ri₈ are situated north of Ricla, in the Montes de los Picarros (Fig. 5). The sections have been measured across the Barranco de la Paridera. The stratigraphic sections comprise the top of the Yátova Fm, the whole Sot de Chera Fm and the base of the Loriguilla Fm, i.e. the Upper Oxfordian and Lower Kimmeridgian.

Section Ri₄

The section Ri₄ has been selected for being one of the outcrops with more abundant bivalves in the Aragonian Branch of the Iberian Range. The material is from the base of Sot de Chera Fm up to the base of Loriguilla Fm (Fig 6).

The following intervals have been distinguished:

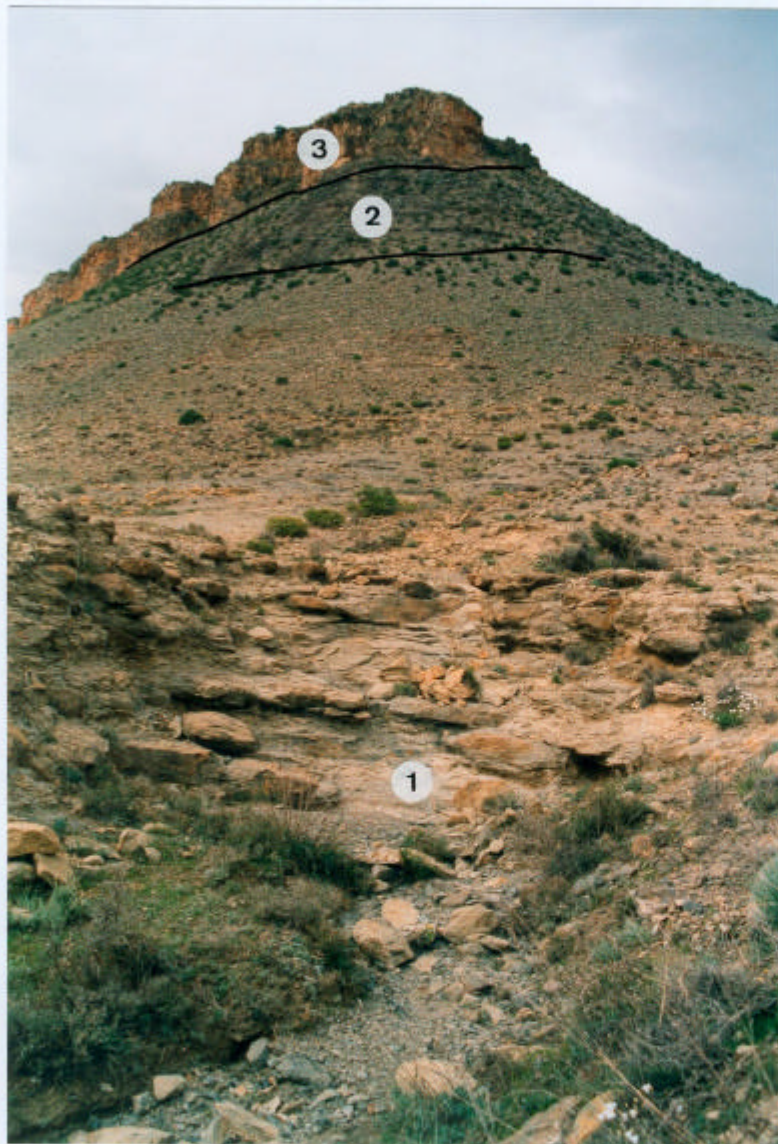


Fig. 6. General view of section Ri₄. 1: Sot de Chera Fm, 2: Loriguilla Fm, 3: Riela Mb.

- *Lower interval* (levels 72-100, Fig. 7a): Approximately 10 m of marl with sandy limestone, becoming more marly towards the top. The dark-grey limestone occur in decimetre to metre thick beds. The abundance of ammonites is high, level 100 being the most fossiliferous horizon. Species characterize the Bimammatum and Hauffianum subzones. Bivalves are rare and belong to the superfamilies Nuculanacea and Pectinacea.

- *Middle interval* (levels 101-176, Fig. 7a-b): Approximately 100 m of marls and limestone with intercalations of marly limestone. The upper part of the succession is more siliciclastic and bivalves are common. Ammonites are rare and the boundary between the Hauffianum-Planula subzones

is placed with some doubts at level 114. Bivalves belong to subclasses Palaeotaxodonta, Pteriomorphia and Heterodonta.

- *Upper interval* (levels 177-238, Fig. 7b): 70 m of marl with intercalated limestone beds. Towards the top, the marl/limestone ratio is decreasing, and these levels are attributed to the Galar subzone. Bivalves are common in the whole interval, especially at some levels at the limestone-marl intercalations. All subclasses are represented, the most abundant species being *Gervillella aviculoides* (J.

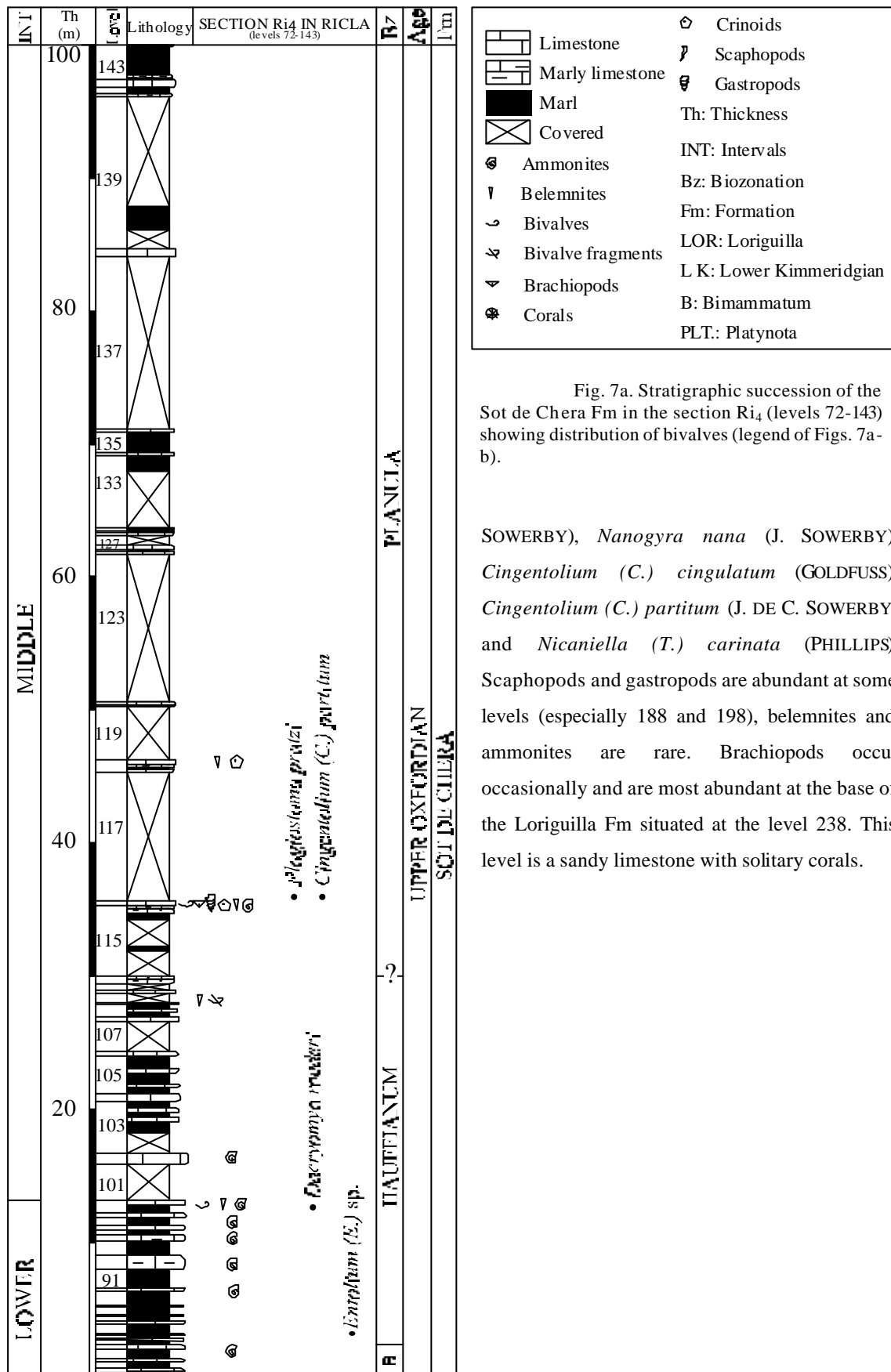


Fig. 7a. Stratigraphic succession of the Sot de Chera Fm in the section Ri₄ (levels 72-143) showing distribution of bivalves (legend of Figs. 7a-b).

SOWERBY), *Nanogyra nana* (J. SOWERBY), *Cingentolium (C.) cingulatum* (GOLDFUSS), *Cingentolium (C.) partitum* (J. DE C. SOWERBY) and *Nicaniella (T.) carinata* (PHILLIPS). Scaphopods and gastropods are abundant at some levels (especially 188 and 198), belemnites and ammonites are rare. Brachiopods occur occasionally and are most abundant at the base of the Loriguilla Fm situated at the level 238. This level is a sandy limestone with solitary corals.

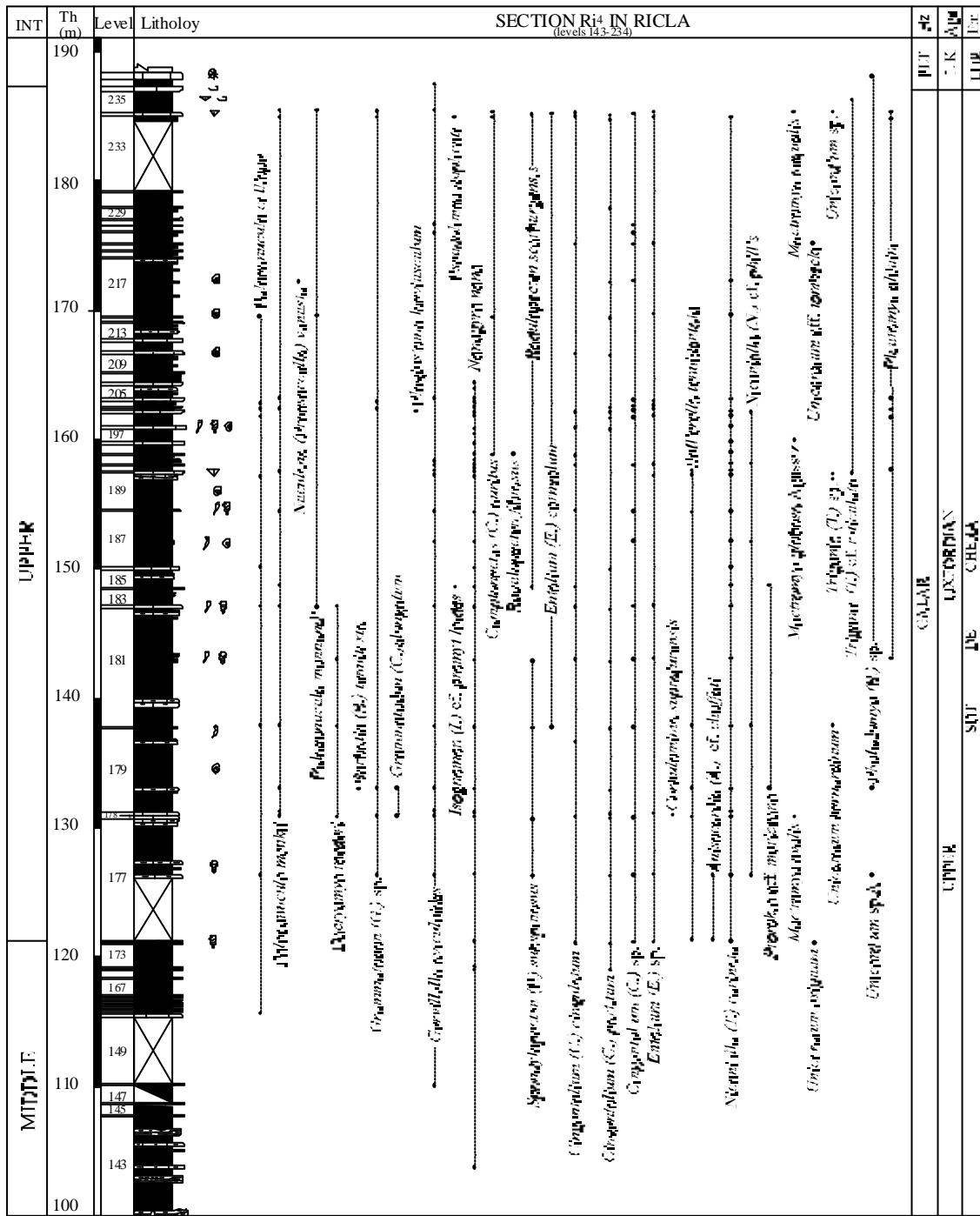


Fig. 7b. Stratigraphic succession of the Sot de Chera Fm in the section Ri₄ (levels 143-238) showing distribution of bivalves.

Section Ri₈

The section Ri₈ parallels that of Ri₄ and is situated ca. 1 km to the North, close to the geographic point called Cabezo Redondo. This outcrop has a similar high abundance and distribution of bivalves. It ranges from the base of the Sot de Chera Fm up to the base of the Loriguilla Fm (Fig. 8).

The numbers of the levels are not the same as in Ri₄, but there are some equivalent intervals:



Fig. 8. General view of the section Ri₄. 1: Sot de Chera Fm, 2: Loriguilla Fm, 3: Riela Mb.

- *Lower interval* (levels 74-89, Fig. 9a): Approximately 6 m of marl with intercalations of marly limestone. Fossils are rare and represented by some ammonites of the Hauffianum subzone.

- *Middle interval* (levels 90-139, Fig. 9a-b): Approximately 60 m of marl with limestone-marl intercalations; the thicker levels are more sandy towards the top. Some levels contain scaphopods, crinoids and bivalves. Among the latter, the superfamilies Nuculacea and Pectinacea are present. Brachiopods, ammonites and belemnites are rare. Between levels 90 and 108, characteristic ammonites of the Hauffianum and Planula subzones are present. From level 108, ammonites indicate the Planula subzone.

- *Upper interval* (levels 140-211, Fig. 9b-c): Around 65 m of marl with limestone-marl intercalations. The marl/limestone ratio decreases towards the top of the succession, which is more sandy. This is the interval with more abundant bivalves, especially between levels 160 and 178. Similar to the upper interval of Ri₄, all subclasses are present. The most abundant species are *Gervillella aviculoides* (J. SOWERBY), *Nanogyra nana* (J. SOWERBY), *Cingetolium (C.) cingulatum* (GOLDFUSS), *Cingetolium (C.) partitum* (J. DE C. SOWERBY) and *Nicaniella (T.) carinata* (PHILLIPS). At level 152 characteristic ammonites of the Galar subzone (Planula Zone) are present.

From level 212 to 224 sandy and bioclastic limestone occurs with solitary corals, brachiopods, and bivalves. These levels belong to the Loriguilla Fm and, with some doubts, are assigned to the Lower Kimmeridgian.

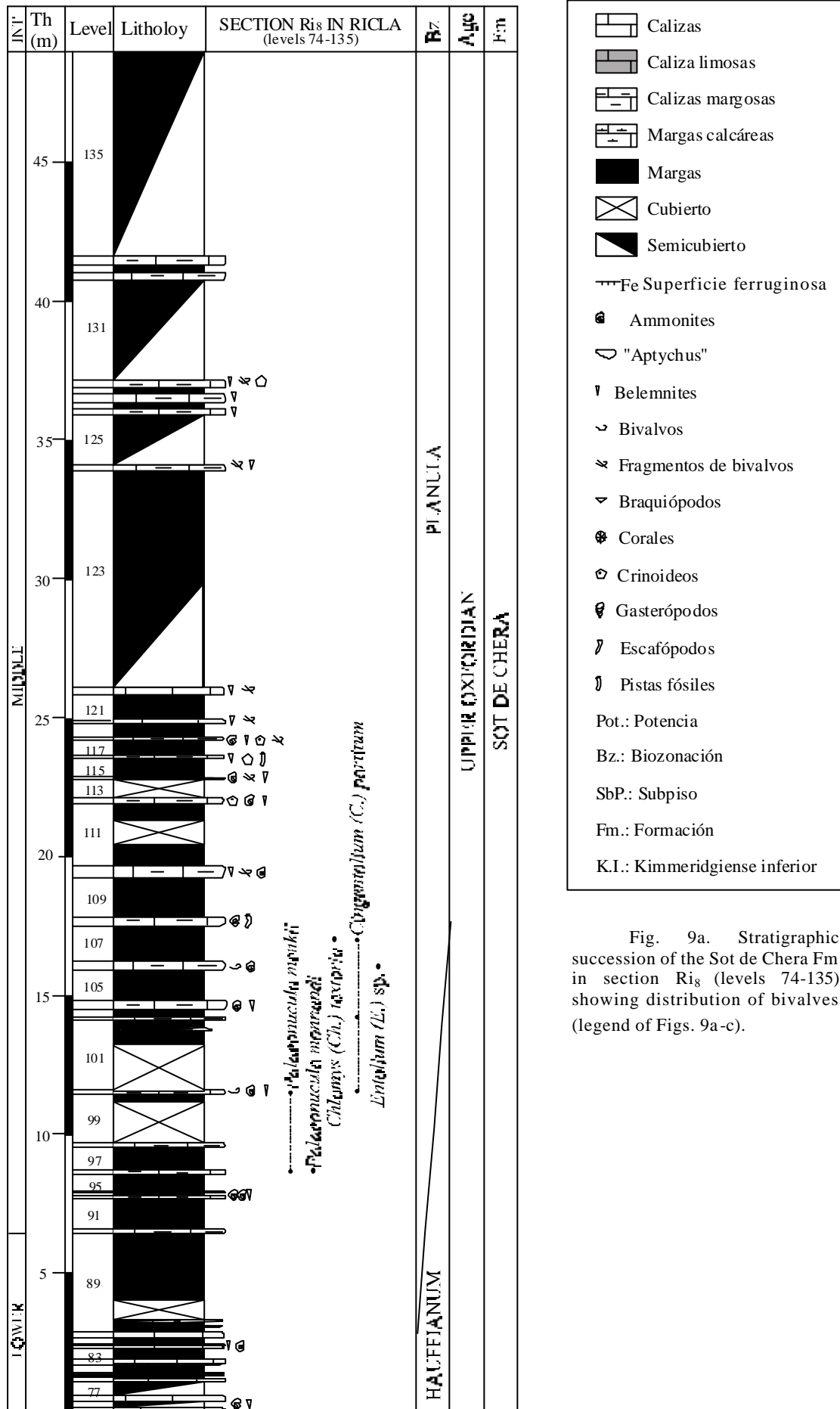


Fig. 9a. Stratigraphic succession of the Sot de Chera Fm in section Ri8 (levels 74-135) showing distribution of bivalves (legend of Figs. 9a-c).

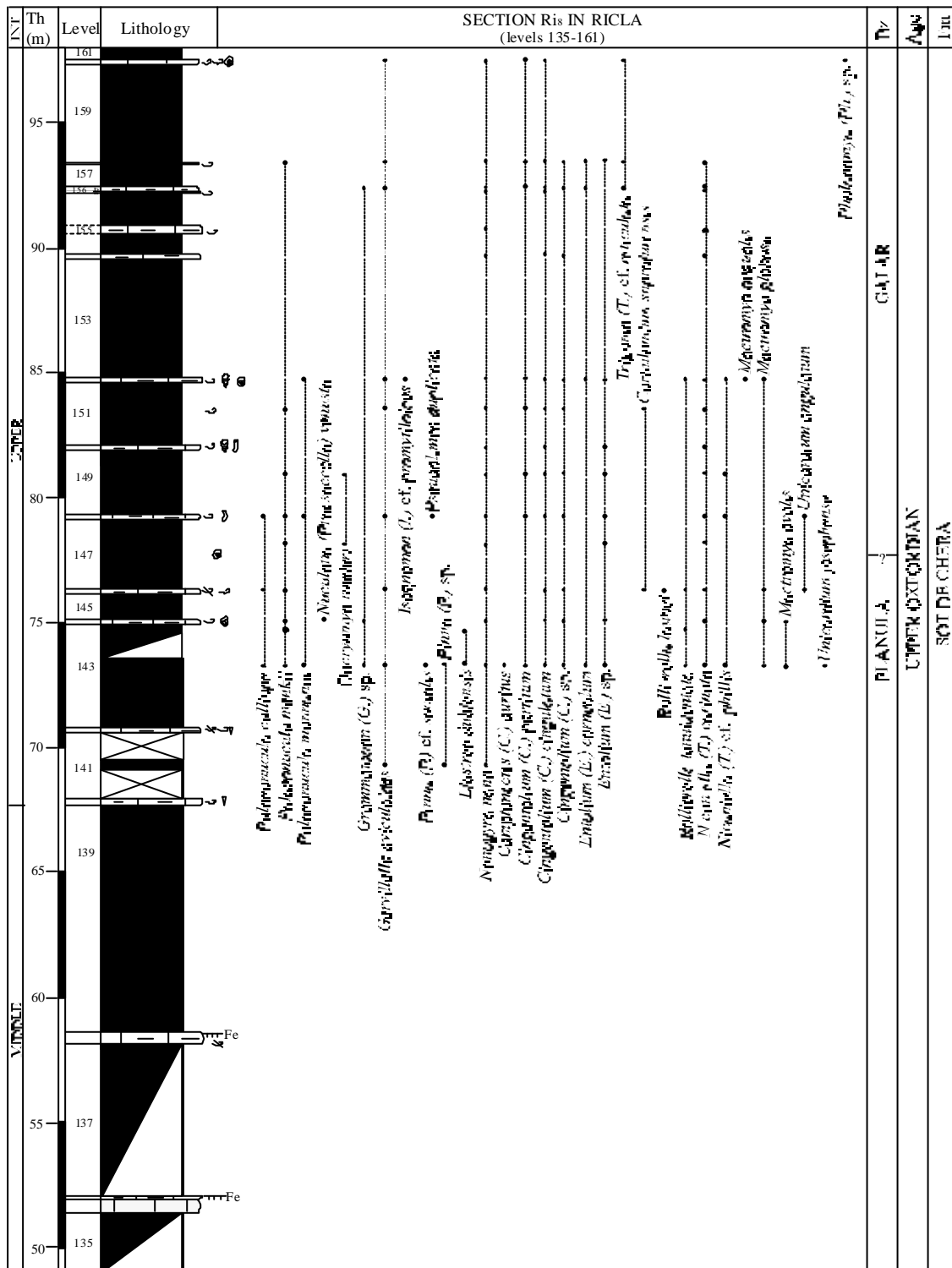


Fig. 9b. Stratigraphic succession of Sot de Chera Fm in section Ri₈ (levels 135-161) showing distribution of bivalves.

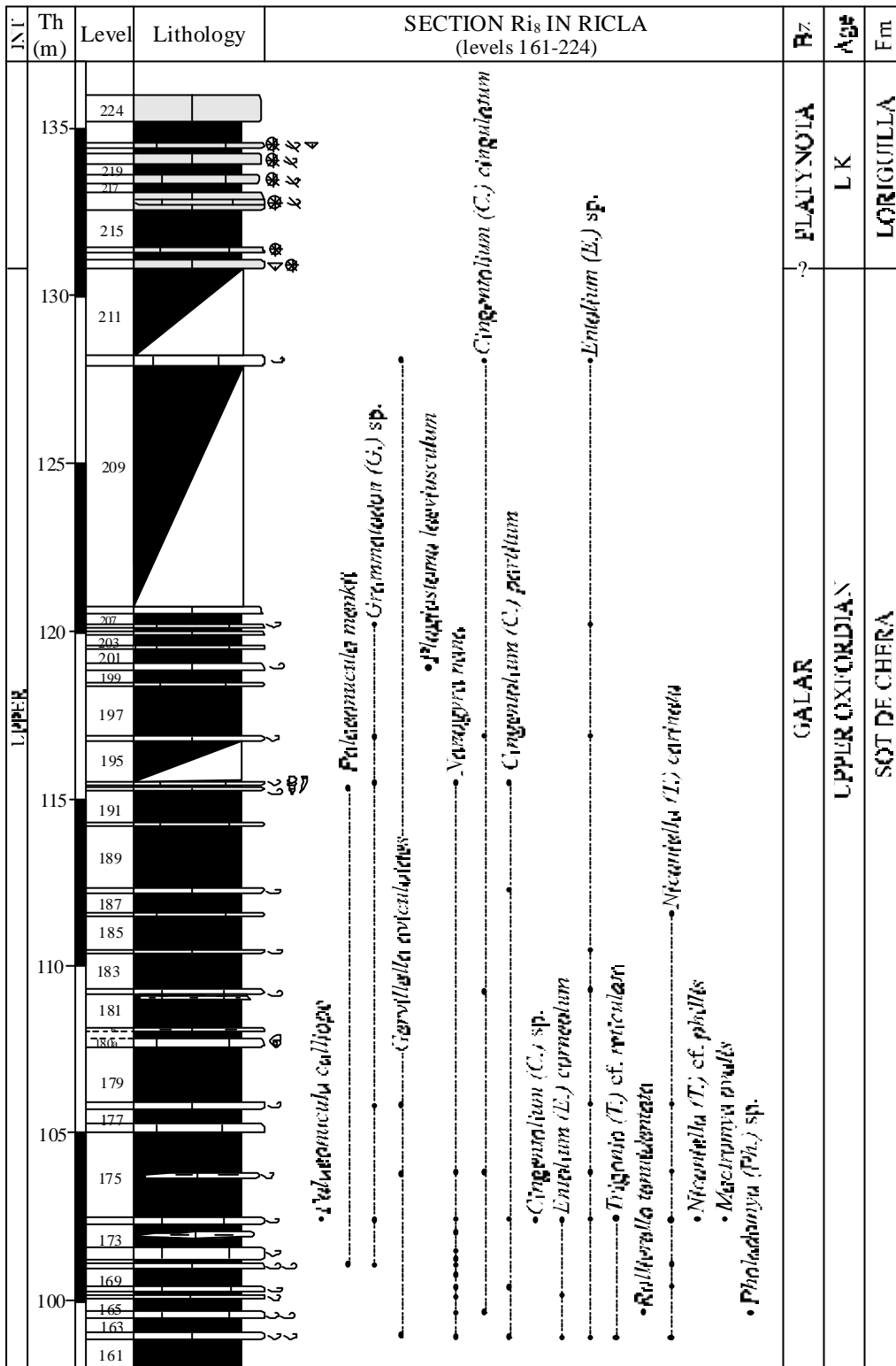


Fig. 9c. Stratigraphic succession of the Sot de Chera Fm (levels 161-211) and lower part of the Loriguilla Fm (levels 212-224) in the section Ri₈ showing the distribution of bivalves.

(b) Section To₃ (Huerva River, Tosos, province of Zaragoza)

In Tosos-Aguilón area, south of Zaragoza, the Yátova and Sot de Chera Formations are well-exposed. Only the lower part of the Yátova Fm is poorly fossiliferous. The most complete section was measured in the Huerva River in Tosos (called To₃). In the area of Aguilón, various sections have been measured and correlated with Tosos. Of these, Ag₈ is the most fossiliferous respect to bivalves (Figs. 10, 37). The studied section comprises the Upper Oxfordian. The Upper Oxfordian of this area was subject of biostratigraphic studies by SEQUEIROS & MELÉNDEZ (1981) and MELÉNDEZ (1989). The most recent data were provided by PÉREZ-URRESTI *et al.* (1999), who revised the age of the lithostratigraphic units, gave the position of the Oxfordian/Kimmeridgian boundary and listed the collected bivalves from this interval.

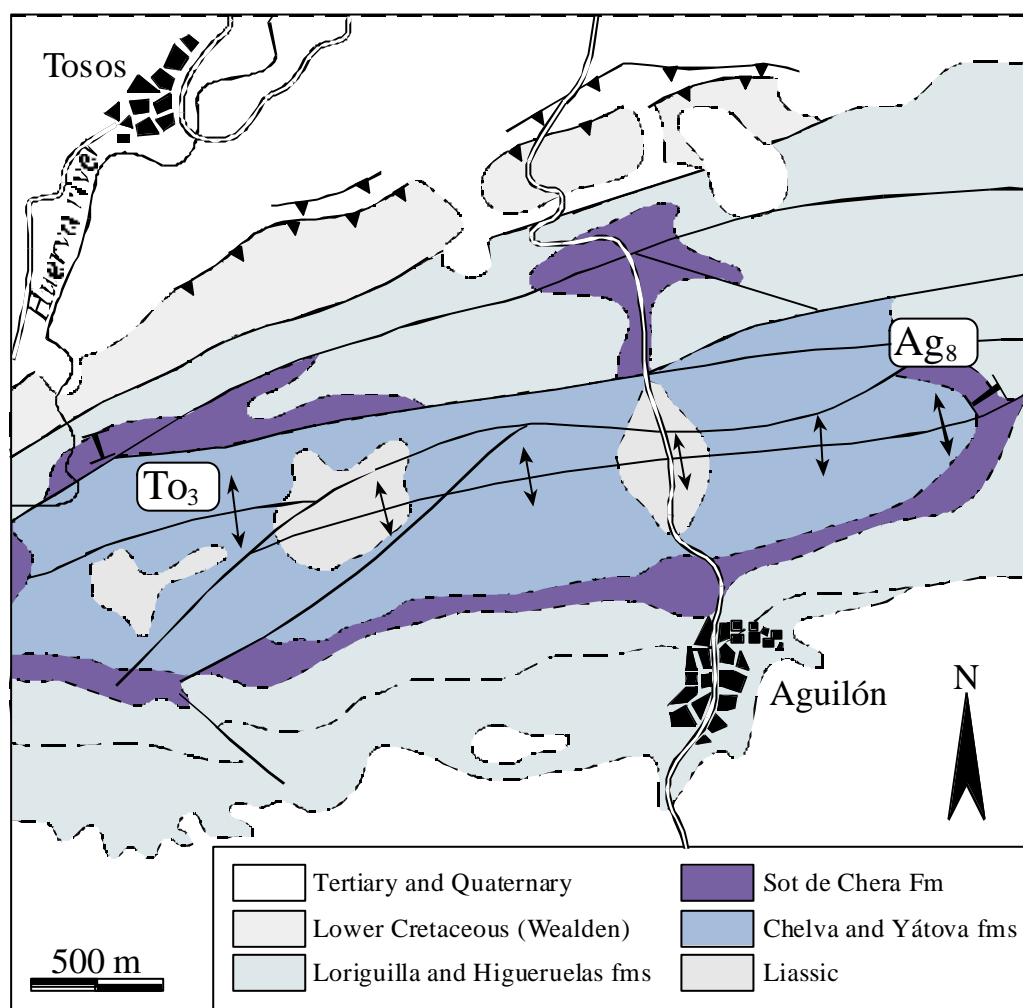


Fig. 10. Geological sketch map of the Tosos-Aguilón area (province of Zaragoza) with position of sections To₃ and Ag₈. (Modified after geological map, scale 1:50.000 n° 439 Azuara, I.G.M.E. (ed.)).

Section To₃ (Huerva river)

The section To₃ exposes an expanded and relatively continuous succession of the Upper Oxfordian and Lower Kimmeridgian. It connects the proximal sections of the "Sierra del Moncayo-valle del Jalón" with the distal sections of the "Plataforma de Arcos" and the eastern part of Calanda. Some levels of the Yátova Fm and three intervals of the Sot de Chera Fm are distinguished (Figs. 11-12).



Fig. 11. General view of section To₃, 1: Yátova Fm, 2: Sot de Chera Fm.

- *Yátova Formation*: The upper levels of this formation are exposed in the section; they consist of 3 m of bedded sponge limestone with with marly intercalations. These rocks belong to the Hypselum subzone (Bimammatum Zone). Ammonites are common and bivalves are rare. The levels 76 and 79 are marly and contain small-sized fossils: ammonites, belemnites, brachiopods, bivalves and rare gastropods. The bivalves belong to families Pectinidae, Palaeolophidae, Limidae and Nuculidae.

- *Sot de Chera Formation*: It consists of marl with limestone intercalations. Bivalves are common and reach their maximum abundance in the two upper intervals.

Interval 1: Approximately 8 m of marl with marl-limestone intercalations. Ammonites of the Hauffianum subzone are present at the base of the interval, and ammonites of the Planula Zone occur towards the upper levels. Solitary corals, crinoids, echinoderms and bivalves of the families Nuculidae, Pholadomyidae, Astartidae and Entoliidae are present.

Interval 2: 10 to 12 m of marl with marl-limestone intercalations which contain echinoderms, bivalves and ammonites of the Planula and Galar subzones.

Interval 3: Approximately 50 m of marl with intercalated limestone beds, the latter becoming thicker towards the base of the Loriguilla Fm; the transition between the two units is gradual. The fossil content is very low, bivalves and ammonites of the Galar subzone occur.

In the intervals 2 and 3, bivalves are more abundant in the levels 110, 112 and 124. Species of the families Limidae, Entoliidae, Pholadomyidae, Pinnidae, Astartidae, Nuculidae, Paralleodontidae, Pectinidae and Bakevelliidae are present. Most abundant are *Cingentolium (C.) partitum* (J. DE C. SOWERBY), *Grammatodon (G.) concinnum* (PHILLIPS) and *Palaeonucula menkii* (ROEMER).

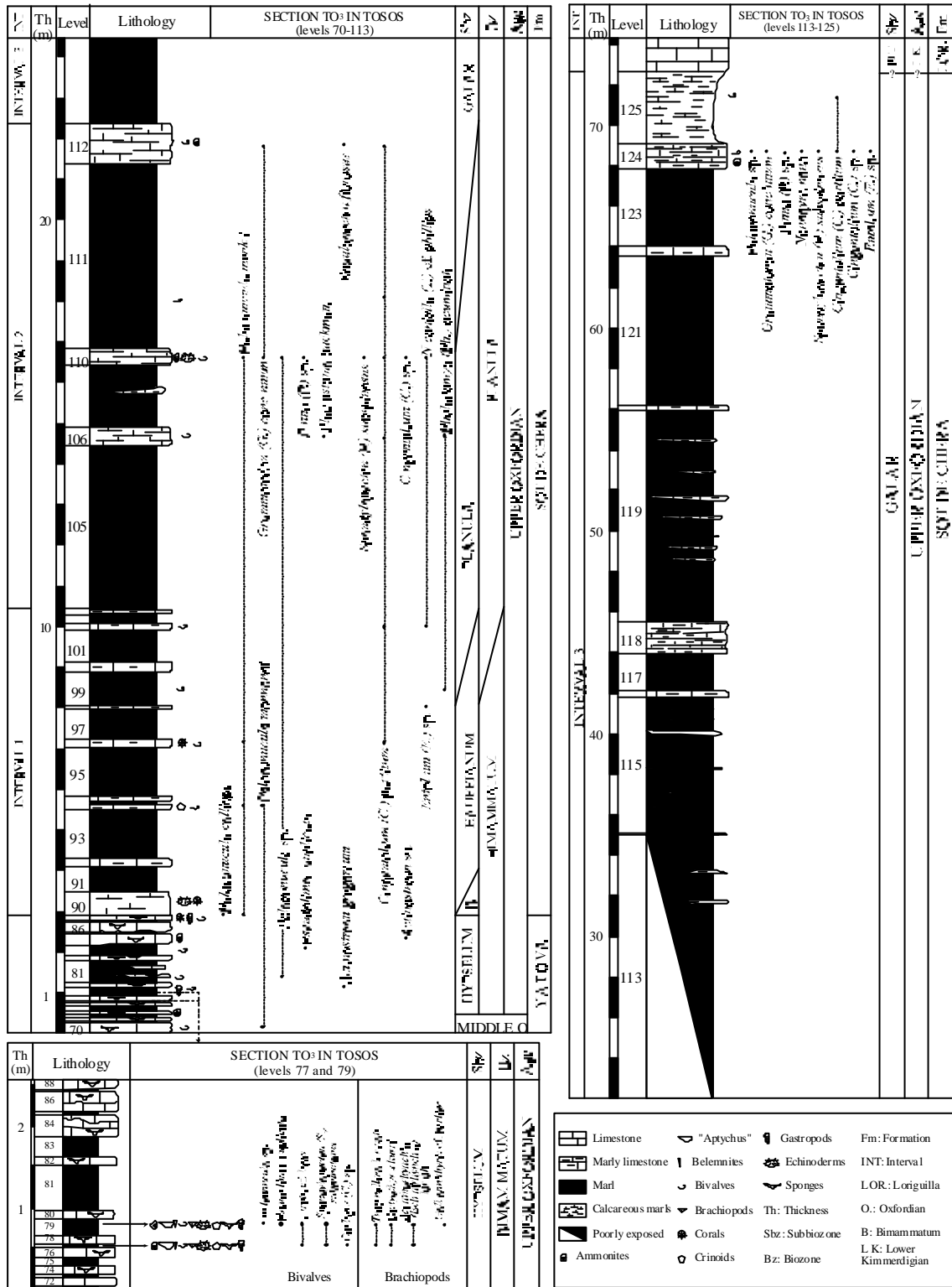


Fig. 12. Stratigraphic succession of section To₃ (Huerva river) that includes Yátova and Sot de Chera formations showing the distribution of bivalves.

(c) Section of Valmadrid (Valmadrid, province of Zaragoza): Val

The section Valmadrid was studied by AURELL (1990). It is situated in the NW of Valmadrid (Fig. 13) and ranges from the top of the Sot de Chera Fm throughout the Loriguilla Fm up to the base of the Higuieruelas Fm (Fig. 14). The section of Valmadrid was selected because the Loriguilla Fm is very rich in bivalves in this area.

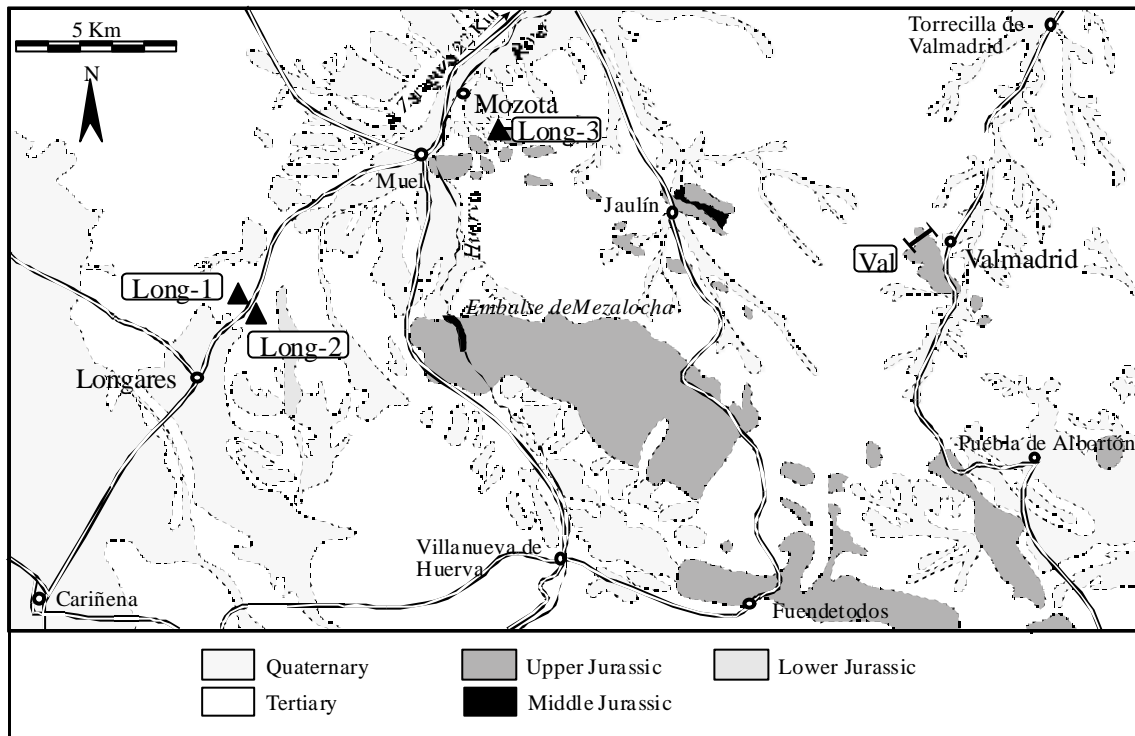


Fig. 13. Geological sketch map of the Longares and Valmadrid area. Long: Longares will be discussed in "additional outcrops" at the end of this chapter. Val: Valmadrid section. (Modified after geological map, scale 1:200.000 n° 32 Zaragoza, I.G.M.E. (ed.)).

Fig. 15 shows the stratigraphic succession at Valmadrid. The upper part of the Sot de Chera Fm is partially covered. The total thickness of the section is around 65 m. The rocks consist of typical limestone-marl rhythms. The lowermost 4 meters, are marly limestone with plant fragments, their top is a ferruginous surface. Upsection, the succession is dominated by marly limestone to compact white and grey limestone. Three intervals are distinguished.

The first interval is about 30 m thick (levels I-VII), consisting of beige marly limestone with intercalations of yellow calcareous marl. The fossil content is low, bivalves are the dominant group. Among them, *Nicaniella (T.) carinata* (PHILLIPS) is the most abundant species.

The second interval is 23 m thick, it starts at the base of level VIII whose top is a ferruginous surface. From there up to level 17, ammonites, gastropods, brachiopods and bivalves (particularly representatives of the Entoliidae and Parallelodontidae) are abundant. Specimens of *Inoperna perplicata* (ÉTALLON) were found only in this section and in Longares. The only specimen of *Ceratomya excentrica* (ROEMER) comes from this section.

The presence of *Progeronia* at level 12 was used to place the Lower-Upper Kimmeridgian boundary, although it may be even lower in the section. However, the scarcity of ammonites does not allow a more precise statement.

The third interval corresponds to the last 10 m of the section. It consists of dark-grey compact, brecciated limestone yielding only few fossils. The transition to the overlying Higuieruelas Fm is gradual.



Fig. 14. General view of the section Val, 1: Sot de Chera Fm, 2: Loriguilla Fm, 3: Higuieruelas Fm.

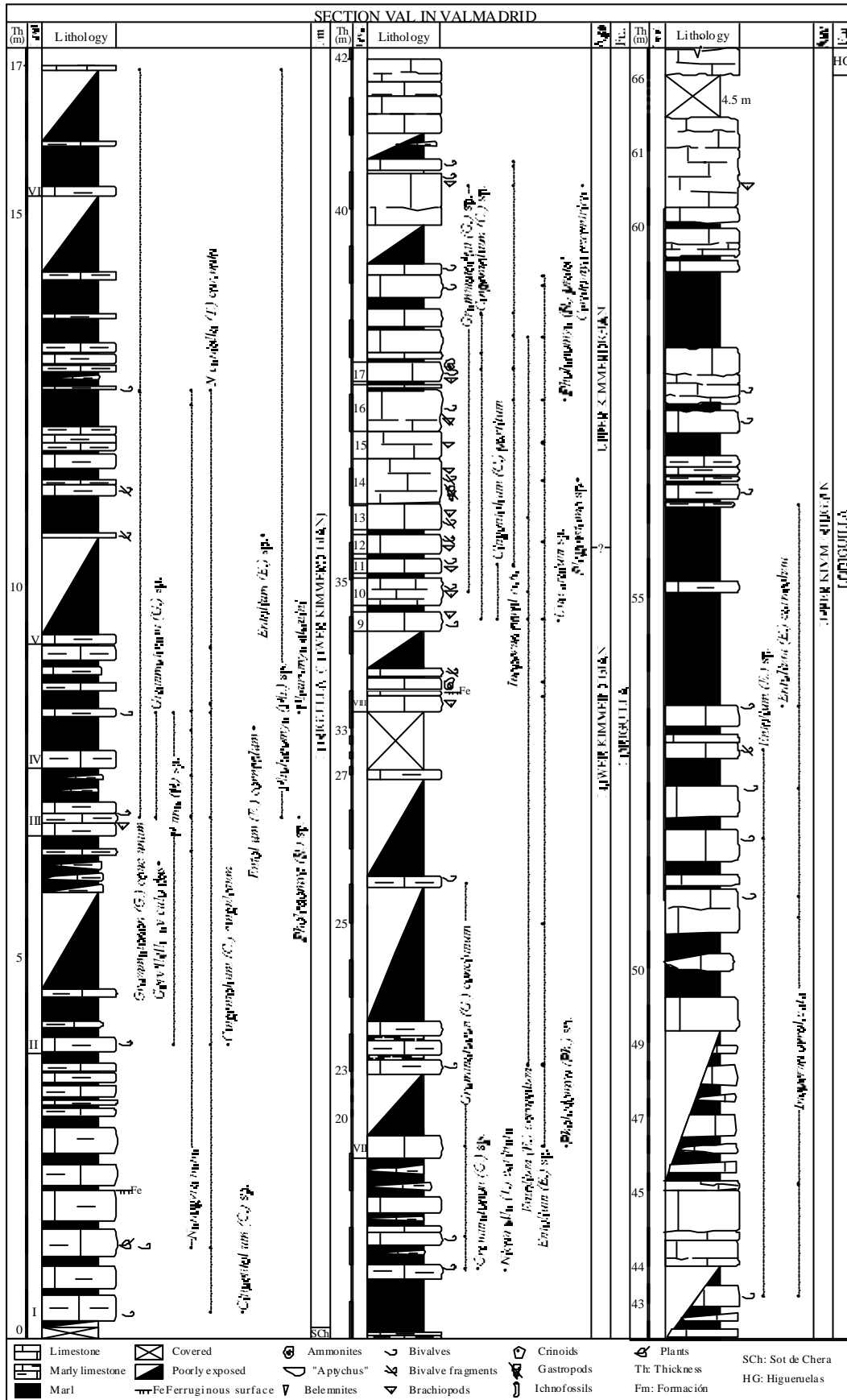


Fig. 15. Section of Valmadriz (Val) comprising mainly of the Loriguilla Fm with distribution of bivalves.

3.2.2. "SIERRA DE ARCOS" AREA.

Several authors studied this area in recent times (Chapter 2). The papers related directly with this work outcrops are as follows: MARÍN & TOULOUSE 1972 and MELÉNDEZ 1978 studied the sequence of Callovian and Oxfordian ammonoids. Other biostratigraphic reviews were realized about the Callovian by SEQUEIROS 1984; SEQUEIROS & MELÉNDEZ 1987; LARDIÉS 1988, 1990, and LARDIÉS *et al.* 1988. Oxfordian ammonoids were studied by MELÉNDEZ 1989; FONTANA 1990; MELÉNDEZ & FONTANA 1993; BELLO 1995, 1996, and PÉREZ-URRESTI 1995, 1996. DELVENE (1997a, 1998, 1999) studied Callovian-Oxfordian bivalves. More recently, MELÉNDEZ *et al.* 1997; AURELL *et al.* 1999a and RAMAJO *et al.* 1999 realized some synthetic works about this geographic area and its relation with other areas of the same basin.

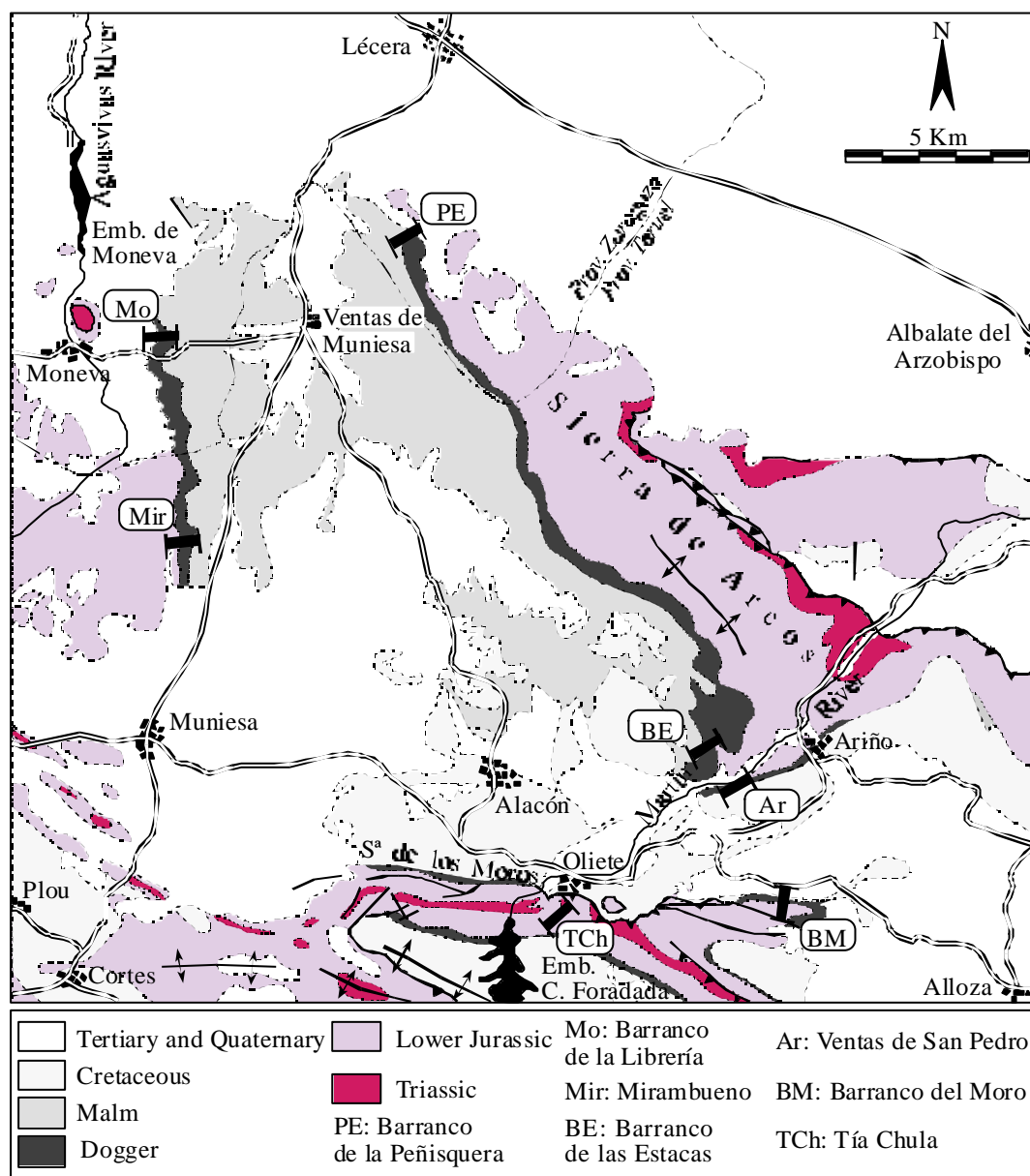


Fig. 16. Geological framework of "Sierra de Arcos" and "Sierra de los Moros" with the location of the studied outcrops. (Modified after geological map, scale 1:200.000 n° Daroca, I.G.M.E (ed.)).

(a) Section "**Barranco de la Peñisquera**" (Lécera, province of Zaragoza): PE

"Barranco de la Peñisquera" (PE) is located in the western margin of the "Sierra de Arcos", about 2 km to the south of Lécera (Fig. 16). The section includes the uppermost part of the Chelva Fm (the uppermost 2.2 m) and the Yátova Fm (Figs. 17 and 18).

- *Chelva Fm*

Total thickness of 2.2 m, two intervals are distinguished. The first one (levels 10a and b) consisting of 0.6 m of bioclastic limestone beige in colour, in tabular strata.

The fossil content is high: brachiopods, belemnites, ammonites (indicating the Lower Callovian) and bivalves. Among bivalves, the families Limidae, Palaeolophidae, Oxitomyidae, Pectinidae, Entoliidae, Pholadomyidae and Pleuromyidae occur. The top of level 10b is a ferruginous surface. The second interval belongs to the "Capa de Arroyofrio" (levels 11-18), consisting of iron-oolithic limestone. The iron-ooliths are heterometric and their size increases to the top of the interval. The fossil content is lower than in the first interval. Among bivalves, scarce specimens of the families Dimyidae, Palaeolophidae and Entoliidae are recorded.

- *Yátova Fm*

Total thickness approximately 5.5 m, two intervals can be distinguished based on the content of sponges. The lower interval (levels 19-32) consists of 3.5 m of grey limestone with sponges, the level 18 shows some dispersed iron-ooliths. The strata are brecciated and the upper levels are irregularly bedded.



Fig. 17. General view of section "Barranco de la Peñisquera" (PE).

Ammonites, belemnites, brachiopods, crinoids and bivalves were registered. Among bivalves, the families Dimyidae, Pectinidae and Entoliidae are present. Towards the level 31, sponge content decreases

and glauconite is present. This interval belongs to the Middle Oxfordian, the top of level 32 marking the boundary to the Upper Oxfordian.

The second interval (levels 33-42) includes glauconitic limestone without sponges in irregular layers. It yielded ammonites, belemnites, brachiopods and bivalves. Ammonites allow to assign these rocks to the Upper Oxfordian. Species of bivalves of the families Limidae, Palaeolophidae, Oxytomidae, Pectinidae and Entoliidae are registered.

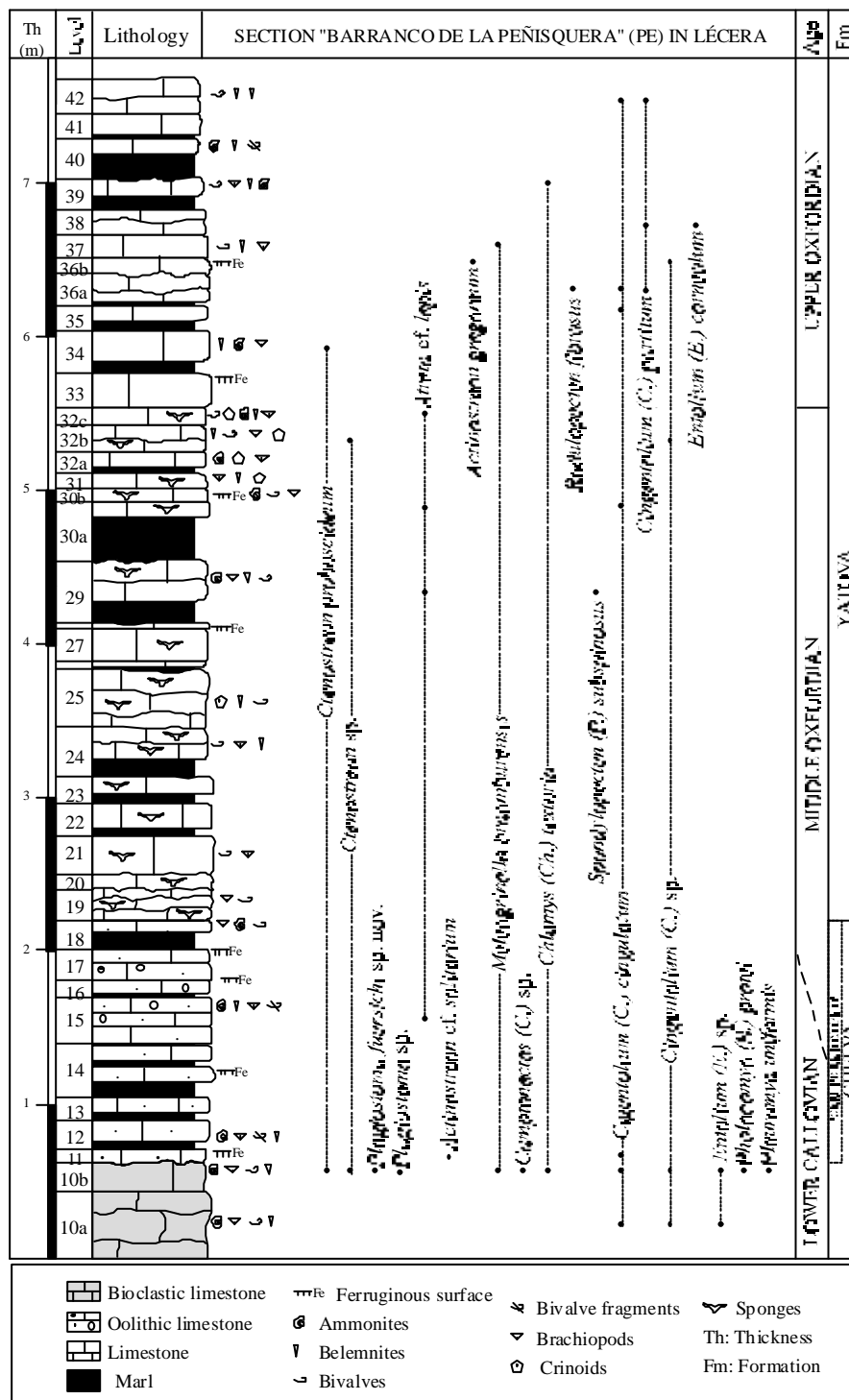


Fig. 18. Stratigraphic succession of the section "Barranco de la Peñisquera" (PE) showing the distribution of bivalve species.

(b) Section of "Barranco de la Librería" (Moneva, province of Zaragoza): Mo

The section Mo is called "Barranco de la Librería" because that is the nearest geographical point of reference marked in the national topographic map (scale 1:50.000) of Muniesa (467). However, this section was called "Barranco de la Molinera" in previous works (BELLO 1995, 1996; PÉREZ-URRESTI 1995, 1996) based on the folk name in the locality Moneva. It is near the very well known outcrop "Barranco de la Vega" described by BULARD (1972). The "Barranco de la Librería" is a tributary of the right bank of the Aguasvivas River, located about 2 km to NE of Moneva (Fig. 16). The section is very similar to that of "Barranco de la Peñisquera" described above. It includes the uppermost part of the Chelva Fm stated below and the Yátova Fm (Figs. 19 and 20). The next intervals are distinguished:



Fig. 19. General view of the section "Barranco de la Librería" at Moneva (Mo).

- *Chelva Fm*

Approximately 1.8 m of total thickness is studied. The lower interval (levels 5-6) consists of bioclastic limestone in tabular layers. Its fossil content includes belemnites, brachiopods, bivalves and Lower Callovian ammonites. Among bivalves, species of the following families are present: Limidae, Pectinidae, Entoliidae and Permophoridae. The upper interval (levels 7-10) is the "Capa de Arroyofrio", consisting of iron-oolithic limestone, the ooids increasing its size towards the upper levels. The fossil content is low, scarce belemnites, brachiopods, bivalves and ammonites. Ammonites allow to assign the levels 7 and 8 to the Lower Callovian; the levels 9 and 10 probably represent the Lower and Middle Oxfordian. Bivalves belong to the families Limidae, Pectinidae and Entoliidae.

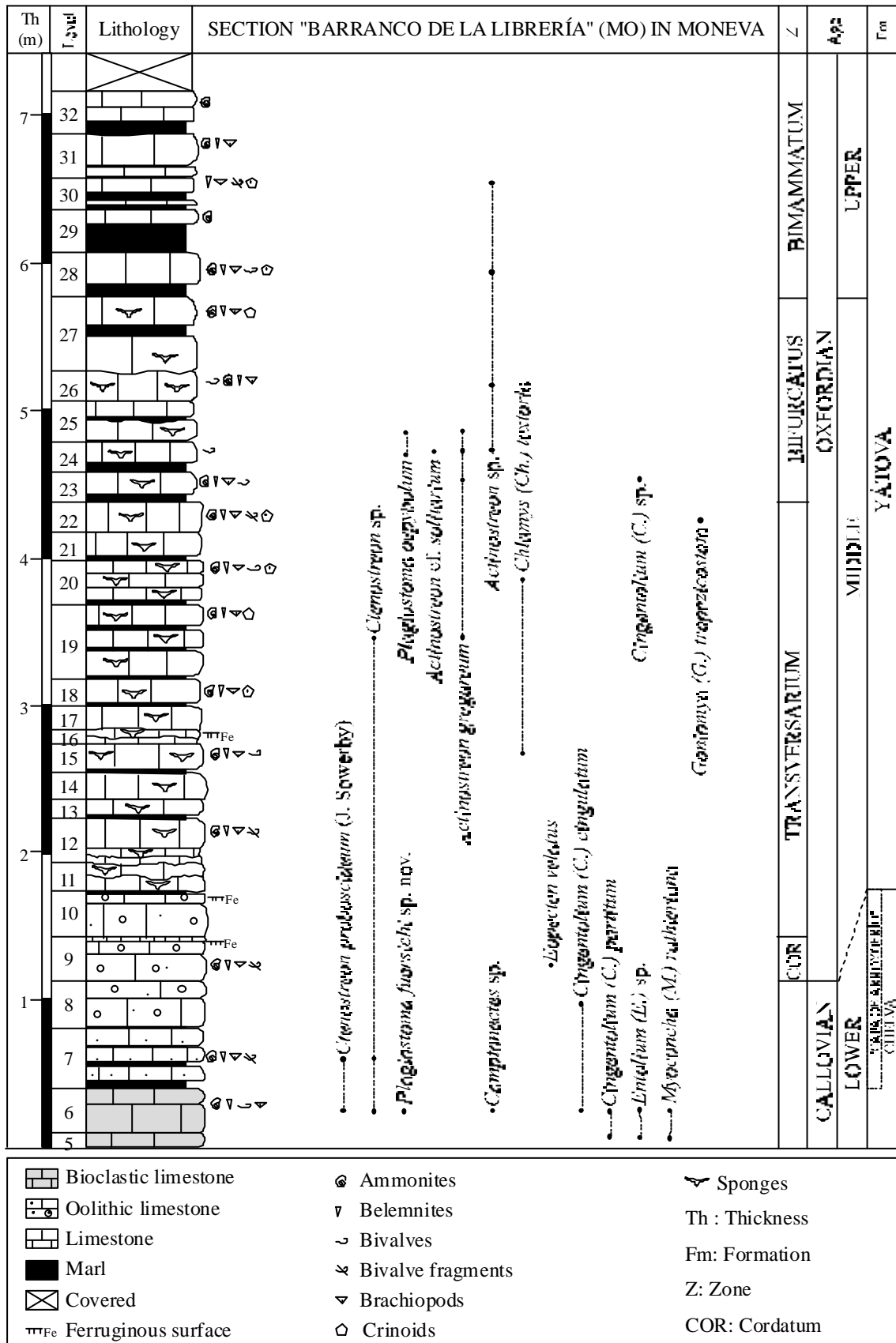


Fig. 20. Stratigraphic succession of the section "Barranco de la Librería" at Moneva (Mo) showing the distribution of bivalve species.

- *Yátova Fm*

Its total thickness is 5.5 m, the intervals are differentiated in relation to the sponges. The lower interval (levels 11 al 27) includes limestone with sponges and intercalated thin marly layers. They are brecciated in the lower part of the interval, becoming more regular towards the top. The fossil content comprises belemnites, brachiopods, crinoids, ammonites and bivalves. Ammonites allow to date the rocks as Middle Oxfordian. Among bivalves, the following families occur: Limidae, Palaeolophidae, Pectinidae, Entoliidae and Pholadomyidae. The available material of *Goniomya (G.) trapezicostata* (PUSCH) comes from this section and from "Barranco de las Estacas" in Ariño. The upper interval (levels 28-32) consists of glauconitic limestone with intercalations of marl, its fossil content is low; ammonites indicate the Upper Oxfordian. Among bivalves only some poorly preserved specimens of family Palaeolophidae occur.

(c) Section of Mirambueno (Muniesa, province of Teruel): Mir

The section called Mirambueno is located at the North of Muniesa, the access is by a way that branches at km 58 from the main road A-222. Outcrop condition as well as fossil content is very poor. The studied materials belong to Chelva and Yátova formations (Fig. 21).

The Chelva formation consists of the level 9, corresponding to the "Capa de Arroyofrío". It is wackestone with heterometric and abundant iron-ooliths. The fossil content is scarce, ammonites of this level belong to the Lower Oxfordian. Above level 9, a level of 20 cm is partly covered; it is included in the "Capa de Arroyofrío" because it consists of iron-oolithic limestone.

The Yátova Formation consists of approximately 3.5 m of grey limestone with sponges in tabular layers. Towards the middle part (levels 16-19) and towards the top (levels 27 and 28) of the interval the beds show a nodular fabric. The level 11 coincides with the base of the interval, it shows dispersed iron-ooliths. Between levels 11 to 15, the fossil content is scarce. Bivalves are concentrated in levels 16 to 24, the families Limidae, Dimyidae, Palaeolophidae, Oxitomyidae, Pectinidae and Entoliidae are present. From the level 21 up to the top of the section, limestone is glauconitic and marl is frequently interbedded at their base.

The rocks are assigned to the Middle Oxfordian, the top of the level 27 is the boundary between the Middle and Upper Oxfordian.

(d) Section of "Barranco de las Estacas" (Ariño, province of Teruel): BE

The section "Barranco de las Estacas" (BE) is located at Wets of west of Ariño, in a tributary of left bank of Martín River (Figs. 16, 22). The interest of this section is the high content of bivalves in one of levels of Callovian and Yátova Fm. The intervals differenced are the next (Fig. 23):

- *Chelva Fm:*

Total thickness is 2.2 m; the first interval (levels 8-12) consists of bioclastic limestone with intercalations of marl in tabular layers. The fossil content is high: ammonites, belemnites, brachiopods and bivalves occur. Ammonites allow assigning the beds to the Lower Callovian. Bivalves are the main group in level 12 with families Limidae, Gryphaeidae, Pectinidae, Entoliidae, Arcticidae, Permophoridae,

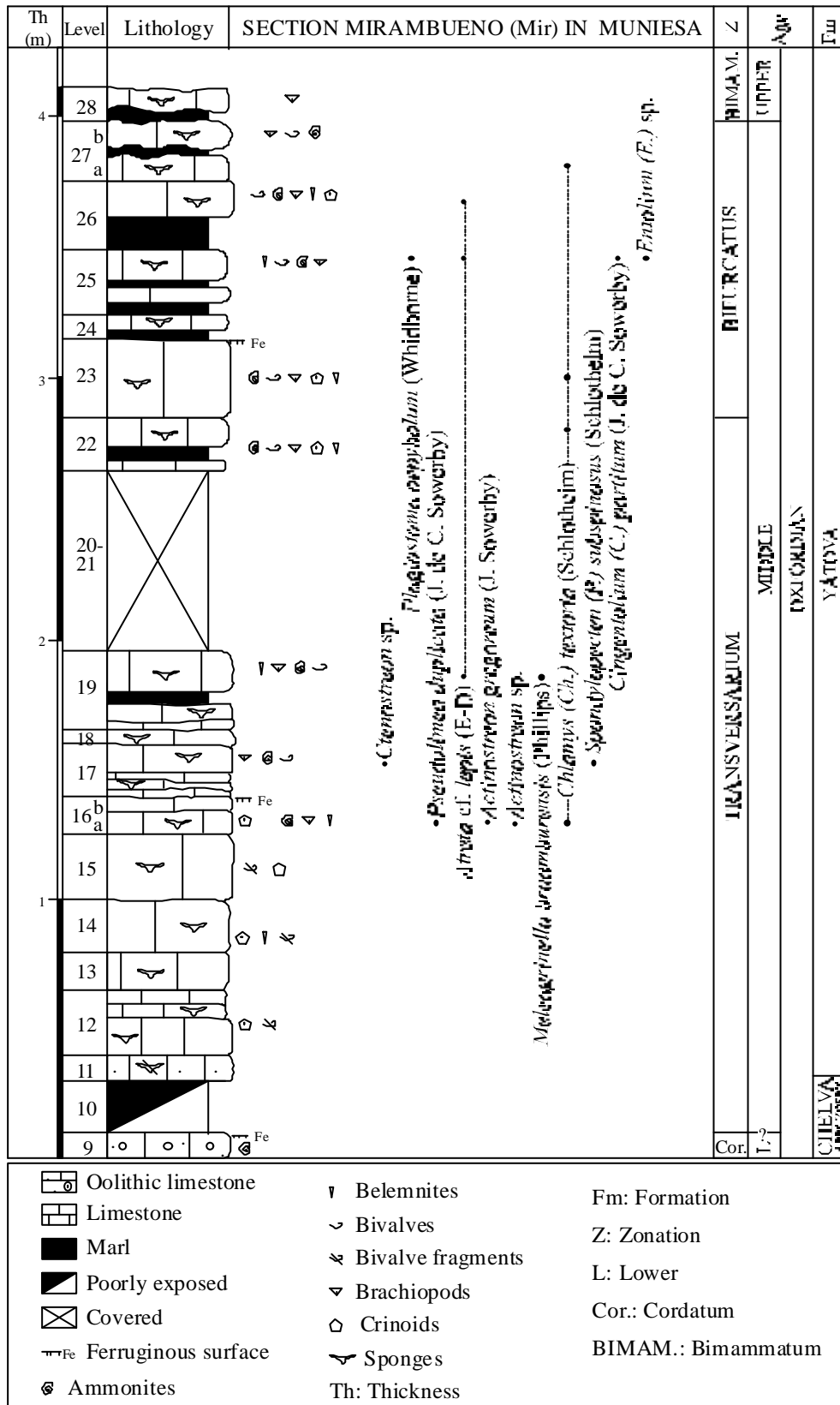


Fig. 21. Stratigraphic succession of the section Mirambueno at Muniesa (Mir) showing the species of bivalves registered.



Fig. 22. General view of section "Barranco de las Estacas" at Ariño (BE).

Astartidae, Pholadomyidae, Pleuromyidae and Thraciidae being present. Among species of bivalves *Plagiostoma fuersichi* sp. nov. is one of the most abundant; the specimens of *Pholadomya* (*Ph.*) *kachchhensis* PANDEY, FÜRSICH & HEINZE come from this section and "Barranco del Moro", and the only specimen of *Thracia depressa* (J. DE C. SOWERBY) comes from this section. The top of level 12 is a hardground.

The second interval (levels 13-19) is the "Capa de Arroyofrío" consisting of 1.2 m of yellow iron-oolithic limestone. They are homometric and dispersed in the levels 13 and 14, becoming larger and heterometric in levels 15 to 19 (MELÉNDEZ *et al.* 1996, 1997). The fossil content is lower than in the first interval, ammonites date the levels 13 to 17 to the Lower Callovian, and levels 18-19 to the Lower and Middle Oxfordian. The abundance of bivalves decreases, families of first interval are present but the number of specimens is low.

- *Yátova Fm:*

The first interval (levels 20-26) comprises 2.5 m of nodulose limestone with sponges. The level 20 contains iron-oids at the base. The fossil content comprises belemnites, brachiopods, ammonites and crinoids. Bivalves are decreasing considerably, only scarce specimens of the families Pectinidae (*Chlamys*) and Mytilidae (*Modiolus*) occur. The rocks are of Middle Oxfordian age.

The second interval (levels 27-60) is 10.6 m thick and composed of glauconitic limestone with marl at the base of the strata. The beds are irregularly at the base and the top of the interval, the middle part shows regular bedding. Between levels 55 and 60, glauconite content decreases. The fossil content comprises ammonites, brachiopods, crinoids, belemnites and bivalves. Ammonites assign the levels 27-29 to the Middle Oxfordian, the rest of the interval to the Upper Oxfordian. The abundance of bivalves is

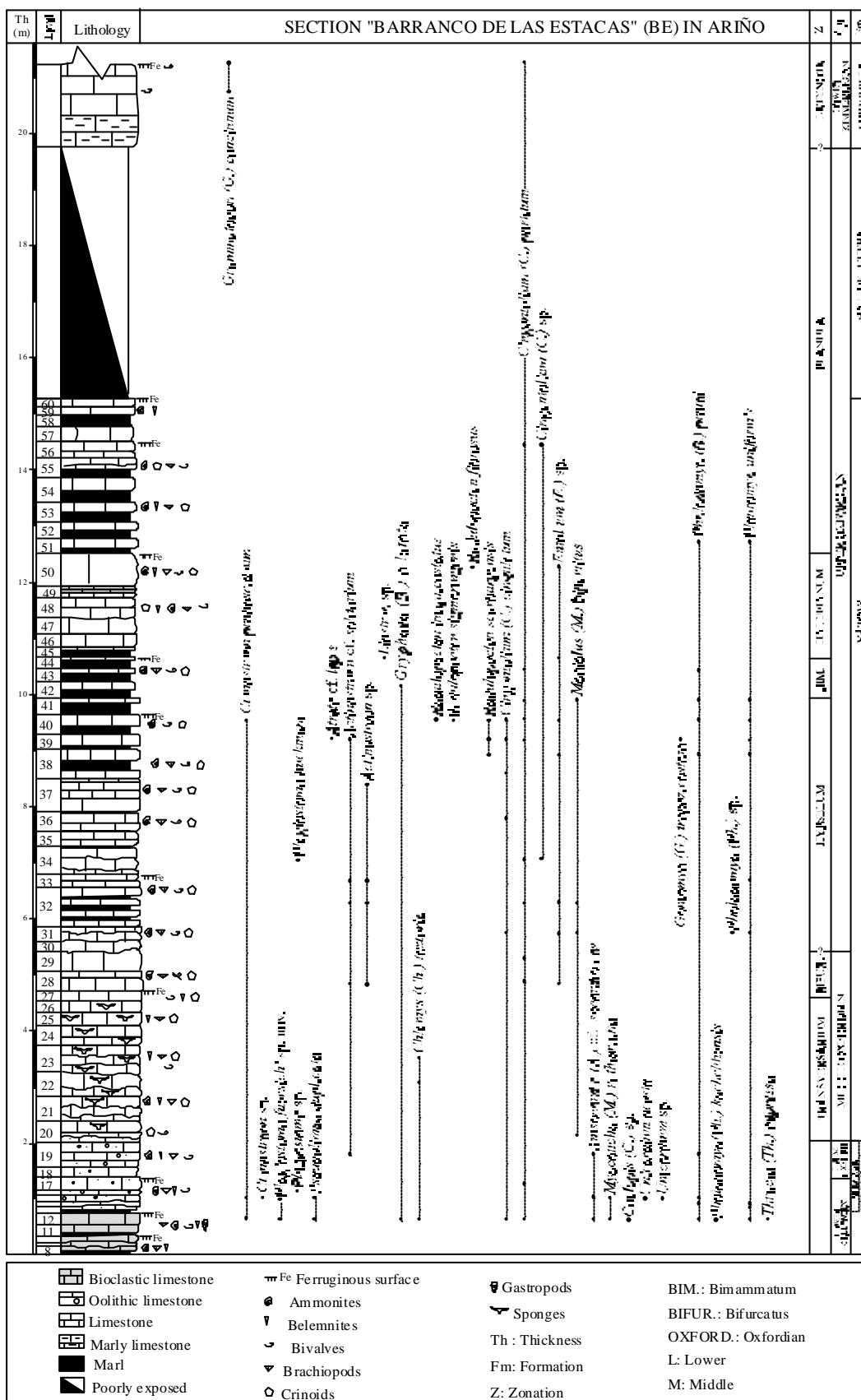


Fig. 23. Stratigraphic succession of section "Barranco de las Estacas" at Ariño (BE) showing distribution of bivalve species.

relatively high, the families Limidae, Palaeolophidae, Gryphaeidae, Pectinidae, Entoliidae, Mytilidae, Pholadomyidae and Pleuromyidae are present.

Lapped by a ferruginous surface, the Yátova Fm, is overlain by there are approximately 4 m of partly covered marl belonging to Sot de Chera Fm; however, due to poor outcrop conditions a palaeontological sampling was not possible.

The uppermost part of the section comprises approximately 1.5 m of limestone belonging to Loriguilla Fm, attributed to the Lower Kimmeridgian with some doubts. In this interval, specimens of *Grammatodon (G.) concinnum* (PHILLIPS) and *Cingetolium (C.) partitum* (J. DE C. SOWERBY) are frequent.

(e) Section of "Ventas de San Pedro" (Oliete, province of Teruel): Ar

The section "Ventas de San Pedro" (Ar) is located to the SW of Ariño, near Oliete, in a tributary of the right bank of the Martín River (Fig. 16). The content of bivalves is lower than the section "Barranco de las Estacas" (BE), but it is representative from the main groups registered in this area. The section includes a part of the Chelva Fm and the Yátova Fm (Figs. 24-25). The following intervals are distinguished:

- Chelva Fm

The section starts with the 40 cm thick level 7, a tabular bioclastic limestone; this level is equivalent to the level 12 of the section "Barranco de las Estacas" described above. Its fossil content comprise belemnites, brachiopods, ammonites, crinoids and bivalves. This level is Early Callovian in age. Among bivalves, the holotype of *Plagiostoma fuersichi* sp. nov. comes from this section.

The levels 8 and 9 represent the "Capa de Arroyofrío", of 0.8 m in thickness, consisting of iron-oolithic limestone. In the level 8, ooids are of small size and relatively homometric. In the level 9, ooids are larger and heterometric; level 8 is Callovian in age, level 9 Early and Middle Oxfordian in age (MELÉNDEZ *et al.* 1997).

- Yátova Fm

The Yátova Fm has a thickness of 9.6 m. The levels 10-22 consist of limestone with sponges in irregular strata, getting more tabular towards the top. The level 10 has iron-ooids at the base. The upper three levels contain a few sponges and they are glauconitic. The fossil content consists of brachiopods, belemnites, ammonites, crinoids and bivalves. These rocks are Middle Oxfordian in age. Bivalves belong to families Limidae, Pectinidae and Entoliidae.

The second interval (levels 23-55) consists of glauconitic limestone in tabular to nodulose strata. Its yielded ammonites, bivalves, belemnites and brachiopods. Levels 23-28 are attributed to the Middle Oxfordian and levels 29-55 to the Upper Oxfordian. Among bivalves the families: Limidae, Pectinidae, Entoliidae, Mytilidae, Pleuromyidae and Pholadomyidae occur. In Pholadomyidae, *Pholadomya (Ph.) protei* (BRONGNIART) is one of the more abundant species.



Fig. 24. General view of section "Ventas de San Pedro" at Oliete (Ar).

3.2.3. "SIERRA DE LOS MOROS" AREA.

The "Sierra de los Moros" is a mountainous area striking NW-SE, located in the SW of the "Sierra de Arcos" between the Martín and Escuriza rivers. Studied materials form part of the anticlinal with the same orientation to the South of Oliete (Fig. 16).

(a) Section of "Barranco del Moro" (Oliete, province of Teruel): BM

The section "Barranco del Moro" (BM) was described for the first time by BULARD (1971, 1972); recently several authors reviewed this section (GÓMEZ 1979; AURELL 1990). The access to the section is from km 37 of the road between Andorra and Oliete. The section BM includes part of the Chelva Fm and the Yátova Fm (Fig. 26); the total thickness is 12 m, Callovian and Middle to Upper Oxfordian rocks are exposed (Fig. 27). Five intervals are distinguished.

- *Chelva Fm*

Interval 1 (levels 2-13): The base of the interval is an iron surface, providing the boundary to the Bathonian. Overlying this surface, approximately 2.5 m of bioclastic limestone (wackestone-packstone) in tabular beds is exposed, becoming more irregular towards the top of the interval. Its fossil content is relatively abundant and comprises ammonites, echinoderms, brachiopods and bivalves. Ammonites allow to assigning these rocks to the Callovian. Among bivalves, the families Limidae, Pectinidae, Entoliidae, Mactromyidae and Pholadomyidae are recorded. The level 13 is marly, its upper boundary is an iron surface.

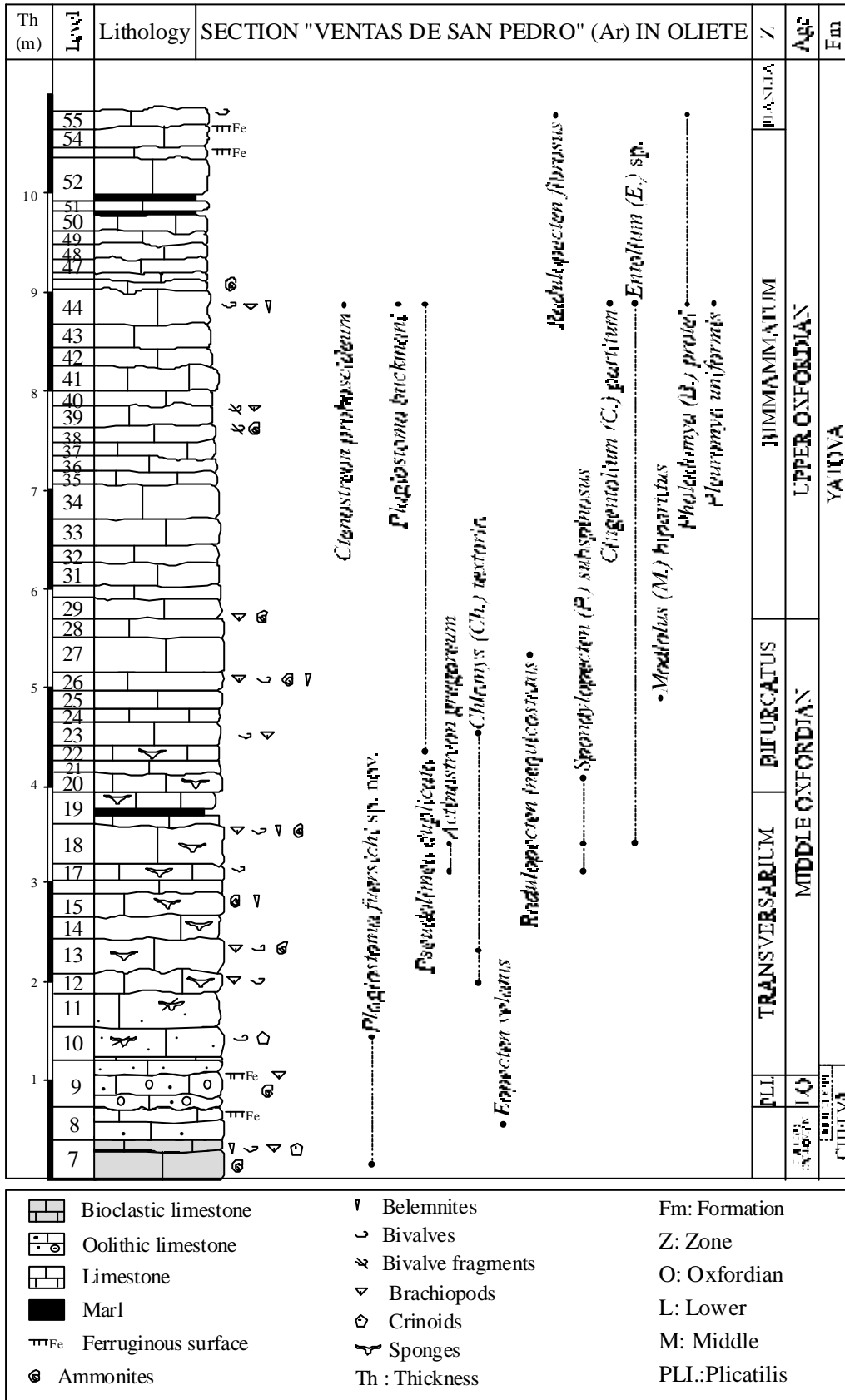


Fig. 25. Stratigraphic succession of section "Ventas de San Pedro" at Oliete (Ar) showing the distribution of bivalve species.



Fig. 26. General view of section "Barranco del Moro" (BM).

Interval 2 (levels 14-16): Both levels (30 and 35 cm respectively) consists of iron-oolithic limestone of the "Capa de Arroyofrío". The ooids are heterometric, their size increases in the upper level. The fossil content is low, some ammonites and scarce belemnites occur. An iron surface separates both levels; the lower level is Callovian and upper one likely Oxfordian in age.

- *Yátova Fm*

Interval 3 (levels 18-24): 2.7 m of compact limestone in irregular beds, the base of level 18 yields iron-ooids. Its fossil content consists of abundant sponges, crinoids, brachiopods and bivalves. Among ammonites, the genus *Larcheria* characterizes the Middle Oxfordian. Bivalves belong to the families Limidae and Pectinidae. Towards the glauconitic top of level 24, sponges decrease.

Interval 4 (levels 25-48): 4.7 m of glauconitic limestone with nodular fabric. Its fossil content comprises ammonites, belemnites, gastropods and brachiopods. Ammonites allow to place the boundary between the Middle and Upper Oxfordian at the base of the level 34. Bivalves of the families Pectinidae, Entoliidae, Pholadomyidae and Pleuromyidae occur. Species of *Cingentolium* are very common in the uppermost of the interval. From the level 44 upwards, the content in glauconite decreases.

Interval 5 (levels 50-56): 1.3 m of compact limestone without glauconite in tabular layers with intercalations of marl at the base of the strata. Ammonites, belemnites, brachiopods, gastropods and bivalves are recorded including characteristic Upper Oxfordian ammonites. Bivalves of the families Entoliidae, Pholadomyidae and Pleuromyidae occur.

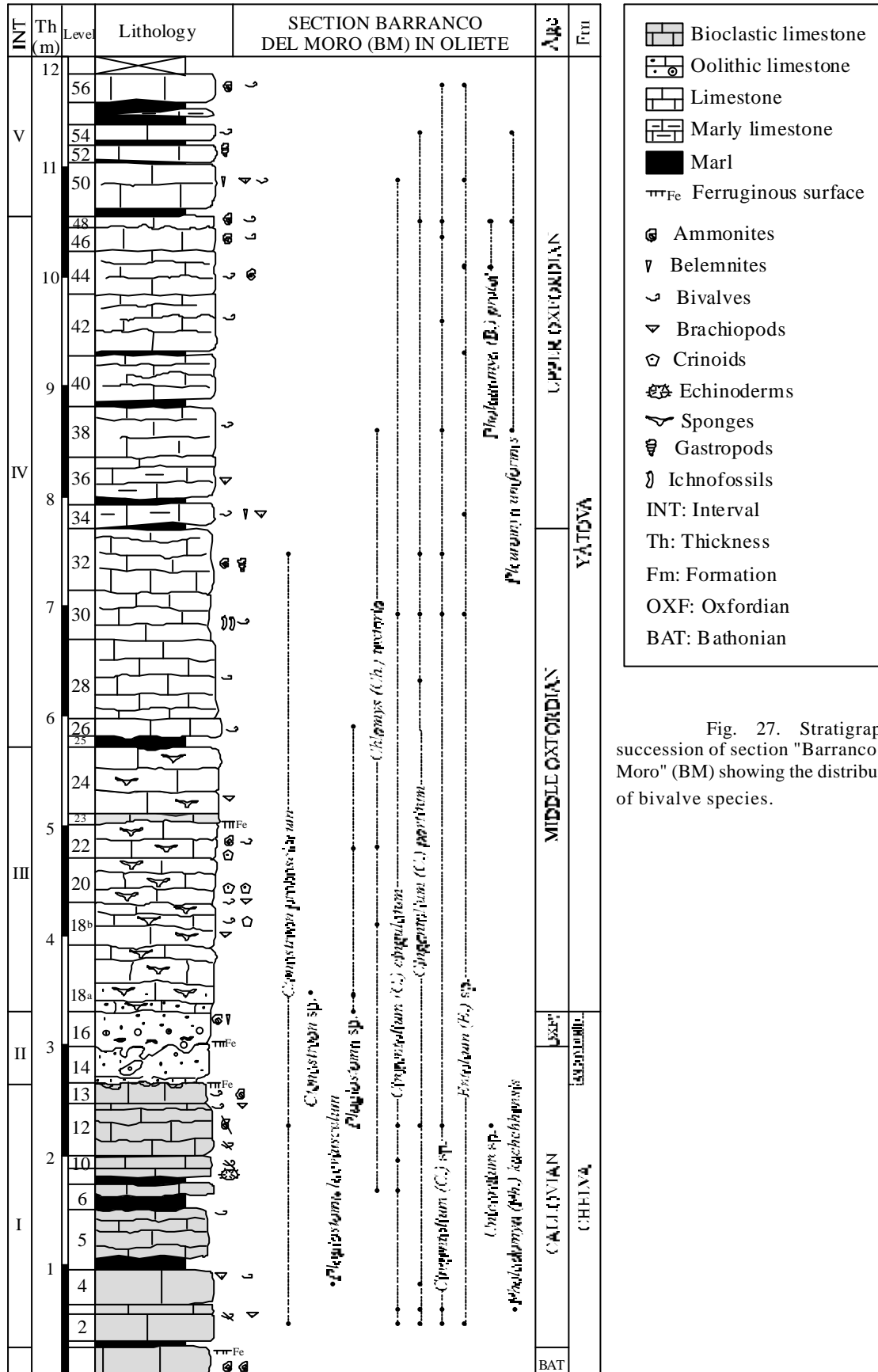


Fig. 27. Stratigraphic succession of section "Barranco del Moro" (BM) showing the distribution of bivalve species.

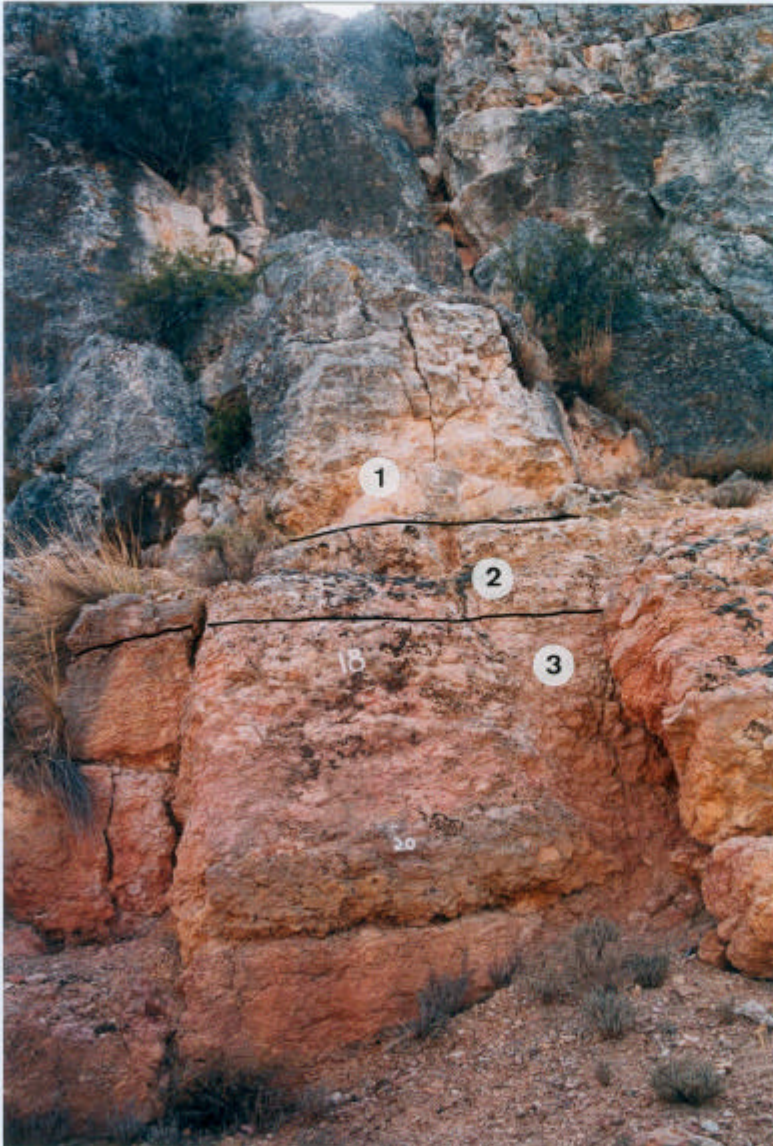
(b) Section of Tía Chula (Oliete, province of Teruel): TCh

The section Tía Chula (TCh) is near the cave paintings called "Tía Chula", located in the Cultural Park of the Martín River, to the South of Oliete (province of Teruel, Fig. 16) in the "Sierra de los Moros". This section was described for the first time by DELVENE *et al.* (1999). The section is in inverted position (Fig. 28), with Lower Cretaceous rocks (Blesa Fm) resting discordantly on it. The thickness is 7.5 m, the exposed rocks correspond to the Chelva and Yátova formations (Fig. 29). The age is Callovian-Middle Oxfordian. There are 4 intervals, distinguished.

- Chelva Fm:

The first interval (levels 0-13) consists of 2.5 m of limestone with marly intercalations, it is Bathonian and Callovian in age. The Bathonian-Callovian boundary is an iron surface with moulds of ammonites. The rocks of this interval are Early Callovian (Bullatus Zone) in age. The level 12 is the most fossiliferous with respect to bivalves, the families Limidae, Entoliidae and Permophoridae are recorded.

The interval 2 (levels 14-16) corresponds to the "Capa de Arroyofrío" (thickness of 0.8 m); two levels distinguished. The lower level consists of limestone with heterometric iron-oids, predominately of



small size; the upper level shows limestone with homometric iron-oids, of larger size (up to 0.5 cm). Both levels are separated by an irregular iron surface. Bivalves are, as usual, scarce in the "Capa de Arroyofrío", although the only specimen of *Prorokia problematica* (BUVIGNIER) comes from this section.

- Yátova Fm:

The third interval (levels 18-26) consisting of 2 m of irregularly limestone with some sponges in massive layers, at the base occasionally yielding iron ooids. Sponges decrease towards the top of the section. The rocks are attributed to the Transversarium Zone. The level

Fig. 28. Boundary between Yátova and Chelva formations of section Tía Chula (TCh). 1: Chelva Fm, 2: "Capa de Arroyofrío" (Chelva Fm), 3: Yátova Fm.

24 shows well preserved sponges and some of them in growth position. In level 26, sponge content decreases considerably, representing a gradual transition to the interval 4, belonging to the Bifurcatus Zone. Bivalves of this interval belong to the families Dymyidae, Pectinidae, Entoliidae and Pleuromyidae.

The interval 4 (levels 28-34) consists of 2.5 m of limestone with sponges; it is poorly fossiliferous and attributed to the Bifurcatus Zone. Scarce bivalves of the families Limidae, Pectinidae, Entoliidae, Pleuromyidae and Pholadomyidae occur.

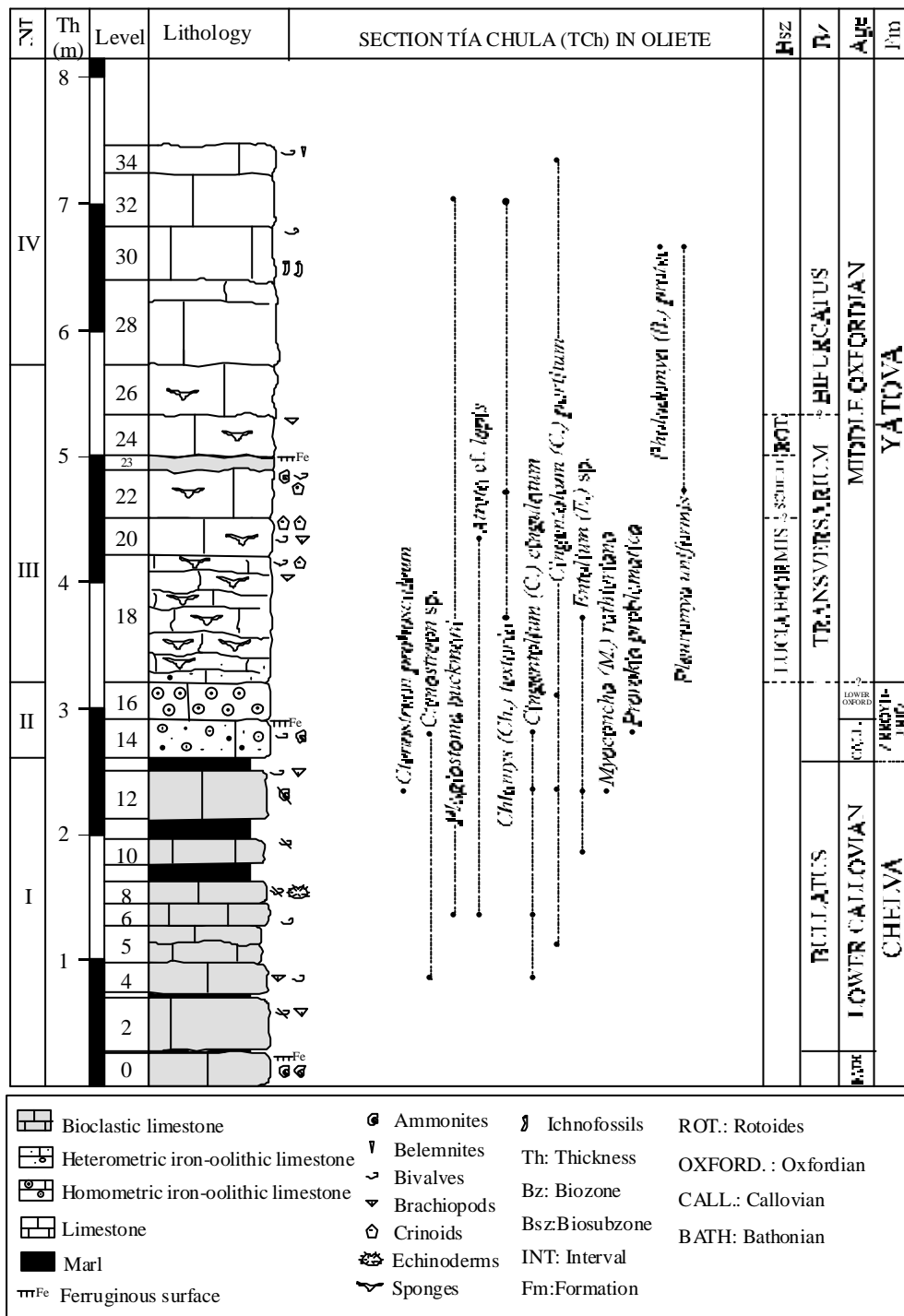


Fig. 29. Stratigraphic succession of section Tía Chula (T Ch) showing the distribution of bivalve species.

3.2.4. "BAJO ARAGÓN" AREA

The sections in the Bajo Aragón area (NE of Teruel) extend from Foz Calanda to La Cañada de Verich. They were studied from stratigraphic point of view by several authors. The more recent references on the Upper Jurassic in this area include AURELL *et al.* (1999), RAMAJO *et al.* (1999) and PÉREZ-URRESTI & DELVENE (2000). The sections show that bivalves are one of the rare fossil groups in the Callovian to Kimmeridgian formations. Locations of the sections are indicated in Figs. 30 and 34.

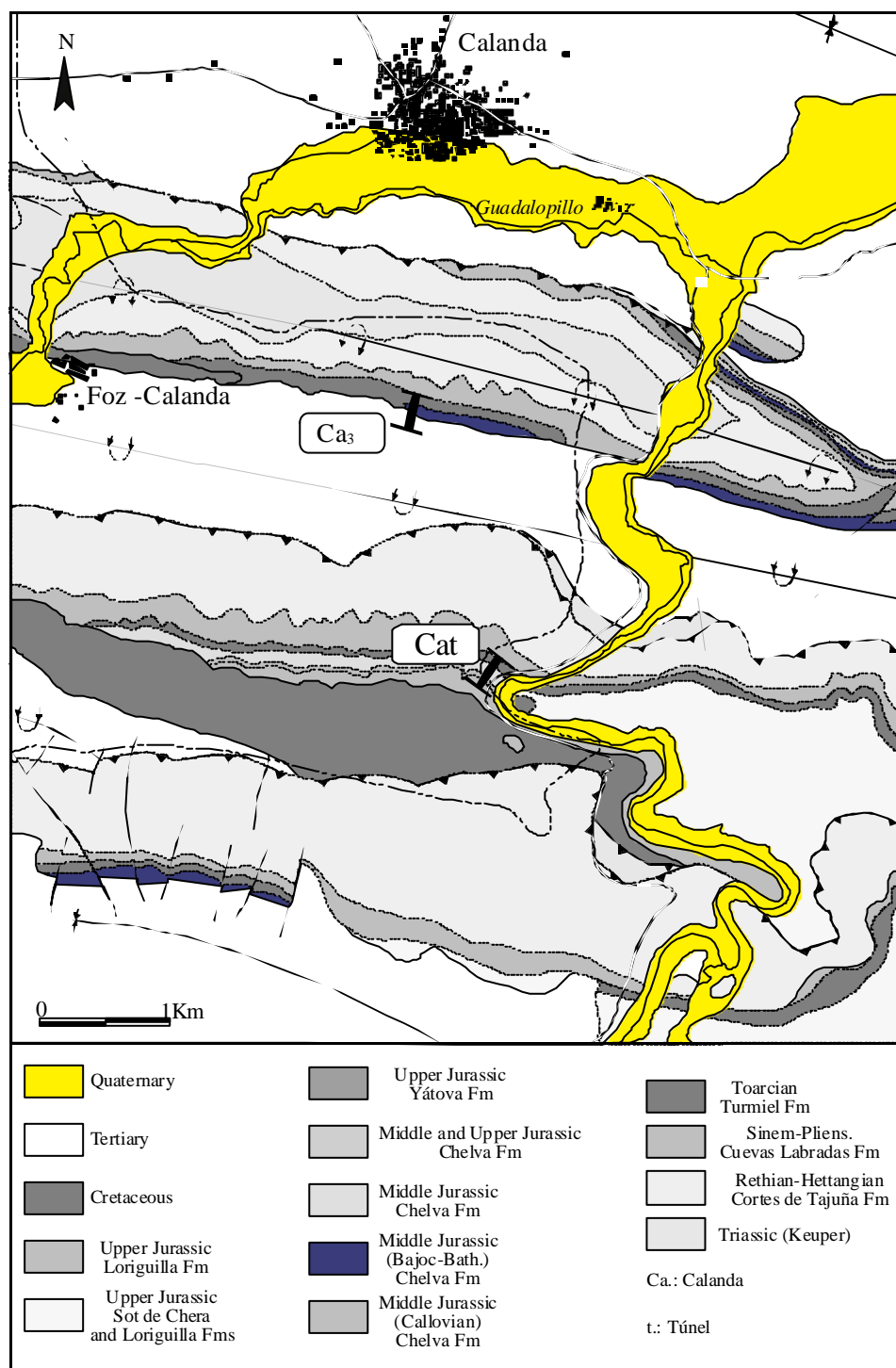


Fig. 30. Geological framework of Bajo Aragón area with location of the outcrops Ca₃ and Cat. (Calanda tunnel), both included in the locality of Foz Calanda. (Modified after geological map, scale 1:50.000 n° 494 Calanda, I.G.M.E. (ed.)).

(a) Section of Calanda 3 (Foz Calanda, province of Teruel): Ca₃

The section Ca₃ is about 2 km to the south of Calanda, at the locality Foz Calanda (Fig. 30). The beds of the Chelva Fm are tilted subvertically, forming the south flank of an anticlinal overthrusting to the north. Rocks of the Yátova Fm (intervals 1-3) are fossiliferous and the outcrop conditions are good (Fig. 31). FONTANA & MELÉNDEZ (1990) described the section in detail, which recently was reviewed by AURELL *et al.* (1999), BELLO *et al.* (1997) and RAMAJO *et al.* (1999). Further intervals are distinguished in the Yátova Fm whose total thickness is 8.5 m (Fig. 32).



Fig. 31. General view of the Yátova Fm in the section Ca₃ in Foz Calanda.

- *Interval 1*: 3 m of mudstone to wackestone with sponges and intercalations of marl (levels 1-30). The first levels yield scarce ammonites of the Transversarium Zone. There are no bivalves in this interval, except for small undeterminable fragments.

- *Interval 2*: 2.5 m of wackestone with sponges with thin intercalations of marl (levels 32-70). The levels 38 to 48 contain abundant ammonites of the Transversarium Zone. In levels 60 and 68, ammonites indicate the Bifurcatus Zone. Bivalves are more abundant in this interval, belonging to the families Pectinidae, Limidae and Palaeolophidae. Most of them are single valves with shell preservation.

- *Interval 3*: The upper interval consists of 2.5 m (levels 71-91) of bioclastic packstone with scarce fragments of sponges (Bimammatum Zone). Bivalves belong to Pectinidae and Palaeolophidae, their abundance is reduced compared to the interval 2. Levels 80-88 consist of an alternation of marly limestone and marl.

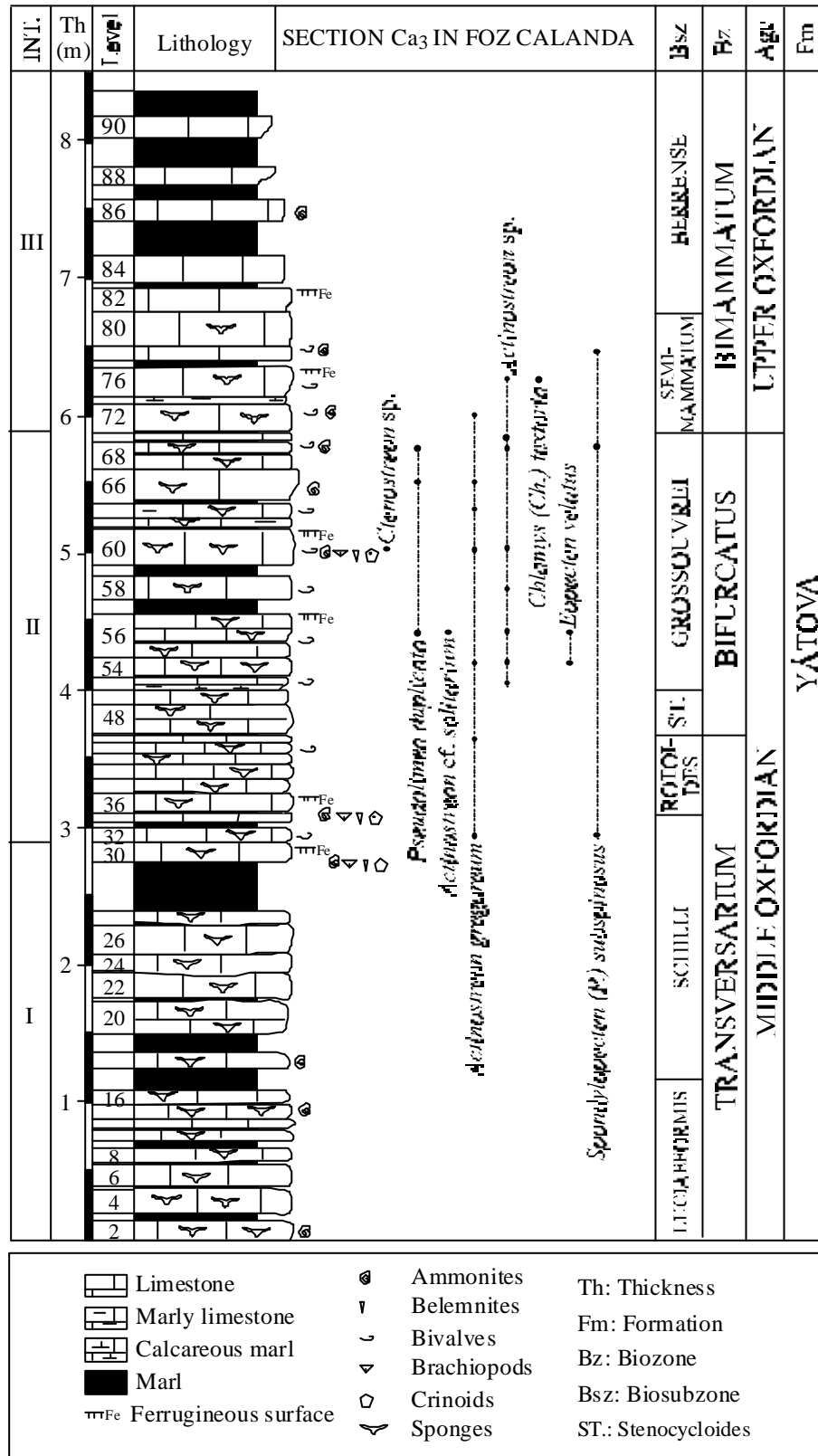


Fig. 32. Stratigraphic succession of the section Ca₃ showing the distribution of bivalve species.

(b) Section of Calanda Túnel (Foz Calanda, province of Teruel): Cat

The section called Cat is located at the tunnels on the road that joins Calanda and Mas de las Matas, at about Km 10.5 of this road (Fig. 30). The next Formations are studied (Fig. 33).

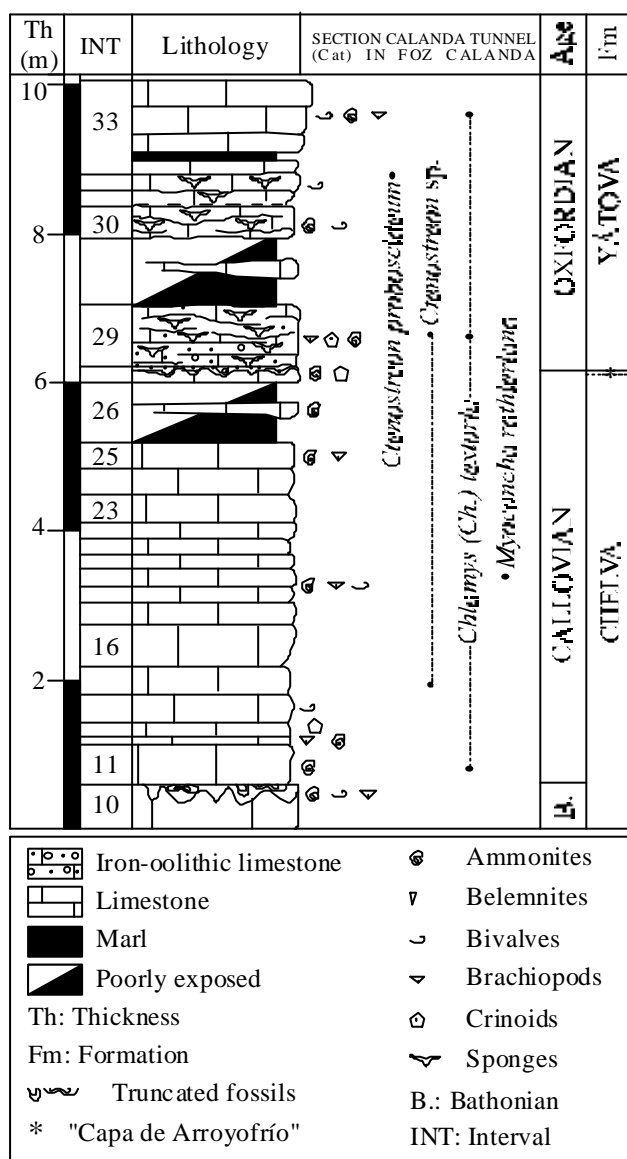


Fig. 33. Stratigraphic succession of the section Calanda tunnel (Cat) in Foz Calanda, showing the distribution of bivalve species.

follow, partially covered at the base (levels 30-32). The decimetric strata are irregularly bedded and laterally pinch out. Among bivalves, *Ctenostreon proboscideum* (J. SOWERBY) and *Chlamys (Ch.) textoria* (SCHLOTHEIM) are present. Finally, level 33 is formed by 1.2 m of glauconitic limestone in regular strata with intercalation of marl. Its fossil content is provided by brachiopods, ammonites and fragments of undeterminable bivalves.

-Chelva Fm

The uppermost rocks of the Bathonian are a reworked level of 40 cm thickness with an irregular upper surface and truncated fossils on top. This surface is interpreted as the Bathonian-Callovian boundary. Among bivalves *Chlamys (Ch.) textoria* (SCHLOTHEIM) is identified, and *Entolium* sp. in Bathonian rocks.

The interval from levels 11-28 consists of 5 m of limestone in tabular strata, partially covered and occasionally with marl intercalations. The rocks are Callovian in age, Lower Callovian ammonites are abundant. Among bivalves, *Myoconcha (M.) rathieriana* D'ORBIGNY and *Ctenostreon* sp. are identified in these levels. An irregular surface with heterometric iron-oids forms the top of the interval; it corresponds to "Capa de Arroyofrío", covered by Oxfordian strata.

-Yátova Fm

Oxfordian rocks (levels 29-33) start with the level 29, a 80 cm thick limestone (wackestone) with sponges and some iron-oids. Among bivalves, *Chlamys (Ch.) textoria* (SCHLOTHEIM) and *Ctenostreon* sp. were identified. Upsection, 1.80 m of limestone with sponges in irregular strata

(c) Section de La Cañada de Verich (La Cañada de Verich, province of Teruel): CV

The section Cañada de Verich (CV) is located near the road that joins Torrevellilla and La Cañada de Verich (A-1409) (Fig. 34).

The following works are related directly with this outcrop providing stratigraphic and palaeontographic points of view: GEYER & PELLEDUHN 1981; FEZER & GEYER 1988; MELÉNDEZ *et al.* 1990; FINKEL 1992; MELÉNDEZ *et al.* 1999 and PÉREZ-URRESTI & DELVENE 2000. Bivalves are poorly represented in this region compared to other areas of the Iberian Range. In this rocks which belong to the Chelva and Yátova formations, there are some specimens of *Chlamys* and *Plagiostoma* but a specific determination is not possible

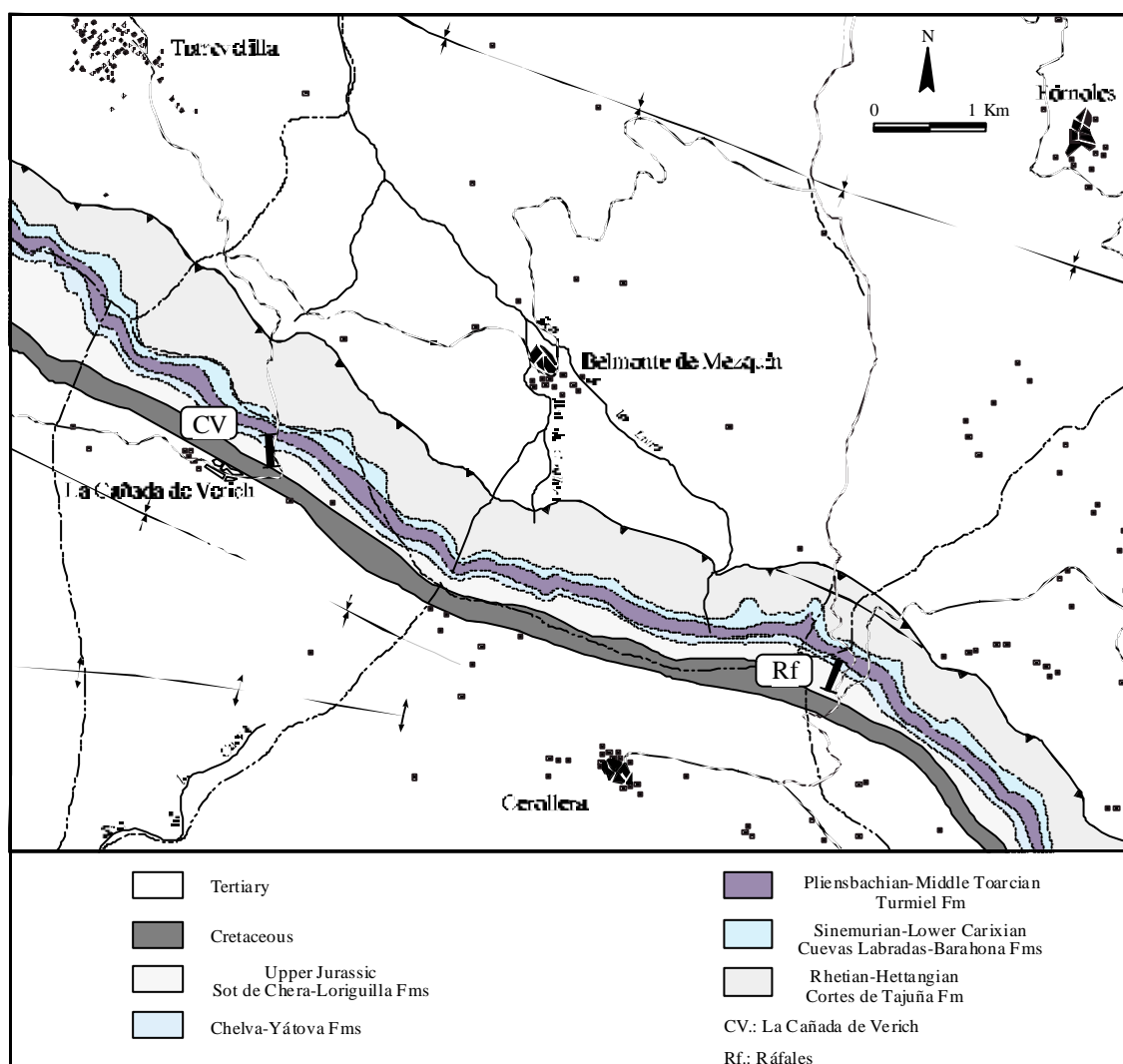


Fig. 34. Geological framework of Bajo Aragón area including the section La Cañada de Verich (CV). (Modified after geological map, scale 1:50.000 n° 495 Castelserás, I.G.M.E. (ed.)).

The rocks of the Loriguilla Fm consist of 75 m of a monotonous rhythmic alternation of white limestone and marl (Figs. 35 and 36). The following intervals are distinguished:



Fig. 35. General view of the Loriguilla Fm in the section La Cañada de Verich (CV), showing the interval I of the stratigraphic succession (Fig. 36) which is the most fossiliferous part of the section.

-*Intervals I y II* (Fig. 36). The first two intervals (levels 10-94) are the most fossiliferous part of the Formation. The more abundant fossils are ammonites, aptychi and some bivalves of the family Entoliidae. Intervals I (levels 10 to 52) and II (levels 53 to 94) consist of mudstone-wackestone with the typical rhythmic aspect of the Loriguilla Fm. Both intervals are separated by a ferruginous surface. The lower interval is more fossiliferous than the upper one. Upper Oxfordian-Lower Kimmeridgian boundary is formed by level 10, the upper part of the succession is Early Kimmeridgian in age.

At the top of level 94, there is a ferruginous surface that is the base of the interval III. The identified species of bivalves belong to the families Entoliidae, Limidae and Pholadomyidae, and some poorly preserved specimens of the Subclass Palaeotaxodonta. They are preserved as single valves, many of them fragmented. Infaunal bivalves (*Pholadomya* and *Palaeotaxodonta*), are preserved as internal moulds, occasionally articulated but generally as single valves. They are not in growth position, they are re-sedimented and are not components of a palaeocommunity.

- *Intervals III-VII* (Fig. 36). These consist of monotonous recrystallized mudstone with rare marly intercalations. Some levels present iron nodules which are relatively abundant and of large size. The fossil content is low compared to the lower intervals: brachiopods, ammonites, aptychi, bivalves of the family Entoliidae, belemnites and ichnofossils are present. The most important are *Chondrites* located near the base of the intervals III and V. GEYER & PELLEDUHN (1981) mentioned sponges at the top of this Formation in adjacent outcrops of Kimmeridgian age (Val de la Piedra); however in La Cañada de Verich sponges are less frequent. The age of the rocks likely corresponds to the upper part of Early Kimmeridgian (Divisum Zone).

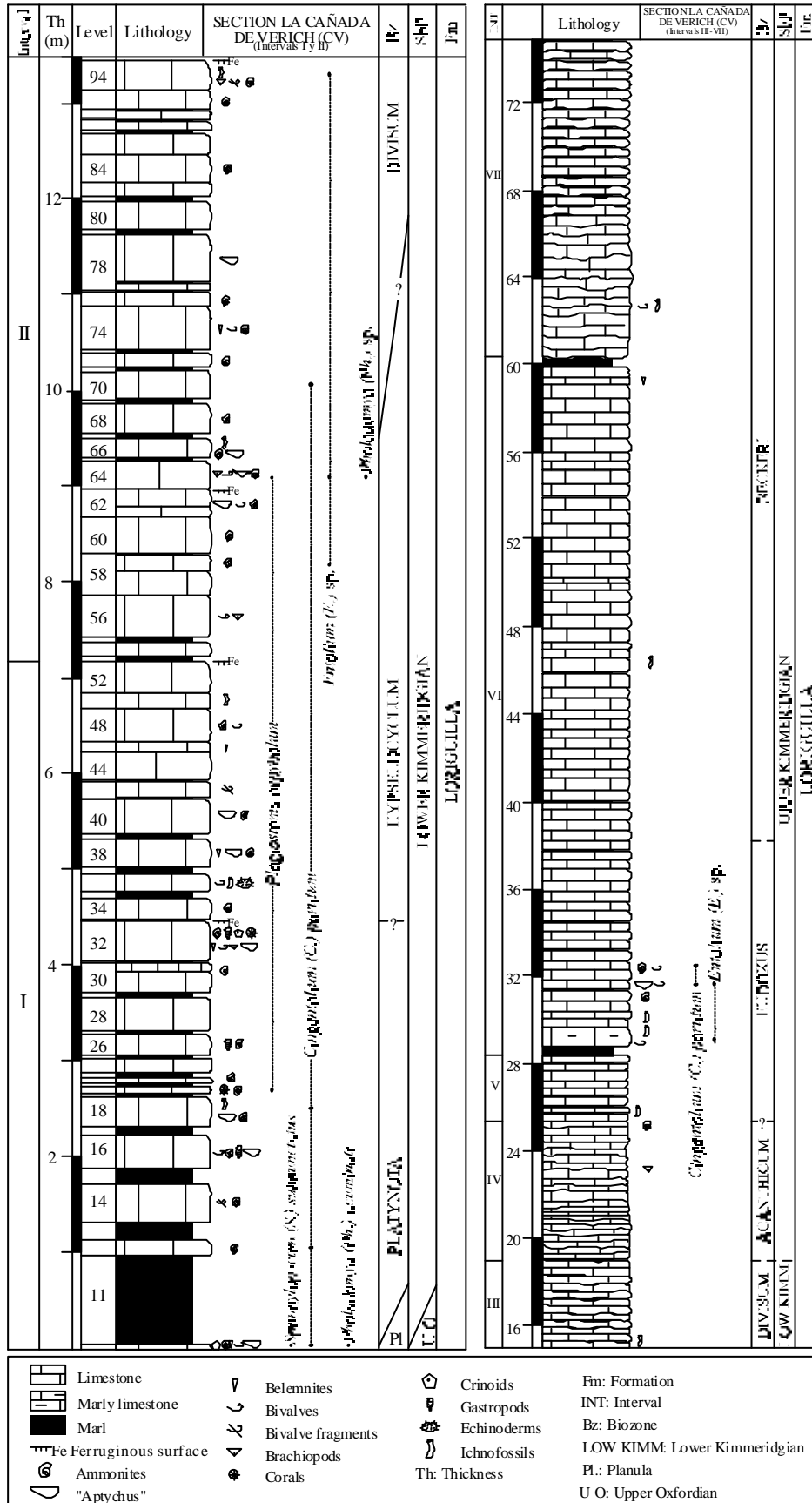


Fig. 36. Stratigraphic succession of the section La Cañada de Verich (CV) showing the distribution of bivalve species.

3.3. ADDITIONAL OUTCROPS

The next geographical points were only briefly treated in this work because the content of bivalves is low. However, the collected material was included in the taxonomic study. They are as follows, located from NW to SE (Figs. 2, 4):

(a) Longares-Muel (province of Zaragoza): Long

Upper Jurassic rocks located south of Zaragoza (Longares, Muel and Mozota) (Figs. 2, 4, 13) were studied by AURELL (1990). The available specimens from these localities come from the Loriguilla Fm, whose lithological features are similar to the section of Valmadrid (3.1.c in this Chapter). However, they are poorly fossiliferous. The bivalves *Nanogyra nana* (J. SOWERBY), *Chlamys (Ch.) textoria* (SCHLOTHEIM) and *Inoperna perplicata* (ÉTALLON) were identified. The specimens of *I. perplicata* were figured (Pl. 5, Figs. 9-10).

(b) Aguilón (province of Zaragoza): Ag

Near Aguilón, (Figs. 2, 4, 10) several sections were measured (Ag₂, Ag₄, Ag₅, Ag₈) in order to compare them with the nearest studied sections. These sections are correlated with the Tosos area (PÉREZ-URRESTI *et al.* 1999). The main interest in the section called Ag₈ is the well-exposed Sot de Chera Fm compared to Tosos, the fossil content is reduced, but the beds where bivalves are abundant (levels To₃/110, To₃/112 and To₃/124, Fig. 12) were correlated. All species identified in the section Ag₈ were registered in the section of Tosos. The most abundant species are: *Cingentolium (C.) partitum* (J. DE C. SOWERBY) and *Palaeonucula menkii* (ROEMER).

One of the paratypes of the species *Plagiostoma fuersichi* sp. nov. (Pl. 2, Fig. 1) comes from the level 106 of the section Ag₂. This level is a lateral equivalent of level 12 of the section "Barranco de las Estacas" (BE) and of the level 7 of the section "Ventas de San Pedro" (Ar) where this species is registered. These beds belong to the uppermost level of the "parte media informal" of the Chelva Fm, just below the "Capa de Arroyofrío"; its age is Callovian (MELÉNDEZ *pers. comm.*, 2000).

(c) Moyuela (province of Zaragoza): My

The area of Moyuela (My) (Figs. 2, 4) was studied by AURELL (1990) and recently by AURELL *et al.* (1997). Middle and Upper Jurassic are recognized: the "Capa de Arroyofrío" (Chelva Fm) and the Yátova, Sot de Chera, Loriguilla and Higuieruelas formations, the latter partly eroded. The specimen of species *Eopecten velatus* (GOLDFUSS) figured in this work (Pl. 4, Fig. 9) comes from the rocks of the Yátova Fm, which is Oxfordian in age (PÉREZ-URRESTI *pers. comm.*, 1999).

(d) Obón-Torre de las Arcas (province of Teruel): Ob-TAr

The Obón-Torre de las Arcas region (Figs. 2, 4) is located in the eastern-most area of the Aragonian Branch in the "Parque Cultural del Río Martín". Middle and Upper Jurassic rocks were studied by AURELL *et al.* (1999b) and RAMAJO *et al.* (2000). In the section of Obón, strata of the Chelva Fm are assigned to Callovian, consisting of 5 m of partly dolomitized limestone. Bivalves are scarce in these levels, disarticulated valves of *Cingentolium (C.) cingulatum* (GOLDFUSS) and *Cingentolium (C.) partitum* (J. DE C. SOWERBY) are present.

In the section located near Torre de las Arcas, the beds of the Yátova Fm have a total thickness of 8.5 m. Limestone with sponges display a thickness of 1.5 m; the fossil content is low, only some brachiopods, crinoids and bivalves, among the latter *Pseudolimea duplicata* (J. DE C. SOWERBY), are present.

(e) **Ráfales (province of Teruel): Rf**

The section called Ráfales (Rf) is located at the road N-232 from Alcañiz to Morella, between kilometre 105 and 106, near the section described by BULARD (1972) (Figs. 2, 4, 34). Recently RAMAJO *et al.* (1998) reviewed it. Callovian to Kimmeridgian rocks are distinguished: Chelva, Yátova, Sot de Chera and Loriguilla formations. The fossil content is scarce in the whole section. Bivalves are a subordinate group and only some undeterminable fragments of ostreids from the Loriguilla Fm are present.

3.4. STRATIGRAPHIC CORRELATION

The synoptic correlation schemes for each region are shown in Figs. 37-39. The figures are modified from recent works in which the author joined the author list.

3.4.1. NORTHWESTERN AREA

Upper Oxfordian materials in Tosos-Aguilón sector (Figs. 2, 37) have a thickness of 60-75 m. In the section To₃, the Yátova Fm and three intervals of the Sot de Chera Fm are recognized (Fig. 12). The outcrop conditions as well as the fossil content at Aguilón are poor. However, the sections Ag₄, Ag₅ and Ag₈ can be correlated with To₃. In section Ag₄, the upper part of Yátova Fm is recognized. In Ag₅, the uppermost levels of the Yátova Fm and the base of the Sot de Chera Fm are recognized. In Ag₈, the Sot de Chera Fm is recognized, although is partially covered, and the levels with abundant bivalves can be directly correlated with levels of To₃.

In the Yátova Fm, the boundary between the Bifurcatus and Bimammatum zones is not very clearly marked. The base of the Bimammatum Zone (Semimammatum Subzone) is placed at the first occurrence of *Epipeltoceras semimammatum* (QUENSTEDT). Limestone of this formation present a decreasing content of sponges and an increase in bioclasts and glauconite towards the uppermost part. There is a hardground at the top, associate with a stratigraphic gap of, probably, the whole Bimammatum Subzone in the section of Tosos.

In Aguilón, the uppermost interval corresponds to the Bimammatum and Hauffianum subzones and a lithological change is observed: the beds are more calcareous than sandy close to the Yátova Fm than the Sot de Chera Fm. Among the benthic groups, brachiopods, crinoids and bivalves are present. Bivalves frequently are byssate epifaunal taxa, such as *Chlamys* or *Ctenostreon*, or cementing as ostreids and *Atreta*.

In Tosos, the rocks of the Sot de Chera Fm were subdivided into three intervals. The lowermost (marl with intercalations of marly limestone) corresponds to the Hauffianum Subzone and the base of the Planula Zone (Proteron biohorizon). The middle interval (marl with intercalations of marly limestone) is attributed to Planula and Galar subzones. The third upper interval (marl with intercalated

limestone beds), belongs to the Galar Subzone, contains the maximum of bivalves at Tosos and at Aguilón (biostratigraphic data are from PÉREZ-URRESTI *et al.* 1999).

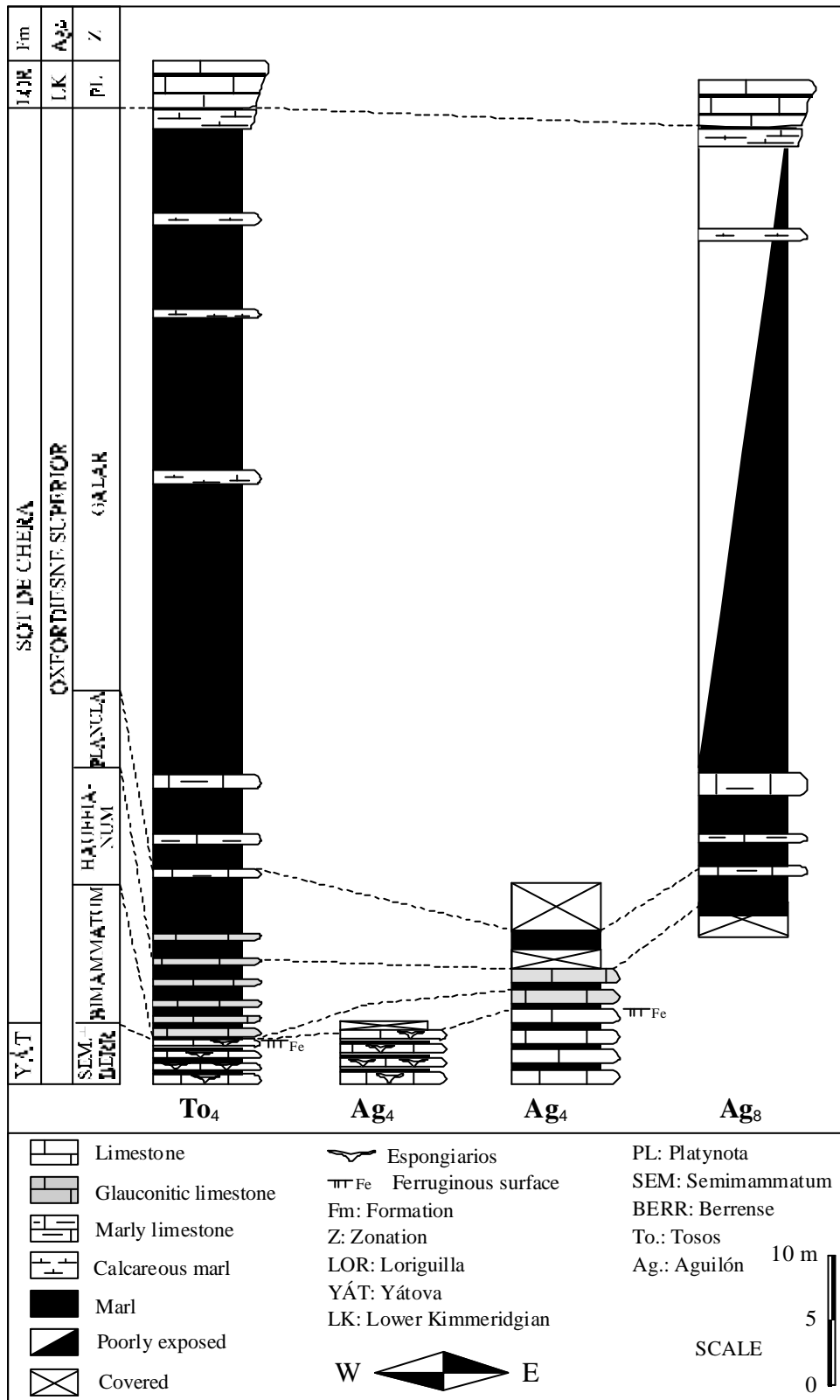


Fig. 37. Stratigraphic correlation of studied sections in Tosos-Aguilón area (province of Zaragoza), modified after PÉREZ-URRESTI *et al.* 1999.

3.4.2. "SIERRA DE ARCOS" - "SIERRA DE LOS MOROS" AREA

In the "Sierra de Arcos" and the "Sierra de los Moros" areas, the Chelva and Yátova formations are very well represented. At the Sierra de Arcos, sections of Barranco de las Estacas (BE) and Ventas de San Pedro (Ar) were selected because of their fossil content is high and the biostratigraphy is well known. At the "Sierra de los Moros", two studied sections, Barranco del Moro (BM) and Tía Chula (TCh) were selected because they have some marker beds which can be easily correlated. Finally, the sections of the Obón-Torre de las Arcas area were selected, because they show slightly different lithology (Figs. 2, 38). The rocks of the Chelva Fm attributed to Bullatus zone (Callovian) vary of thickness along the sections. At the "Sierra de Arcos" area, the thickness is approximately 1 m, at the "Sierra de los Moros" is 2.5 m and at Obón-Torre de las Arcas is up to 5 m. A ferruginous surface at the top of these rocks is frequently developed; the "Capa de Arroyofrío" rests on this surface. The thickness of the "Capa de Arroyofrío" varies between 1 m at the "Sierra de Arcos" and 0.65 m at the "Sierra de los Moros"; it is absent at Obón-Torre de las Arcas area. The lower part of this unit is attributed to the Callovian, and a part of uppermost of Lower and Middle Oxfordian. The taphonomic features and biostratigraphy of these levels are complex, see MELÉNDEZ *et al.* (1997) for details. The Middle and Upper Oxfordian Yátova Fm shows two generally well differentiated intervals. The lower one consists of limestone with sponges; its thickness varies from 0.7 m at Obón to 2.5 m at Torre de las Arcas. The upper interval, consisting of glauconitic limestone without sponges, varies between 2.5 and 10 m; it is absent at Obón. (Most data are from RAMAJO *et al.* 2000).

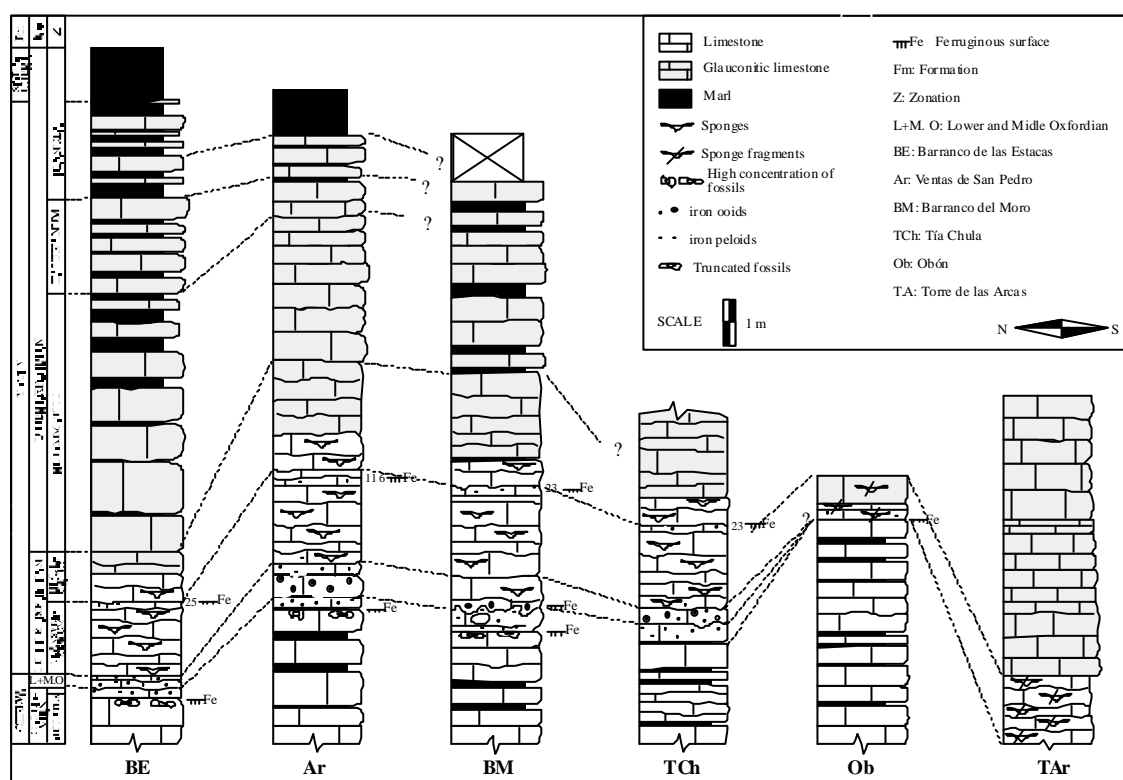


Fig. 38. Stratigraphic correlation of studied sections in the Sierra de Arcos and Sierra de los Moros (province of Teruel), modified after RAMAJO *et al.* 2000.

3.4.3. "BAJO ARAGÓN" AREA

The outcrops selected for correlation are Ca₃, Cat and La Cañada de Verich as well as the section of Ráfales. Although the fossil content is low in Ráfales, it exposes all formations of the Middle and Upper Jurassic (Figs. 2, 39). The rocks of the Chelva Fm including the "Capa de Arroyofrío" are not very well represented in this area. At the section Foz Calanda (Ca₃) the beds are partially covered. At Cat and Ráfales, the Callovian rocks are better exposed and can reach up to 3 m in the section of Ráfales. The rocks of the Yátova Fm have a total thickness between 5 and 7.5 m, their age is Middle and Late Oxfordian. In this formation like in the most sections of the Iberian Range, two intervals can be distinguished. The lower one yields abundant sponges and the upper one, without sponges and a high content of glauconite. The Sot de Chera Fm, that is thinner in this area, has the best exposure at La Cañada de Verich (3.75 m) and Ráfales (3 m); the other sections of this formation are partially covered. The Loriguilla Fm was studied at southeastern sections, where outcrop conditions are optimal; the thickness is 75 m at La Cañada de Verich and 65 m at Ráfales. The base of this formation is tentatively considered the base of Platynota Zone. Most part of the data are from RAMAJO *et al.* 1998; AURELL *et al.* 1999a and PÉREZ-URRESTI & DELVENE 2000.

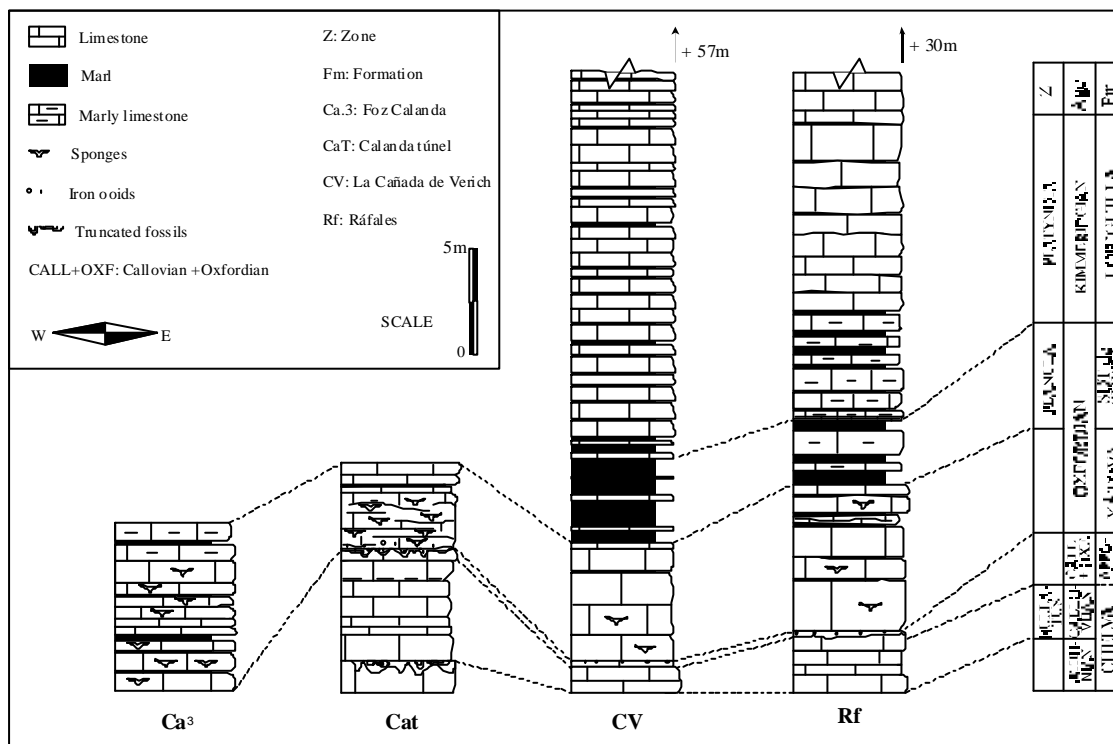


Fig. 39. Stratigraphic correlation of studied sections in the "Bajo Aragón" (province of Teruel), modified after RAMAJO *et al.* 1998.

4. TAXONOMY

4.1. BIOMETRIC PARAMETERS

Figure 40 shows the biometric parameters used for each taxonomic group. The measurements were carried out whenever preservation of the material allowed it. All measurements are in mm.

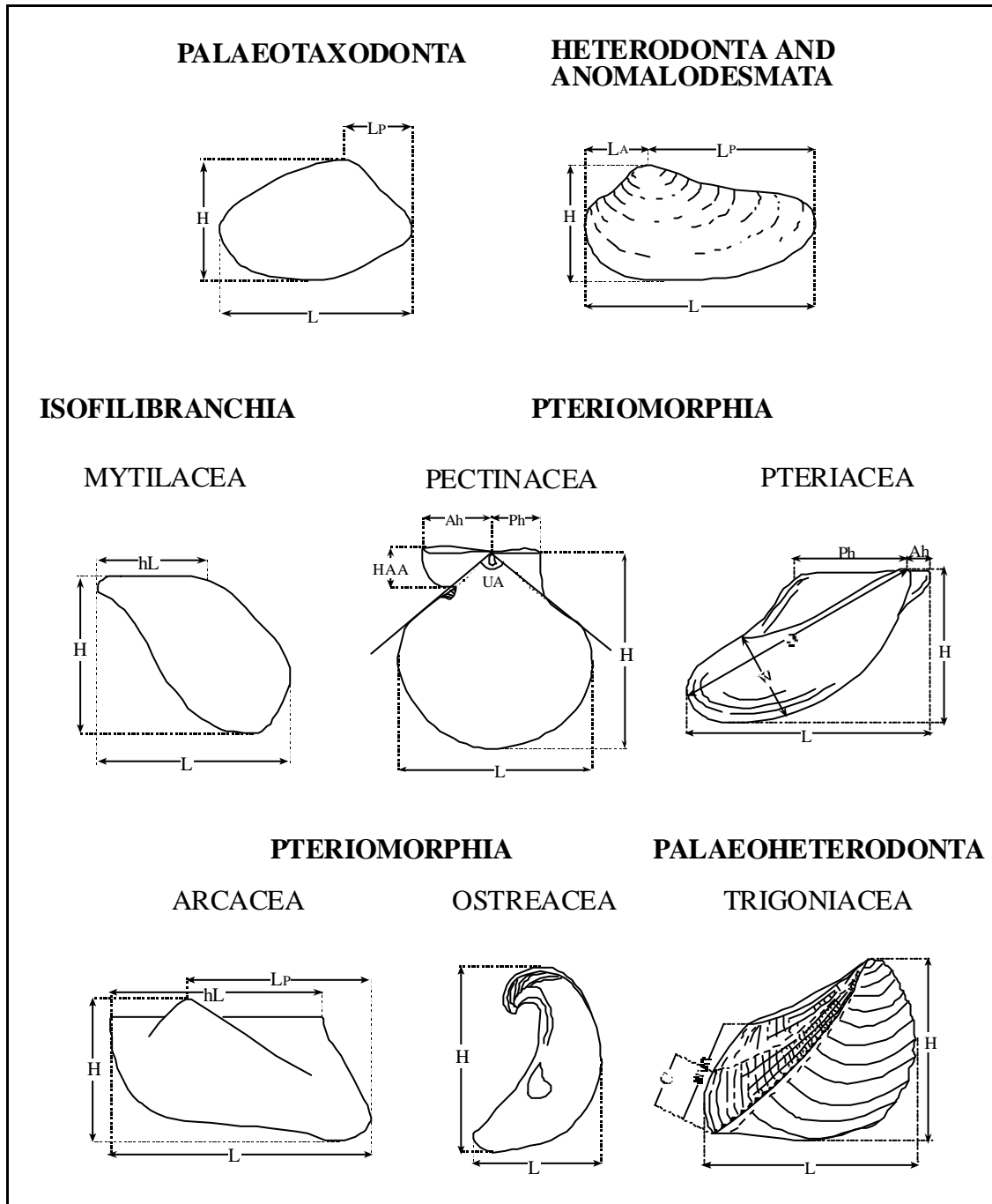


Fig. 40. Biometric parameters used for each taxonomic group. The following abbreviations are used: H: height, L: length, LA: anterior length, LP: posterior length, UA: umbonal angle, hL: length of hinge, HAA: height of anterior auricle, Ah: anterior length of hinge, Ph: posterior length of hinge, W: width, D: diagonal, C: distance between marginal carina and middle carina (Modified after JOHNSON 1984; MALCHUS 1990; JAITLY *et al.* 1995; MUSTER 1995; PANDEY *et al.* 1996; FÜRSICH & HEINZE 1998).

The tables show only the most representative measurements of each species, the graphs include all measured specimens. The studied material has been deposited in the *Museo Paleontológico de la Universidad de Zaragoza* (MPZ 97/48-100; MPZ 98/101-140; MPZ 97/141-406; MPZ 00/737-3392).

4.2. SYSTEMATIC DESCRIPTIONS

The classification scheme of AMLER (1999) and AMLER *et al.* (2000) is used for parts in this paper.

Subclass **Palaeotaxodonta** KOROBKOV 1954

Order **Nuculoidea** DALL 1889

Superfamily **Nuculacea** GRAY 1824

Family **Nuculidae** GRAY 1824

Genus *Palaeonucula* QUENSTEDT 1930

Type species. *Nucula hammeri* DEFRANCE 1825.

Palaeonucula calliope (D'ORBIGNY 1850)

Pl. 1, Fig. 1-2

1850 *Nucula calliope* sp. nov. - D'ORBIGNY: 339, N° 177.

? 1875 *Nucula cottaldi* sp. nov. - DE LORIOU in DE LORIOU & PELLAT: 295, pl. 17, figs. 11-15.

? 1894 *Nucula* cf. *cottaldi* DE LORIOU - DE LORIOU: 33, pl. 4, fig. 8-8a.

1925 *Nucula calliope* D'ORBIGNY - COTTREAU: 153, pl. 18 (39), figs. 21-22.

1978 *Palaeonucula calliope* (D'ORBIGNY) - DUFF: 25, pl. 1, figs. 14-16, 18-21.

1991 *Palaeonucula calliope* (D'ORBIGNY) - DUFF: 37, pl. 1, figs. 2-3.

MATERIAL. 3 articulated specimens, 7 right and 8 left valves in shell preservation. 2 articulated internal moulds. Although the shells are fragile and frequently fragmented, preservation is good. Total number of specimens: 20 (MPZ 00/737-756).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/744	14.6	10.5	11
MPZ 00/745	13.7	9.2	-
MPZ 00/746	12.9	9.4	-
MPZ 00/756	21.1	14.4	-

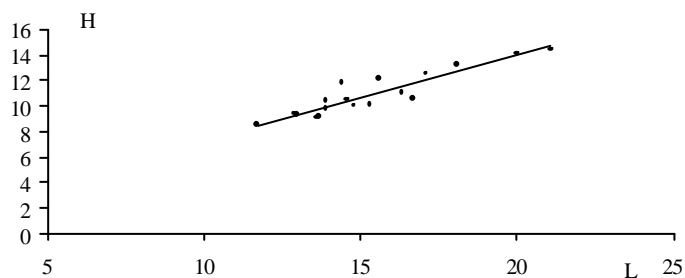


Fig. 41. Length/height ratio of *Palaeonucula calliope* (D'ORBIGNY). Scale in mm.

DESCRIPTION. Specimens medium-sized (maximum length 21 mm, Fig. 41), strongly inflated, especially in the central area; subrectangular to subelliptical in outline, equivalved, very inequilateral. Umbones very prominent, opisthogyrate and only little recurved. Dorsal margin slightly concave, anterior margin short, straight forming an angle of 130° with the posteroventral margin. Posterior margin concave forming an angle of 120° with ventral margin. Ventral margin convex and arched. Ornamentation consisting of very dense, irregularly spaced, commarginal growth lines.

REMARKS. The material has been included in *Palaeonucula calliope* (D'ORBIGNY) because of the very prominent umbones and the characteristic strong inflation. DUFF (1978: 27) mentioned the brief diagnosis given by D'ORBIGNY, and the difficulty of identifying the species on the basis of this description. DUFF considered *Nucula cottaldi* DE LORIOLO as a synonym of *Palaeonucula calliope* (D'ORBIGNY) and regarded the description by DE LORIOLO (1875) as the first recognizable description of *P. calliope* (D'ORBIGNY), DE LORIOLO ignored D'ORBIGNY's name when introducing *Nucula cottaldi*. In the present study, *Nucula cottaldi* DE LORIOLO is -with some doubts- considered to be a synonym of *P. calliope*. There is a great variability in the figures of this species in the various publications by DE LORIOLO. The figures in his 1875 and 1897 monographs show some differences to the material from the Iberian Chain: the umbones are situated more posteriorly, and the dorsal and posterior margins are straight. Of DE LORIOLO's figures of *N. cottaldi*, the specimens from the Upper Oxfordian of the Jura Bernois, Switzerland (DE LORIOLO 1894), identified by him as *Nucula cf. cottaldi*, are the most similar to the material from the Iberian Chain.

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (?) (Yátova and Sot de Chera formations) at Aguilón, Tosos and Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Like other genera belonging to the order Nuculoida, *Palaeonucula* is a mobile bivalve, using its labial palps to feed on organic matter present in the sediment. As all species of *Palaeonucula*, its shape is triangular, similar to Recent species whose life habits were studied by YONGE (1939). Trophic group: deposit-feeder.

Palaeonucula menkii (ROEMER 1836)

Pl. 1, Fig. 3-4, 6

1836 *Nucula menkii* sp. nov. - ROEMER: 98, pl. 6, figs. 10, 78.

1929 *Nucula menkii* ROEMER - ARKELL: 33, pl. 1, figs. 1-1a.

v 1988 *Palaeonucula menkii* (ROEMER) - FÜRSICH & WERNER: 108, pl. 1, figs. 1-3 [see for extensive synonymy list].

1990 *Palaeonucula menkii* (ROEMER) - CLAUSEN & WIGNALL: 101, pl. 1, figs. C-D.

v 1995 *Palaeonucula menkii* (ROEMER) - JAITLY *et al.*: 158, pl. 2, figs. 3-6.

MATERIAL. 22 right, 20 left valves and 6 articulated specimens in shell preservation. One internal mould of a left valve. Total number of specimens: 49 (MPZ 00/757-805).

All specimens are well preserved although the shell is fragile, and sometimes fragmented.

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/761	9.4	6.6	5.2
MPZ 00/764	7.1	4.8	-
MPZ 00/781	24.5	16.4	-
MPZ 00/792	11.7	8.9	-

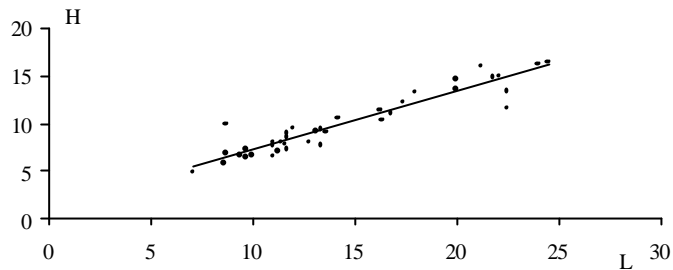


Fig. 42. Length/height ratio of *Palaeonucula menkii* (ROEMER). Scale in mm.

DESCRIPTION. Specimens medium-sized (maximum length 24.5 mm), moderately inflated, oval-elliptical in outline, equivalved, very inequilateral. Umbones pointed in the juvenile stage becoming broader and rounded in the adult stage; opisthogyrate, only little recurved and posteriorly located. Dorsal margin straight to convex. Faint, broadly arched anterior carina extending from the umbo to the anterior end. Posterior region reduced, course of posterior margin changing with growth. In juvenile specimens, the posterior margin is concave just below the umbones, becoming convex towards the ventral margin. In adult specimens, it is concave through. In both cases, it forms an angle of 90° to 100° with the ventral margin. Anterior margin convex, forming an angle of 90° to 100° with the ventral margin. Surface of shell covered with dense irregularly spaced commarginal growth lines, the irregularity being most striking in adult specimens.

REMARKS. The specimens have been included in *Palaeonucula menkii* (ROEMER) because of their characteristic oval-elliptical shape, and the presence of a faint anterior carina. For discussion of this species and synonymy see FÜRSICH & WERNER (1988). Our material has been compared to material described by the latter authors from the Kimmeridgian of Portugal; it fits their figures perfectly. *P. menkii* (ROEMER) is a medium-sized nuculid with an average length of 14 mm. Our specimens are up to 24.5 mm long (Fig. 42), but as their morphological features are identical to those of *P. menkii* (ROEMER) there is no reason to place them in another species.

OCCURRENCE. Oxfordian and Lower Kimmeridgian (?) (Yátova and Sot de Chera formations) at Aguilón, Tosos and Riela (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Palaeonucula calliope* (D'ORBIGNY). Trophic group: deposit-feeder.

Palaeonucula monnandi CHAVAN 1952

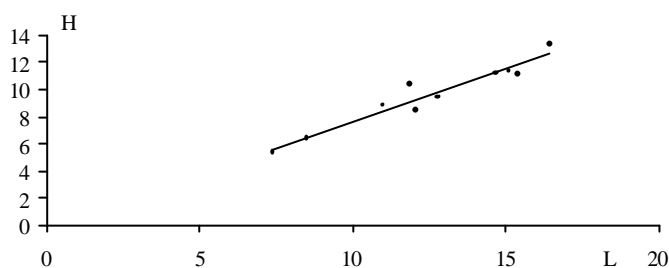
Pl. 1, Fig. 5

1952 *Nuculopsis* (*Palaeonucula*) *monnandi* sp. nov. - CHAVAN: 4, pl. 1, figs. 4-6.

MATERIAL. 1 right, 6 left valves and 2 articulated specimens in shell preservation. 3 internal moulds of right valves. Total number of specimens: 12. Most of them are well preserved (MPZ 00/806-817).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT
MPZ 00/810	7.4	5.3
MPZ 00/812	12.1	8.4
MPZ 00/814	12.8	9.4
MPZ 00/815	16.45	13.25

Fig. 43. Length/height ratio of *Palaeonucula monnandi* CHAVAN. Scale in mm.

DESCRIPTION. Shell medium to small in size (maximum length 16.45 mm, Fig. 43), strongly inflated, elliptical-trigonal in outline, equivalved and inequilateral. Umbones prominent, broad, opisthogyrate and situated posteriorly. Dorsal and posterior margins straight. Posterior margin forming an angle of approximately 90° with ventral margin. Anterior and ventral margins convex especially the ventral one that is distinctly convex. Surface covered with irregularly spaced commarginal growth lines.

REMARKS. The studied material has been included in *Palaeonucula monnandi* CHAVAN because of its strong inflation (especially towards the ventral margin) and its length and height dimensions that differ from those of *P. calliope* (D'ORBIGNY) and *P. menkii* (ROEMER).

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (Yátova and Sot de Chera formations) at Tosos and Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Palaeonucula calliope*. Trophic group: deposit-feeder.

Palaeonucula sp.

Pl. 1, Fig. 7

MATERIAL. Well preserved internal moulds of 20 articulated specimens, 1 right and 2 left valves (MPZ 00/818-840).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/818	8	5	5
MPZ 00/822	6.6	4.6	4.7
MPZ 00/827	7.4	5	4.5
MPZ 00/832	4.2	3.1	2.9

DESCRIPTION. Specimens small-sized, strongly inflated, trigonal in outline, equivalved, very inequilateral. Umbones prominent, opisthogyrate and placed very posteriorly. Posterior and dorsal margins straight to concave. Anterior and ventral margins convex, the latter elliptical. Taxodont hinge, teeth chevron-shaped, arranged perpendicular to dorsal margin. Adductor muscle scars oval, posterior adductor scar larger than anterior one. Visceral muscle scars occupying distinct furrow that extends from the anterior side of the umbones towards the ventral margin. Exterior features not observed.

REMARKS. The described material has been included in *Paleonucula* because of its taxodont hinge, strong inflation, and very prominent umbones. The morphology of the specimens is close to *P. calliope* (D'ORBIGNY) and *P. cottaldi* (DE LORIO), especially the very prominent umbones, but a specific identification is not possible.

OCCURRENCE. Upper Oxfordian (Yátova Fm) at Tosos (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Palaeonucula calliope*. Trophic group: deposit-feeder.

Superfamily **Nuculanacea** ADAMS & ADAMS 1858

Family **Nuculanidae** ADAMS & ADAMS 1858

Genus *Nuculana* LINK 1807

Type species. *Arca rostrata* CHEMNITZ 1774.

Subgenus *Praesaccella* COX 1940

Type species. *Nuculana (Praesaccella) juriana* COX 1940.

Nuculana (Praesaccella) venusta (SAUVAGE & RIGAUX 1871)

Pl. 1, Fig. 8

1871 *Leda venusta* sp. nov. - SAUVAGE & RIGAUX: 356.

1872 *Leda venusta* SAUVAGE & RIGAUX - SAUVAGE & RIGAUX: 180, pl. 11, fig. 7.

1875 *Leda venusta* SAUVAGE - DE LORIO & PELLAT: 292, pl. 17, fig. 17.

1878 *Leda venusta* SAUVAGE - STRUCKMANN: 86, pl. 2, fig. 5.

1990 *Dacryomya venusta* (SAUVAGE) - CLAUSEN & WIGNALL: 101, pl. 1, figs. E-F.

MATERIAL. 2 left valves in shell preservation (MPZ 00/841-842).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	N RIBS
MPZ 00/841	6.8	4.3	≅40

DESCRIPTION. Shell small-sized, strongly inflated, triangular in outline, equivalved, inequilateral. Umbones not very prominent, broad, opisthogyrate and subcentral. Anterodorsal margin convex, posterodorsal margin concave, forming a right angle with the ventral margin, the latter being broadly convex. Posterior region rostrate. Ornamentation consisting of approximately 40 radial ribs that intersect commarginal growth lines resulting in a regular reticulate pattern.

REMARKS. The material from the Iberian Chain has been included in *Leda venusta* SAUVAGE & RIGAUX because of its triangular shape and reticulate ornamentation. The only difference is that our material is less rostrate than *Leda venusta* SAUVAGE & RIGAUX. The species is included in *Nuculana* (*Praesaccella*) because of its rostrate posterior end and radial ornamentation. *Nuculana* (*P.*) *venusta* (SAUVAGE & RIGAUX) differs from *Nuculana* (*P.*) *favrei* (CHOFFAT 1888: 47, pl. 11, figs. 16-18) by its radial ornamentation. The latter being ornamented with very delicate radial ribs.

OCCURRENCE. Oxfordian and Lower Kimmeridgian (?) (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Palaeonucula*. Trophic group: deposit-feeder.

Family **Polidevciidae** KUMPERA, PRANTL & RUZICKA 1960

Genus *Dacryomya* AGASSIZ 1840

Type species. *Nucula lacryma* J. DE C. SOWERBY 1824.

Dacryomya roederi (DE LORIO 1897)

Pl. 1, Fig. 9

1897 *Leda roederi* sp. nov. - DE LORIO: 117, pl. 14, figs. 23-25.

MATERIAL. 3 right and 8 left valves in shell preservation. The material is well preserved although the rostrate posterior region is commonly fragmented (MPZ 00/843-853).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT
MPZ 00/845	5.1	3
MPZ 00/850	7.7	4.7
MPZ 00/851	6.9	4.4
MPZ 00/852	7.5	4.4

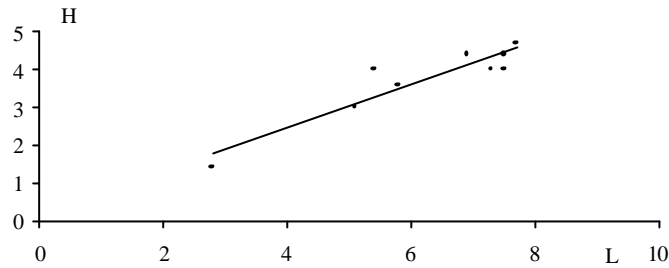


Fig. 44. Length/height ratio of *Dacryomya roederi* (DE LORIO). Scale in mm.

DESCRIPTION. Shell small in size (maximum length 7.7 mm, Fig. 44), strongly inflated, triangular in outline, equivalved, very inequilateral. Umbones small, pointed, orthogyrate to opisthogyrate. Anterodorsal margin convex and rounded. Ventral margin convex, elliptical. Posterior region rostrate, forming an angle of 35° with ventral margin. Posterodorsal margin concave, escutcheon well developed. Surface of shell covered with distinct commarginal lines. Taxodont hinge teeth observed in some specimens.

REMARKS. The material described perfectly fits the figure from the Upper Oxfordian of the Jura Bernois, Switzerland, given by DE LORIO (1897: 117, pl. 14, figs. 23-25) especially the rounded anterior and broadly convex ventral margin. *Dacryomya lacryma* (J. DE C. SOWERBY 1824) has a much more smaller anterior region and a greater height than *Dacryomya roederi* (DE LORIO).

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Palaeonucula*. Trophic group: deposit-feeder.

Subclass **Pteriomorphia** BEURLEN 1944

Order **Arcoidea** STOLICZKA 1871

Superfamily **Arcacea** LAMARCK 1809

Family **Arcidae** LAMARCK 1809

Subfamily **Arcinae** LAMARCK 1809

Genus *Barbatia* GRAY 1842

Type species. *Arca barbata* LINNÉ 1758.

Subgenus *Barbatia* GRAY 1842

Barbatia (Barbatia) tenuitexta (MORRIS & LYCETT 1853)

Pl. 1, Fig. 11

1853 *Arca tenuitexta* sp. nov. - MORRIS & LYCETT: 45, pl. 5, fig. 9.

1995 *Barbatia (Barbatia) tenuitexta* (MORRIS & LYCETT) - JAITLY *et al.*: 164, pl. 3, figs. 4-5.

MATERIAL. 1 well preserved articulated specimen (MPZ 00/854).

DESCRIPTION. Shell medium-sized (34.5 mm in length), strongly inflated, elongated-oval, equivalved, inequilateral. Umbones broad, prominent and prosogyrate with a faint posterior umbonal carina. Anterior region slightly expanded. Anterior and posterior margins convex, dorsal and ventral margins straight. Ornamentation consisting of fine radial ribs intersecting with commarginal growth lines resulting in a cancellate pattern.

REMARKS. The specimen from the Iberian Chain closely resembles the figure of *Arca tenuitexta* of MORRIS & LYCETT (1853: 45, pl. 5, fig. 9) from the Great Oolite of England, especially with respect to its elongated-oval shape and ornamentation. It differs from it, however, by lacking the distinctly developed umbonal carina. As opposed to the holotype of *Arca tenuitexta* (7.5 mm long), the studied specimen is much larger (34.5 mm long). However, the remaining features of the shell allow to include the specimen in *Barbatia (B.) tenuitexta* (MORRIS & LYCETT) without doubts.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. STANLEY (1970: 90) established some criteria for distinguishing epibyssate and infaunal arcids, such as length-height ratio. The L/H ratio of *Barbatia (B.) tenuitexta* (MORRIS & LYCETT) is 1.36 and thus is very close to 1.35, a value to identify infaunal bivalves of epibyssate bivalves (STANLEY 1970). The high inflation of the shell suggests that its capability of burrowing was limited. Most likely, the species lived epifaunally, attached by a small byssus. Trophic group: low level suspension-feeder.

Family **Parallelodontidae** DALL 1898

Subfamily **Grammatodontinae** BRANSON 1942

Genus *Grammatodon* MEEK & HAYDEN 1861

Type species. *Arca (Cucullaea) inornata* MEEK & HAYDEN 1859.

Subgenus *Grammatodon* MEEK & HAYDEN 1861

Grammatodon (Grammatodon) concinnum (PHILLIPS 1829)

Pl. 1, Fig. 10

1829 *Cucullaea concinna* sp. nov. - PHILLIPS: pl. 5, fig. 9.

1978 *Grammatodon (Grammatodon) concinnus* (PHILLIPS) - DUFF: 36, pl. 2, figs. 7, 11-17, 19.

v 1988 *Grammatodon (Grammatodon) concinnus* (PHILLIPS) - FÜRSICH & WERNER: 116, pl. 2, figs. 2-5.

1990 *Grammatodon (Grammatodon) concinnus* (PHILLIPS) - CLAUSEN & WIGNALL: 103, pl. 1, figs. G-I.

1991 *Grammatodon (Grammatodon) concinnus* (PHILLIPS) - DUFF: 42, pl. 1, fig. 15.

MATERIAL. Most specimens are internal moulds, some of them single valves, mainly left ones, and others articulated, predominantly preserved in "butterfly position". Occasionally, remains of shell are seen. Total number of specimens: 42 (MPZ 00/855-896).

MEASUREMENTS SPECIMEN	LENGTH	HEIGHT	L/H
MPZ 00/856	16.1	8.8	1.8
MPZ 00/866	12.95	9.2	1.4
MPZ 00/882	11.3	7.3	1.5
MPZ 00/889	10.1	7.4	1.3
MPZ 00/891	7.9	6.75	1.1
MPZ 00/893	11.2	7.5	1.5

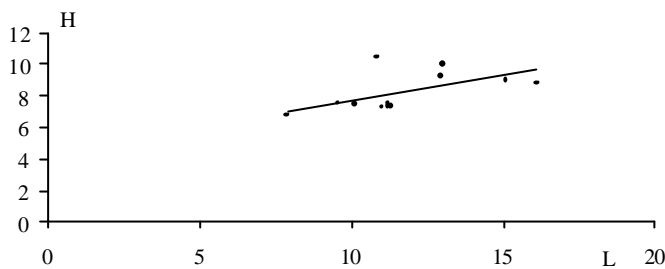


Fig. 45. Length/height ratio of *Grammatodon (Grammatodon) concinnum* (PHILLIPS). Scale in mm.

DESCRIPTION. Specimens medium to small in size (Fig. 45), strongly inflated, subrectangular in shape, equivalved, inequilateral. Umbones small, prosogyrate, protruding beyond the hinge line. Hinge line straight and long. Distinct, slightly sigmoidal posterior umbonal carina and faint anterior umbonal carina present. Anterior region covered with 5 distinct radial ribs, anterior margin convex. Posterior region with a straight margin and an ornamentation consisting of 7 to 15, most commonly 12, faint radial ribs, much finer than the anterior ones. Valves ornamented with commarginal growth lines. Occasionally, a variable number of very faint radial riblets extend from the anterior umbonal carina, posteriorly, intersecting with commarginal growth lines to produce a fine cancellate pattern. Ventral margin arched.

REMARKS. *Grammatodon (G.) concinnum* (PHILLIPS) has been described as a very variable species by several authors, especially with respect to number and strength of ribs. Our material has been included in *Grammatodon (G.) concinnum* (PHILLIPS) because of its subrectangular shape and sigmoidal posterior carina. *Grammatodon (G.) concinnum* (PHILLIPS) and *Grammatodon (G.) jurianum* COX (1940: 43, pl. 2, figs. 15-20) from Kachchh (India), are close, the main difference being the sigmoidal umbonal carina in *Grammatodon (G.) concinnum* (PHILLIPS) compared to the straight one in *Grammatodon (G.) jurianum* COX.

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (Yátova, Sot de Chera and Loriguilla formations) at Aguilón, Tosos and Valmadrid (province of Zaragoza).

CORTÁZAR (1885: 129, 226) reported *Arca concinna?* PHILLIPS from some localities near Teruel (Iberian Range).

PALAEOAUTECOLOGY. According to STANLEY (1970), the length (L)/Height (H) ratio of *G. (G.) concinnum* (PHILLIPS) is > 1.35 in most part of the specimens, and this suggest that they lived

epifaunally. *Grammatodon* is frequently preserved in "butterfly position". Trophic group: low level suspension-feeder.

Grammatodon (Grammatodon) sp.

MATERIAL. Most specimens are poorly preserved internal moulds, some of them preserved as single valves, others articulated. Preservation in "butterfly position" is common. Total number of specimens: 34 (MPZ 00/3202-3235).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	L/H
MPZ 00/3214	22.7	17.7	1.28
MPZ 00/3217	15.2	11.5	1.32
MPZ 00/3222	21.6	14.8	1.45
MPZ 00/3227	13.8	11.9	1.15
MPZ 00/3229	20.5	14.7	1.39
MPZ 00/3233	30.5	17.8	1.71

DESCRIPTION AND REMARKS. Shell medium to large in size, strongly inflated and subrectangular in shape, equivalved, inequilateral. Umbones small, prosogyrate, anteriorly located. Anterior margin convex, posterior one straight, truncated. Ventral margin arched. An umbonal carina developed anteriorly and posteriorly. Posterior region ornamented with distinct radial ribs. On the flank, occasionally faint radial ribs can be seen. Surface of shell covered with irregularly spaced commarginal growth lines. The studied specimens have been included in *Grammatodon (G.)* because of their distinct posterior carina. The shape of this carina is sigmoidal, less than in *Grammatodon (G.) concinnum* (PHILLIPS); otherwise, the shape is close to that species. However, because of the poor preservation a specific identification is not possible.

OCCURRENCE. Upper Oxfordian-Lower Kimmeridgian (Sot de Chera and Loriguilla formations) at Ricla and Valmadrid (province of Zaragoza).

PALAEOAUTECOLOGY. As for *G. (G.) concinnum* (PHILLIPS). Trophic group: low level suspension-feeder.

Subgenus *Cosmetodon* BRANSON 1942

Type species. *Arca keyserlingii* D'ORBIGNY 1850.

Grammatodon (Cosmetodon) elongatum (J. DE C. SOWERBY 1824)

Pl. 1, Fig. 12

1824 *Cucullaea elongata* sp. nov. - J. DE C. SOWERBY: 67, pl. 447, fig. 1.
v 1988 *Grammatodon (Cosmetodon) elongatum* (J. DE C. SOWERBY) - FÜRSICH & WERNER: 118, pl. 2, figs. 8-11, text-fig. 8.

MATERIAL. 1 right and 1 left valve in shell preservation (MPZ 00/897-898).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LP	LH
MPZ 00/897	28.8	10.75	19.2	21.85
MPZ 00/898	25.4	11.3	15.4	21.6

DESCRIPTION. Shell medium in size (maximum length 28.8 mm), elongated in shape, equivalved, very inequilateral. Umbones not very prominent, orthogyrate to slightly prosogyrate, anteriorly located. Faint, broad anterior and posterior umbonal carina present, the latter more distinct. Dorsal and anterior margins straight forming an angle of 90°. Ventral margin faintly convex, paralleling the dorsal margin with a byssal gape in the middle part of the shell. Posterior margin oblique, sigmoidal. Surface of shell covered with fine and regular radial ribs intersecting with commarginal lines varying in strength and with growth halts. Part of hinge partially observed in one specimen. Anterior lateral teeth short and oblique in relation to hinge line and posterior lateral teeth long and nearly parallel to hinge line.

REMARKS. This species has been described as highly variable by FÜRSICH & WERNER (1988: 118). The present material belongs to the strongly elongated variety with a medium L/H ratio of 2.4.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. The mean-L/H ratio of 2.4 of our specimens from Spain suggests that the species was epibyssate (STANLEY 1970). In fact, the relict of a byssal sinus is present in the middle of the ventral margin, but the shell is fragmented just in this part. FÜRSICH (1982: 17) considered the very similar *Grammatodon (C.) keyserlingii* (D'ORBIGNY 1850) as having lived endobyssate, similar to some Palaeozoic species of *Parallelodon* (STANLEY 1972). Accordingly, because of the strongly expanded posterior region, *Grammatodon (C.) elongatum* (J. DE C. SOWERBY) was probably a semi-infaunal bivalve. Trophic group: low level suspension-feeder.

Order **Pterioida** NEWELL 1965

Suborder **Pteriina** NEWELL 1965

Family **Bakevelliidae** KING 1850

Genus *Gervillella* WAAGEN 1907

Type species. *Perna aviculoides* J. SOWERBY, 1814.

Gervillella aviculoides (J. SOWERBY 1814)

Pl. 1, Figs. 13-14

1814 *Perna aviculoides* J. SOWERBY: 147, pl. 66, figs. 1-4.

1933 *Gervillia aviculoides* (J. SOWERBY) - ARKELL: 203, pl. 26, figs. 1-5.

1990 *Gervillia aviculoides* (J. SOWERBY) - CLAUSEN & WIGNALL: 109, pl. 3, figs. A-F.

v 1989 *Gervillia (Gervillella) aviculoides* (J. SOWERBY) - FÜRSICH & WERNER: 114, pl. 5, figs. 1-5; pl. 17, figs. 1-2.

v 1995 *Gervillella aviculoides* (J. SOWERBY) - JAITLY *et al.*: 172, pl. 7, fig. 1.

1995 *Gervillella aviculoides* (J. SOWERBY) - MUSTER: 63, pl. 11, figs. 1-7, pl. 12, figs. 1-2, text-fig. 47.

MATERIAL. 59 articulated specimens, 24 left, 4 right and 20 single valves in shell preservation. Internal moulds of 2 single valves and 1 external mould of one left valve. In general, the material is well preserved. Total number of specimens: 110 (MPZ 00/899-1008).

MEASUREMENTS.

SPECIMENS	L	H	INFLATION	W	D	D/W
MPZ 00/900	116.4	36	16.85	22.7	112.4	4.95
MPZ 00/908	115.9	30.7	20.4	21	113.3	5.39
MPZ 00/919	95	28.9	10.6	19	90	4.73
MPZ 00/970	101.9	28.3	13	21.2	114.4	5.39
MPZ 00/983	135.7	48.9	23.4	29.2	154.6	4.60
MPZ 00/987	147.6	29.9	-	28	147.3	5.26
MPZ 00/1005	129.65	34	-	26.95	130.6	4.84

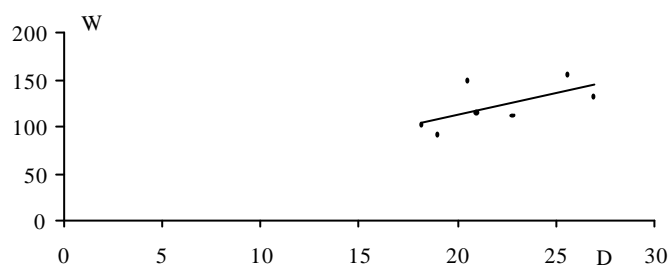


Fig. 46. Diagonal (D)/width (W) ratio of *Gervillella aviculoides* (J. SOWERBY). Scale in mm.

DESCRIPTION. Specimens large (Fig. 46), thick-shelled, moderately to strongly inflated, oblique-elongated in shape, strongly inequilateral, approximately equivalved, although the left valve is slightly more inflated than the right one. This inflation decreases posteriorly in both valves. Umbones acute, small and orthogyrate. Dorsal margin straight extending for close to half the shell-length, anterior margin broadly arched. Anterior auricle short and breaking off very easily; in the available material it is never complete. Posterior auricle long and broad. Ornamentation consisting of irregularly spaced dense commarginal growth lines, sometimes forming folds, especially near the posteroventral margin.

Interior of shell observed in some specimens; ligament area with rectangular pits of variable size and irregularly spaced.

REMARKS. The specimens from the Iberian Range are included in *Gervillella aviculoides* (J. SOWERBY) based on their large size and the thickness of the shell. According to MUSTER (1995), *Gervillella aviculoides* (J. SOWERBY) possesses a Diagonal (D)/Width (W) ratio between 3 and 4, and the angle between the dorsal margin and the diagonal is 20°. In contrast, in *Gervillella lanceolata* (MÜNSTER), the D/W ratio is between 5 and 6 and the mentioned angle 15°. In the best preserved specimens if it is possible to measure the D/W ratio, being between 4 and 5.5, and the mentioned angle being close to 20°. These values do not fit exactly MUSTER's (1995) definition of *Gervillella aviculoides* (J. SOWERBY), probably partly because the preservation does not allow precise measurements. However, the measurements are closer to *G. aviculoides* (J. SOWERBY) than to *G. lanceolata* (MÜNSTER 1833). Moreover, in the latter species the posterior margin is curved up rather than regularly arched.

OCCURRENCE. Upper Oxfordian and Kimmeridgian (Sot de Chera and Loriguilla formations) at Ricla and Valmadrid (province of Zaragoza).

PALAEOAUTECOLOGY. *Gervillella* has been interpreted as a semi-infaunal byssate bivalve (STANLEY 1972; FÜRSICH 1977; MUSTER 1995). Because of its large size and thick shell, specimens of *Gervillella*, provided a stable substrate for other benthic organisms, it is commonly encrusted by small specimens of *Nanogyra* and serpulids. Specimens in growth position were not found, and no preferential orientation has been observed. Trophic group: middle level suspension-feeder.

Family **Isognomonidae** WOODRING 1925

Genus *Isognomon* SOLANDER in LIGHTFOOT 1786

Type species. *Ostrea perna* LINNÉ 1767.

Subgenus *Isognomon* SOLANDER in LIGHTFOOT 1786

Isognomon (Isognomon) cf. promytiloides ARKELL 1933

Pl. 2, Fig. 5

cf. 1819 *Perna mytiloides* sp. nov. - LAMARCK: 142, n° 2 (*non* HERMANN, 1781; *non* GMELIN, 1788).

cf. 1933 *Isognomon promytiloides* nom. nov. - ARKELL: 207, pl. 27, figs. 2-3, text-figs. 49-51.

v cf. 1989 *Isognomon (Isognomon) promytiloides* ARKELL - FÜRSICH & WERNER: 122, pl. 10, figs. 1a-b.

MATERIAL. At some levels in the outcrops at Ricla (Ri₄ and Ri₈), especially at the levels Ri₄/184 and Ri₈/152, fragmented valves of *Isognomon* are common forming important constituents of the beds, but being impossible to remove from the rock. The shell is thick but very fragile. The specimens always occur in shell preservation. At least 9 specimens, 8 articulated ones and 1 right valve are present (MPZ 00/1009-1017).

DESCRIPTION. Specimens large (maximum length > 110 mm), with thick shell and low inflation. Rounded-rectangular in shape, equivalved, strongly inequilateral. Umbones pointed, not prominent, prosogyrate, situated at anterior end. Anterior margin concave just below the umbo, then becoming convex. Dorsal margin straight to faintly convex, forming an angle of approximate 90° with the posterior margin which is also faintly convex. Ventral margin strongly convex. Ligament area broad, with irregular narrow pits. Ornamentation consisting of commarginal growth lines and folds.

REMARKS. The studied specimens have been included in *Isognomon (I.) promytiloides* ARKELL with some doubts. An extensive synonymy list is found in ARKELL (1933: 207). There are some differences between the studied material and *Isognomon (I.) promytiloides* ARKELL. However, because of the poor preservation, it is not possible to identify a new species at present. The size of the specimens from the Iberian Range is much larger, with a length > 110 mm. The anterior margin is similar to *Isognomon (I.) promytiloides* ARKELL, however, the concave part is less produced. *I. (I.) subplana* (ÉTALLON 1862) has a much more quadrate shape; in *I. (I.) rugosum* (MÜNSTER 1835) the anterior margin is much more straight and the posterior margin strongly arched.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. *Isognomon (I.) cf. promytiloides* ARKELL has been interpreted as an epifaunal byssate bivalve, similar to most members of the family. Trophic group: low level suspension-feeder.

Superfamily **Pinnacea** LEACH 1819

Family **Pinnidae** LEACH 1819

Genus *Pinna* LINNÉ 1758

Type species. *Pinna rudis* LINNÉ 1758.

Subgenus *Pinna* LINNÉ 1758

Pinna (Pinna) cf. socialis D'ORBIGNY 1850

Pl. 1, Fig. 15

cf. 1850 *Pinna socialis* sp. nov. - D'ORBIGNY: 53, n° 148.

cf. 1932 *Pinna socialis* D'ORBIGNY - COTTREAU: 8, pl. 1 (66), figs. 16-17.

MATERIAL. 2 articulated internal moulds with remains of shell. The material is fragmented and the shell is very fragile.

DESCRIPTION. Shell medium in size, compressed, wedge-shaped, equivalved and strongly inequilateral. Umbones acute, terminal, with a middle furrow extending up to posterior region and dividing the shell into two similar halves. Dorsal and ventral margins straight, forming an angle of approximately 40°. Posterior margin truncated, straight, forming an angle of close to 90° with dorsal and ventral margins. Ornamentation consisting of commarginal folds, very distinct close to the dorsal margin, and faint radial lines seen from the middle of the shell up to the umbo.

REMARKS. The studied material has been included in *Pinna (P.) socialis* D'ORBIGNY with some doubts. This is partly due to its poor preservation, partly due to the presence of the faint radial ornamentation. In contrast, the ornamentation of *Pinna (P.) socialis* D'ORBIGNY consists solely of commarginal folds. *Pinna (P.) sandfootensis* ARKELL 1933 exhibits some features similar to our material: a straight, truncated posterior margin and a faint radial ornamentation, but in contrast to our material the radial ornamentation extends across the total height of the shell.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Jurassic species of *Pinna* have been interpreted as semi-infaunal byssate bivalves (OSCHMANN 1988), therefore represent the same life habits as Recent relatives (YONGE 1953; STANLEY 1970). Trophic group: high level suspension-feeder.

Pinna (Pinna) sp.

MATERIAL. 3 articulated specimens in shell preservation, 10 fragmented valves in varying states of preservation. Total number of specimens: 13 (MPZ 00/1020-1032).

DESCRIPTION AND REMARKS. Medium in size, strongly convex, wedged-shaped, equivalved and inequilateral. Umbones acute, terminal. Posterior margin truncated, forming a right angle with the dorsal margin. Cross-section of the shell rhomboidal. Ornamentation consisting of commarginal folds and radial ribs throughout the shell. Because of the poor preservation a specific identification is not possible.

OCCURRENCE. Upper Oxfordian-Kimmeridgian (Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid, Aguilón and Tosos (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Pinna (P.) socialis* D'ORBIGNY. Trophic group: high level suspension-feeder.

Order **Limoida** RAFINESQUE 1815

Family **Limidae** RAFINESQUE 1815

Genus *Ctenostreon* EICHWALD 1862

Type species. *Ostracites pectiniformis* SCHLOTHEIM 1820.

Ctenostreon proboscideum (J. SOWERBY 1820)

Pl. 2, Figs. 2-3

1820 *Lima proboscidea* sp. nov. - J. SOWERBY: 115, pl. 264.

1879 *Lima proboscidea* J. SOWERBY - MALLADA: pl. 31, figs. 1-2.

1885 *Lima proboscidea* J. SOWERBY - MALLADA: pl. 31, figs. 1-2.

1932 *Ctenostreon proboscideum* (J. SOWERBY) - ARKELL: 145, pl. 15, fig. 3.

1936 *Ctenostreon proboscideum* (J. SOWERBY) - ARKELL: pl. 54, figs. 2-4.

1952 *Ctenostreon proboscideum* (J. SOWERBY) - COX: 64, pl. 5, figs. 13-14.

1958 *Ctenostreon proboscideum* (J. SOWERBY) - ALMELA & SANZ: pl. 26, fig. 2.

1971 *Ctenostreon proboscideum* (J. SOWERBY) - VÖRÖS: 185, pl. 3, fig. 4.

1995 *Ctenostreon proboscideum* (J. SOWERBY) - JAITLY *et al.*: 178, pl. 10, figs. 2-3, 7, pl. 11, figs. 2, 5.

MATERIAL. Most specimens are internal moulds with remains of shell, some of them fragmented. Total number of specimens: 49 (MPZ 97/48-96).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	N RIBS
MPZ 97/48	90.7	87	33.5	11
MPZ 97/49	79.5	-	26.05	10
MPZ 97/57	77.5	72	29.5	11
MPZ 97/58	67.9	68.45	-	11
MPZ 97/59	97.7	93.7	33.5	12
MPZ 97/76	81.45	-	32.2	11

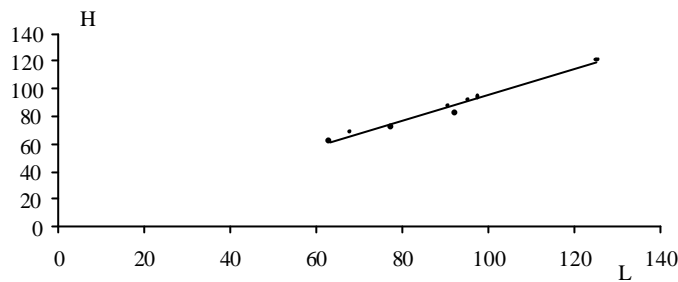


Fig. 47. Length/height ratio of *Ctenostreon proboscideum* (J. SOWERBY). Scale in mm.

DESCRIPTION. Shell large in size (Fig. 47), weakly inflated, equidimensional, equivalved, a little inequilateral. Umbones not prominent, prosogyrate. Ornamentation consisting of 9 to 14 (mostly 11) straight radial ribs of equal strength and regularly spacing. The ribs intersect with commarginal growth lines. As a result the surface of the shell is scaly.

REMARKS. Three species of *Ctenostreon* are common during Jurassic: *C. rugosum* (SMITH 1817), *C. proboscideum* (J. SOWERBY 1820) and *C. pectiniforme* (SCHLOTHEIM 1820). They have been treated by numerous authors, many of them have considered them to be synonyms, in which case *C. rugosum* (SMITH), the oldest one, would have priority. ARKELL (1932: 145-148) recognised clear differences between the three species with respect to general shape, size and shape of auricles, and number of radial ribs, the last feature being the most characteristic one. *C. rugosum* (SMITH) has between 9 and 10 radial ribs, *C. proboscideum* (J. SOWERBY) between 11 and 13 and *C. pectiniformis* (SCHLOTHEIM) 14. Nevertheless, many authors regarded number of ribs and shape as highly variable in each species and not as a diagnostic feature. ABERHAN (1994: 24) evaluated the descriptions and figures of the three species, concluding that it is not possible to distinguish between them. In the studied material from Spain the prevailing number of ribs is 11, although occasionally 9 or 14 radial ribs are present. Following ARKELL (1932), the material from Spain should be included in *C. proboscideum* (J. SOWERBY) because the number of ribs is in the range of variation of this species and the material has been collected from comparable stratigraphic levels, i. e. Callovian-Oxfordian, in the Ariño-Moneva area. The shape of the shell differs from the three species mentioned, which could be due to intraspecific variation. The valves are equidimensional, although the measurements are not very exact because of the fragmented nature of the shells. They are not circular as in *C. pectiniformis* (SCHLOTHEIM), their height-length ratio not exceeding 1 as in *C. proboscideum* (J. SOWERBY).

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Moneva, Lécera (province de Zaragoza) and Ariño-Oliete (province of Teruel).

VILANOVA Y PIERA (1863: 67) reported *Lima proboscidea* SOWERBY from “Grande Oolita” at Obón and Ariño (Teruel). EZQUERRA (1854: 178) mentioned this species from the Jurassic of Guadalajara and Logroño. CORTÁZAR (1885: 128, 222, 226) reported it from the “Grupo Liásico” and “Grupo Oolítico” at some localities of Teruel. MALLADA figured *Lima proboscidea* SOWERBY (1879, 1885: pl.

31, figs. 1-2). ALMELA & SANZ (1958) reported it from the Toarcian, refiguring MALLADA's illustration and including it in *Ctenostreon*.

PALAEOAUTECOLOGY. Like most members of the family Limidae, *Ctenostreon* is interpreted as an epifaunal byssate bivalve. Trophic group: low level suspension-feeder.

Ctenostreon sp.

MATERIAL. 20 internal moulds of single valves with remains of shell (MPZ 97/97-100; MPZ 98/101-116).

DESCRIPTION AND REMARKS. Specimens of variable size, weakly inflated, irregular in outline, suboval, equivalved, inequilateral. Umbones small, pointed, prosogyrate. Surface covered with at least 12 to 13 radial ribs that intersect with commarginal growth lines thereby becoming scaly. A more detailed description is not possible because of the poor preservation. However, it is possible to include it in *Ctenostreon* because of the characteristic ornamentation.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Moneva, Lécera (province of Zaragoza), Muniesa, Ariño, Oliete and Foz Calanda (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Ctenostreon proboscideum* (J. SOWERBY). Trophic group: low level suspension-feeder.

Genus *Plagiostoma* J. SOWERBY 1814

Type species. *Plagiostoma giganteum* J. SOWERBY, 1814, subsequently designated by STOLICZKA (1871).

Plagiostoma fuersichi sp. nov.

Pl. 2, Fig. 1; Pl. 3, Figs. 6-7

Derivation of name. After Prof. Franz T. Fürsich (Univ. Würzburg).

Type material. Holotype: MPZ 98/118, from Callovian (Chelva Fm) at Oliete (province of Teruel). Paratypes: MPZ 98/121, from Callovian (Chelva Fm) at Ariño (province of Teruel); MPZ 98/117, from Callovian (Chelva Fm) at Aguilón (province of Zaragoza).

MATERIAL. Internal moulds with remains of shell of 14 articulated specimens, 11 right, 11 left and 2 single valves. 2 right valves in shell preservation. The total number of radial ribs is not possible to count because the shell is very thin and frequently fragmented. Total number of specimens: 40 (MPZ 98/117-140; MPZ 97/141-156).

MEASUREMENTS SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 98/117 (Paratype)	57.8	61.7	-
MPZ 98/118 (Holotype)	66.3	70.8	40.4
MPZ 98/120	68	73.9	39.5
MPZ 98/131	58.5	66.9	31.3
MPZ 98/136	59.2	64.9	-

DIAGNOSIS. Morphologic features similar to *Lima (Plagiostoma) calvata* ZAKHAROV (1966: 66, pl. 18, figs 1-5), but with more than 75 sinuous radial ribs, with punctate interstices.

DESCRIPTION. Shell medium-sized, height always greater than length. Strongly inflated, especially greatest inflation being in the anterior region, oval to triangular in shape, equivalved, very inequilateral. Umbones acute, prominent, orthogyrate to prosogyrate. Anterior margin straight, with the relict of a lunule that occupies most of the anterior region. Posteroventral and ventral margins convex forming a semicircular line. Ornamentation consisting of more than 75 radial ribs, sinuous, with punctate interstices. Commarginal growth lines present throughout the shell, in adult stage forming folds. Auricles partially observed, similar in size, ornamentation of posterior auricle identical to the rest of the shell, that of the anterior one not observed.

REMARKS. In spite of the moderate preservation, the rich material allows to describe the species adequately. The specimens cannot be accommodated in any of the known species. The morphological features are very close to *Plagiostoma calvatum* ZAKHAROV, height-length ratio > 1 being an uncommon feature in *Plagiostoma*, and the new species only differs from *P. calvatum* by the presence of radial ornamentation. It differs from *Plagiostoma punctatum* J. SOWERBY 1815 in that the posterior margin of *Plagiostoma fuersichi* nov. sp. is more convex and rounded. The differences to *Plagiostoma buckmani* COX consist of a straighter anterior margin and more prominent and pointed umbones.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Aguilón, Moneva, Lécera (province of Zaragoza) and Ariño-Oliete (province of Teruel).

PALAEOAUTECOLOGY. Interpreted like most species of *Plagiostoma* as an epifaunal byssate bivalve. Trophic group: middle level suspension-feeder.

Plagiostoma laeviusculum J. SOWERBY 1822

Pl. 3, Fig. 1

1822 *Plagiostoma laeviusculum* sp. nov. - J. SOWERBY: 112, pl. 382.

1931 *Lima (Plagiostoma) laeviuscula* (SOWERBY) - ARKELL: 129, pl. 12, figs. 2-3.

1932 *Lima (Plagiostoma) laeviuscula* (SOWERBY) - ARKELL: pl. 14, figs. 1-3.

v 1989 *Plagiostoma laeviusculum* J. SOWERBY - FÜRSICH & WERNER: 152, pl. 16, figs. 7-10.

MATERIAL. 3 fragmented right valves in shell preservation (MPZ 97/157-159).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 97/157	29.4	32.5
MPZ 97/158	18.9	22.9
MPZ 97/159	-	32.3

DESCRIPTION. Shell medium in size, strongly inflated, oval in outline, equivalved, inequilateral. Umbones acute, slightly opisthogyrate, anteriorly located. Anterior margin straight to concave, ventral margin convex, rounded. Posterior margin straight. Ornamentation consisting of more than 50 radial ribs, most likely around 60. The ribs are a little sinuous, especially towards the ventral margin of the shell. The interstices between the ribs exhibit a punctate pattern, especially in the umbonal region.

REMARKS. The studied material fits *Plagiostoma laeviusculum* J. SOWERBY, especially the outline of the shell. The ornamentation of our material falls within the range of variation of this species. ARKELL (1931: 129) described the great variability of this character in material from the Oxfordian of England. For example, punctae in the interstices between the ribs are not present in all specimens. FÜRSICH & WERNER (1989) have described the common lack of ornamentation at the centre of the shell in their material from the Kimmeridgian of Portugal.

OCCURRENCE. Callovian and Oxfordian (Chelva, Yátova and Sot de Chera formations) at Ricla (province of Zaragoza) and Oliete (province of Teruel).

PALAEOAUTECOLOGY. Like other species of *Plagiostoma*, *P. laeviusculum* J. SOWERBY is interpreted as an epifaunal byssate bivalve. Trophic group: middle level suspension-feeder.

Plagiostoma buckmani COX 1943

Pl. 3, Figs. 2-3

1943 *Lima (Plagiostoma) buckmani* sp. nov. - Cox: 174, pl. 25, figs. 71a-c.

MATERIAL. 2 right and 3 left valves in shell preservation. All of them fragmented, the umbones and general shape cannot be described in detail (MPZ 97/160-164).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 97/162	25.7	20.3
MPZ 97/164	18.1	19.4

DESCRIPTION. Shell medium in size, strongly inflated, especially in the umbonal area. Oblique, equivalved, very inequilateral. Umbones prominent, broad and orthogyrate. Anterior and posterodorsal margins straight, forming an angle of close to 90°, remaining margins convex. Ornamentation consisting of dense radial lines, sinuous and irregularly spaced. The interstices between ribs are punctate at all growth stages. Commarginal irregularly spaced growth lines are present on the whole shell.

REMARKS. The studied material was not easy to identify because of its poor state of preservation. The material was included in *Plagiostoma buckmani* COX because of the strongly inflation and the ornamentation. This species is very close to *Plagiostoma punctatum* J. SOWERBY, usually known from the Lower Jurassic, but it has been described by JAITLEY *et al.* (1995: 179) also from the Middle Jurassic of Kachchh (India). The differences to *Plagiostoma punctatum* J. SOWERBY 1815 are the stronger inflation and the less oblique shell, the ornamentation being very similar in both species.

OCCURRENCE. Callovian, Oxfordian (Chelva, Yátova and Sot de Chera formations) at Tosos (province of Zaragoza) and Ariño-Oliete (province of Teruel).

PALAEOAUTECOLOGY. Like other species of *Plagiostoma*, *P. buckmani* COX is interpreted as an epifaunal byssate bivalve. Trophic group: middle level suspension-feeder.

Plagiostoma oepybolum (WHIDBORNE 1883)

Pl. 2, Fig. 4

1883 *Lima oepybolum* sp. nov. - WHIDBORNE: 503, pl. 17, fig. 1-1a.

1943 *Lima (Plagiostoma) oepybolum* WHIDBORNE - COX: 158, pl. 8, figs. 7-9.

MATERIAL. 1 right and 2 left valves in shell preservation, 2 internal moulds of right valves with remains of shell. Most specimens fragmented (MPZ 97/165-169).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	N RIBS
MPZ 97/165	58.8	50.5	45

DESCRIPTION. Shell medium in size, moderately to strongly inflated, oblique, semi-elliptical in outline, equivalved, inequilateral. Umbones broad, not prominent and orthogyrate. Anterior and posterior margins straight, forming an angle of slightly $> 90^\circ$. Ventral margin semicircular. Ornamentation consisting of 45 to 50 radial ribs, prominent and high, generally straight, although occasionally sinuous near the ventral margin. Interstices twice as wide as the ribs and transversely striated, a feature that could be observed in the best preserved parts of shell.

REMARKS. The material from the Iberian Range is included in *Plagiostoma oepybolum* (WHIDBORNE) because the general shape of the shell, inflation and size of umbones, and ornamentation are similar.

OCCURRENCE. Callovian, Oxfordian (Yátova and Loriguilla formations) at Moneva (province of Zaragoza), Muniesa and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. As for other species of *Plagiostoma*. Trophic group: middle level suspension-feeder.

Plagiostoma pratzii (BOEHM 1881)

Pl. 3, Fig. 4

v 1881 *Lima pratzii* sp. nov. - BOEHM: 179, pl. 37 (21), fig. 6a, b.

1883 *Lima pratzii* BOEHM - BOEHM: 636, pl. 69, figs. 17-19.

v 1975 *Plagiostoma pratzii* (BOEHM) - YAMANI: 77, pl. 4, fig. 15, text-fig. 24.

MATERIAL. 2 right and 4 left valves in shell preservation. The material is fragmented (MPZ 97/170-175).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT
MPZ 97/171	29	23
MPZ 97/172	37	27.3
MPZ 97/174	39.5	28.8

DESCRIPTION. Medium in size, strongly inflated, especially at the centre of the shell. Obliquely oval-elongated in shape with length greater than height, equivalved, very inequilateral. Umbones broad, not prominent and orthogyrate. Anterior margin straight forming an angle of 95° with the dorsal margin. Ventral margin strongly convex, posterior margin broadly arched. Ornamentation consisting of dense radial ribs of equal strength, sinuous, especially in ventral region. Interspaces between the ribs punctate.

REMARKS. The studied material is very close in shape and ornamentation to *Plagiostoma pratzii* as figured by BOEHM (1881). It is also close to *Plagiostoma rigidulum* PHILLIPS 1829, but the latter species has transversely striated interspaces and the anterior margin is less convex.

OCCURRENCE. Oxfordian (Yátova and Sot de Chera formations) at Ricla and Moneva (province of Zaragoza).

PALAEOAUTECOLOGY. As for other species of *Plagiostoma*. Trophic group: middle level suspension-feeder.

Plagiostoma sp.

MATERIAL. 2 right and 2 left valves in shell preservation. Internal moulds of 4 right and 2 left valves. The material is fragmented and poorly preserved. Total number of specimens: 10 (MPZ 97/176-185).

DESCRIPTION AND REMARKS. The material included in this group is heterogeneous, not all specimens belonging to the same species. The poor preservation of the material does not allow identification at the species level. All specimens exhibit the following features: medium to large size, a length-height ratio > 1 and an oblique, oval shape. Inflation moderate to strong shells, equivalved and very inequilateral. Umbones orthogyrate to opisthogyrate protruding beyond the hinge line. Ornamentation consisting of faint radial ribs with punctate interspaces in some specimens.

OCCURRENCE. Callovian, Oxfordian and Kimmeridgian (Chelva, Yátova and Loriguilla formations) at Valmadrid, Lécera (province of Zaragoza) and Ariño-Oliete, La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. As for other *Plagiostoma* species. Trophic group: middle level suspension-feeder.

Genus *Pseudolimea* ARKELL in DOUGLAS & ARKELL 1932

Type species. *Pseudolimea duplicata* J. DE C. SOWERBY 1827.

Pseudolimea duplicata (J. DE C. SOWERBY 1827)

Pl. 3, Fig. 5

1827 *Plagiostoma duplicata* sp. nov. - J. DE C. SOWERBY: 114, pl. 559, fig. 3.

v 1989 *Pseudolimea duplicata* (J. DE C. SOWERBY) - FÜRSICH & WERNER: 150, pl. 16, figs. 5-6, text-fig. 23 [see for extensive synonymy list].

? 1997a *Pseudolimea duplicata* (J. DE C. SOWERBY) - BERNAD: 14, pl. 1, figs. 3, 5.

MATERIAL. 2 articulated specimens, 1 right, 6 left, 3 single valves in shell preservation. Internal moulds of 1 right, 5 left valves. Many specimens are fragmented. Total number of specimens: 18 (MPZ 97/186-203).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	N RIBS
MPZ 97/186	21.1	20	-	18
MPZ 97/187	24	22.4	12.7	28
MPZ 97/190	24.1	21.1	-	21
MPZ 97/192	9	8.5	-	24
MPZ 97/198	21.7	21.6	-	25

DESCRIPTION. Shell small to medium in size, moderately to strongly inflated, oval in shape, equivalved, very inequilateral. Umbones pointed, prominent, protruding beyond the hinge line. Anterodorsal margin straight to slightly concave. Posterior and ventral margins convex. Ornamentation consisting of 18 to 25 primary radial ribs, angular in cross-section with interspaces broader than the ribs. Ornamentation highly variable, sometimes even within a single specimen. All specimens with 13 secondary radial riblets. In some specimens interspaces with distinct transverse striae, producing a spinous aspect.

REMARKS. The studied material has been included in *Pseudolimea duplicata* (J. DE C. SOWERBY) without doubts. For discussion and synonymy see FÜRSICH & WERNER (1989). This species usually has between 18 and 25 primary radial ribs. One specimen from the Iberian Range has 28. In this case, however, the primary ribs are faint at the anterior and posterior margins and cannot be easily distinguished from the secondary ones. The general shape and ornamentation corresponds to *Pseudolimea duplicata* (J. DE C. SOWERBY).

OCCURRENCE. Callovian, Oxfordian, (Chelva, Yátova and Sot de Chera formations) at Ricla, Tosos (province of Zaragoza), Muniesa, Ariño, Oliete, Torre de las Arcas and Foz Calanda (province de Teruel).

The species has been reported and figured from the Lower Jurassic of (BERNAD 1997a). It has been reported from the Pliensbachian-Toarcian at La Almunia de Doña Godina and Ricla (province of Zaragoza), from the Toarcian at Rambla del Salto (Sierra Palomera, province of Teruel) (BERNAD 1996a,b) and from the Toarcian-Aalenian at Fuentelsaz (province of Guadalajara) by BERNAD (1996c: 62, fig. 3.5; 1999c).

PALAEOAUTECOLOGY. Like most members of the Limidae, *Pseudolimea duplicata* (J. DE C. SOWERBY) was an epifaunal bivalve, most likely living byssally attached with the commissural plane oriented vertically. Trophic group: low level suspension-feeder.

Order **Ostreoida** FÉRUSAC 1822

Superfamily **Dimyiacea** FISCHER 1886

Family **Dimyidae** FISCHER 1886

Genus *Atreta* ÉTALLON 1862

Type species. *Ostrea blandina* D'ORBIGNY 1850.

The presence of two muscle scars places *Atreta* in the family Dimyidae (FÜRSICH & WERNER 1989; HODGES 1991) instead of Plicatulidae (COX & HERTLEIN 1969). According to WALLER (1978) and HODGES (1991), the superfamily Dimyacea is included in the order Ostreoida.

Atreta cf. *lepis* (EUDES-DESLONGCHAMPS 1858)

Pl. 3, Fig. 12

cf. 1858 *Plicatula lepis* sp. nov. - EUDES-DESLONGCHAMPS: 120, pl. 18, figs. 36-38.

cf. 1858 *Plicatula alternans* sp. nov. - EUDES-DESLONGCHAMPS: 121, pl. 18, figs. 11-20.

MATERIAL. 35 right valves, many of them fragmented. Only the internal features of these valves have been observed. The aragonitic internal shell has been dissolved and muscle scars and hinge could not be observed (MPZ 97/204-238).

DESCRIPTION. Shell small in size (maximum 10.7 mm in length), suborbicular. Right valve cemented, interior surface concave for most part, except for a bulge close to the margins. In the concave area ornamentation consists of faint divaricate radial ribs, and some commarginal lines. The radial ribs extend from the umbo towards the ventral margin, but stop when reaching the bulge. As a result, the interior part of the bulge is ornamented. The rest of the shell up to the margins is smooth.

REMARKS. The two species defined by EUDES-DESLONGCHAMPS (1858): *Plicatula lepis* and *Plicatula alternans* are considered to be synonyms, with *A. lepis* (E-D) having page priority. Our material

fits well the description and figures by EUDES-DESLONGCHAMPS (1858), but the material is assigned to *A. lepis* (E-D) with some doubts because of its poor preservation.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Tosos, Aguilón, Lécera (province of Zaragoza) and Muniesa, Ariño and Oliete (province of Teruel).

PALAEOAUTECOLOGY. *Atreta* cf. *lepis* (EUDES-DESLONGCHAMPS) was an epifaunal bivalve cemented to the substrate with its right valve. Trophic group: low level suspension-feeder.

Superfamily **Ostreacea** WILKES 1810

Family **Palaeolophidae** MALCHUS 1990

The family Palaeolophidae was defined by MALCHUS (1990) to include *Lopha* and related genera of Triassic to Cretaceous age. According to this author, the members of Palaeolophidae differ from Recent species of *Lopha* in their shell structure.

Genus *Actinostreon* BAYLE 1878

Type species. *Ostrea solitaria* J. SOWERBY 1824.

Actinostreon gregareum (J. SOWERBY 1815)

Pl. 3, Figs. 9, 13

1815 *Ostrea gregarea* sp. nov. - J. SOWERBY: 19, pl. 111, figs. 1, 3.

1881 *Ostrea gregaria* SOWERBY. - MALLADA: pl. 30B, figs. 11-12.

1885 *Ostrea gregaria* SOWERBY. - MALLADA: 104, pl. 30B, figs. 11-12.

1933 *Lopha gregarea* (J. SOWERBY) - ARKELL: 183, pl. 22, figs. 5, 6, pl. 23, figs. 1-4.

1952 *Lopha gregarea* (J. SOWERBY) - COX: 96, pl. 4, fig. 2, pl. 10, figs. 7-13.

1995 *Actinostreon gregareum* (J. SOWERBY) - JAITLY *et al.*: 186, pl. 13, fig. 13, pl. 14, figs. 1-5.

1997 *Lopha gregarea* (J. SOWERBY) - BERNAD: 14, pl. 2, figs. 4-5, 7.

1998 *Actinostreon gregareum* (J. SOWERBY) - HOLZAPFEL: 105, pl. 6, figs. 18-19, 21.

MATERIAL. 16 right, 4 left valves, 1 articulated specimen and 3 single fragments. In general, the specimens are fragmented. Total number of specimens: 24 (MPZ 97/239-262).

DESCRIPTION. Medium in size (maximum 30.7 mm in height), moderately inflated, elongated in shape. Irregular in outline with height greater than length. Slightly inequivalved, especially because of the attachment area, very inequilateral. Umbones small, acute, only partially observed. Ventral margin with characteristic zigzag pattern. Ornamentation consisting of strong, irregular, dichotomous radial ribs.

REMARKS. *Actinostreon* is a very common ostreid in the Jurassic, and there are two morphotypes: *A. solitarium* (J. DE C. SOWERBY) is circular in shape and *A. gregareum* (J. SOWERBY) is more elongated. According to ARKELL (1933: 186), the two morphotypes differ in shape and number of ribs; *gregareum* has 30 to 40 and *solitarium* between 20 and 25 ribs. However, some authors are of the opinion that both morphotypes belong to the same species (JAITLY *et al.* 1995), because where large

populations are available for study, one of the morphotypes dominates, but there are also individuals of the second morphotype as well as intermediate forms. In this study, the two morphotypes have been treated as separate following ARKELL (1933), as the poor state of preservation of the material does not allow to make any conclusions with respect to this problem.

OCCURRENCE. Oxfordian (Yátova Fm) at Tosos, Moneva, Lécera (province of Zaragoza), Muniesa, Ariño, Oliete and Foz Calanda (province of Teruel).

This species has been mentioned from the Lower Jurassic of province of Teruel (MALLADA 1881, 1885). It has been reported from the Lower Jurassic of Spain (BERNAD 1997a), in particular from the Toarcian-Aalenian at Fuentelsaz (province of Guadalajara) (BERNAD 1996c), and at Molina de Aragón (province of Guadalajara) (BERNAD 1999a).

PALAEOAUTECOLOGY. *Actinostreon gregareum* (J. SOWERBY) was an epifaunal bivalve cemented to the substrate with its left valve. Trophic group: low level suspension-feeder.

Actinostreon cf. solitarium (J. DE C. SOWERBY 1824)

Pl. 3, Fig. 8, 14

cf. 1824 *Ostrea solitaria* sp. nov. - J. DE C. SOWERBY: 105, pl. 468, fig. 1.

cf. 1933 *Lopha solitaria* (J. DE C. SOWERBY) - ARKELL: 185, pl. 22, fig. 4, pl. 23, figs. 5-7.

MATERIAL. 4 right, 1 left valve and 6 fragments single valves. All specimens are fragmented. Total number of specimens: 11 (MPZ 97/263-273).

DESCRIPTION. Medium to small in size, moderately inflated, strongest inflation in the centre of the shell. Shape orbicular, in some specimens height exceeding length. Ornamentation consisting of strong irregular radial, divaricate ribs.

REMARKS. The specimens have been included in *Actinostreon solitarium* (J. DE C. SOWERBY) with some doubts because of their poor preservation. All of them exhibit the most characteristic features of this species: a circular shape, a smaller number of radial ribs than *A. gregareum* (J. SOWERBY) and a zigzag-folded ventral margin, but not as marked as in *A. gregareum* (J. SOWERBY).

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Lécera and Moneva (province of Zaragoza), Ariño, Oliete and Foz Calanda (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Actinostreon gregareum* (J. SOWERBY). Trophic group: low level suspension-feeder.

Actinostreon sp.

MATERIAL. 27 fragments of poorly preserved single shells (MPZ 97/274-300).

REMARKS. The material included here most likely belongs to one of the two species described above. However, the poor preservation does not allow a specific identification. The specimens are included in *Actinostreon* because of their strong divaricate ribs and zigzag-folded ventral margin.

OCCURRENCE. Oxfordian (Yátova Fm) at Tosos, Moneva (province of Zaragoza), Ariño, Oliete, Muniesa and Foz Calanda (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Actinostreon gregareum* (J. SOWERBY). Trophic group: low level suspension-feeder.

Family **Ostreidae** WILKES 1810Genus *Liostrea* DOUVILLÉ 1904

Type species. *Ostrea sublamellosa* DUNKER 1846.

Liostrea dubiensis (CONTEJEAN 1860)

Pl. 3, Fig. 11

1860 *Ostrea dubiensis* sp. nov. - CONTEJEAN: 320, pl. 21, figs. 4-11.

1904 *Ostrea ogerieni* sp. nov. - DE LORIO: 249, pl. 26, figs. 1-5.

1936 *Ostrea dubiensis* CONTEJEAN - ARKELL: 366, pl. 55, figs. 4-5 [see for extensive synonymy list].

1935 *Ostrea (Liostrea) dubiensis* CONTEJEAN - COX: 171, pl. 17, figs. 4-5.

1971 *Liostrea dubiensis* (CONTEJEAN) - PUGACZEWSKA: 252, pl. 14, figs. 1-7.

MATERIAL. 2 well preserved right valves (MPZ 97/301-302).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 97/301	19	28.7
MPZ 97/302	10.7	20.2

DESCRIPTION. Shell medium in size, inequivalved, very inequilateral, of oval shape. Right valve flat, opercular. Ligamental area triangular, straight and flat. Adductor muscle scar oval and situated very posteriorly. Posterior and anterodorsal margins straight, anteroventral and ventral margins convex. Exterior of the valve ornamented with commarginal growth lines, more distinct and lamellar towards the ventral margin.

REMARKS. The studied material has been included in *Liostrea* because the ligament area is straight rather than curved as, for example in *Nanogyra*. *Ostrea dubiensis* CONTEJEAN has been described in detail by earlier authors. Morphologically, it is highly variable, its shape commonly is triangular, and occasionally semicircular as in the present material. The last feature prompted DE LORIO (1904) to create

a new species, *Ostrea ogerieni* DE LORIO, that is here considered to be a synonym of *O. dubiensis* CONTEJEAN.

OCCURRENCE. Upper Oxfordian at Riela (province of Zaragoza).

PALAEOAUTECOLOGY. *Liostrea* was an epifaunal bivalve cemented with its left valve to the substrate. Trophic group: low level suspension-feeder.

Liostrea sp.

MATERIAL. 1 fragmented articulated specimen (MPZ 97/303).

DESCRIPTION AND REMARKS. Shell medium-sized (52.4 mm in length), triangular in shape, inequivalved, very inequilateral. Left valve strongly inflated towards ventral region, dorsal half of the shell flat to concave, serving as attachment area. Right valve opercular. Umbones not observed. Posterior margin straight, anterior and ventral margins convex. Ornamentation consisting of commarginal growth lines and folds, more distinct towards the ventral margin. The poor preservation does not allow a specific identification.

OCCURRENCE. Upper Oxfordian at Ariño (province of Teruel).

PALAEOAUTECOLOGY. *Liostrea* was an epifaunal bivalve cemented with its left valve to the substrate. Trophic group: low level suspension-feeder.

Family **Gryphaeidae** VYALOV 1936

Genus *Gryphaea* LAMARCK 1801

Type species. *Gryphaea arcuata* LAMARCK 1801.

Subgenus *Bilobissa* STENZEL 1971

Type species. *Gryphaea bilobata* J. DE C. SOWERBY 1835.

Gryphaea (Bilobissa) dilatata J. SOWERBY 1816

Pl. 3, Fig. 10

1816 *Gryphaea dilatata* sp. nov. - J. SOWERBY: 113, pl. 149, fig. 1.

1932 *Gryphaea dilatata* J. SOWERBY - ARKELL: 160, pl. 18, figs. 1-2, pl. 19, figs. 1-1a, pl. 20, figs. 1-13, text-fig. 28-42 [see for extensive synonymy list].

1933 *Gryphaea dilatata* J. SOWERBY - ARKELL: pl. 21, figs. 1-12.

1971 *Gryphaea dilatata* J. SOWERBY - PUGACZEWSKA: 277, pl. 17, figs. 1-4, pl. 18, figs. 1-3.

1978 *Gryphaea (Bilobissa) dilatata* J. SOWERBY - DUFF: 81.

1991 *Gryphaea (Bilobissa) dilatata* J. SOWERBY - DUFF: 61, pl. 5, fig. 1a-b.

MATERIAL. 2 well preserved left valves (MPZ 97/304-305).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 97/304	37.9	40.9

DESCRIPTION. Shell medium in size, triangular in shape, inequivalved, very inequilateral. Left valve strongly inflated, flat to concave attachment area occupying most part of the umbonal region. A sulcus running from the umbo to the posteroventral margin divides the shell into two parts, posterior part being considerably smaller. Ornamentation consisting of commarginal growth lines.

REMARKS. ARKELL (1932) and DUFF (1978) thoroughly discussed the differences and synonymies of the Jurassic species of *Gryphaea*. They mentioned a large size especially for *G.(B.) dilatata* J. SOWERBY. DUFF (1978: 81) mentioned up to 198 mm in height. In contrast, the present material has a maximum height of 40.9 mm. It could represent juvenile individuals, a suggestion which is supported by the comparatively large attachment area. DUFF (1978) distinguished between *G (B.) dilobotes* DUFF 1978, *G (B.) lituola* LAMARCK 1819 and *G (B.) dilatata* J. SOWERBY using the development of the posterior sulcus as a specific criterion. According to him, despite overlapping morphological variants, the three species can be separated when large population are studied. Moreover, he considered them stratigraphically distinct, the first two species occurring in the Middle and Upper Callovian, the third one in the Lower Oxfordian respectively. Our two specimens come from Callovian and Upper Oxfordian rocks of the same outcrop and are very similar to *Gryphaea (Bilobissa) dilatata* J. SOWERBY. They differ from *Gryphaea (Bilobissa) dilobotes* DUFF in that the posterior region is only weakly developed.

OCCURRENCE. Callovian and Upper Oxfordian at Ariño (province of Teruel).

PALAEOAUTECOLOGY. *Gryphaea* was an epifaunal bivalve cemented with its left valve to the substrate at the juvenile stage, but free-living at the adult stage. Trophic group: low level suspension-feeder.

Genus *Nanogyra* J. SOWERBY 1822

Type species. *Gryphaea nana* J. SOWERBY 1822.

Nanogyra nana (J. SOWERBY 1822)

Pl. 4, Figs. 1-2, 6-7

1822 *Gryphaea nana* sp. nov. - J. SOWERBY: 114, pl. 383, fig. 3.

1932 *Exogyra nana* (J. SOWERBY) - ARKELL: 175, pl. 17, figs. 2-21, pl. 18, figs. 3-11, pl. 19, figs. 4-4a, text-fig. 48 [see for extensive synonymy list].

1971 *Nanogyra nana* (J. SOWERBY) - PUGACZEWSKA: 281, pl. 1, figs. 1, 3-5, 7, pl. 2, figs. 1-4, pl. 24, figs. 1-6, pl. 25, figs. 1-7, pl. 26, figs. 1-6, pl. 27, figs. 1-6 [see for extensive synonymy list].

1978 *Nanogyra nana* (J. SOWERBY) - DUFF: 84, pl. 9, figs. 2-5.

1995 *Nanogyra nana* (J. SOWERBY) - JAITLY *et al.*: 189, pl. 16, figs. 13-15, pl. 17, figs. 1-2.

MATERIAL. 162 right, 583 left valves, and 23 articulated specimens, all well preserved. Total number of specimens: 768 (MPZ 97/306-406; MPZ 00/1033-1699).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT
MPZ 97/312	11.7	18.4
MPZ 97/318	12.7	19.2
MPZ 97/322	8	12
MPZ 97/333	7.6	10
MPZ 97/347	17.4	21.5
MPZ 97/367	21.8	26.3
MPZ 00/1080	16.8	21.4
MPZ 00/1114	5.2	7.8

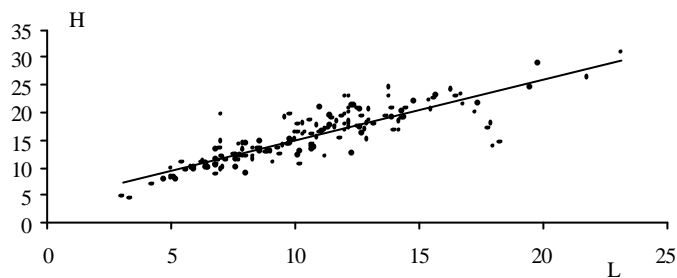


Fig. 48. Length/height ratio of *Nanogyra nana* (J. SOWERBY). Scale in mm.

DESCRIPTION. Shell small in size (maximum 26.3 mm in height, Fig. 48), of variable shape, but in general semicircular, with height greater than length, inequivalved and very inequilateral. Umbones small, strongly recurved and opisthogyrate. Posterior margin straight, anterior margin broadly, ventral margin narrowly convex.

Right valve flat, opercular, with a ridge bordering the margins interiorly, adductor muscle scar oval, very posteriorly located. Exterior ornamentation consisting of commarginal lamellar growth lines.

Left valve strongly inflated, especially towards the centre of the shell, with small to tiny attachment area. Ornamentation consisting of irregularly spaced commarginal folds. Interior not observed.

REMARKS. *Nanogyra nana* (J. SOWERBY) is a very common and well known species in the Jurassic all over the world. The material from the Iberian Range has been included in this species because of its small size, recurved umbones, and lack of radial ornamentation that distinguishes *Nanogyra nana* (J. SOWERBY) from other species of *Nanogyra* such as *Nanogyra virgula* (DEFRANCE 1821).

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (Sot de Chera and Loriguilla formations) at Ricla, Tosos and Valmadrid (province of Zaragoza).

PALAEOAUTECOLOGY. *Nanogyra nana* was an epifaunal bivalve cemented with its left valve to the substrate, usually found in muddy sediments. Trophic group: low level suspension-feeder.

Order **Pectinoida** NEWELL & BOYD 1995

Superfamily **Monotacea** FISCHER 1887

Family **Oxytomidae** ICHIKAWA 1958

Genus *Meleagrinnella* WHITFIELD 1885

Type species. *Avicula curta* HALL 1852.

Meleagrinnella braamburensis (PHILLIPS 1829)

Pl. 4, Fig. 3

1829 *Avicula braamburensis* sp. nov. - PHILLIPS: pl. 6, fig. 6.

1978 *Meleagrinnella braamburensis* (PHILLIPS) - DUFF: 58, pl. 4, figs. 20, 24, 26-28, 31-32, pl. 5, figs. 1, 2, 6, 11, text-figs. 18-19.

MATERIAL. 3 right valves and 1 left valve, poorly preserved (MPZ 00/1700-1703).

DESCRIPTION. Shell medium in size (maximum 26.8 mm in length), strongly inflated, subcircular in shape, inequivalved and subequilateral. Umbones well developed and orthogyrate.

Right valve covered with about 36 primary radial ribs, between which faint secondary ribs are intercalated.

Left valve with more than 30 irregularly spaced radial ribs of variable strength.

In both valves commarginal ornamentation is present, in the right valve commarginal growth lines intersect with the radial ribs resulting in a scaly pattern, in the left valve growth lines are irregular, conspicuous especially towards the ventral margin of the shell.

REMARKS. The material from the Iberian Range has been included in *Meleagrinnella braamburensis* (PHILLIPS) because of the ornamentation of the valves. DUFF (1978) described *Meleagrinnella braamburensis* (PHILLIPS) in detail and discussed the main differences to *Meleagrinnella echinata* (SMITH 1817) related to morphology and stratigraphic position. The maximum size of *Meleagrinnella echinata* (SMITH) is smaller than that of *M. braamburensis* (PHILLIPS) (up to 20 mm length), and both valves have fewer radial ribs, up to 16 in the right valve and up to 40 in the left one. Our material differs from *Meleagrinnella ovalis* (PHILLIPS 1829) because the latter has a radial ornamentation that is similar in both valves.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Tosos, Lécerca (province of Zaragoza) and Muniesa (province of Teruel).

PALAEOAUTECOLOGY. The life habits of *Meleagrinnella* have been interpreted in different ways. DUFF (1978) suggested that *Meleagrinnella* lived similar to *Oxytoma*, i. e. as a byssate epifaunal bivalve. As the substrate was soft, he thought it unlikely that it rested on the sea floor but regarded it as "pendant". In contrast, OSCHMANN (1988), assumed different life habits for the two genera: According to him, *Oxytoma* might have been a "pendant" bivalve and *Meleagrinnella* lived on the sediment surface. The

available material does not yield additional information on the life habit of the species. Accordingly, *Meleagrinnella* was either a low or high level suspension-feeder.

Superfamily **Pectinacea** WILKES 1810

Family **Pectinidae** WILKES 1810

Genus *Camptonectes* AGASSIZ in MEEK 1864

Type species. *Pecten lens* J. SOWERBY 1818.

Subgenus *Camptonectes* AGASSIZ in MEEK 1864

Camptonectes (Camptonectes) auritus (SCHLOTHEIM 1813)

Pl. 4, Fig. 5

1813 *Chamites auritus* sp. nov. - SCHLOTHEIM: 103.

1952 *Camptonectes auritus* (SCHLOTHEIM) - COX: 23, pl. 2, fig. 6.

1978 *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM) - DUFF: 66, pl. 5, figs. 22, 25, text-fig. 22.

1984 *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM) - JOHNSON: 113, pl. 3, figs. 25-40 [see for extensive synonymy list].

v 1989 *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM) - FÜRSICH & WERNER: 136, pl. 15, figs. 1-5.

1990 *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM) - CLAUSEN & WIGNALL: 118, pl. 5, fig. G.

1995 *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM) - JAITLY *et al.*: 195, pl. 19, figs. 1-4.

MATERIAL. 9 single valves in shell preservation. Due to the poor state of preservation it is not possible to observe the dorsal region and determinate which valves are represented, but all specimens show the characteristic ornamentation of the species (MPZ 00/1704-1712).

DESCRIPTION. Shell medium in size, strongly inflated, suborbicular in shape, inequivalved, inequilateral. Ornamentation consisting of dense, very faint divaricate ribs with punctate interstices as a result of the intersection of ribs with commarginal growth lines. Some commarginal growth bands are very distinct towards the ventral region.

REMARKS. *Camptonectes (C.) auritus* (SCHLOTHEIM) is a very common and well known species in the Jurassic. For an extensive discussion and synonymy see JOHNSON (1984). Our material has been included in this species because of its faint divaricate ornamentation.

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (?) (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. *Camptonectes (C.) auritus* (SCHLOTHEIM) has been interpreted as an epifaunal byssate bivalve (JOHNSON 1984) Trophic group: low level suspension-feeder.

Camptonectes (Camptonectes) sp.

MATERIAL. 2 single fragmented valves in shell preservation (MPZ 00/1713-1714).

REMARKS. The material is poorly preserved but the radial divaricated ornamentation can be observed, an identification at the species level is not possible.

OCCURRENCE. Callovian (Chelva Fm) at Moneva and Lécera (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Camptonectes (C.) auritus* (SCHLOTHEIM). Trophic group: low level suspension-feeder.

Genus *Chlamys* ROEDING 1798

Type species. *Pecten islandicus* MÜLLER 1776.

Subgenus *Chlamys* ROEDING 1798*Chlamys (Chlamys) textoria* (SCHLOTHEIM 1820)

Pl. 4, Figs. 4, 8

1820 *Pectinites textorius* sp. nov. - SCHLOTHEIM: 229.

1984 *Chlamys (Chlamys) textoria* (SCHLOTHEIM) - JOHNSON: 163, pl. 6, figs. 10-12, pl. 7, figs. 1-23, pl. 8, figs. 1-3, 5-20, ?fig. 4 [see for extensive synonymy list].

v 1989 *Chlamys (Chlamys) textoria* (SCHLOTHEIM) - FÜRSICH & WERNER: 138, pl. 11, figs. 2-4.

1995 *Chlamys (Chlamys) textoria* (SCHLOTHEIM) - JAITLY *et al.*: 197, pl. 20, figs. 3-7.

1997 *Chlamys textoria* (SCHLOTHEIM) - BERNAD: 4, pl. 3, fig. 15.

MATERIAL. 3 right valves, one of them in shell preservation, the other two external moulds with remains of shell, 1 left valve in shell preservation. The remaining specimens are single valves (external moulds or in shell preservation), usually fragmented. Total number of specimens: 42 (MPZ 00/1715-1756).

DESCRIPTION. Shell medium in size (maximum 38.2 mm in height), with height greater than length. Moderately inflated, the left valve more so than the right one which has a tendency to become flat. Suborbicular to suboval in shape, inequivalved, inequilateral. Umbones not prominent and orthograte. Auricles separated clearly from the disc, occasionally preserved. Anterior auricle of right valve with a well developed byssal notch. Ornamentation consisting of up to 38 radial ribs, usually of equal strength, intersecting with commarginal growth lines resulting in a scaly pattern. Auricles with the same radial and commarginal ornamentation.

REMARKS. *Chlamys (Ch.) textoria* (SCHLOTHEIM) is a well known species treated thoroughly by JOHNSON (1984). Our material has been included in this species because of its scaly radial ornamentation.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Ricla, Aguilón, Moneva, Lécera (province of Zaragoza) and Muniesa, Ariño, Oliete, Calanda (province of Teruel).

The species has been reported from the Liassic of Spain (BERNAD 1997a) e.g. from the Pliensbachian-Toarcian at La Almunia de Doña Godina area (province of Zaragoza) and Toarcian at La Rambla del Salto (Sierra Palomera, province of Teruel) (BERNAD 1996a,b).

PALAEOAUTECOLOGY. *Chlamys (Ch.) textoria* (SCHLOTHEIM) has been interpreted as an epifaunal byssate bivalve due to its well developed byssal notch (DUFF 1978; JOHNSON 1984). Trophic group: low level suspension-feeder.

Genus *Eopecten* DOUVILLÉ 1897

Type species. *Hinnites tuberculatus* GOLDFUSS errore pro *Spondylus tuberculosus* GOLDFUSS 1836.

Eopecten velatus (GOLDFUSS 1833)

Pl. 4, Fig. 9

- 1833 *Pecten velatus* sp. nov. - GOLDFUSS: 45, pl. 90, fig. 2.
1879 *Pecten velatus* GOLDFUSS - MALLADA: pl. 32, fig. 7.
1885 *Hinnites velatus* GOLDFUSS - MALLADA: 101.
1885 *Pecten velatus* GOLDFUSS - MALLADA: pl. 32, fig. 7.
1966 *Velata tumida* (ZIETEN) - BEHMEL & GEYER: pl. 5, fig. 3.
1984 *Eopecten velatus* (GOLDFUSS) - JOHNSON: 150, pl. 5, figs. 4-5, 7-8 [see for extensive synonymy list].
v 1989 *Eopecten velatus* (GOLDFUSS) - FÜRSICH & WERNER: 140, pl. 13, figs. 1-3.
1995 *Eopecten velatus* (GOLDFUSS) - JAITLY *et al.*: 196, pl. 19, figs. 5, 9-11, pl. 20, fig. 1.
1997 *Eopecten velatus* (GOLDFUSS) - BERNAD: 9, pl. 3, fig. 16.

MATERIAL. 7 left valves, 6 in shell preservation and 1 internal mould, all of them poorly preserved (MPZ 00/1757-1763).

DESCRIPTION. Shell medium to large in size (maximum height 47 mm), inequivalved, inequilateral. Left valve strongly convex, somewhat irregular in outline. Umbones broad, prominent and orthogyrate. Ornamentation consisting of dense radial ribs of varying strength, whereby primary and secondary ribs can be distinguished. Some ribs with small tubercles similar to material from the Kimmeridgian of Portugal described by FÜRSICH & WERNER (1989). Anterior auricle of left valve poorly delimited from the disc, radially ornamented. Surface of shell covered with irregularly spaced commarginal growth bands.

REMARKS. In spite of its poor preservation, the material from the Iberian Range can be placed with confidence in *Eopecten velatus* (GOLDFUSS) because of the characteristic irregular radial ornamentation of the left valve.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Tosos, Moneva, Moyuela (province of Zaragoza), Oliete and Foz Calanda (province of Teruel).

VILANOVA Y PIERA (1863) reported *Pecten velatus* GOLDFUSS from the Liassic at Abejuela (province of Teruel). BEHMEL & GEYER (1966: pl. 5, fig. 3) mentioned and figured *Velata tumida* (ZIETEN) from the Lower Jurassic of the Sierra de Albarracín, a specimen that most likely represents *Eopecten velatus* (GOLDFUSS) (this determination is in agreement with M. GAHR *pers. comm.* 1999). BERNAD (1997a) mentioned and figured *Eopecten velatus* (GOLDFUSS) from other localities of early Jurassic age in Spain.

PALAEOAUTECOLOGY. JOHNSON (1984) interpreted *Eopecten velatus* (GOLDFUSS) as an epifaunal byssate bivalve. Trophic group: low level suspension-feeder.

Genus *Radulopecten* ROLLIER 1911

Type species. *Pecten hemicostatus* MORRIS & LYCETT 1853.

Radulopecten fibrosus (J. SOWERBY 1816)

Pl. 4, Fig. 16

1816 *Pecten fibrosus* sp. nov. - J. SOWERBY: 84, pl. 136, figs. 2.

1978 *Chlamys (Radulopecten) fibrosa* (J. SOWERBY) - DUFF: 72, pl. 6, figs. 2, 7-9, text-fig. 24.

1984 *Radulopecten fibrosus* (J. SOWERBY) - JOHNSON: 203, pl. 10, figs. 7-18, 20-22, ? fig. 24 [see for extensive synonymy list].

v 1989 *Radulopecten fibrosus* (J. SOWERBY) - FÜRSICH & WERNER: 139, pl. 12, figs. 2-3.

MATERIAL. External mould of 1 right valve. 4 single valves, 2 in shell preservation, 1 external mould and 1 internal mould. Material strongly fragmented. Total number of specimens: 5 (MPZ 00/1764-1768).

DESCRIPTION. Shell medium in size (maximum height 30 mm), weakly to moderately inflated. Oval in outline, height greater than length, inequivalved, inequilateral. Umbones inconspicuous, orthogyrate. Ornamentation consisting of at least 10 distinct, broad radial ribs and very faint radial lines in the interstices. Radial ornamentation intersects with commarginal growth lines resulting in a fibrous appearance in the best preserved specimens. Auricles asymmetric, and ctenolium observed in one specimen.

REMARKS. The faint radial lines and oval outline distinguish this species from *Radulopecten scarburgensis* (YOUNG & BIRD) whose outline is more rounded.

OCCURRENCE. Oxfordian (Yátova Fm) at Lécera (province of Zaragoza), Ariño and Oliete (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Chlamys* (*Ch.*) based on the deep byssal notch, ctenolium and strongly asymmetric auricles (JOHNSON 1984). Trophic group: low level suspension-feeder.

Radulopecten inequicostatus (YOUNG & BIRD 1822)

Pl. 4, Fig. 17

- 1822 *Pecten inequicostatus* sp. nov. - YOUNG & BIRD: 235, pl. 9, fig. 7.
1930 *Chlamys (Aequipekten) inaequicostatus* (PHILLIPS) - ARKELL: pl. 8, figs. 4-7.
1931 *Chlamys (Radulopecten) inaequicostata* (PHILLIPS) - ARKELL: 118.
1935 *Chlamys inaequicostata* (YOUNG & BIRD) - ARKELL: xiv.
1936 *Chlamys (Radulopecten) inequicostata* (YOUNG & BIRD) - ARKELL: pl. 52, figs. 1, 3.
1965 *Chlamys (Radulopecten) inequicostata* (YOUNG & BIRD) - COX: 57, pl. 7, fig. 5.
1984 *Radulopecten inequicostatus* (YOUNG & BIRD) - JOHNSON: 217, pl. 11, figs. 2, 4, 7-9 [see for extensive synonymy list].

MATERIAL. 2 external moulds of fragmented single valves (MPZ 00/1769-1770).

DESCRIPTION. Shell large in size (maximum 59.3 mm in length), strongly inflated, suborbicular in outline, equilateral. Umbones prominent, orthogyrate. Ornamentation consisting of 8 radial folds, those in the middle of the shell wider than those anteriorly and posteriorly. The two specimens are probably right valves with ribs broader and flatter than spaces between them which are concave and narrow. Surface of shell covered with commarginal growth lines, irregularly spaced and more conspicuous at adult growth stages.

REMARKS. Although most early authors assigned the species *inequicostatus* to PHILLIPS (1829), ARKELL (1935) correctly attributed authorship to YOUNG & BIRD (1822). JOHNSON (1984) described and discussed the species in detail. Our material has been included in *Radulopecten inequicostatus* (YOUNG & BIRD) because of the irregular radial ornamentation.

OCCURRENCE. Upper Oxfordian at Ariño and Oliete (province of Teruel).

PALAEOAUTECOLOGY. *R. inequicostatus* (YOUNG & BIRD) has been interpreted by JOHNSON (1984) as an epifaunal bivalve with one of the valves in contact with the substrate, and byssate in juvenile stages due to the presence of a small byssal notch. According to JOHNSON, the irregular ornamentation, strong inflation and thick shell are indicative of a sessile life habit. Trophic group: low level suspension-feeder.

Radulopecten scarburgensis (YOUNG & BIRD 1822)

Pl. 4, Fig. 13

- 1822 *Pecten scarburgensis* sp. nov. - YOUNG & BIRD: 234, pl. 9, fig. 10.
1978 *Chlamys (Radulopecten) scarburgensis* (YOUNG & BIRD) - DUFF: 70, pl. 5, figs. 19, 20, 23, 24, 26, 27, pl. 6, figs. 1, 5-6.
1984 *Radulopecten scarburgensis* (YOUNG & BIRD) - JOHNSON: 209, pl. 10, figs. 23, 25-29, ?fig. 19, pl. 11, figs. 1, 3.
v 1989 *Radulopecten scarburgensis* (YOUNG & BIRD) - FÜRSICH & WERNER: 139, pl. 12, fig. 4.

MATERIAL. 3 internal moulds and 2 external moulds of single valves. All specimens are fragmented. Total number of specimens: 5 (MPZ 00/1771-1775).

DESCRIPTION. Shell medium to large in size (maximum length 58.7 mm), moderately inflated, rounded in outline, inequivalved, inequilateral. Umbones inconspicuous, orthogyrate. Ornamentation consisting of at least 10 radial ribs of approximately equal strength.

REMARKS. The studied material has been included in *Radulopecten scarburgensis* (YOUNG & BIRD) because of the kind and number of radial ribs and rounded shape. In this respect it differs clearly from *Radulopecten fibrosus* (J. SOWERBY).

OCCURRENCE. Upper Oxfordian and Lower Kimmerdigian (?) (Yátova and Sot de Chera formations) at Riela (province of Zaragoza) and Ariño (province of Teruel).

PALAEOAUTECOLOGY. According to JOHNSON (1984), the small byssal notch and subsymmetric auricles of *Radulopecten scarburgensis* (YOUNG & BIRD) suggest an epifaunal byssate mode of life in early growth stages, and a free reclining mode of life in later growth stages. Trophic group: low level suspension-feeder.

Radulopecten sigmaringensis (ROLLIER 1915)

Pl. 4, Fig. 10

1915 *Pecten* (*Aequipecten*) *sigmaringensis* sp. nov. - ROLLIER: 474.

1984 *Radulopecten sigmaringensis* (ROLLIER) - JOHNSON: 216, pl. 11, figs. 5-6.

v 1989 *Radulopecten sigmaringensis* (ROLLIER) - FÜRSICH & WERNER: 139, pl. 9, fig. 2.

MATERIAL. 1 articulated specimen in shell preservation, the left valve well preserved (MPZ 00/1776).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	N RIBS	Ah	Ph
MPZ 00/1776	63	59	22.9	11	10	8.9

DESCRIPTION. Shell large in size, strongly inflated, suborbicular in shape, equivalved, equilateral. Umbones inconspicuous, orthogyrate; umbonal angle: 105°. Auricles subequal, the anterior one slightly larger. Ornamentation of left valve with 11 distinct radial ribs, separated by interspaces up to double the width of the ribs. The ribs intersect with dense commarginal growth lines resulting in a scaly appearance, short spines developed towards the antero- and posteroventral margins.

REMARKS. The specimen from the Iberian Range has been included in *Radulopecten sigmaringensis* (ROLLIER), described and discussed in detail by JOHNSON (1984), because of the number of ribs of the left valve and the spinous ornamentation. Our specimen is very similar to the figure of *R. sigmaringensis* given by FÜRSICH & WERNER (1989) from the Upper Jurassic of the Lusitanian basin.

OCCURRENCE. Upper Oxfordian at Ariño (province of Teruel).

PALAEOAUTECOLOGY. According to JOHNSON (1984), *Radulopecten sigmaringensis* (ROLLIER) had a life habit similar to *R. scarburgensis* (YOUNG & BIRD). Trophic group: low level suspension-feeder.

Genus *Spondylopecten* ROEDER 1882

Type species. *Pecten* cf. *erinaceus* BUVIGNIER; ROEDER 1882.

Subgenus *Spondylopecten* ROEDER 1882

Spondylopecten (Spondylopecten) subpunctatus (MÜNSTER 1833)

Pl. 4, Figs. 12, 14-15

1833 *Pecten subpunctatus* sp. nov. - MÜNSTER in GOLDFUSS: 48, pl. 90, figs. 13a-b.

1984 *Spondylopecten (Spondylopecten) subpunctatus* (MÜNSTER) - JOHNSON: 97, pl. 3, figs. 15-19 [see for extensive synonymy list].

1989 *Spondylopecten (Spondylopecten) subpunctatus* (MÜNSTER) - FÜRSICH & WERNER: 134, pl. 11, figs. 5, 8.

MATERIAL. 1 articulated specimen and 19 single valves in shell preservation, usually fragmented (MPZ 00/1777-1796).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	N RIBS
MPZ 00/1778	5.1	5.5	28
MPZ 00/1779	4.6	4.8	31
MPZ 00/1780	5.3	5	32
MPZ 00/1786	6.2	6.6	30

DESCRIPTION. Shell small in size (maximum height: 6.9 mm), strongly inflated, suborbicular, inequilateral. Umbones broad, prominent, orthogyrate, projecting beyond the hinge line. Ornamentation consisting of 26 to 32 regularly spaced radial ribs of approximately equal strength. The ribs diverge towards the anterior and posterior margins. Auricles exhibiting radial and commarginal ornamentation. Surface of shell covered with regularly spaced commarginal growth lines, well seen in the interspaces between the ribs of the better preserved specimens.

REMARKS. JOHNSON (1984) included in *Spondylopecten (S.) subpunctatus* (MÜNSTER) specimens with 27 to 36 or 37 radial ribs. He considered the number of ribs as an important species-specific feature. The specimen figured in Pl. 4, Fig. 12 has 30 radial ribs, but its inequilaterality and divergence of ribs at the anterior margin resembles *S. (S.) cardinatus* (QUENSTEDT 1858) (JOHNSON 1984: pl. 3, fig. 21). Thus, the determination of this specimen is a little doubtful. *Spondylopecten (S.) palinurus* (D'ORBIGNY) has 26 or less radial ribs, and is therefore difficult to separate from specimens of *Spondylopecten (S.) subpunctatus* with few ribs. Clearly the change from one to another species is gradual. Our material has been included in *Spondylopecten (S.) subpunctatus* (MÜNSTER) because the doubtful specimens belong to the same stratigraphic and geographic position than the specimens that

clearly fall within the range of variation of *S. (S.) subpunctatus* (MÜNSTER). All specimens are strongly inflated and come from the Oxfordian times. According to JOHNSON (1984), the inflation of this species is distinct during Oxfordian. This observation is supported by our material.

OCCURRENCE. Oxfordian and Kimmeridgian (Yátova and Loriguilla formations) at Tosos, Lécera (province of Zaragoza) and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. According to JOHNSON (1984), *Spondylopecten (S.) subpunctatus* (MÜNSTER) lived similar to *S. (Plesiopecten) subspinosus* (SCHLOTHEIM). Trophic group: low level suspension-feeder.

Subgenus *Plesiopecten* MUNIER-CHALMAS 1887

Type species. *Pectinites subspinosus* SCHLOTHEIM 1820.

Spondylopecten (Plesiopecten) subspinosus (SCHLOTHEIM 1820)

Pl. 4, Fig. 11

1820 *Pectinites subspinosus* sp. nov. - SCHLOTHEIM: 223.

1936 *Plesiopecten subspinosus* (SCHLOTHEIM) - ARKELL: 364, pl. 53, figs. 4-5.

1984 *Spondylopecten (Plesiopecten) subspinosus* (SCHLOTHEIM) - JOHNSON: 84, pl. 3, figs. 1-5, 7, ? fig. 6 [see for extensive synonymy list].

v 1989 *Spondylopecten (Plesiopecten) subspinosus* (SCHLOTHEIM) - FÜRSICH & WERNER: 135, pl. 11, fig. 7.

1995 *Spondylopecten (Plesiopecten) subspinosus* (SCHLOTHEIM) - JAITLY *et al.*: 194, pl. 18, figs. 14-15.

MATERIAL. 2 articulated specimens, one of them in "butterfly position", 18 single valves in shell preservation. The specimens are usually fragmented, without auricles (MPZ 00/1797-1816).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	N RIBS
MPZ 00/1797	6.6	5.1	14
MPZ 00/1804	7	7.2	12
MPZ 00/1811	5.4	5.3	14

DESCRIPTION. Shell small in size (maximum height: 11.8 mm), strongly inflated, suborbicular, equidimensional, equivalved, equilateral. Umbones broad, prominent, orthogyrate, projecting beyond the hinge line. Ornamentation consisting of 12 to 14 broad and high radial ribs of equal strength. The interspaces are deep and narrower than the ribs. Surface of shell covered with commarginal growth lines that are thick and well developed in the interspaces.

REMARKS. JOHNSON (1984) mentioned as characteristic feature of *Spondylopecten (P.) subspinosus* (SCHLOTHEIM) the presence of 11 to 13 radial ribs. The specimens from the Iberian Range have up to 14 ribs, but in these cases, 12 are prominent and the remaining 2 more faint, situated close to the anterior and posterior margin respectively.

OCCURRENCE. Upper Oxfordian (Yátova and Sot de Chera formations) at Riela, Tosos, Aguilón, Lécera (province of Zaragoza), Muniesa, Oliete and Foz Calanda (province of Teruel).

DE VERNEUIL & COLLOMB (1852) reported *Pecten subspinosus* SCHLOTHEIM from the Oxfordian between Alustante and Prados Redondos (province of Teruel). EZQUERRA (1854) mentioned it from the Jurassic at Alustante and Prados (province of Teruel).

PALAEOAUTECOLOGY. JOHNSON (1984) analysed the life habits of *Spondylopecten (P.) subspinosus* (SCHLOTHEIM) and noted its affinity to reefal environments. It is interpreted as an epifaunal byssate bivalve, at least in juvenile stages. According to JOHNSON (1984), strong inflation, thick shell and prominent ornamentation did not allow it to swim. Trophic group: low level suspension-feeder.

Family **Entoliidae** VON TEPPNER 1922

Genus *Cingentolium* YAMANI 1983

Type species. *Pecten cingulatus* GOLDFUSS 1835 (*non* PHILLIPS).

YAMANI (1983) erected the genus *Cingentolium* to include some species referred earlier on to *Entolium*. *Cingentolium* differs from *Entolium* in the presence of internal lateral ridges at the umbonal region. In internal moulds, this ridges are grooves. Many authors do not agree with this opinion and think that this feature is the result of a diagenetic process (JOHNSON 1984). An exhaustive review of this problem is treated by DAMBORENEA (*in press*).

Subgenus *Cingentolium* YAMANI 1983

Cingentolium (Cingentolium) cingulatum (GOLDFUSS 1835)

Pl. 5, Figs. 1, 4, 7b

1835 *Pecten cingulatus* PHILLIPS - GOLDFUSS: 74, pl. 99, figs. 3a-b.

v 1983 *Cingentolium (Cingentolium) cingulatum* (GOLDFUSS) - YAMANI: 7, pl. 1, figs. 1-5, text-fig. 1.

MATERIAL. In general single valves (an identification as right or left valves was impossible as the auricles are not preserved). There are external and internal moulds but shell preservation dominates. 5 articulated specimens in shell preservation. Total number of specimens: 171 (MPZ 00/1817-1987).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	UA
MPZ 00/1823	16.8	20	4.6	100
MPZ 00/1892	19.7	23.5	-	101
MPZ 00/1905	30.1	32.5	-	100
MPZ 00/1909	23.6	20.3	-	86
MPZ 00/1978	21	23.9	-	96

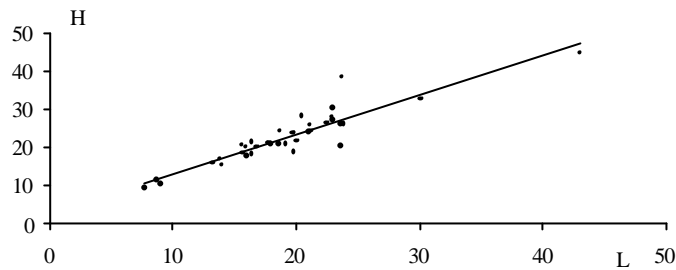


Fig. 49. Length/height ratio of *Cingentolium (C.) cingulatum* (GOLDFUSS). Scale in mm.

DESCRIPTION. Shell medium in size (maximum length: 23.9 mm, Fig. 49), weakly inflated, oval in shape, equivalved, equilateral. Umbones broad, orthogyrate, with an umbonal angle varying between 80° and 103°. Auricles symmetrical, smooth. Auricles of right valve not projecting beyond dorsal margin in contrast to auricles of left valve. Internally, on each side of the a linear radial ridge is seen as well as dense radial lines; in internal moulds, the former are preserved as grooves and the latter as ribs. External ornamentation of both valves consisting of regularly spaced commarginal growth lines.

REMARKS. The material from the Iberian Range is identical to material included in *Cingentolium (C.) cingulatum* (GOLDFUSS) by YAMANI (1983). The species is close to *C. (C.) partitum* (J. DE C. SOWERBY) and differs from it in the presence of dense internal radial lines observed clearly in shells (as grooves) or in internal moulds (as ribs). GOLDFUSS in his original description attributed the species *cingulatus* to PHILLIPS (1829: pl. 5, fig. 2). However, PHILLIPS (1829) had recorded his specimen as *Pecten* sp. For this reason, the author of the name *cingulatus* is GOLDFUSS and not PHILLIPS.

OCCURRENCE. Callovian-Kimmeridgian (Chelva, Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid, Moneva, Lécera (province of Zaragoza), Ariño, Oliete and Obón (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Entolium*. Frequently preserved as pavements or together with individuals of *C. (C.) partitum* (GOLDFUSS). Trophic group: low level suspension-feeder.

Cingentolium (Cingentolium) partitum (J. DE C. SOWERBY 1840)

Pl. 5, Figs. 3, 5-7a

1840 *Pecten partitus* sp. nov. - J. DE C. SOWERBY: 328, pl. 22, figs. 5, 5a.

v 1995 *Cingentolium (Cingentolium) partitum* (J. DE C. SOWERBY) - JAITLY *et al.*: 193, pl. 18, figs. 10-13.

MATERIAL. Mainly, single valves (identification of right and left valves in most cases impossible as auricles are not preserved). There are external and internal moulds but shell preservation dominates. 3 articulated specimens in shell preservation. Total number of specimens: 206 (MPZ 00/1988-2193).

MEASUREMENTS			
SPECIMEN	LENGTH	HEIGHT	UA
MPZ 00/1991	7.3	9	105
MPZ 00/1997	24.3	27.5	106
MPZ 00/2008	19.5	24.2	95
MPZ 00/2060	24.5	27.6	105
MPZ 00/2063	24	27.6	97

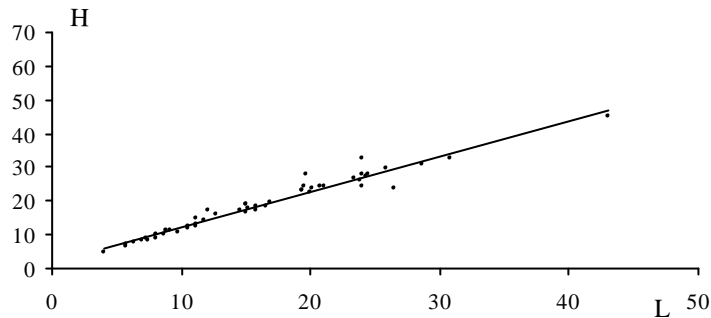


Fig. 50. Length/height ratio of *Cingentolium (C.) partitum* (J. DE C. SOWERBY). Scale in mm.

DESCRIPTION. Shell medium to large in size (maximum height: 60.5 mm, Fig. 50), weakly inflated, oval, equivalved, equilateral. Umbones broad, orthogyrate, umbonal angle varying between 80° and 106°. On each side of the umbo a straight internal ridge can be observed. Auricles symmetrical, smooth. Auricles of right valve not projecting beyond dorsal margin in contrast to auricles of left valve. Surface of shell covered with regularly spaced commarginal growth lines, sometimes commarginal bands are observed, especially in the ventral region of adult individuals.

REMARKS. This species is abundant in all stratigraphic horizons studied in the Iberian Range. *Pecten partitus* J. DE C. SOWERBY was placed by JAITLY *et al.* (1995) in *Cingentolium*, based on the presence of two well developed linear ridges, symmetric auricles and commarginal ornamentation.

OCCURRENCE. Callovian-Kimmeridgian (Chelva, Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid, Aguilón, Tosos, Moneva, Lécera (province of Zaragoza), Muniesa, Ariño, Oliete, Obón and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Entolium*. Frequently preserved as pavements together with specimens of the same species or with *C. (C.) cingulatum* (GOLDFUSS). Trophic group: low level suspension-feeder.

Cingentolium (Cingentolium) sp.

MATERIAL. All specimens are single valves, identification of right and left valves not possible as in most specimens auricles are not preserved. There are external and internal moulds but shell preservation dominates. Total number of specimens: 134 (MPZ 00/2194-2327).

DESCRIPTION AND REMARKS. The material included in *Cingentolium* (*C.*) sp. clearly belongs to the genus as indicated by features such as internal ridges. Because of the poor preservation it was not possible to assign it either to *C. (C.) cingulatum* (GOLDFUSS) or *C. (C.) partitum* (J. DE C. SOWERBY).

OCCURRENCE. Callovian-Kimmeridgian (?) (Chelva, Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid, Aguilón, Tosos, Moneva, Lécera (province of Zaragoza), Ariño and Oliete (province of Teruel).

PALAEOAUTECOLOGY. Similar to *C. (C.) partitum* (J. DE C. SOWERBY) Trophic group: low level suspension-feeder.

Genus *Entolium* MEEK 1865

Type species. *Pecten demissus* PHILLIPS, 1829, illustrated by QUENSTEDT 1858.

Subgenus *Entolium* MEEK 1865

Entolium (Entolium) corneolum (YOUNG & BIRD 1828)

Pl. 5, Fig. 2

1828 *Pecten corneolus* sp. nov. - YOUNG & BIRD: 234, pl. 9, figs. 5.

1829 *Entolium demissus* sp. nov. - PHILLIPS: pl. 6, fig. 5.

1978 *Entolium (Entolium) corneolum* (YOUNG & BIRD) - DUFF: 62, pl. 4, figs. 25, 29-30, pl. 5, figs. 3-5, text-fig. 20 [see for extensive synonymy list].

1984 *Entolium (Entolium) corneolum* (YOUNG & BIRD) - JOHNSON: 45, pl. 1, figs. 24-26.

v 1989 *Entolium (Entolium) corneolum* (YOUNG & BIRD) - FÜRSICH & WERNER: 133, pl. 8, figs. 3-4.

1995 *Entolium (Entolium) corneolum* (YOUNG & BIRD) - JAITLY *et al.*: 193, pl. 18, figs. 8-9.

MATERIAL. In general single valves (identification of right and left valves in most cases impossible as auricles are not preserved). There are external and internal moulds but shell preservation dominates. Total number of specimens: 23 (MPZ 00/2328-2350).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	UA
MPZ 00/2333	30.2	41.7	102
MPZ 00/2337	26.4	32	85
MPZ 00/2346	22.1	28.8	-

DESCRIPTION. Shell medium to large in size (maximum height: 41.7 mm), weakly inflated with inflation being occasionally more pronounced in the umbonal region. Outline oval, higher than long, equivalved, equilateral. Umbones small, broad, orthogyrate, umbonal angle ranging from 85° to 102°. Auricles subequal, symmetrical, auricles of right valve not projecting dorsal margin, in contrast to auricles of left valve. Surface of shell covered with faint commarginal growth lines.

REMARKS. *Entolium (E.) corneolum* (YOUNG & BIRD) differs from *Cingentolium (C.) partitum* (J. DE C. SOWERBY) by its lack of internal lateral ridges in the umbonal region. In the Iberian Range, this species is not very abundant compared to species of *Cingentolium*.

OCCURRENCE. Upper Oxfordian and Kimmeridgian (Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid and Lécera (province of Zaragoza).

PALAEOAUTECOLOGY. According to STANLEY (1970) and DUFF (1978) the thin shell, symmetrical auricles and high umbonal angle show that *Entolium* was a free living epifaunal bivalve able to swim. Trophic group: low level suspension-feeder.

Entolium (Entolium) sp.

MATERIAL In general single fragmented valves. For most specimens it was not possible to identify right and left valves because the auricles are not preserved. There are external and internal moulds, but shell preservation dominates. Total number of specimens: 156 (MPZ 00/3236-3391).

REMARKS. The studied material included in *Entolium (E.) sp.* most likely belongs to *E. (E.) corneolum* (YOUNG & BIRD), but a specific identification is not possible due to the poor preservation.

OCCURRENCE. Callovian-Kimmeridgian (Chelva, Yátova, Sot de Chera and Loriguilla formations) at Ricla, Valmadrid, Tosos, Lécera, Moneva, (province of Zaragoza) and Muniesa, Ariño, Oliete, Foz Calanda and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. Similar to *Entolium corneolum* (YOUNG & BIRD). Trophic group: low level suspension-feeder.

Subclass **Isofilibranchia** IREDALE 1939

Order **Mytiloidea** FÉRUSAC 1822

Superfamily **Mytilacea** RAFINESQUE 1815

Family **Mytilidae** RAFINESQUE 1815

Subfamily **Lithophaginae** ADAMS & ADAMS 1857

Genus *Inoperna* CONRAD in KERR 1875

Type species. *Modiolus (Inoperna) carolinensis* CONRAD 1875.

Inoperna perplicata (ÉTALLON 1863)

Pl. 5, Figs. 8-10

1863 *Mytilus perplicatus* sp. nov. - ÉTALLON in THURMANN & ÉTALLON: 223, pl. 29, fig. 8.
v 1988 *Inoperna perplicata* (ÉTALLON) - FÜRSTICH & WERNER: 126, pl. 11, figs. 1-2, text-fig. 13.

MATERIAL. Internal moulds of 12 articulated specimens, 3 right valves and 3 single valves. External moulds of 1 right valve, 2 left valves and 1 single valve. Almost all of them are fragmented, so no measurements could be taken. In most specimens remains of shell are preserved. 5 specimens found in growth position. Total number of specimens: 22 (MPZ 00/2351-2372).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/2351	88	31.2	11.7

DESCRIPTION. Shell medium-sized, strongly elongated, ensiform, equivalved and very inequilateral. Dorsal and ventral margins approximately parallel, posterior margin strongly rounded. Umbones not very prominent; a rounded posterior umbonal carina divides the shell in two well differentiated regions. Area ventral of the umbonal ridge covered with growth lines, area dorsal of it covered with ribs approximately parallel to growth lines. These primary ribs bifurcate into 2 to 3 secondary ribs of the same thickness half the distance between the dorsal margin and the umbonal carina. Occasionally, some simple secondary ribs are intercalated.

REMARKS. The specimens from the Iberian Range are close to material from the Kimmeridgian of Portugal (FÜRSICH & WERNER 1988); ornamentation and shape being identical. FÜRSICH & WERNER (1988) discussed in detail the synonymies of *Inoperna perplicata* (ÉTALLON) and the main differences between this species and *Inoperna sowerbyana* (D'ORBIGNY 1850) [= *I. plicata* (SOWERBY 1819)]. The studied material from the Iberian Chain was included in *Inoperna perplicata* (ÉTALLON), because the primary ribs bifurcate into 2 or 3 secondary ribs of similar thickness. This species differs from *Inoperna sowerbyana* (D'ORBIGNY), mentioned by MALLADA (1884, 1885) from the Sierra of Albarracín whose primary ribs bifurcate into secondary ribs (from 2 to more than 3) of smaller size than that of the primary ones.

OCCURRENCE. Kimmeridgian (Loriguilla Fm) at Valmadrid and Longares (province of Zaragoza).

PALAEOAUTECOLOGY. POJETA & PALMER (1976) wrote: "Furthermore, not all lithophagins bore into rocky substrates;...lithophagin *Inoperna plicata* (J. SOWERBY) in life position in the Middle Jurassic rocks of England where it occurs in calcareous mudstones (biomicrites) living semi-infaunally". *Inoperna perplicata* (ÉTALLON) had the same mode of life (HEINZE 1991; HOLZAPFEL 1998), the arched shape coinciding well with that of semi-infaunal mytilids. Approximately 25% of the specimens of *Inoperna perplicata* (ÉTALLON) in mudstone of the Loriguilla Fm were found in growth position. Their orientation is similar to that of *Modiolus (M.) bipartitus* J. SOWERBY. Trophic group: middle level suspension-feeder.

Subfamily **Modiolinae** KEEN 1958Genus *Modiolus* LAMARCK 1799Type species. *Mytilus modiolus* LINNÉ 1758.Subgenus *Modiolus* LAMARCK 1799*Modiolus (Modiolus) bipartitus* J. SOWERBY 1818

Pl. 6, Fig. 5

1818 *Modiola bipartita* sp. nov. - J. SOWERBY: 17, pl. 210, fig. 4 (*non* fig. 3).1884 *Mytilus bipartitus* (J. SOWERBY) - MALLADA: pl. 43, fig. 7.1885 *Mytilus bipartitus* (J. SOWERBY) - MALLADA: 90, pl. 43, fig. 7.1929 *Modiola bipartita* J. SOWERBY - ARKELL: 55, pl. 2, figs. 1-4.1978 *Modiolus (Modiolus) bipartitus* J. SOWERBY - DUFF: 41, pl. 2, figs. 28-33.1982 *Modiolus (Modiolus) bipartitus* J. SOWERBY - FÜRSICH: 20, figs. 7 C-D.1991 *Modiolus (Modiolus) bipartitus* J. SOWERBY - DUFF: 43, pl. 1, fig. 19.

MATERIAL. 4 articulated specimens and 1 right valve in shell and good preservation (MPZ 00/2373-2377).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	hL
MPZ 00/2373	37.8	28.4	21.6	11
MPZ 00/2374	35.3	29.4	27	13.5
MPZ 00/2375	38	27.95	23.7	12.4

DESCRIPTION. Shell medium in size, oblique and elongated, very convex, equivalved and very inequilateral. Hinge short and straight. Umbones prominent, slightly recurved and prosogyrate, with a posterior umbonal carina. Ventral margin broadly concave. Dorsal margin straight, becoming convex towards the posterior end; anterior and posterior margins strongly convex. Ornamentation consisting of very fine and dense growth lines.

REMARKS. The material is included in *Modiolus (M.) bipartitus* J. SOWERBY for its prominent umbonal carina and its ornamentation of dense, fine, commarginal growth lines. The synonymy of this species, so common in the Upper Jurassic, was discussed thoroughly by ARKELL (1929) and DUFF (1978). The studied material fits perfectly the figures given by MALLADA (1884, 1885).

OCCURRENCE. Oxfordian (Yátova Fm) of Ariño- Oliete (province of Teruel).

The species was figured and described by MALLADA (1884, 1885), from the Oxfordian of Albarracín and Frías (province of Teruel). MALLADA (1892: 100) mentioned it from Griegos (province of Teruel). DE VERNEUIL & COLLOMB (1852) and EZQUERRA (1854) reported it from the Jurassic of Frías (province of Teruel), VILANOVA Y PIERA (1863) from the "Oxfordico" of Albarracín and Frías (province of Teruel), CORTÁZAR (1885) from the "Grupo Oolítico" of Teruel, and BERNAD (1997a) from the Liassic of Spain.

PALAEOAUTECOLOGY. STANLEY (1970, 1972) demonstrated that several Recent species of *Modiolus* had a semi-infaunal byssate mode of life, shown also by morphological differences to *Mytilus*. In *Modiolus*, the hinge is approximately parallel to a line that connects the muscle scars. The anterior muscle scar is bigger than in *Mytilus* and elongated and the general shape of the shell is more cylindrical than conical. When the byssal retractor muscles, which are situated posterior of the byssus, contract, the resultant of the forces pulls the shell into the substrate. The features of the Jurassic species of *Modiolus* are comparable to those of the Recent species of the genus. FÜRSICH (1976, 1977, 1982) interpreted *Modiolus (M.) bipartitus* J. SOWERBY as endobyssate. The available material exhibits the typical cylindrical shape of the genus. The concave part of the ventral margin most likely corresponds to the position of the byssal gape. Trophic group: middle level suspension-feeder.

Subclass **Palaeoheterodonta** NEWELL 1965

Order **Trigonioida** DALL 1889

Recently, this group has been studied by COOPER (1991) and LEANZA (1993, 1996). The classification scheme of COOPER (1991) is used in this study. LEANZA's scheme (1996) is similar to COOPER's (1991), with slight modifications.

Suborder **Trigoniina** DALL 1889

Superfamily **Trigoniacea** LAMARCK 1819

Family **Trigoniidae** LAMARCK 1819

Genus *Trigonia* BRUGUIÈRE 1789

Type species: *Venus sulcata* HERMANN 1781.

Subgenus *Trigonia* BRUGUIÈRE 1789

Trigonia (Trigonia) cf. reticulata AGASSIZ 1840

Pl. 6, Fig. 1

cf. 1840 *Trigonia reticulata* sp. nov. - AGASSIZ: 39, pl. 11, fig. 10.

cf. 1930 *Trigonia reticulata* AGASSIZ - ARKELL: 81, pl. 6, figs. 1-4.

MATERIAL. 4 right valves and 3 articulated specimens in shell preservation. 2 articulated internal moulds. The material in poorly preserved and generally distorted. Total number of specimens: 9 (MPZ 00/2378-2386).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	C	INFLATION
MPZ 00/2378	35.5	29.7	-	27.6
MPZ 00/2382	65.2	61.3	24.7	42.2
MPZ 00/2384	-	47	16.4	32.5

DESCRIPTION. Shells medium to large in size (maximum length 65.2 mm), strongly inflated, trigonal in outline, equivalved, very inequilateral. Umbones broad, prominent and slightly opisthogyrate. Anterior and ventral margins convex. Ornamentation of flanks consisting of approximately 12 commarginal ribs. Area flat, separated from the flanks by a very well developed carina. Area and carina with transverse striae that exceed in number the commarginal ribs on flanks. Area subdivided by middle carina and covered with radial riblets which intersect the transverse striae to produce a reticulate pattern.

REMARKS. The material has been included in *Trigonia (T.) reticulata* AGASSIZ with some doubts because of its poor preservation. AGASSIZ (1840) erected the species on a fragment of shell with the characteristic reticulate ornamentation of the area. In our material, the area is poorly preserved but it is possible to observe the characteristic reticulate ornamentation and fits perfectly the figure of ARKELL (1930), especially with respect to general shape and ornamentation of the area. The specimens differ from ARKELL's material in having a smaller number of commarginal ribs but they are smaller (61.3 mm in height) than the specimens from the Oxfordian of England (maximum height 100 mm). In trigoniids, the number of commarginal ribs on the flanks is a less diagnostic feature as ornamentation of escutcheon and area.

OCCURRENCE. Upper Oxfordian-Lower Kimmeridgian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Mesozoic trigoniids have been interpreted as shallow infaunal, non siphonate bivalves with a growth position similar to *Neotrigonia*, the only living genus of the family (STANLEY 1977). Prosogyrate umbones facilitate burrowing, and most infaunal bivalves exhibit this feature (STANLEY 1975). However, trigoniids have orthogyrate to opisthogyrate umbones. The evolution of the marked opisthogyrate character of this group can be related to the ornamentation (STANLEY 1977) that assists the burrowing process. STANLEY (1977) placed shells of trigoniids in two categories (1977: 881). The first category comprises shells with a pyramidal posterodorsal region, usually delimited by a carina. The second one includes more elongated species with a recurved, rostrate posterior region. Transitional morphologies also occur. Our material belongs to the first category, and growth position was most likely so that the straight posteroventral margin touched the sediment-water interface. Trophic group: low level suspension-feeder.

Trigonia (Trigonia) sp.

MATERIAL. 1 articulated specimen and 1 left valve, both poorly preserved (MPZ 00/2387-2388).

REMARKS. The material included in *Trigonia (T.) sp.* is similar to the material identified as *Trigonia cf. reticulata* AGASSIZ. Specimens triangular in outline, ornamentation of flanks consisting of commarginal ribs, carina well developed, and area with reticulate ornamentation. It is not possible to describe the material in detail due to its poor state of preservation. The stratigraphic and geographic

position is identical to *Trigonia cf. reticulata* AGASSIZ, so the probability that the specimens belong to this species is high.

OCCURRENCE. Upper Oxfordian-Lower Kimmeridgian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Trigonia cf. reticulata* AGASSIZ. Trophic group: low level suspension-feeder.

Subclass **Heterodonta** NEUMAYR 1883

Order **Myoida** STOLICZKA 1870

Suborder **Myina** STOLICZKA 1870

Superfamily **Myacea** LAMARCK 1809

Family **Corbulidae** LAMARCK 1818

Subfamily **Corbulinae** GRAY 1823

Genus *Corbulomima* VOKES 1945

Type species: *Corbulomima nuciformis* VOKES 1945.

Corbulomima suprajurensis (D'ORBIGNY 1850)

Pl. 6, Fig. 4

1850 *Corbula suprajurensis* sp. nov. - D'ORBIGNY: 50, n°107.

1931 *Corbula suprajurensis* D'ORBIGNY - COTTREAU: 182, pl. 20 (65), fig. 9.

1952 *Corbulomima suprajurensis* (D'ORBIGNY) - CHAVAN: 122, pl. 4, figs. 72-75.

1990 *Corbulomima suprajurensis* (D'ORBIGNY) - CLAUSEN & WIGNALL: 136, pl. 9, figs. A-B, E.

MATERIAL. 2 articulated specimens and 1 right valve in shell preservation (MPZ 00/2389-2391).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/2389	5.7	4	-
MPZ 00/2390	5	3.6	5
MPZ 00/2391	4.1	3.3	3.3

DESCRIPTION. Shell small-sized (maximum height 4 mm), strongly inflated, especially in the umbonal region. Inequivalved, right valve larger than left one, outline subtrigonal and strongly inequilateral. Umbones prominent, prosogyrate, with sinuous posterior umbonal carina. The ventral margin is sinuous posteriorly and broadly convex anteriorly. The posterior end is rostrate. The thick shell is covered with commarginal growth lines.

REMARKS. The material has been included in *Corbulomima suprajurensis* (D'ORBIGNY) because of its small size, strong inflation and sinuous posterior ventral margin. It differs from

Corbulomima carinata (BUVIGNIER) which has a less distinct sinuous ventral margin and a finer ornamentation.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Some siphonate shallow infaunal Recent corbulids can produce a byssus and are sedentary (YONGE 1946). This life habit is also likely in the case of *Corbulomima suprajurensis* (D'ORBIGNY) because its shape is similar to some of these Recent species such as *Corbula gibba* (OLIVI). The Jurassic species of *Corbulomima* have been interpreted as siphonate shallow infaunal bivalves (DUFF 1978). This author used the shape of the posterior margin to reconstruct the depth of burrowing of different species of *Corbulomima*. Species with a truncated posterior margin are shallower burrowers (e. g. *Corbulomima macneillii* (MORRIS)) than species with a rostrate posterior margin such as *Corbulomima suprajurensis* (D'ORBIGNY), in which the siphons are assumed to have been longer. Trophic group: low level suspension-feeder.

Order **Veneroida** ADAMS & ADAMS 1856

Superfamily **Arcticacea** NEWTON 1891

Family **Arcticidae** NEWTON 1891

Genus *Anisocardia* MUNIER-CHALMAS 1863

Type species: *Anisocardia elegans* MUNIER-CHALMAS 1863.

Subgenus *Anisocardia* MUNIER-CHALMAS 1863

Anisocardia (Anisocardia) cf. choffati DE LORIO 1904

Pl. 6, Fig. 7

cf. 1904 *Anisocardia choffati* sp. nov. - DE LORIO: 162, pl. 20, figs. 6-8 (*non* BÖHM).

MATERIAL. 2 articulated specimens in shell preservation (MPZ 00/2392; MPZ 00/3392).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/3392	18.6	16.9	14.8

DESCRIPTION. Shell medium to small in size, strongly inflated, trigonal in outline, equivalved, inequilateral. Umbones broad, prominent, recurved and prosogyrate. Anterodorsal margin excavated, anterior and posterior margins convex, the latter slightly truncated. Ventral margin weakly curved. Ornamentation consisting of regular, fine commarginal growth lines. In the posterior region, very fine radial striae are present, extending for approximately 1/3 of shell length. Due to the poor preservation of the specimens, the number of striae could not be counted.

REMARKS. In shape and ornamentation, the material from the Iberian Range corresponds to *Anisocardia choffati* DE LORIO. It differs from it by the posterior umbonal carina of the latter.

The material differs from *Protocardia choffati* BÖHM (1901) in the umbones of the latter being more pointed and smaller, the umbonal carina being very prominent, and the posterior margin being strongly truncated.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Riela (province of Zaragoza).

PALAEOAUTECOLOGY. According to DUFF (1978), *Anisocardia* is a siphonate infaunal bivalve with a life habit close to that of *Rollierella*. Trophic group: low level suspension-feeder.

Anisocardia (Anisocardia) cf. isocardioides (BLAKE & HUDLESTON 1877)

Pl. 6, Fig. 2

cf. 1877 *Protocardium isocardioides* sp. nov. - BLAKE & HUDLESTON: 397, pl. 14, fig. 12.

cf. 1934 *Anisocardia isocardioides* (BLAKE & HUDLESTON) - ARKELL: 273, pl. 36, figs. 1, 2.

MATERIAL. Internal moulds of 7 articulated specimens and 1 right valve, some of them with remains of shell. Total number of specimens: 8 (MPZ 00/2393-2400).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION
MPZ 00/2394	29.3	33.4	19.8
MPZ 00/2399	25.6	28.2	19.1

DESCRIPTION. Shell medium-sized, higher than long, oval to triangular in outline, strongly inflated, equivalved and inequilateral. Umbones prominent, recurved and prosogyrate. Anterodorsal margin deeply excavated, anterior margin substraight and truncated. Posterior and ventral margins convex and well rounded. Ornamentation consisting of fine commarginal growth lines.

REMARKS. *A. isocardioides* (BLAKE & HUDLESTON) is close to *A. globosa* (ROEMER 1839), the main differences between them having been thoroughly discussed by ARKELL (1934: 274-275). The material from the Iberian Range, included in *A. isocardioides* (BLAKE & HUDLESTON) with some doubts because of its poor preservation, differs from this species in being less rounded and in having a straighter anterior margin.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at Ariño (province of Teruel).

PALAEOAUTECOLOGY. As in other *Anisocardia*. Trophic group: low level suspension-feeder.

Genus *Rollierella* COSSMANN 1924

Type species: *Isocardia laubei* ROLLIER 1913.

Rollierella laubei (ROLLIER 1913)

Pl. 6, Fig. 9

1867 *Isocardia cordata* BUCKMANN - LAUBE: 41, pl. 4, fig. 1 (*non* BUCKMANN).

1913 *Isocardia laubei* sp. nov. - ROLLIER: 209.

1924 *Pseudotrapezium (Rollierella) laubei* (ROLLIER) - COSSMANN: 48, pl. 5, figs. 33-36.

MATERIAL. 1 articulated specimen with remains of shell (MPZ 00/2401).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LP	INFLATION
MPZ 00/2401	27.7	28.2	16.9	18.8

DESCRIPTION. Shell medium-sized (27.7 mm in length), strongly inflated, suborbicular in outline, equivalved, very inequilateral. Umbones broad, recurved and prosogyrate. Dorsal margin substraight to convex, external opisthodontic ligament preserved occupying most part of the posterodorsal margin. Anterodorsal margin concave, deeply excavated. Anterior and ventral margins well rounded, posterodorsal margin forming an angle of approximately 120° with the posteroventral margin. Ornamentation consisting of fine commarginal growth lines.

REMARKS. Shape and external ligament of the specimen perfectly fit *Isocardia laubei* ROLLIER 1913. ROLLIER did not figure the species, but made reference to the figure of *Isocardia cordata* BUCKMANN of LAUBE (1867). This species was included in the subgenus *Rollierella* by COSSMANN (1924), regarded as genus at present.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. *Rollierella laubei* (ROLLIER) has the characteristic globose shape of the genus and is interpreted as a slow burrowing shallow infaunal bivalve with short siphons. Trophic group: low level suspension-feeder.

Rollierella tenuidentata WELLNHOFER 1964

Pl. 6, Figs. 3, 6, 8

v 1964 *Rollierella tenuidentata* sp. nov. - WELLNHOFER: 70, pl. 5, figs. 1-23, pl. 6, figs. 1-8, text-fig. 45-46.

MATERIAL. 12 specimens in shell preservation: 7 articulated, 2 right and 3 left valves. Internal moulds of 3 articulated specimens, 2 right and 2 left valves. The articulated specimens are commonly preserved in "butterfly position". Total number of specimens: 19 (MPZ 00/2402-3420).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LP	INFLATION
MPZ 00/2406	32.5	26	21.4	-
MPZ 00/2407	28.7	26.6	15.5	-
MPZ 00/2408	33.6	28.9	18.4	-
MPZ 00/2411	24.7	21	13.3	16.8

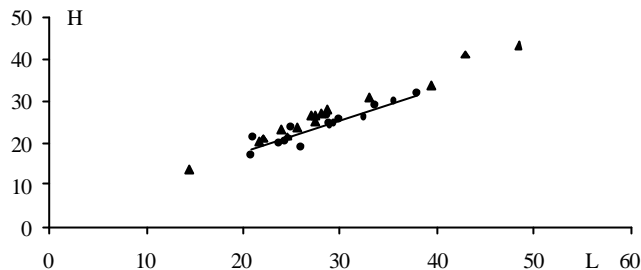


Fig. 51. Length/height ratio of *Rollierella tenuidentata* WELLNHOFER. Scale in mm. Circles represent the material from the Iberian Range, and triangles material from WELLNHOFER (1964: 71).

DESCRIPTION. Shell medium-sized (maximum length 35.6 mm), inflated, oval in outline, longer than high, equivalved and very inequilateral. Umbones prominent and prosogyrate. Anterodorsal margin excavated, posterodorsal margin feebly convex. Remaining margins regularly rounded. Ornamentation consisting of commarginal growth lines.

Features of the hinge of a right valve have been observed (Pl. 6, Fig. 8). It is "lucinoid" with the cardinals 3a and 3b well seen. Due to its poor preservation, no information is available on the presence of lateral teeth.

REMARKS. The material fits *Rollierella tenuidentata* WELLNHOFER, the described hinge features falling in the variability of the species (WELLNHOFER 1964: pl. 6). The shape of the shell and the H/L ratio agree well with paratypes and the holotype of the species (Fig. 51).

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Riela (province of Zaragoza).

PALAEOAUTECOLOGY. DUFF (1978) regarded globose *Rollierella* as a slow burrowing shallow-infaunal bivalves with short siphons. *Rollierella tenuidentata* WELLNHOFER being longer than high is less inflated and more suboval than other species of the genus. This indicates that it could burrow faster, but lived close to the sediment-water interface as its common occurrence in "butterfly position" indicates. Trophic group: low level suspension-feeder.

Superfamily **Carditacea** FLEMING 1820

Family **Permophoridae** VAN DE POEL 1959

Subfamily **Myoconchinae** NEWELL 1957

Genus *Myoconcha* J DE C. SOWERBY 1824

Type species: *Myoconcha crassa* J. DE C. SOWERBY 1824.

Subgenus *Myoconcha* J. DE C. SOWERBY 1824

Myoconcha (Myoconcha) rathieriana D'ORBIGNY 1850

Pl. 6, Figs. 14, 15

1850 *Myoconcha rathieriana* sp. nov. - D'ORBIGNY: 370, N° 369.1901 *Myoconcha rathieriana* D'ORBIGNY - DE LORIOI: 91, pl. 6, figs. 1, 1a, 1b.1906 *Myoconcha rathieriana* D'ORBIGNY - PERON: 95, pl. 5, figs. 4, 5.1927 *Myoconcha rathieriana* D'ORBIGNY - COTTREAU: 128.1928 *Myoconcha rathieriana* D'ORBIGNY - COTTREAU: pl. 5 (47), fig. 18.1998 *Myoconcha (Myoconcha) rathieriana* D'ORBIGNY - HOLZAPFEL: 111, pl. 7, figs. 16-17.

MATERIAL. Mainly articulated internal moulds with remains of shell. Total number of specimens: 25 (MPZ 00/2421-2445).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION	hL
MPZ 00/2421	70.8	44.6	27.9	54
MPZ 00/2422	72.3	38.4	28.6	54
MPZ 00/2433	91.2	42.4	-	64.9

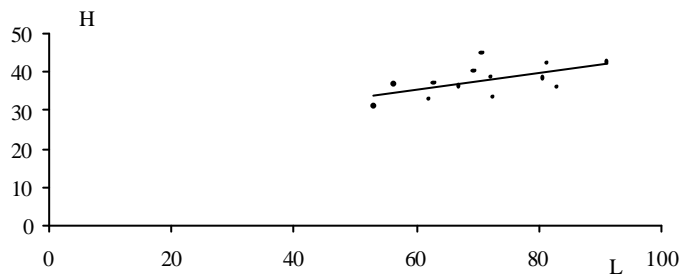


Fig. 52. Length/height ratio of *Myoconcha (M.) rathieriana* D'ORBIGNY. Scale in mm.

DESCRIPTION. Shell medium-sized (maximum length 91 mm, Fig. 52), moderately inflated, modioliform, equivalved and very inequilateral. Umbones not prominent, placed near the anterior end, orthogyrate to prosogyrate. Dorsal margin straight to convex with conspicuous umbonal carina running close to the dorsal margin. On internal moulds, an oval posterior adductor muscle scar placed close to the posterior end as well as a suborbicular anterior adductor muscle scar have been observed. Occasionally, the very thick shell is observed, its surface is covered with dense commarginal growth lines and very faint radial riblets.

REMARKS. The specimens have been included in *Myoconcha (M.) rathieriana* D'ORBIGNY because of their suboval shape and near-parallel dorsal and ventral margins. On most of the available specimens, preserved as internal moulds, only commarginal growth lines can be observed on remains of shell, but the right valve of an articulated specimen (Pl. 6, Fig. 14) shows the characteristic radial ribs of the species.

OCCURRENCE. Callovian (Chelva Fm) at Moneva (province of Zaragoza) Ariño, Oliete and Foz Calanda (province of Teruel).

PALAEOAUTECOLOGY. Because of its modioliform and elongated shape, *Myoconcha* probably was a semi-infaunal, byssate bivalve. Trophic group: medium level suspension-feeder.

Superfamily **Crassatellacea** FÉRUSSAC 1822

Family **Astartidae** D'ORBIGNY 1844

Subfamily **Astartinae** D'ORBIGNY 1844

Genus *Nicaniella* CHAVAN 1945

Type species: *Astarte communis* ZITTEL & GOUBERT 1861.

Subgenus *Nicaniella* CHAVAN 1945

Nicaniella (Nicaniella) cf. phillis (D'ORBIGNY 1850)

Pl. 6, Fig. 12

cf. 1850 *Astarte phillis* sp. nov. - D'ORBIGNY: 363, n° 253.

cf. 1927 *Astarte phillis* D'ORBIGNY - COTTREAU: 117, pl. 16 (46), figs. 6, 7.

cf. 1978 *Nicaniella (Trautscholdia) phillis* (D'ORBIGNY) - DUFF: 98, pl. 11, figs. 18-22, 25-28, pl. 12, figs. 1-4, text-figs. 30-31.

cf. 1991 *Nicaniella (Trautscholdia) phillis* (D'ORBIGNY) - DUFF: 70, pl. 7, fig. 10a-b.

MATERIAL. 3 right, 7 left and 3 single valves in shell preservation or with remains of shell. Most of them poorly preserved. Total number of specimens: 13 (MPZ 00/2446-2458).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	N RIBS
MPZ 00/2451	13.5	11.2	+ 11
MPZ 00/2452	12	10.2	+ 11

DESCRIPTION. Shell small in size (maximum length 13.5 mm), weakly inflated, oval to trigonal in outline, longer than high, equivalved, inequilateral. Umbones broad and prosogyrate, projecting beyond the hinge line. Anterodorsal margin concave, posterodorsal one straight. Ventral margin broadly convex, internally crenulated. Surface covered with at least 11 commarginal ribs.

REMARKS. DUFF (1978: 98) placed *Astarte phillis* D'ORBIGNY in *Nicaniella (Trautscholdia)* because of the presence of cardinal tooth 3a, a typical feature of this subgenus. However, KELLY (1992: 118) showed that in many species of *Nicaniella (Nicaniella)* 3a is weakly developed. KELLY (1992) as well as FÜRSICH *et al.* (2000) are of the opinion that the absence or presence of 3a is not a critical feature for separation of the subgenera. Moreover, KELLY placed species into the subgenus *Trautscholdia* that have narrow and inflated umbones. In our material, features of the hinge have not been observed, but the general shape of shell and the broad and weakly inflated umbones suggest that it is better included in the subgenus *Nicaniella*.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla and Tosos (province of Zaragoza).

PALAEOAUTECOLOGY. According to DUFF (1978: 17) *Nicaniella* is considered as a non-siphonate infaunal bivalve. The strong inflation, strong commarginal lines and thick shell imply that it was a slow burrower. Trophic group: low level suspension-feeder.

Subgenus *Trautscholdia* COX & ARKELL 1948

Type species: *Astarte cordata* TRAUTSCHOLD 1861.

Nicaniella (Trautscholdia) carinata (PHILLIPS 1829)

Pl. 6, Figs. 10-11, 13

1829 *Astarte carinata* sp. nov. - PHILLIPS: pl. 5, fig. 3.

1978 *Nicaniella (Trautscholdia) carinata* (PHILLIPS) - DUFF: 97, pl. 11, figs. 12-17, 23, 24.

1983 *Nicaniella (Trautscholdia)* - MELÉNDEZ *et al.*: 39.

1991 *Nicaniella (Trautscholdia) carinata* (PHILLIPS) - DUFF: 70, pl. 7, fig. 9.

MATERIAL. 550 specimens, most of them in shell preservation, often articulated and many of them found in growth position (MPZ 00/2459-3008).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION	N RIBS
MPZ 00/2464	9.6	8.8	-	12
MPZ 00/2704	8	7	6.75	11
MPZ 00/2705	7.8	7.7	-	13
MPZ 00/2727	7.5	7.15	-	10
MPZ 00/2752	3.8	3.45	-	7
MPZ 00/2755	7.25	6.4	5.5	10
MPZ 00/2831	7.5	7.3	6	9

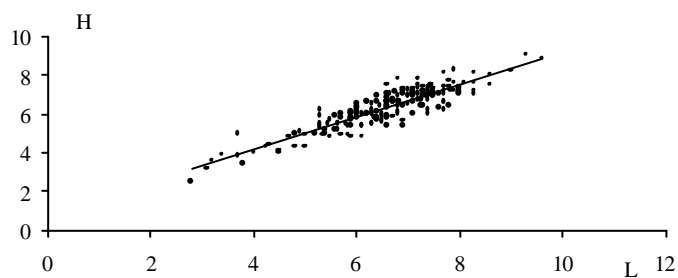


Fig. 53. Length/height ratio of *Nicaniella (Trautscholdia) carinata* (PHILLIPS). Scale in mm.

DESCRIPTION. Shell small-sized (maximum height 8.5 mm, Fig. 53), strongly inflated, globose, trigonal in outline, equivalved and inequilateral. Umbones prominent, recurved and prosogyrate, strongly projecting beyond the hinge line. Anterodorsal and posterodorsal margins concave, anterodorsal one deeply excavated. Ventral margin semi-circular and internally crenulated. Ornamentation consisting of regularly spaced commarginal ribs of similar thickness. Number of ribs ranging from 8 to 14, 10 being

the most common number. In juvenile specimens the number may be as low as 7. Very fine commarginal growth lines covering the whole shell. In the juvenile stage, the shell is rounded and turns trigonal when reaching the adult stage. Strongly inflated in both stages, but commonly more so in adult specimens. Some small and poorly inflated specimens (5 mm in length) have the same number of commarginal ribs (eight) as some adult specimens. They probably represent stunted individuals.

REMARKS. The specimens are very similar to those figured by DUFF (1978). Possibly, according to him, the number of commarginal ribs varies between 8 and 12, 10 being the most common. As described above, our material exhibits between 7 and 14 ribs, the latter being relatively rare. *Nicaniella (T.) carinata* (PHILLIPS) is one of the most common species in the Sot de Chera Fm and all ontogenetic stages are well represented as is the morphological variation. *Nicaniella (Trautscholdia) cordata* (TRAUTSCHOLD), is similar in shape to *Nicaniella (T.) carinata* (PHILLIPS), but the number of commarginal ribs is higher (15-20) according to ARKELL (1934: 240). DUFF (1978: 98) considered *Nicaniella (T.) mosae* (D'ORBIGNY 1850) as a junior synonym of *Nicaniella (Trautscholdia) cordata* (TRAUTSCHOLD 1860).

OCCURRENCE. Oxfordian and Kimmeridgian (Sot de Chera and Loriguilla formations) at Ricla and Valmadrid (province of Zaragoza).

The only record of *Nicaniella (Trautscholdia)* from the Iberian Range so far is by MELÉNDEZ *et al.* (1983: 39) who reported it from the Upper Oxfordian at Moscardón (province of Teruel). Judging from their description it is clear that they belong to *Nicaniella (T.) carinata* (PHILLIPS).

PALAEOAUTECOLOGY. As for *Nicaniella (Nicaniella) phillis* (D'OBIRGNY). Trophic group: low level suspension-feeder.

Genus *Prorokia* BOEHM 1883

Types species: *Cardita ovalis* QUENSTEDT 1852.

Prorokia aff. *moriceana* (DOLLFUS 1863)

Pl. 6, Fig. 17

aff. 1863 *Cardita moriceana* sp. nov. - DOLLFUS: 66, pl. 11, figs. 8-11, pl. 13, fig. 6.

MATERIAL. 2 articulated specimens, 3 right, 4 left valves and 1 single valve, all well preserved. Total number of specimens: 10 (MPZ 00/3009-3018).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	LP	INFLATION
MPZ 00/3009	22.8	16	13.2	-
MPZ 00/3012	23.3	16.4	13.2	9.8
MPZ 00/3015	19.3	14.7	10.1	-
MPZ 00/3018	20.7	14.8	11.6	-

DESCRIPTION. Shell small-sized (maximum length 23.3 mm), inflated, oval to subquadrate in outline, equivalved and inequilateral. Umbones small, acute, prosogyrate; rounded umbonal carina present extending to posteroventral margin. Ventral margin straight and internally crenulated. Anterior margin rounded, convex, the posterior one less so. Surface of shell covered with irregularly spaced commarginal growth lines.

Of internal features of the shell, the hinge of a right valve has been partially observed. It is of the "lucinoid" type (according to CASEY 1952) with cardinals 3a and 3b forming an inverted "V" (Pl. 6, Fig. 17b).

REMARKS. Our material differs from *P. moriceana* (DOLLFUS) which is more oval in shape, has a more convex ventral margin. In *P. moriceana* (DOLLFUS) the anterodorsal margin is more markedly excavated than in our material. The dorsal margin of *P. moriceana* (DOLLFUS) is straight and changes its inclination abruptly, approximately one-fourth of shell height from the umbo, up to posterior margin. In our material, however, the dorsal margin is weakly curved and less steeply inclined towards the posterior. *Astarte meriani* GREPPIN (1899: 87, pl. 8, fig. 9) is a close species, but more oval.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. *Prorokia* is considered here as a shallow infaunal bivalve. The genus has been interpreted as a non-siphonate and mobile bivalve by PUGACZEWSKA (1986). Because of its thick shell and ornamentation it was most likely a slow burrower. Trophic group: low level suspension-feeder.

Prorokia problematica (BUVIGNIER 1852)

Pl. 6, Fig. 16

1852 *Cardita problematica* sp. nov. - BUVIGNIER: 18, pl. 15, figs. 18-23.

? 1893 *Prorockia munieri* DE LORIOL: 109, pl. 8, figs. 8, 9.

1934 *Prorokia problematica* (BUVIGNIER) - ARKELL: 254, pl. 33, figs. 11-13.

1936 *Prorokia problematica* (BUVIGNIER) - ARKELL: pl. 51, figs. 8, 8a.

1982 *Prorokia cf. problematica* (BUVIGNIER) - PUGACEWSKA in BIRKENMAJER *et al.*: 126, pl. 43, fig. 2.

MATERIAL. 1 well-preserved composite mould of a right valve (MPZ 00/3019).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 00/3019	10.5	10

DESCRIPTION. Specimen small-sized (length 10.5 mm), convex, oval in outline and very inequilateral. Umbones small, pointed and prosogyrate; with rounded posterior umbonal carina demarcating the area of greatest inflation. Ventral margin nearly straight forming a right angle with the posterior margin. Ornamentation consisting of commarginal growth lines, which are less spaced anteriorly and posteriorly.

REMARKS. The specimen fits the descriptions given by ARKELL (1934, 1936), especially his pl. 33, fig. 13 and pl. 51, fig. 8. It is more strongly inflated, but this is a variable feature. ARKELL (1934) regarded the English specimens as close to *P. problematica* (BUVIGNIER) with respect to shape, and close to *P. munieri* DE LORIOLE 1893 with respect to ornamentation. As BUVIGNIER's figures are drawings in which the ribbing has been formalized, he considered both species as synonyms. ARKELL's view of the close relationship of the two species is supported by the present specimen. Shape and ornamentation of *P. munieri* DE LORIOLE is close to that of our specimen, but its length is greater and it is less equidimensional. It is therefore included in the synonymy with some doubts.

OCCURRENCE. Callovian (Chelva Fm) at Oliete (province of Teruel).

PALAEOAUTECOLOGY. Shallow infaunal bivalve similar to other species of *Prorokia*. Due to globose shape, it probably burrowed even more slowly than *Prorokia* aff. *moriceana* (DOLLFUS). Trophic group: low level suspension-feeder.

Subfamily **Opinae** CHAVAN 1952

Genus *Coelopsis* FISCHER (ex MUNIER CHALMAS, MS) 1887

Type species: *Opis lunulata* MILLER (errore pro *Cardita lunulata* J. SOWERBY 1819).

Subgenus *Coelopsis* FISCHER (ex MUNIER CHALMAS, MS) 1887

Coelopsis (Coelopsis) sp.

Pl. 7, Fig. 1

MATERIAL. Internal moulds of 5 right and 1 left valve; 1 right valve in shell preservation. Total number of specimens: 7 (MPZ 00/3020-3026).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT
MPZ 00/3020	14.6	18.1
MPZ 00/3021	14.9	16.9

DESCRIPTION AND REMARKS. Specimens small in size, subtrapezoidal, strongly inflated, equivalved and inequilateral. Umbones acute, recurved, prosogyrate and projecting for a beyond hinge line with deep lunule and anterior umbonal carina, anterior margin truncate, posterior and ventral margins convex and regularly rounded. Ornamentation consisting of irregularly spaced commarginal growth lines. The material has been included in *Coelopsis (Coelopsis)* because of the recurved umbones and deep lunule. A specific identification is not possible due to the poor preservation of the specimens.

OCCURRENCE. Callovian and Upper Oxfordian (Chelva and Yátova formations) at Tosos (province of Zaragoza) and Ariño (province of Teruel).

PALAEOAUTECOLOGY. *Coelopsis* has been interpreted as a non-siphonate shallow infaunal bivalve. Trophic group: low level suspension-feeder.

Superfamily **Lucinacea** FLEMING 1828

Family **Mactromyidae** COX 1929

Genus *Mactromya* AGASSIZ 1843

Type species: *Mya rugosa* ROEMER 1836 (= *Lutraria concentrica* MÜNSTER in GOLDFUSS 1841).

The differences between *Unicardium* D'ORBIGNY and *Mactromya* AGASSIZ are not clear (FÜRSICH *et al.* 2000) because the diagnoses given by CHAVAN (1969) are not sufficient to differentiate between the two genera. For the time being, FÜRSICH *et al.* (2000) distinguish them based on their shape: *Unicardium* is more rounded and globose and *Mactromya* elliptical to subrectangular. Irregular commarginal ribbing can be present in both genera.

Mactromya aequalis AGASSIZ 1843

Pl. 7, Fig. 4

1843 *Mactromya aequalis* sp. nov. - AGASSIZ: 196, pl. 9d, figs. 5-8.

1935 *Mactromya aequalis* AGASSIZ - COX: 183, pl. 19, figs. 16-17b.

1939 *Mactromya aequalis* AGASSIZ - STEFANINI: 259, pl. 27, fig. 1.

1965 *Mactromya aequalis* AGASSIZ - COX: 97, pl. 15, fig. 7.

2000 *Mactromya aequalis* AGASSIZ - FÜRSICH *et al.*: 70, pl. 1, figs. 6-9, 16.

MATERIAL. 2 poorly preserved composite internal moulds (MPZ 00/3027-3028).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3027	44.2	32	16.6

DESCRIPTION. Specimens medium to large in size, inflated, subquadrate, equivalved and near-equilateral. Umbones prominent, orthogyrate to prosogyrate with rounded posterior umbonal carina. Anterior and posterior margins nearly straight, forming an angle of approximately 90° with the straight ventral margin. Ornamentation consisting of irregularly spaced commarginal growth lines and folds, stronger in the ventral half of the specimens.

REMARKS. The material has been included in *Mactromya aequalis* AGASSIZ because of its equilaterality, subquadrangular shape and irregularity of commarginal ornamentation. The only difference to AGASSIZ's figures is that the umbones are less prominent. In this respect the material from the Iberian Range is closer to COX's (1935) figures from the Callovian and Oxfordian of British Somaliland. *Mactromya aequalis* AGASSIZ differs from *Mactromya quadrata* (ROEMER 1836) in being less elongated.

OCCURRENCE. Upper Oxfordian and Lower Kimmeridgian (?) (Sot de Chera Fm) at Ricla (province of Zaragoza). The species has been reported by MALLADA (1885, 1892) in Lower and Middle

Jurassic strata of the Iberian Range. CORTÁZAR (1885) mentioned it from the "Grupo Oolítico" at Royuela (province of Teruel).

PALAEOAUTECOLOGY. The shape of *Mactromya* is characteristic for an infaunal mode of life (slow and shallow burrower). As some Recent lucinids, *Mactromya* may have been able to produce a mucus-lined tube and thus live at greater depth than the length of the siphons would allow. Trophic group: low level suspension-feeder.

Mactromya globosa AGASSIZ 1843

Pl. 7, Fig. 2

1843 *Mactromya globosa* sp. nov. - AGASSIZ: 200, pl. 9d, figs. 9-14.

1897 *Unicardium globosum* D'ORBIGNY (AGASSIZ) - DE LORIOL: 87, pl. 12, figs. 11-12.

MATERIAL. 5 articulated specimens in shell preservation, most of them deformed (MPZ 00/3029-3033).

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3029	31.3	22.4	11.4
MPZ 00/3032	36.5	31.2	13.8

DESCRIPTION. Shell medium-sized, strongly inflated and globose, subquadrangular to oval in outline, equivalved and slightly inequilateral. Umbones rounded, prosogyrate, projecting beyond straight dorsal margin. Anterior margin subtruncated, posterior margin convex, ventral margin nearly straight. Ornamentation consisting of regularly spaced commarginal growth lines.

REMARKS. The material from the Iberian Range has been included in *Mactromya globosa* AGASSIZ because of its strong inflation and elliptic outline. It is included in *Mactromya* because presents typical subrectangular shape.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Riela (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to *Mactromya aequalis* AGASSIZ. Trophic group: low level suspension-feeder.

Mactromya ovalis (D'ORBIGNY 1850)

Pl. 7, Fig. 3

1850 *Unicardium ovale* sp. nov. - D'ORBIGNY: 366, N° 310.

1927 *Unicardium ovale* D'ORBIGNY - COTTREAU: 123, pl. 16 (46), fig. 31.

MATERIAL. 1 right and 3 left valves in shell preservation, 1 internal mould of a left valve. Total number of specimens: 5 (MPZ 00/3034-3038).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3034	27.4	21.2	10.2
MPZ 00/3036	28.4	24.2	8.4

DESCRIPTION. Shell medium to small in size, moderately inflated and suborbicular in outline, equivalved, near-equilateral. Umbones rounded, orthogyrate to prosogyrate with faint posterior umbonal carina. Anterior and posterior margins convex, regularly rounded, ventral margin sub-straight. Ornamentation consisting of irregularly spaced commarginal growth lines.

REMARKS. The described material has been included in *Mactromya ovalis* (D'ORBIGNY) because of its outline, and the size. It has been included in *Mactromya* because of its equilaterality.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. Similar to other species of *Mactromya*. Trophic group: low level suspension-feeder.

Genus *Unicardium* D'ORBIGNY 1850

Type species: *Corbula cardioides* PHILLIPS 1829.

Unicardium aceste D'ORBIGNY 1850

Pl. 7, Fig. 5

1850 *Unicardium aceste* sp. nov. - D'ORBIGNY: 366, N° 307.

1927 *Unicardium aceste* D'ORBIGNY - COTTREAU: 122, pl. 16 (46), figs. 26-27.

1934 *Mactromya aceste* (D'ORBIGNY) - ARKELL: 306, pl. 42, figs. 1-5.

MATERIAL. Poorly preserved internal moulds of 2 articulated specimens (MPZ 00/3039-3040).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA	INFLATION
MPZ 00/3039	39.5	34.8	15.9	26
MPZ 00/3040	39.2	34.2	17.4	19.2

DESCRIPTION. Shell medium-sized, orbicular, very globose, equivalved, inequilateral. Umbones prominent, slightly prosogyrate, projecting beyond hinge line. Posterior and ventral margins convex and regularly rounded anterior margin somewhat truncated. Ornamentation consisting of irregularly spaced commarginal growth lines.

REMARKS. The specimens have been included in *Unicardium*, because of their orbicular and globose shape. Our material differs slightly from *Unicardium aceste* D'ORBIGNY as figured by COTTREAU (1927), in the umbones being more rounded, and projecting less beyond the hinge line.

OCCURRENCE. Callovian (Chelva Fm) at Ariño and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium angulatum BOEHM 1883

Pl. 7, Fig. 6

1883 *Unicardium angulatum* sp. nov. - BOEHM: 511, pl. 53, figs. 16-18.

MATERIAL. 2 right valves and 1 articulated specimen in "butterfly position" (MPZ 00/3041-3043).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3041	33.2	30.2	16
MPZ 00/3043	32.3	27.5	12.4

DESCRIPTION. Shell medium-sized, strongly inflated, subquadrate, equivalved and inequilateral. Umbones narrow, prosogyrate with a posterior umbonal carina. Dorsal and posterior margins straight, anterior and ventral margins convex. Ornamentation consisting of regularly spaced commarginal growth lines.

REMARKS. The material fits perfectly *Unicardium angulatum* BOEHM in shape and inflation.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium bernardinum D'ORBIGNY 1850

Pl. 7, Fig. 7

1850 *Unicardium bernardinum* sp. nov. - D'ORBIGNY: 366, N° 314.

1927 *Unicardium bernardinum* D'ORBIGNY - COTTREAU: 124, pl. 16 (46), fig. 32.

MATERIAL. 1 right valve and 1 articulated specimen in "butterfly position" (MPZ 00/3044-3045).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3044	19.3	17.8	10.8

DESCRIPTION. Shell small-sized, strongly inflated, suboval in outline, equivalved and inequilateral. Umbones prominent, near mesial, prosogyrate, with a very faint posterior umbonal carina. Anterior and ventral margins convex, rounded, posterior margin slightly truncated. Ornamentation consisting of regularly spaced dense commarginal growth lines.

REMARKS. The material from Iberian Range agrees well with *Unicardium bernardinum* D'ORBIGNY as figured by COTTREAU (1927), except that the posterior umbonal carina on the posterior region is less distinct.

OCCURRENCE. Upper Oxfordian (Yátova and Sot de Chera formations) at Ricla and Aguilón (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium exiguum DE LORIO 1904

Pl. 7, Fig. 8

1904 *Unicardium exiguum* sp. nov. - DE LORIO: 179, pl. 21, figs. 5-7.

MATERIAL. 1 well preserved right valve (MPZ 00/3046).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3046	13	10.6	5

DESCRIPTION. Shell very small, strongly inflated, equivalved and very inequilateral, oval in outline. Umbones pointed, prosogyrate, situated anteriorly. Anterior and ventral margins rounded, convex, posterior margin convex but obliquely truncated. Ornamentation consisting of regularly spaced dense, commarginal growth lines.

REMARKS. The specimens fits *Unicardium exiguum* as figured by DE LORIO (1904).

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium josephense DE LORIO 1888

Pl. 7, Fig. 11

1888 *Unicardium josephense* sp. nov. - DE LORIO: 239, pl. 25, fig. 6.

MATERIAL. 2 right valves, 1 left valve and 1 articulated specimen. Total number of specimens: 4 (MPZ 00/3047-3050).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3047	25.2	23	13.8
MPZ 00/3049	33.8	30.6	13.45

DESCRIPTION. Shell medium in size, equivalved and inequilateral, moderately inflated, suborbicular with prominent, near-mesial, prosogyrate umbones. Posterodorsal margin oblique, anterior

one slightly truncated, remaining margins regularly curved. Ornamentation consisting of fine, dense commarginal growth lines.

REMARKS. The material has been included in *U. josephense* DE LORIOI because of its rounded shape and larger anterior region compared to the posterior one. This species is close to *U. tombecki* DE LORIOI 1872 but differs from it because of its less expanded anterior region and corresponding greater height-length ratio.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium aff. *tombecki* DE LORIOI 1872

Pl. 7, Fig. 9

aff. 1872 *Unicardium tombecki* sp. nov. - DE LORIOI in DE LORIOI *et al.*: 253, pl. 15, fig. 7.

MATERIAL. 1 articulated internal mould with remains of shell (MPZ 00/3051).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3051	20.9	17.8	11.2

DESCRIPTION. Shell medium in size, subquadrate, moderately inflated, equivalved, inequilateral. Umbones prominent, prosogyrate, situated three-fifth of shell length from the anterior end. Posterior margin truncated, ventral and anterior margins rounded and convex. Anterior part of shell produced, longer than posterior one.

REMARKS. The specimen is close to *U. tombecki* DE LORIOI (1872: 253, pl. 15, fig. 7) with respect to shape and produced anterior region. It differs from that species in having less recurved umbones.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium sp. A

Pl. 7, Fig. 10

MATERIAL. 1 articulated and fragmented specimen in shell preservation (MPZ 00/3052).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3052	27.2	20.9	9

DESCRIPTION AND REMARKS. Shell medium-sized, weakly inflated, oval in outline, equivalved, near equilateral. Umbones broad, submesial, orthogyrate to slightly prosogyrate. Anterior, posterior and ventral margins convex and rounded. Ornamentation consisting of regularly spaced commarginal growth lines. The specimen resembles *U. cardioides* (PHILLIPS 1829: pl. 14, fig. 12), from the Liassic of South England, but in the latter the ventral margin is much straighter. It has been included in *Unicardium* because of its outline, but due to its poor preservation a specific identification has not been possible. It differs from *Unicardium* sp. in being less inflated, having a smaller height-length ratio and broader umbones.

OCCURRENCE. Upper Oxfordian (Sot de Chera Fm) at Ricla (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Unicardium sp.

MATERIAL. Internal moulds of 6 right, 10 left valves, 4 articulated specimens and 1 single valve. Total number of specimens: 21 (MPZ 00/3053-3073).

DESCRIPTION AND REMARKS. Specimens medium to large in size (maximum length 43 mm), of suborbicular shape, very globose, equivalved, nearly equilateral. Umbones prominent, prosogyrate. Margins rounded, convex. Ornamentation consisting of irregularly spaced commarginal growth lines. Due to the poor preservation a specific identification of the specimens is not possible, but they resemble *U. aceste* D'ORBIGNY.

OCCURRENCE. Callovian (Chelva Fm) at Ariño and Oliete (province of Teruel). Lower Kimmeridgian at Ricla and Valmadrid (province of Zaragoza).

PALAEOAUTECOLOGY. As in *Mactromya*. Trophic group: low level suspension-feeder.

Subclass **Anomalodesmata** DALL 1889

Order **Pholadomyoidea** NEWELL 1965

Superfamily **Pholadomyacea** KING 1844

Family **Pholadomyidae** GRAY 1847

Genus *Goniomya* AGASSIZ 1841

Type species. *Mya angulifera* J. SOWERBY 1819.

Subgenus *Goniomya* AGASSIZ 1841

Goniomya (Goniomya) trapezicostata (PUSCH 1837)

Pl. 7, Fig. 12

- 1837 *Lutraria trapezicostata* sp. nov. - PUSCH: 80, pl. 8, fig. 10.
 1842 *Goniomya inflata* sp. nov. - AGASSIZ: 20, pl. 1, fig. 15.
 1852 *Pholadomya trapezina* sp. nov. - BUVIGNIER: 8, pl. 8, figs. 14-18.
 1852 *Pholadomya trapezina* BUVIGNIER - DE VERNEUIL & COLLOMB: 112, pl. 3, fig. 7.
 1881 *Pholadomya trapezina* (BUVIGNIER) - MALLADA: pl. 30 B, fig. 1.
 1885 *Goniomya trapezina* (BUVIGNIER) - MALLADA: 76.
 1885 *Pholadomya trapezina* (BUVIGNIER) - MALLADA: pl. 30 B, fig. 1.
 1965 *Goniomya trapezicostata* (PUSCH) - COX: 129, pl. 21, figs. 2-3.
 1975 *Goniomya trapezicostata* (PUSCH) - PUGACZEWSKA: 75, pl. 7, figs. 3-6, pl. 11, fig. 4.
 1996 *Goniomya (Goniomya) trapezicostata* (PUSCH) - PANDEY *et al.*: 58, pl. 4, fig. 6.

MATERIAL. Internal moulds of an articulated specimen and a right valve (MPZ 00/3074-3075).

MEASUREMENTS

SPECIMEN	HEIGHT
MPZ 00/3074	28.6
MPZ 00/3075	32.2

DESCRIPTION. Specimens medium-sized, elongated-oval in outline, equivalved and inequilateral. Anterior and posterior margins smoothly rounded. Umbones acute and prosogyrate; with umbonal carina. Divaricate ornamentation consisting of horizontal bars in the middle of the valve that join diagonal bars, present on the anterior and posterior flanks. The angle between horizontal and diagonal bars is approximately 40°. The horizontal bars are of the same thickness or thinner than the diagonal bars.

REMARKS. Some species of *Goniomya* exhibit horizontal bars at the juvenile stage; with growth, the ornamentation changes into a very characteristic "V-shaped" pattern (for example *Goniomya (G.) literata* (J. SOWERBY)). In some species, the divaricate ornamentation is replaced by commarginal ornamentation at the adult stage (for example *Goniomya (G.) bicarinata* FÜRSICH 1982). *G. trapezicostata* (PUSCH) differs from other species of this genus in keeping horizontal bars throughout growth. The studied bivalves are not very well preserved, but they are adult individuals (their height being 30 mm), and the characteristic divaricate ornamentation can clearly be observed. They are included in *Goniomya (G.) trapezicostata* (PUSCH) without any doubt.

OCCURRENCE. Middle Oxfordian (Yátova Fm) at Moneva (province of Zaragoza) and Upper Oxfordian (Yátova Fm) at Ariño (province of Teruel).

Goniomya (G.) trapezina (BUVIGNIER) was mentioned repeatedly and figured from the Jurassic of the Iberian Range. DE VERNEUIL & COLLOMB (1852: pl. 3, fig. 7) figured it as *Pholadomya trapezina* BUVIGNIER from the Oxfordian of Frías and Villar del Cobo (province of Teruel). VILANOVA Y PIERA (1863: 66), mentioned it from the same localities and stratigraphic position, indicating that

their material was collected by DE VERNEUIL. They, probably, refer to the same material. MALLADA (1881: lám. 30B, fig. 1; 1885: 76, lám. 30B, fig. 1; 1892: 102) included *trapezina* in the genus *Goniomya* refiguring DE VERNEUIL's original figure. The species *Goniomya* (*G.*) *trapezina*, is considered to be a junior synonym of *Goniomya* (*G.*) *trapezicostata* (PUSCH). Other authors mentioning this species from the Iberian Range, are EZQUERRA (1854) who reported it from the same localities and stratigraphical position as the previous authors and CORTÁZAR (1885) who found it in the "Grupo Oolítico" of the province of Teruel.

PALAEOAUTECOLOGY. *G. trapezicostata*, was like other bivalves of the family Pholadomyidae, a deep infaunal bivalve with long siphons. The divaricate ornamentation possibly supported the burrowing process. Trophic group: low level suspension-feeder.

Genus *Pholadomya* G. B. SOWERBY 1823

Type species. *Pholadomya candida* G. B. SOWERBY 1823.

Subgenus *Pholadomya* G. B. SOWERBY 1823

Pholadomya (*Pholadomya*) *acuminata* HARTMANN 1830

Pl. 7, Figs. 13-14

1830 *Pholadomya acuminata* sp. nov. - HARTMANN in ZIETEN: 87, pl. 66, fig. 1.

1874 *Pholadomya acuminata* HARTMANN in ZIETEN - MOESCH: 55, pl. 22, figs. 4-6.

1878 *Pholadomya acuminata* HARTMANN in ZIETEN - DE LORIOU: 137, pl. 21, fig. 13-14.

? 1881 *Pholadomya acuminata* HARTMANN in ZIETEN - MALLADA: 80, pl. 30 A, figs. 6-7.

MATERIAL. 5 articulated internal moulds (MPZ 00/3076-3080).

DESCRIPTION. Specimens small-sized for the genus (length of our material approximately 30-50 mm), strongly inflated. The generally triangular shape of the specimens is partly the result of strong compactional deformation of specimens preserved in growth position. The original shape is triangular to trapezoidal, equivalved and strongly inequilateral. The umbones are prominent, recurved and prosogyrate. The anterior margin is truncated and the posterior one rounded without siphonal gapes, the ventral margin is straight. The ornamentation consists of 12 to 13 radial ribs. All ribs are of equal strength, they are concentrated towards the anterior region and are increasingly spaced towards the posterior region of the valve. Commarginal growth lines are present throughout, forming tubercles where they intersect the radial ribs.

REMARKS. The material has been included in *Pholadomya* (*Ph.*) *acuminata* HARTMANN based on its size (maximum length 37 mm), subtriangular outline (apart from deformation), truncated anterior margin and the number of radial ribs (the diagnosis of the species referring to 12 and 15). *Pholadomya* (*Ph.*) *acuminata* HARTMANN differs from *Pholadomya* (*Ph.*) *genevensis* PICTET in having less strongly recurved umbones. Although having a similar number of radial ribs, their thickness changes in the latter species towards the posterior. As a result the ornamentation pattern is much more heterogeneous than in *Pholadomya* (*Ph.*) *acuminata* HARTMANN. The present specimens can be

accommodated in *Pholadomya (Ph.) acuminata* HARTMANN, mentioned and figured by MALLADA (1885) from the Oxfordian of Frías-Albarracín, only with some doubts, because the radial ribs could not be observed in the figure, although they are mentioned in the text (p. 80-81), numbering between 12 and 15. MALLADA (1885) finishes by writing: "...cruzadas por arrugas concéntricas que en algunas variedades predominan sobre aquéllas, borrándolas casi por completas". This is interpreted that on the figured specimen radial ornamentation is not preserved.

OCCURRENCE Upper Oxfordian and Kimmeridgian (Yátova, Sot de Chera and Loriguilla formations) in Aguilón, Tosos (province of Zaragoza) and La Cañada de Verich (province of Teruel).

MALLADA (1892) mentioned the species from the Oxfordian of the same area and DEREIMS (1898) from the Lower Oxfordian of Jabaloyas-Griegos (province of Teruel).

PALAEOAUTECOLOGY. Deep burrower; trophic group: low level suspension-feeder.

Pholadomya (Pholadomya) kachchhensis PANDEY, FÜRSICH & HEINZE 1996

Pl. 7, Fig. 15

1994 *Pholadomya (Ph.) inornata* J. SOWERBY - FÜRSICH *et al.*: pl. 2, fig. 4.

1996 *Pholadomya (Pholadomya) kachchhensis* nom. nov. - PANDEY *et al.*: 53, pl. 1, figs. 1-4, 6-10.

MATERIAL. Two articulated internal moulds (MPZ 00/3081-3082).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	H/L	INFLATION (I)	I/L
MPZ 00/3081	59	36	0.61	32	0,54

DESCRIPTION. Specimen medium-sized, inflated and elongated-oval in outline, equivalved and strongly inequilateral. Umbones are prominent and orthogyrate. Anterior and posterior margins rounded, ventral margin smoothly convex. Posterior end with siphonal gape. The number and nature of radial ribs cannot be observed very well, but at least two very faint radial ribs are seen on the posterior flank of the valve.

REMARKS. PANDEY *et al.* (1996: 53-54) discuss *Pholadomya (Ph.) kachchhensis* PANDEY *et al.* and *Pholadomya (Ph.) inornata* J. DE C. SOWERBY 1840 and the difference between the genera *Pholadomya* and *Homomya*. According to them, species with radial ribs although they are very fine or delicate, should be included in *Pholadomya*. In spite of its poor preservation, the specimen can be included in *Pholadomya (Ph.) kachchhensis* because of its elongated-oval shape and the presence of delicate radial ribs near the posterior margin. *Pholadomya (Ph.) inornata* J. DE C. SOWERBY. (30-40 mm in length) differs from *Pholadomya (Ph.) kachchhensis* PANDEY *et al.* (40-80 mm in length) in being much smaller, and the presence of an anterior carina.

OCCURRENCE. Callovian (Chelva Fm) at Ariño and Oliete (province of Teruel).

PALAEOAUTECOLOGY. Deep-infaunal bivalve with long siphons. Trophic group: low level suspension-feeder.

Pholadomya (Pholadomya) sp.

MATERIAL. Internal moulds of 6 articulated specimens and 2 left valves, all of them very deformed (MPZ 00/3083-3090).

DESCRIPTION AND REMARKS. Specimens small-sized (36 mm in length), subtriangular in outline, equivalved and inequilateral. Umbones prominent and orthogyrate to prosogyrate. Anterior margin truncated, posterior one with siphonal gape. Ventral margin straight. Ornamentation consisting of radial ribs that intersect with the growth lines. Due to the poor preservation of the material not possible to identify the species. In particular, the biometric parameters and the number of radial ribs could not be measured. The specimens were included in *Pholadomya (Ph.)* for their subtriangular outline and their truncated anterior margin.

OCCURRENCE. Oxfordian and Kimmeridgian (Yátova and Sot de Chera formations) of Ricla, Valmadrid, Aguilón (province of Zaragoza), Ariño and La Cañada de Verich (province of Teruel).

PALAEOAUTECOLOGY. Like other species of *Pholadomya*. Trophic group: low level suspension-feeder.

Subgenus *Bucardiomya* ROLLIER in COSSMANN 1912

Type species. *Pholadomya bucardium* AGASSIZ 1842.

Pholadomya (Bucardiomya) protei (BRONGNIART 1821)

Pl. 8, Figs. 1, 4-5

1821 *Cardium protei* sp. nov. - BRONGNIART: 570, pl. 7, fig. 7.

1935 *Pholadomya protei* (BRONGNIART) - ARKELL: 333, pl. 46, figs. 8-9, pl. 47, figs. 1-4.

1991 *Pholadomya (Bucardiomya) protei* (BRONGNIART) - DUFF: 74, pl. 8, fig. 1.

MATERIAL. Internal moulds of 51 articulated specimens, 10 right valves and 5 left valves. Some of them are fragmented and occasionally with remains of shell. 30 % of the specimens were preserved in growth position (MPZ 00/3091-3156).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT	INFLATION	N° RIBS
MPZ 00/3101	81.8	97.7	77.2	4
MPZ 00/3103	82	94.9	76	4
MPZ 00/3104	92.5	104.4	92.9	3
MPZ 00/3126	55	75.3	57.6	4
MPZ 00/3127	63.6	75.3	67.35	4
MPZ 00/3131	-	-	-	4
MPZ 00/3134	62.2	69.9	56	4
MPZ 00/3151	82.4	83.55	69.6	4
MPZ 00/3152	103	107	100.3	4
MPZ 00/3156	45.4	45.6	33.3	4

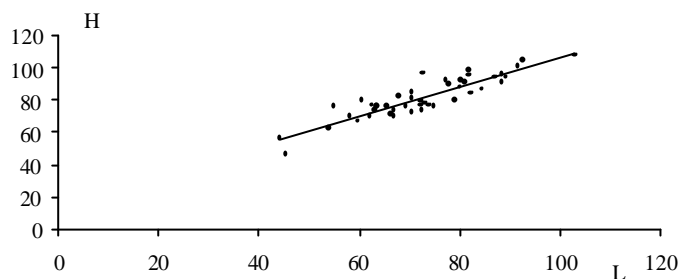


Fig. 54. Length/height ratio of *Pholadomya (Bucardiomya) protei* (BRONGNIART). Scale in mm.

DESCRIPTION. Specimens large (maximum height 107 mm, Fig. 54) and strongly convex, triangular in outline, equivalved and very inequilateral. Umbones prominent, orthogyrate to prosogyrate. Anterior end truncated, heart-shaped in cross-section, posterior one with siphonal gape. Ventral margin straight to slightly convex. Ornamentation consisting of four, less commonly five, thick, radial ribs. The first three radial ribs from the anterior margin are more regularly spaced than the rest. The intercostal space is up to 12 mm, measured at the ventral margin. At intersecting points with growth lines the ribs form small tubercles. In the available material most of the specimens have been eroded; only near the umbo ornamentation can be observed.

REMARKS. The material has been included in *Pholadomya (B.) protei* (BRONGNIART). It is one of the most abundant bivalve species in the Aragonian Branch of the Iberian Range. The diagnosis indicates that the ornamentation could consist of 4 to 6 radial ribs, in some cases even 7. In the Spanish material, as well as the English material described by ARKELL (1935: 335) the commonest number of ribs is 4. The presence of three relatively regularly spaced ribs close to the anterior margin and the truncated nature of the anterior margin are the characteristic features of the species.

OCCURRENCE. Callovian-Oxfordian (Chelva and Yátova formations) at some localities of the Sierra de Arcos and the Sierra de los Moros (province of Teruel) and at Lécera (province of Zaragoza). One specimen comes from the Kimmeridgian, Loriguilla Fm, at Valmadrid (province of Zaragoza).

CORTÁZAR (1885) and MALLADA (1892) mentioned the species from the "Grupo Oolítico" and the Oxfordian of the river Arcos (province of Teruel) respectively, DEREIMS (1898) from the Upper Jurassic of the Sierra de Javalambre (province of Teruel).

PALAEOAUTECOLOGY. *Pholadomya (B.) protei* (BRONGNIART) is interpreted as a deep infaunal bivalve with a long siphon. The presence of large serpulids on the posteroventral area of the shell in some specimens, particularly ones preserved in growth position has been interpreted as due to *post-mortem* colonisation (DELVENE 1997a). Apparently these infaunal bivalves were occasionally partly excavated by high energy events (possible storms) leaving the posteroventral margin exposed (Fig. 55) and providing a substrate for colonisation by serpulids. The preferential area of colonisation and the fact that many *Pholadomya* with serpulids are preserved in growth positions or close to it, demonstrate that the bivalves were not reworked. Trophic group: low level suspension-feeder.

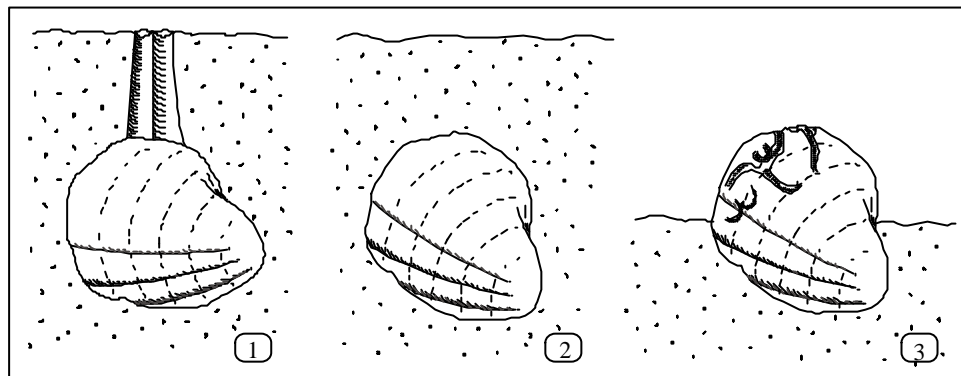


Fig. 55. 1: Growth position of *Pholadomya (Ph.) protei* (BRONGNIART). 2: Shell after decay of soft parts. 3: During high energy events, the shell is partially exhumed and the exposed posteroventral region is colonised by serpulids.

Pholadomya (Bucardiomya) sp.

MATERIAL. 3 articulated internal moulds (MPZ 00/3157-3159).

DESCRIPTION AND REMARKS. Subtriangular in outline, equivalved and very inequilateral. Umbones prominent and orthogyrate to prosogyrate. Anterior margin truncated, and posterior one rounded, convex. Ventral margin straight to convex. Ornamentation consisting of radial ribs that intersect with concentric growth lines, forming tubercles at some of the intersection points. The poor preservation of the material did not allow to measure the biometric parameters and to count the number of radial ribs. The specimens were included in *Pholadomya (B.)* because of their subtriangular outline, truncated anterior margin, and because their height is greater than their length.

OCCURRENCE. Oxfordian and Kimmeridgian (Sot de Chera and Loriguilla formations) of Ricla and Valmadrid (province of Zaragoza).

PALAEOAUTECOLOGY. As other species of *Pholadomya*. Trophic group: low level suspension-feeder.

Family **Pleuromyidae** DALL 1900Genus *Pleuromya* AGASSIZ 1842

Type species. *Mya gibbosa* J. DE C. SOWERBY 1823.

Pleuromya alduini (BRONGNIART 1821)

Pl. 8, Figs. 2-3

1821 *Donacites alduini* sp. nov. - BRONGNIART: 571, pl. 7, fig. 6 a-b.

1934 *Pleuromya alduini* (BRONGNIART) - ARKELL: 321, pl. 44, figs. 1-9.

1978 *Pleuromya alduini* (BRONGNIART) - DUFF: 115, pl. 13, figs. 5-10, 12, 15.

1997 *Pleuromya alduini* (BRONGNIART) - BERNAD: 22, pl. 3, fig. 9.

MATERIAL. Internal moulds of 4 articulated specimens, 3 right valves and 7 left valves, some of them fragmented and some with remains of the shell (MPZ 00/3160-3173).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	LA
MPZ 00/3160	21.5	12.1	6
MPZ 00/3161	27.8	19	12.3
MPZ 00/3162	28	18.3	9
MPZ 00/3165	32.7	21.3	10.7
MPZ 00/3167	41.8	27.9	14.8
MPZ 00/3168	25.9	17	-
MPZ 00/3173	33.7	21.4	10.7

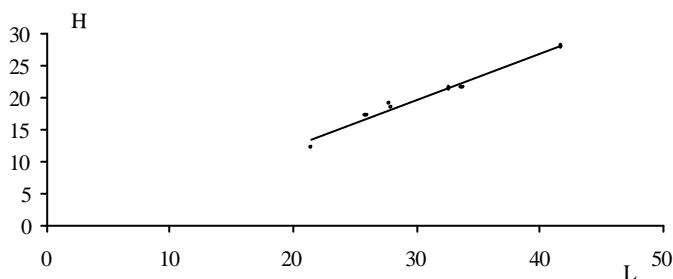


Fig. 56. Length/height ratio of *Pleuromya alduini* (BRONGNIART). Scale in mm.

DESCRIPTION. Specimens medium-sized (Fig. 56), slightly convex and not very elongated, subquadrangular in outline, equivalved and very inequilateral. Umbones orthogyrate and not very prominent. Anterior margin forming an angle of approximately 90° with the anteroventral margin. Ventral margin convex. Neither lunule nor escutcheon present, but as in *P. uniformis* (J. SOWERBY), a deep sulcus runs from below the umbones towards the anteroventral margin. Ornamentation consisting of irregularly spaced commarginal growth lines. No posterior gape was observed, possibly due to the poor preservation of the specimens.

REMARKS. PANDEY *et al.* (1996) showed intermediate forms between *P. uniformis* (J. SOWERBY) and *P. alduini* (BRONGNIART) in the Jurassic of Kachchh. In almost all cases of the Iberian Range both species can be well differentiated. *P. alduini* (BRONGNIART) has a truncated anterior margin forming an angle of 90° with the anteroventral margin, the ventral margin being strongly convex. *P. uniformis* (J. SOWERBY), in contrast, has a rounded anterior margin and the convexity of the ventral margin is less, so the general outline is more elongated. Moreover the shell of *P. uniformis* (J. SOWERBY) is more strongly inflated. In spite of these differences, some specimens (Pl. 8, Fig. 7) included in *P. uniformis* (J. SOWERBY) are transitional to *P. alduini* (BRONGNIART). Moreover, *P. alduini* (maximum length: 41.8 mm) is smaller than *P. uniformis* (J. SOWERBY) (maximum length: 61.5 mm).

OCCURRENCE. Oxfordian and Kimmeridgian (Sot de Chera and Loriguilla formations) in Ricla and Valmadrid (province of Zaragoza).

This species was mentioned by MALLADA (1892), DEREIMS (1898), BERNAD (1997a) from the Lower Jurassic of Spain. BERNAD (1996a,b) mentioned it from the Toarcian of La Almunia-Ricla (province of Zaragoza) and the Rambla del Salto (Sierra Palomera, province of Teruel) and from the Barahona Fm in Soria (BERNAD 1997a: pl. 3, fig. 9).

PALAEOAUTECOLOGY. In the studied outcrops, *P. uniformis* (J. SOWERBY) is common in limestone (Yátova and Chelva formations) of Callovian-Oxfordian age, while *P. alduini* (BRONGNIART) is common in marly sediments of the Upper Oxfordian-Kimmeridgian Sot de Chera Fm. There are no biostratigraphic reasons for this, and according to ARKELL (1934: 323), *P. alduini* (BRONGNIART) exhibits a preference for marly sediments in England.

P. alduini (BRONGNIART) is considered to be a deep infaunal bivalve with long siphons. It was not found in growth position and the percentage of disarticulated valves is higher (60%) than that of articulated specimens. Trophic group: low level suspension-feeder.

Pleuromya uniformis (J. SOWERBY 1813)

Pl. 8, Figs. 6-7

1813 *Unio uniformis* sp. nov. - J. SOWERBY: 83, pl. 33, fig. 4.

1935 *Pleuromya uniformis* (J. SOWERBY) - ARKELL: 325, pl. 45, figs. 1-13.

1978 *Pleuromya uniformis* (J. SOWERBY) - DUFF: 116, pl. 13, figs. 11, 14, 18, 21.

1982 *Pleuromya uniformis* (J. SOWERBY) - FÜRSICH: 106, figs. 39 A-D.

1996 *Pleuromya uniformis* (J. SOWERBY) - PANDEY *et al.*: 62, pl. 7, figs. 5-11.

MATERIAL. 26 articulated internal moulds, some of them fragmented, some with remains of shell (MPZ 00/3174-3199).

MEASUREMENTS

SPECIMEN	LENGTH	HEIGHT	INFLATION	LA
MPZ00/3177	61.5	31.7	25.7	16
MPZ00/3191	42.1	30.6	23.85	30
MPZ00/3193	42.75	25.3	23.7	11.2
MPZ00/3195	32	20.3	15.2	10
MPZ00/3196	42.6	24.6	19.4	15

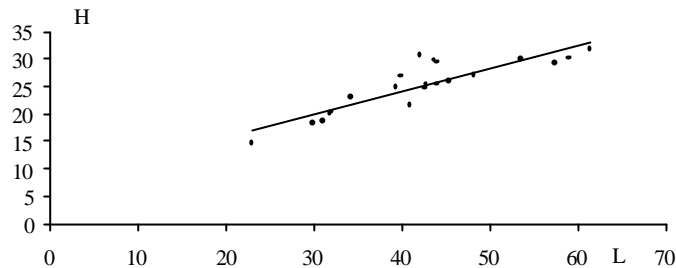


Fig. 57. Length/height ratio of *Pleuromya uniformis* (J. SOWERBY). Scale in mm.

DESCRIPTION. Specimens medium to large in size (Fig. 57), equivalved and inequilateral. Elongated in outline and highly inflated. Anterior margin rounded, anterodorsal margin concave. Ventral margin broadly arched. Umbones orthogyrate and not very prominent, although some are pointed. They are situated at 1/4 of shell length from the anterior end. No lunule or escutcheon seen. On the anterior flank distinct furrow runs from just below the umbones to the anteroventral margin. A siphonal gape is present at the posterior end. As this part of the shell is usually broken, it is not possible to estimate the length in all specimens. The surface is covered with irregularly spaced commarginal growth lines.

REMARKS. *P. uniformis* (J. SOWERBY) is a very common bivalve in the Jurassic worldwide. The synonymies of this species have been discussed thoroughly by ARKELL (1935) and DUFF (1978). The existence of intermediate forms between *P. alduini* (BRONGNIART) and *P. uniformis* (J. SOWERBY) and the main differences between them, were explained earlier on.

OCCURRENCE. Callovian and Oxfordian (Chelva and Yátova formations) at some localities in the Sierra de Arcos and the Sierra de los Moros (province of Teruel).

BERNAD (1996b) mentioned this species from the Toarcian of the Rambla del Salto (Sierra Palomera, province of Teruel).

PALAEOAUTECOLOGY. Deep infaunal bivalve with long siphons. Some specimens were found in growth position. Trophic group: low level suspension-feeder.

Superfamily **Ceratomyacea** ARKELL 1934

Family **Ceratomyidae** ARKELL 1934

Genus *Ceratomya* SANDBERGER 1864

Type species. *Isocardia excentrica* ROEMER 1836.

Ceratomya excentrica (ROEMER 1836)

Pl. 8, Fig. 8

1836 *Isocardia excentrica* VOLTZ MS. - ROEMER: 106, pl. 7, fig. 4.

1934 *Ceratomya excentrica* (ROEMER) - ARKELL: 316, pl. 43, figs. 11-12.

MATERIAL. 1 articulated and fragmented internal mould (MPZ 00/3200).

DESCRIPTION. Specimen large (height >70 mm), strongly convex, equivalved and very inequilateral. Umbones not preserved but apparently strongly prosogyrate. Posterior margin rounded, and ventral margin strongly arched. Ornamentation consisting of ribs that at the juvenile stage (1/4 of height) are commarginal. Ventrally of this part, the ribs follow a smoothly sinuous trajectory that crosses the shell up to intersect with the ventral margin. Thickness of the ribs increasing progressively from the dorsal to the ventral margin.

REMARKS. As the specimen is poorly preserved, the description cannot be more precise and detailed. There are two relatively abundant species in the Oxfordian-Kimmeridgian of Europe: *C. concentrica* (J. DE C. SOWERBY 1825) and *C. excentrica* (ROEMER). The main difference between both species is the ornamentation. In *C. concentrica* (J. DE C. SOWERBY), it consists of commarginal ribs, and in *C. excentrica* (ROEMER) it consists of divaricated ribs. As in the available specimen the ornamentation is clearly not commarginal and as some ribs intersect with the posteroventral margin it can be included in *C. excentrica* (ROEMER). ARKELL (1934) mentioned the high variability of the excentric ornamentation of this species.

OCCURRENCE. Kimmeridgian (Loriguilla Fm) at Valmadrid (province of Zaragoza).

C. excentrica (ROEMER) has been reported by previous authors from the Iberian Range, such as VILANOVA Y PIERA (1863) from the Kimmeridgian between Josa and Obón (province of Teruel); DONAYRE (1873) reported this species from the Jurassic of Aguilón (province of Zaragoza), MALLADA (1885, 1892) from Lower Jurassic and the Oxfordian of several Aragonian localities (Table 5 in Chapter 2), CORTÁZAR (1885) from the "Grupo Oolítico" of Pobo and River Arcos (province of Teruel), and DEREIMS (1898) from the Upper Jurassic of the Sierra de Javalambre (province of Teruel).

PALAEOAUTECOLOGY. Shallow infaunal bivalve with short siphons. Trophic group: low level suspension-feeder.

Superfamily **Pandoracea** RAFINESQUE 1815

Family **Thraciidae** STOLICZKA 1870

Genus *Thracia* J. DE C. SOWERBY 1823 (ex LEACH MS)

Type species. *Mya pubescens* PULTENEY 1799.

Subgenus *Thracia* J. DE C. SOWERBY 1823 (ex LEACH MS)

Thracia (Thracia) depressa (J. DE C. SOWERBY 1823)

Pl. 8, Fig. 9

1823 *Mya depressa*. sp. nov. - J. DE C. SOWERBY: 19, pl. 418.1936 *Thracia depressa* J. DE C. SOWERBY - ARKELL: 354, pl. 50, figs. 7-10.1978 *Thracia (Thracia) depressa* J. DE C. SOWERBY - DUFF: 118, pl. 13, figs. 13, 19-20, 22, 23, 28.1982 *Thracia (Thracia) depressa* J. DE C. SOWERBY - FÜRSICH: 113, figs. 42 A-F.1991 *Thracia (Thracia) depressa* J. DE C. SOWERBY - DUFF: 77, pl. 8, figs. 9-10.

MATERIAL. Internal mould with remains of shell of 1 left valve (MPZ 00/3201).

MEASUREMENTS.

SPECIMEN	LENGTH	HEIGHT
MPZ 00/3201	33.5	22.8

DESCRIPTION. Shell compressed, subtriangular in outline, strongly inequilateral. Umbones small, pointed, slightly opisthogyrate, located near the middle of the shell. Anterior margin rounded, posterior one truncated. Posterior umbonal carina present. Ornamentation of fine commarginal growth lines that can be observed particularly well near the ventral margin where the thin shell is preserved.

REMARKS. Due to the high morphological variability of the species, many authors considered *Thracia depressa* (J. DE C. SOWERBY) and *Thracia incerta* (THURMANN in ROEMER 1836) as synonyms. According to DUFF (1978: 119-120), *Thracia incerta* (THURMANN in ROEMER) usually occurs in the Kimmeridgian-Portlandian, as has been observed by other authors, and it is more elongated, with the umbones located in the anterior region. The triangular outline of the available specimen places it firmly in *Thracia depressa* (J. DE C. SOWERBY).

OCCURRENCE. Callovian (Chelva Fm) at Ariño (province of Teruel).

PALAEOAUTECOLOGY. The elongated outline, compressed and thin shell and posterior gape identify *Thracia depressa* (J. DE C. SOWERBY) as a fast-burrowing and deep bivalve. According to YONGE (1937) the Recent *Thracia pubescens* (PULTENEY) is able to produce mucus-lined tubes in the sediment as a continuation of the siphons and therefore is able to burrow deeper than the length of the siphons would allow. Trophic group: low level suspension-feeder.

5. PALAEOECOLOGY

5.1. METHODS OF STUDY AND TERMINOLOGY

Bed by bed sampling of 14 sections described in Chapter 2 resulted in approximately 3000 specimens of bivalves representing 83 species. 49 samples from four of the sections were selected for a quantitative palaeoecological analysis. The number of individuals was calculated as follows: Bivalves were counted as one individual when articulated. Of disarticulated specimens, the most common valve was counted. When the distinction between right and left valve was not possible, the number of disarticulated specimens was divided by two. According to FÜRSICH (1984) the term "assemblage" is used for autochthonous, but not recurrent or else allochthonous groupings of individuals. The term "association" is used for autochthonous, recurrent groupings of individuals which correspond to relics of palaeocommunities. The palaeoecological associations described here refer only to the bivalve fraction of the benthic fauna.

For grouping samples in bivalve associations a Q-mode hierarchical cluster analysis has been used. The resulting dendrogram based on the Ward Method (Fig. 58) gives a good separation of clusters. The various clusters were combined in five associations and two assemblages. The rest of the samples (Ri₄/184, BE/40, Ri₄/234, BE/39, BE/31, Ri₈/152) contain only few individuals, are statistically not significant and biologically meaningless. For this reason, they are not considered any further.

5.2. TROPHIC GROUPS AND LIFE HABIT GROUPS

The palaeoautecology of bivalves was described in Chapter 4, and is summarised in Fig. 59. It is based on information by YONGE (1937, 1939, 1946, 1953); STANLEY (1970, 1972, 1975, 1977); POJETA & PALMER (1976); FÜRSICH (1976, 1977, 1980, 1982); DUFF (1978); JOHNSON (1984); PUGACZEWSKA (1986); OSCHMANN (1988); HEINZE (1991); MUSTER (1995); HOLZAPFEL (1998) and on own observations.

According to WALKER (1972), the trophic nucleus, the most abundant faunal elements, is approximately 80%.

5.3. DESCRIPTION OF ASSOCIATIONS

5.3.1. *Nanogyra nana-Nicaniella (T.) carinata* ASSOCIATION (ASSOCIATION 1)

The *Nanogyra nana-Nicaniella (T.) carinata* association (Table 9, Fig. 60a) occurs only in the Sot de Chera Fm of the Ricla sector, especially in marly limestone. It consists of 19 samples with 18 species and 676 individuals. There are two species within the trophic nucleus: *Nanogyra nana* (67.8%) and *Nicaniella (T.) carinata* (14.8%). Epifaunal bivalves (76.5%) dominate over infaunal ones (19.9%), and *Gervillella aviculoides* is the only semi-infaunal bivalve (3.8%). Suspension-feeders represent 98.4% of bivalves, only the species of *Palaeonucula* (1.6%) are deposit-feeders. Bivalves are the main benthic group; additional faunal elements are a few specimens of scaphopods, gastropods, and brachiopods. Nektic elements occur occasionally and consist of ammonites. *Nanogyra* is an epifaunal bivalve that dominates in association. Usually left valves are far more abundant than right valves. The reason is that the cemented left valves have a higher preservation potential.

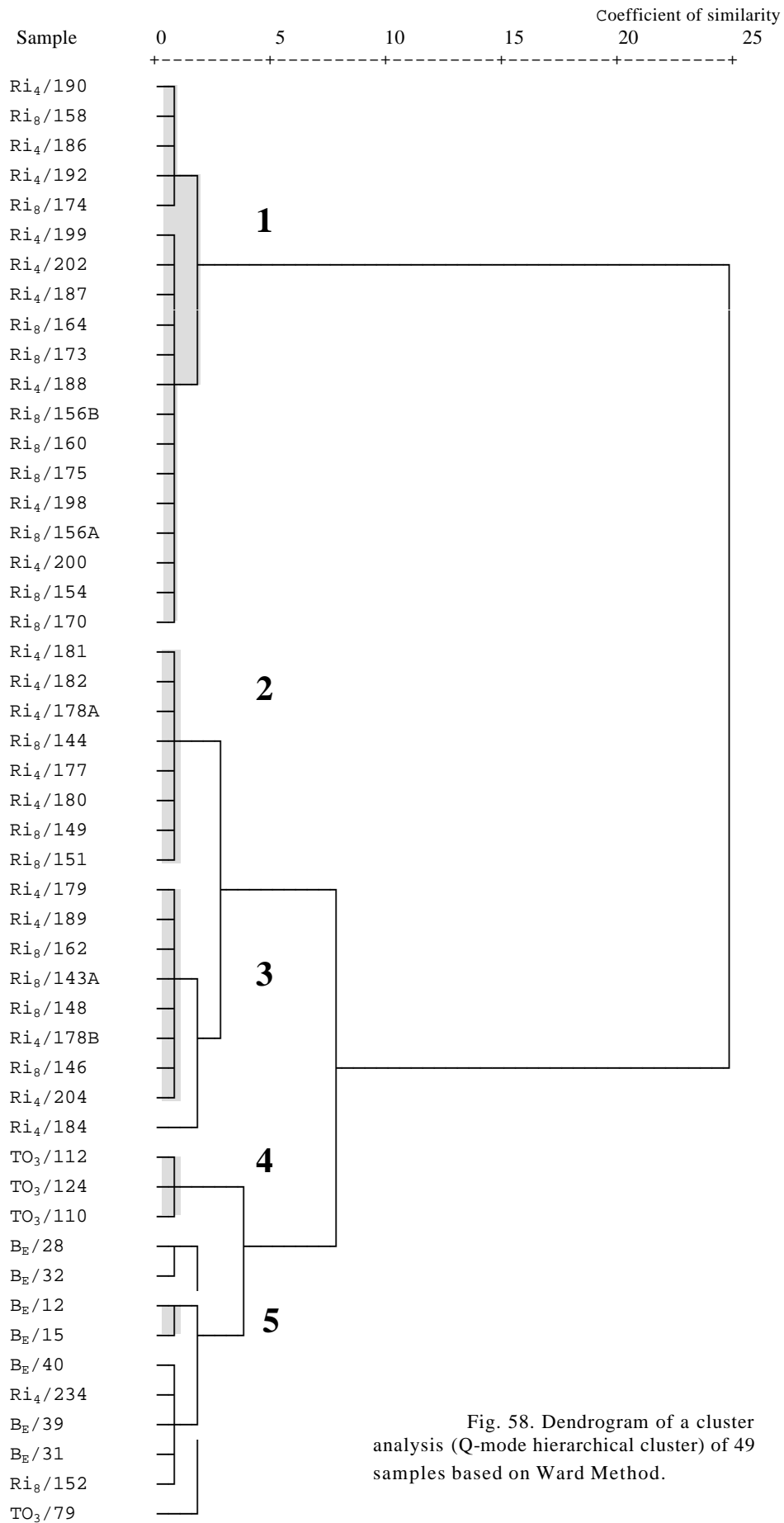


Fig. 58. Dendrogram of a cluster analysis (Q-mode hierarchical cluster) of 49 samples based on Ward Method.

		LIFE-HABIT							TROPHIC-GROUPS			DISTRIBUTION								
		epifaunal	infaunal	epibenthic	byssal	suspension-feeding	deposit-feeding	filter-feeding	low level	middle level	high level	deposit-feeders	suspension-feeders	epifaunal	infaunal	epibenthic	byssal	SPATIAL		TEMPORAL
																		low level	middle level	high level
Nuculidae	<i>Palaeonucula</i>																			
Nuculanidae	<i>Nuculana (Praesaccella)</i>																			
Polidevciidae	<i>Dacryomya</i>																			
Arcidae	<i>Barbatia (Barbatia)</i>																			
Parallelodontidae	<i>Grammatodon (Grammatodon)</i>																			
	<i>Grammatodon (Cosmetodon)</i>																			
Bakevellidae	<i>Gervillia</i>																			
Isognomonidae	<i>Isognomon (Isognomon)</i>																			
Pinnidae	<i>Pinna (Pinna)</i>																			
Limidae	<i>Ctenostreon</i>																			
	<i>Plagiostoma</i>																			
	<i>Pseudolimea</i>																			
Dimyidae	<i>Atrina</i>																			
Palaeolophidae	<i>Actinostreon</i>																			
Ostreidae	<i>Liostraea</i>																			
Gryphaeidae	<i>Gryphaea (Bilobissa)</i>																			
	<i>Nanogyra</i>																			
Oxytomidae	<i>Meleagrinea</i>	○	○					○	○											
Pectinidae	<i>Camptonectes (Camptonectes)</i>																			
	<i>Chlamys (Chlamys)</i>																			
	<i>Eopecten</i>																			
	<i>Radulopecten</i>																			
	<i>Spondylopecten (Spondylopecten)</i>																			
	<i>Spondylopecten (Plesiopecten)</i>																			
Entolidae	<i>Cingetolium (Cingetolium)</i>																			
	<i>Entolium (Entolium)</i>																			
Mytilidae	<i>Inoperna</i>																			
	<i>Modiolus (Modiolus)</i>																			
Trigoniidae	<i>Trigonia (Trigonia)</i>																			
Corbulidae	<i>Corbulomima</i>																			
Arctiidae	<i>Anisocardia (Anisocardia)</i>																			
	<i>Rollierella</i>																			
Permporphoridae	<i>Myoconcha (Myoconcha)</i>																			
Astartidae	<i>Nicaniella (Nicaniella)</i>																			
	<i>Nicaniella (Trautscholdia)</i>																			
	<i>Prorokia</i>																			
	<i>Coelopsis (Coelopsis)</i>																			
Mactromyidae	<i>Mactromya</i>																			
	<i>Unicardium</i>																			
Pholadomyidae	<i>Goniomya (Goniomya)</i>																			
	<i>Pholadomya (Pholadomya)</i>																			
	<i>Pholadomya (Bucardiomya)</i>																			
Pleuromyidae	<i>Pleuromya</i>																			
Ceratomyidae	<i>Ceratomya</i>																			
Thraciidae	<i>Thracia (Thracia)</i>																			

Fig. 59. Summary of the life-habit, trophic-groups and spatial and temporal distribution of the bivalves identified in this study. White circles indicate two possibilities of life habit and trophic group in *Meleagrinea*.

The right valves, being much thinner and opercular, are easily fragmented. The large abundance of left valves and the presence of some right ones indicate that the fauna is autochthonous. The size of *Nanogyra* remains constant in the various samples that constitute the association. Most part of the infaunal bivalves and the semi-infaunal *Gervillella* are articulated, and many of them occur in shell preservation. *Nicaniella (T.) carinata* is represented in various ontogenetic stages. The infaunal *Rollierella tenuidentata* is usually preserved in "butterfly position" indicating that it was a very shallow burrower.

Species of bivalves	Relative abundance (%)	Presence (%)
* <i>Nanogyra nana</i>	67.8	100
* <i>Nicaniella (T.) carinata</i>	14.8	78.9
<i>Gervillella aviculoides</i>	3.9	42
<i>Cingentolium (C.) cingulatum</i>	2.8	57.9
<i>Cingentolium (C.) partitum</i>	2.1	47.4
<i>Grammatodon (G.)</i> sp.	1.8	26.3
<i>Entolium (E.) corneolum</i>	1.2	15.8
<i>Trigonia (T.)</i> cf. <i>reticulata</i>	0.9	21.1
<i>Rollierella tenuidentata</i>	0.9	15.8
<i>Palaeonucula menkii</i>	0.9	21.1
<i>Palaeonucula calliope</i>	0.7	26.3
<i>Pleuromya alduini</i>	0.6	15.8
<i>Nicaniella (N.)</i> cf. <i>phillis</i>	0.6	21.1
<i>Entolium (E.)</i> sp.	0.4	21.1
<i>Pholadomya (Ph.)</i> sp.	0.3	10.5
<i>Mactromya ovalis</i>	0.2	5.3
<i>Cingentolium (C.)</i> sp.	0.2	5.3
<i>Plagiostoma laeviusculum</i>	0.2	5.3

TABLE 9. Relative abundance and presence percentage of bivalves of the *Nanogyra nana-Nicaniella (T.) carinata* association. *: Trophic nucleus. Number of individuals: 676.

5.3.2. *Nicaniella (T.) carinata-Cingentolium* ASSOCIATION (ASSOCIATION 2)

The *Nicaniella (T.) carinata-Cingentolium* association (Table 10, Fig. 60b) occurs in the Sot de Chera Fm of the Ricla sector. It consists of eight samples with 23 species and 293 individuals. There are seven species within the trophic nucleus: *Nicaniella (T.) carinata* (57.3%), *Cingentolium (C.) partitum* (9.6%), *Cingentolium (C.) cingulatum* (5.5%), *Nanogyra nana* (5.5%), *Gervillella aviculoides* (3.8%), *Entolium (E.)* sp. (3.4%) and *Palaeonucula menkii* (3.4%). The most important taxa of the trophic nucleus are *Nicaniella (T.) carinata* and the two species of *Cingentolium*. Infaunal bivalves (68.7%) dominate over epifaunal ones (27.1%). The proportion of infaunal bivalves increased compared to the *Nanogyra nana-Nicaniella (T.) carinata* association. Moreover semi-infaunal bivalves are represented by two species (*Gervillella aviculoides* and *Grammatodon (C.) elongatum*) and their relative abundance is slightly higher (4.1%). Suspension-feeders represent 92.5 % of the bivalves, although deposit-feeders increased considerably (7.5%), the Nuculacea being represented by three species of *Palaeonucula*, *Dacryomya*, and *Nuculana (Praesaccella)*. Bivalves are the main benthic group but the percentage of gastropods and scaphopods has, more than doubled compared to that of the *Nanogyra nana-Nicaniella (T.) carinata* association. Nekitic elements are occasionally recorded and consist of ammonites.

Of *Nicaniella (T.) carinata* both juvenile and adult individuals are present, articulated as well as single valves. The second-most important component of the trophic nucleus, *Cingentolium*, is usually present as single valves in shell preservation.

Species of bivalves	Relative abundance (%)	Presence (%)
* <i>Nicaniella (T.) carinata</i>	57.3	100
* <i>Cingentolium (C.) partitum</i>	9.6	87.5
* <i>Cingentolium (C.) cingulatum</i>	5.5	75
* <i>Nanogyra nana</i>	5.5	100
* <i>Gervillella aviculoides</i>	3.8	62.5
* <i>Entolium (E.)</i> sp.	3.4	62.5
* <i>Palaeonucula menkii</i>	3.4	75
<i>Dacryomya roederi</i>	2.4	62.5
<i>Spondylopecten (P.) subspinosus</i>	1.4	50
<i>Grammatodon (G.)</i> sp.	1.4	37.5
<i>Nicaniella (N.)</i> cf. <i>phillis</i>	1	37.5
<i>Palaeonucula monnandi</i>	0.7	12.5
<i>Palaeonucula calliope</i>	0.7	25
<i>Rollierella tenuidentata</i>	0.7	25
<i>Mactromya ovalis</i>	0.7	25
<i>Pleuromya alduini</i>	0.3	12.5
<i>Grammatodon (C.) elongatum</i>	0.3	12.5
<i>Nuculana (P.) venusta</i>	0.3	12.5
<i>Mactromya globosa</i>	0.3	12.5
<i>Anisocardia (A.)</i> cf. <i>choffati</i>	0.3	12.5
<i>Unicardium</i> sp. A	0.3	12.5
<i>Unicardium bernardinum</i>	0.3	12.5
<i>Entolium (E.) corneolum</i>	0.3	12.5

TABLE 10. Relative abundance and presence percentage of bivalves of the *Nicaniella (T.) carinata*-*Cingentolium* association. *: Trophic nucleus. Number of individuals: 293.

5.3.3. *Nicaniella (T.) carinata*-*Gervillella aviculoides* ASSOCIATION (ASSOCIATION 3)

The *Nicaniella (T.) carinata*-*Gervillella aviculoides* association (Table 11, Fig. 60c) occurs in the Sot de Chera Fm of Riela sector. It consists of eight samples with 30 species and 239 individuals. The trophic nucleus is formed by six species: *Nicaniella (T.) carinata* (28.5%), *Gervillella aviculoides* (19.7%), *Nanogyra nana* (15.5%), *Cingentolium (C.) partitum* (7.1%), *Palaeonucula menkii* (5%), and *Entolium (E.) corneolum* (2.9%). Infaunal bivalves (45.2%) dominate over epifaunal bivalves (33.3%) although the difference is not very big and distinctly smaller than in the *Nicaniella (T.) carinata*-*Cingentolium* association. However, compared to the latter, the proportion of semi-infaunal bivalves increased considerably (21.8%) and consists of three species: *Gervillella aviculoides*, *Pinna (P.)* cf. *socialis* and *Grammatodon (C.) elongatum*. Suspension-feeders represent 91.7% of the bivalves, the percentage of deposit-feeders made up by three species being similar to that of the previous association (8.3%). Bivalves are the main benthic group, the remaining benthic groups (scaphopods, gastropods and brachiopods) occurs sporadically. Nektic elements are infrequent and consist of ammonites.

Nicaniella (T.) carinata, the main component of trophic nucleus, is well represented like in the previous associations. Juvenile and adult individuals are present specimens are commonly articulated. The second main component of the trophic nucleus, *Gervillella aviculoides*, usually occurs articulated and in shell preservation. Left valves of *Nanogyra nana* dominate over right ones. The remaining epifaunal bivalves, most of them belonging to the families Pectinidae and Entoliidae, are preserved as single valves. Among infaunal bivalves, *Rollierella tenuidentata* and *Unicardium angulatum* occur in "butterfly position".

Species of bivalves	Relative abundance (%)	Presence (%)
* <i>Nicaniella (T.) carinata</i>	28.5	100
* <i>Gervillella aviculoides</i>	19.7	100
* <i>Nanogyra nana</i>	15.5	87.5
* <i>Cingetolium (C.) partitum</i>	7.1	62.5
* <i>Palaeonucula menkii</i>	5	75
* <i>Entolium (E.) corneolum</i>	2.9	25
<i>Palaeonucula calliope</i>	2.5	50
<i>Cingetolium (C.) cingulatum</i>	2.5	50
<i>Entolium (E.)</i> sp.	2.5	50
<i>Pinna (P.)</i> cf. <i>socialis</i>	1.7	12.5
<i>Rollierella tenuidentata</i>	1.3	37.5
<i>Unicardium josephense</i>	1.3	12.5
<i>Nicaniella (N.)</i> cf. <i>phillis</i>	1.3	25
<i>Unicardium angulatum</i>	1.3	25
<i>Grammatodon (G.)</i> sp.	0.8	25
<i>Palaeonucula monnandi</i>	0.8	25
<i>Barbatia (B.) tenuitexta</i>	0.4	12.5
<i>Grammatodon (C.) elongatum</i>	0.4	12.5
<i>Prorokia</i> aff. <i>moriceana</i>	0.4	12.5
<i>Pholadomya (B.)</i> sp.	0.4	12.5
<i>Trigonia (T.)</i> sp.	0.4	12.5
<i>Trigonia (T.)</i> cf. <i>reticulata</i>	0.4	12.5
<i>Liostraea dubiensis</i>	0.4	12.5
<i>Camptonectes (C.) auritus</i>	0.4	12.5
<i>Pseudolimea duplicata</i>	0.4	12.5
<i>Corbulomima suprajurensis</i>	0.4	12.5
<i>Rollierella laubei</i>	0.4	12.5
<i>Mactromya globosa</i>	0.4	12.5
<i>Cingetolium (C.)</i> sp.	0.4	12.5
<i>Pleuromya alduini</i>	0.4	12.5

TABLE 11. Relative abundance and presence percentage of bivalves of the *Nicaniella (T.) carinata*-*Gervillella aviculoides* association. *: Trophic nucleus. Number of individuals: 239.

5.3.4. *Grammatodon (G.) concinnum*-*Cingetolium (C.) partitum* ASSOCIATION (ASSOCIATION 4)

The *Grammatodon (G.) concinnum*-*Cingetolium (C.) partitum* association (Table 12, Fig. 60d) occurs in the Sot de Chera Fm of the Tosos sector. It consists of three samples with 10 species and 42 individuals. There are three species in the trophic nucleus: *Grammatodon (G.) concinnum* (50%), *Cingetolium (C.) partitum* (19.1%) and *Entolium (E.)* sp. (7.1%). Epifaunal bivalves (85.8%) dominate over infaunal ones (9.6%). *Pinna (P.)* sp. is the only semi-infaunal bivalve (4.8%). Suspension-feeders account for 92.8%, the rest (7.2%) are deposit-feeders represented by *Palaeonucula*. Bivalves are the main benthic group; in addition, some echinoderms are present. Nectic elements occur occasionally and consist of ammonites.

In general, most of the constituents of the association are preserved as single valves. Only some specimens of *Grammatodon (G.) concinnum* are articulated.

Species of bivalves	Relative abundance (%)	Presence (%)
* <i>Grammatodon (G.) concinnum</i>	50	100
* <i>Cingetolium (C.) partitum</i>	19.1	100
* <i>Entolium (E.)</i> sp.	7.1	33.3
<i>Pinna (P.)</i> sp.	4.8	66.7
<i>Spondylopecten (P.) subspinosus</i>	4.8	66.7
<i>Palaeonucula menkii</i>	4.8	33.3
<i>Radulopecten fibrosus</i>	2.4	33.3
<i>Palaeonucula</i> sp.	2.4	33.3
<i>Nanogyra nana</i>	2.4	33.3
<i>Nicaniella (N.)</i> cf. <i>phillis</i>	2.4	33.3

TABLE 12. Relative abundance and presence percentage of bivalves of the *Grammatodon (G.) concinnum*-*Cingetolium (C.) partitum* association. *: Trophic nucleus. Number of individuals: 42.

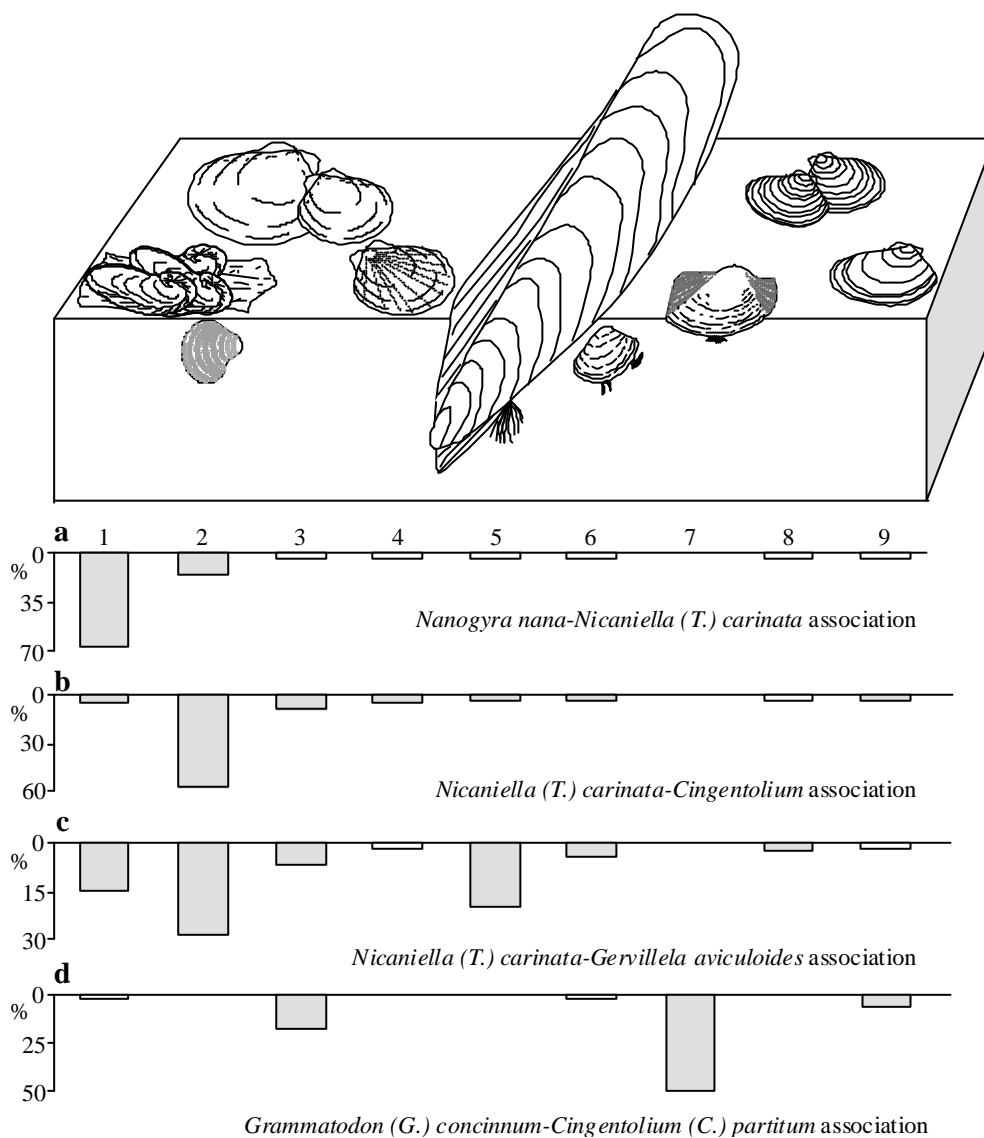


Fig. 60. Trophic nucleus of the *Nanogyra nana*-*Nicaniella (T.) carinata* association (a); *Nicaniella (T.) carinata*-*Cingetolium* association (b); *Nicaniella (T.) carinata*-*Gervillella aviculoides* association (c); *Grammatodon (G.) concinnum*-*Cingetolium (C.) partitum* association (d). 1: *Nanogyra nana*; 2: *Nicaniella (T.) carinata*; 3: *Cingetolium (C.) partitum*; 4: *Cingetolium (C.) cingulatum*; 5: *Gervillella aviculoides*; 6: *Palaeonucula menkii*; 7: *Grammatodon (G.) concinnum*; 8: *Entolium (E.) corneolum*; 9: *Entolium (E.)* sp. Grey rectangles: relative abundances species of the trophic nucleus; white rectangles: relative abundances of species not being part of the trophic nucleus.

5.3.5. *Myoconcha (M.) rathieriana-Plagiostoma fuersichi* ASSOCIATION (ASSOCIATION 5)

The *Myoconcha (M.) rathieriana-Plagiostoma fuersichi* association (Table 13, Fig. 61) occurs in the Callovian Chelva Fm of the Ariño sector. It consists of two samples with 18 species and 118 individuals. The trophic nucleus contains six species: *Myoconcha (M.) rathieriana* (17%), *Plagiostoma fuersichi* (16%), *Ctenostreon proboscideum* (15.3%), *Pholadomya (B.) protei* (15.3%), *Unicardium* sp. (10.2%) and *Anisocardia (A.)* cf. *isocardioides* (5.9%). Epifaunal (43.3%) and infaunal (40%) bivalves are nearly equally abundant. Among infaunal bivalves, approximately half are deep burrowers, the other half are shallow burrowers. The only semi-infaunal bivalve is *Myoconcha (M.) rathieriana* (17%), one of the main components of trophic nucleus. All bivalves are suspension-feeders. Bivalves are the main benthic group, although brachiopods ("terebratulids") are also abundant; in addition, some gastropods are present. Nektic elements are abundant and consist of ammonites and belemnites.

Most of the epifaunal bivalves and the semi-infaunal *Myoconcha* are articulated. In general, they occur in shell preservation, except for *Myoconcha* whose very thick shell is occasionally completely recrystallised and more often not preserved. Internal moulds of serpulids occur in some internal moulds of *Myoconcha* (Pl. 6, Fig. 15). Originally encrusting the interior of the valves, they indicate that encrustation took place post-mortem.

Deep burrowers bivalves are always articulated, and occur usually in growth position. The post-mortem colonisation of large serpulids on the posteroventral area of *Pholadomya (Bucardiomya) protei* (Pl. 8, Fig. 1) was explained in Chapter 4 (Fig. 55). In this case, colonisation was external, and the calcareous tubes of serpulids are preserved.

The taphonomic features show that there is no evidence of reworking. Thus, the association can be regarded as the bivalve relict of a community.

Species of bivalves	Relative abundance (%)	Presence (%)
* <i>Myoconcha (M.) rathieriana</i>	17.0	100
* <i>Plagiostoma fuersichi</i>	16	50
* <i>Ctenostreon proboscideum</i>	15.3	100
* <i>Pholadomya (B.) protei</i>	15.3	100
* <i>Unicardium</i> sp.	10.2	50
* <i>Anisocardia (A.)</i> cf. <i>isocardioides</i>	5.9	100
<i>Coelopsis (C.)</i> sp.	4.2	50
<i>Ctenostreon</i> sp.	3.4	50
<i>Cingentolium (C.) cingulatum</i>	2.5	50
<i>Pseudolimea duplicata</i>	2.5	100
<i>Pleuromya uniformis</i>	1.7	50
<i>Gryphaea (Bilobissa) dilatata</i>	0.9	50
<i>Chlamys (Chlamys) textoria</i>	0.9	50
<i>Cingentolium (C.) partitum</i>	0.9	50
<i>Thracia (Th.) depressa</i>	0.9	50
<i>Pholadomya (P.) kachchhensis</i>	0.9	50
<i>Plagiostoma</i> sp.	0.9	50
<i>Unicardium aceste</i>	0.9	50

TABLE 13. Relative abundance and presence percentage of bivalves of the *Myoconcha (M.) rathieriana-Plagiostoma fuersichi* association. *: Trophic nucleus. Number of individuals: 118.

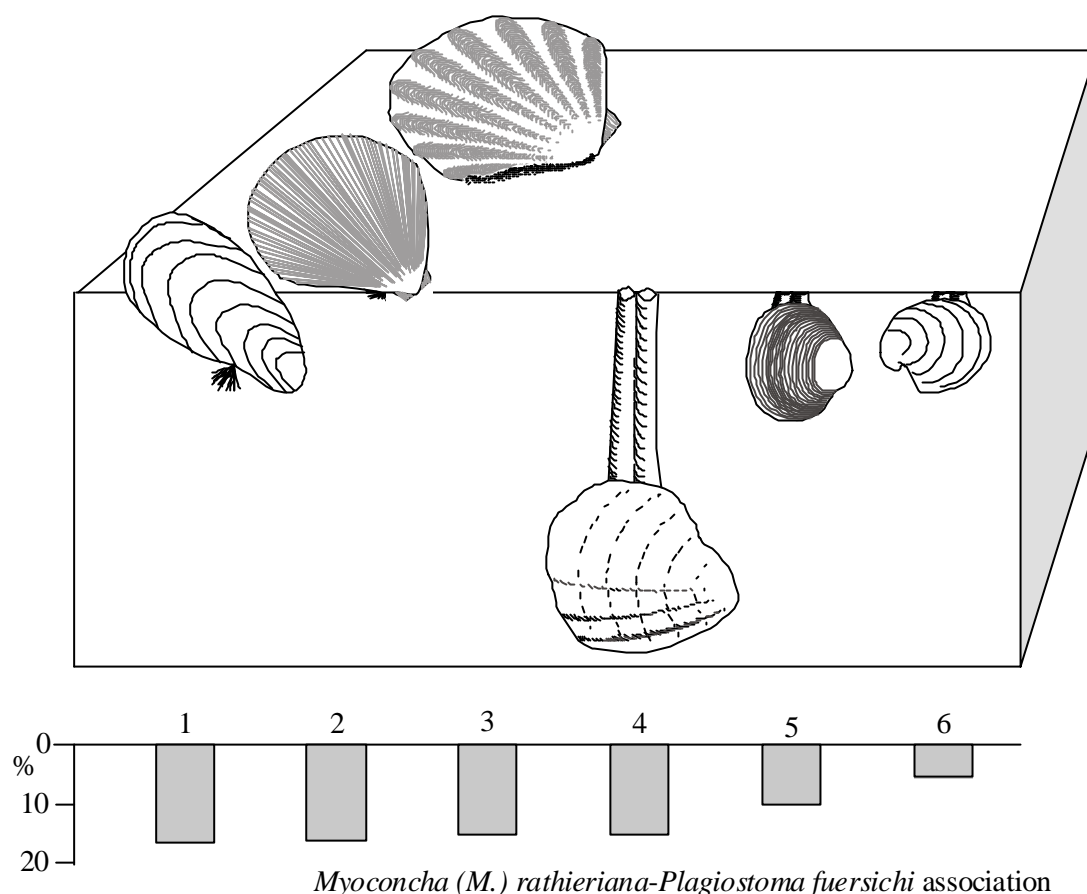


Fig. 61. Trophic nucleus of the *Myoconcha (M.) rathieriana*-*Plagiostoma fuersichi* association. 1: *Myoconcha (M.) rathieriana*; 2: *Plagiostoma fuersichi*; 3: *Ctenostreon proboscideum*; 4: *Pholadomya (B.) protei*; 5: *Unicardium* sp.; 6: *Anisocardia (A.)* cf. *isocardioides*. The grey rectangles indicate the relative abundance of a species within the trophic nucleus.

5. 4. DESCRIPTION OF ASSEMBLAGES

The two assemblages come from the Yátova Fm. According to KRAUTTER (1998), the Yátova Fm is characterized by very low sedimentation rates. As a result, the source of nutrients is low and suspension-feeders (bivalves, crinoids or serpulids) are less abundant than in other late Jurassic settings. Sponges are well adapted to these conditions, although the low nutrient level is reflected in the low diversity and type of sponges of the Yátova Fm (KRAUTTER 1998).

Bivalves are usually disarticulated and epifaunal taxa dominate. Cemented taxa such as *Actinostreon* or *Atreta* are commonly present.

5.4.1 "TOSOS ASSEMBLAGE"

The "Tosos assemblage" (Table 14) occurs exclusively in the Yátova Fm (Upper Oxfordian) of the Tosos region. It consists of numerous small-sized benthic taxa of which not all could be identified. Among the bivalves, there are four species: *Palaeonucula* sp., *Atreta* cf. *lepis*, *Spondylopecten (S.) subpunctatus*, and *Pseudolimea duplicata*, corresponding to 13% of the assemblage. Moreover, there are many fragments of bivalves that could not be identified so that the total number of individuals could not be determined. Brachiopods are the dominant group (53%), among them *Monticlarrella trilobotes*, *Trigonellina loricata*, *Dictyothyris kurri*, *Galliennithyris* cf. *berlieri* and *Acanthorhynchia*

(*Echinirhynchia*) *lorioli*. Another abundant group are Echinodermata (crinoids and echinoids). Calices of *Eugeniocrinites caryophyllites* account for 24.7% of the total fauna and a large number of different kinds of crinoids ossides, among them "*Pentacrinites*", is present. Finally, 9.2% of the total fauna are gastropods. Sponges are an abundant group in this part of the Yátova Fm; some of them are quite small. Nectic elements are also well represented and consist of small-sized ammonites (including *Aptychus*) and belemnites.

Benthic groups	N° Individuals	Relative abundance (%)
Bivalves (total)	42	13
<i>Palaeonucula</i> sp.	20	
<i>Atreta</i> cf. <i>lepis</i>	11	
<i>Spondylopecten</i> (<i>S.</i>) <i>subpunctatus</i>	9	
<i>Pseudolimea duplicata</i>	2	
Brachiopods	172	53
Gastropods	30	9.2
Crinoids (<i>Eugeniocrinites</i>)	80	24.7

TABLE 14. Relative abundance and number of individuals of benthic groups of the "Tosos assemblage". Total number of individuals: 324.

Members of the Nuculacea are uncommon in the Yátova Fm, found only in the To₃ section. The analysed levels (77 and 79, Fig. 12) consist of marl and are intercalated between levels of sponge wackestone. In this assemblage, epifaunal groups dominate over infaunal ones, brachiopods and crinoids accounting for close to 80%. Among bivalves, almost half lived epifaunally, of them, half were cementing. The latter belong to *Atreta* (always the cemented right valves are preserved), which sometimes lived attached to sponge fragments.

Apparently, the domination of epifauna over infauna seems to indicate that the substrate was relatively consolidated and stable, especially for crinoids and brachiopods. The good preservation of the fossils indicates that the transport was insignificant. The high diversity and relative abundance of brachiopods show that the conditions were more optimal for this group than for bivalves. The water energy might have been lower, than normal in Yátova Fm, so that members of the Nuculacea could feed on organic matter in the substrate. The small size of specimens could have been caused by the generally very low nutrient supply.

5.4.2. "BARRANCO DE LAS ESTACAS ASSEMBLAGE"

The "Barranco de las Estacas assemblage" occurs in limestone of Yátova Fm at "Barranco de las Estacas" (Ariño). It consists of 2 samples with 5 species and 21 individuals. The species are: *Cingetolium* (*C.*) *partitum* (42.9%), *Entolium* (*E.*) sp. (19%), *Actinostreon* sp. (19%), *Actinostreon* cf. *solitarium* (14.3%) and *Modiolus* (*M.*) *bipartitus* (4.8%). All bivalves are suspension-feeders, epifauna (95.2%) dominating over semi-infauna (*Modiolus*). Bivalves are not the dominant group; the benthic fauna consist of similar proportions of bivalves, brachiopods (terebratulids) and crinoids. Nectic elements (ammonites) are common.

Due to the low number of individuals in the samples, the given relative abundances are statistically not significant. Faunal composition, taphonomic features and sediment suggest that the substrate was stable and relatively firm, and the water energy medium to high.

5.5. ENVIRONMENTAL FACTORS CONTROLLING BIVALVE ASSOCIATIONS

5.5.1. SUBSTRATE

Substrate was the main factor controlling the bivalve associations in space and time. Interrelated associations 1, 2 and 3 (Figs. 62a, 63) occur in the upper interval of the Sot de Chera Fm (Upper Oxfordian) of the Ricla area. This interval was described in sections Ri₄ and Ri₈ (Figs. 7b, 9b-c) and is characterized by a decreasing marl/limestone ratio. The three associations occur in both marl and limestone. The marl contains flakes and dispersed bioclasts. The limestones are mudstone to wackestone, sometimes argillaceous-silty or even sandy, with a noticeable amount of quartz. In association 1, epifaunal bivalves dominate, among them *Nanogyra nana* with more than 80%. The substrate was relatively stable, the most stable one of the first three associations described above, but soft enough for burrowing infaunal bivalves. The attachment areas of *Nanogyra nana* are very tiny even in adult individuals. FÜRSICH & OSCHMANN (1986: 72-73) considered it very likely that *Nanogyra nana* with very small attachment areas, and occurring in sediments that apparently had been soft were free recliners for most of their life. According to SEILACHER (1984) and FÜRSICH & OSCHMANN (1986: Fig. 8b) a possible pathway for ostreids to survive on soft substrates is to grow in a three-dimensional spiral. In our material there is no evidence of this kind of growth. The very tiny attachment areas and the relatively soft substrate (mudstone, muddy sediments) suggest that *Nanogyra nana* was initially attached to small hard substrates and later became free living. The presence of clusters formed exclusively by this species indicate that *Nanogyra nana* could also remain cemented during all its life in this type of substrate. In association 2, infaunal bivalves dominate over epifaunal ones indicating the existence of an instable substrate of low consistency. Semi-infaunal bivalves slightly increased in number; epifaunal taxa are dominated by *Cingentolium* and *Nanogyra nana*. In association 3, the percentage of infaunal bivalves decreased, although it is still higher than that of epifaunal ones. However, the proportion of semi-infaunal bivalves has increased. This means that the substrate was a little more stable and cohesive than that of association 2.

Association 4 (Figs. 62a, 63) occurs only in peloidal calcareous mudstone with scattered quartz grains of the Sot de Chera Fm, but not in the marl. Epifaunal bivalves clearly dominate over infaunal and semi-infaunal ones indicating a stable and cohesive substrate.

Lastly, association 5 (Figs. 62b, 63), is found in wackestone with peloids and bioclasts (filaments), than can change into a peloidal packstone, quartz grains are totally absent. Epifaunal and infaunal bivalves are equally abundant, indicating that the substrate was soft enough for burrowing bivalves but also stable enough for epifaunal bivalves.

5.5.2. WATER ENERGY

There is a variation in the water energy in the three first associations. Association 1 reflects relatively high energy level, because of the dominance of epifaunal bivalves. The dominance of shallow infaunal bivalves in association 2 indicates a decrease in the energy level. In association 3, the energy level is thought to have been intermediate between that of associations 1 and 2.

In association 4, the water energy was medium, sufficiently high for the epibyssate suspension-feeding *Grammatodon (G.) concinnum* (50% of association), but low enough for organic matter, the food for deposit-feeders (>7% *Palaeonucula*), to accumulate in the sediment.

The energy level of association 5 was medium to high, as indicated by the dominance of byssate bivalves among the epifauna. Moreover, all bivalves were suspension-feeders. This means that the water energy level was sufficiently high to keep organic matter in suspension.

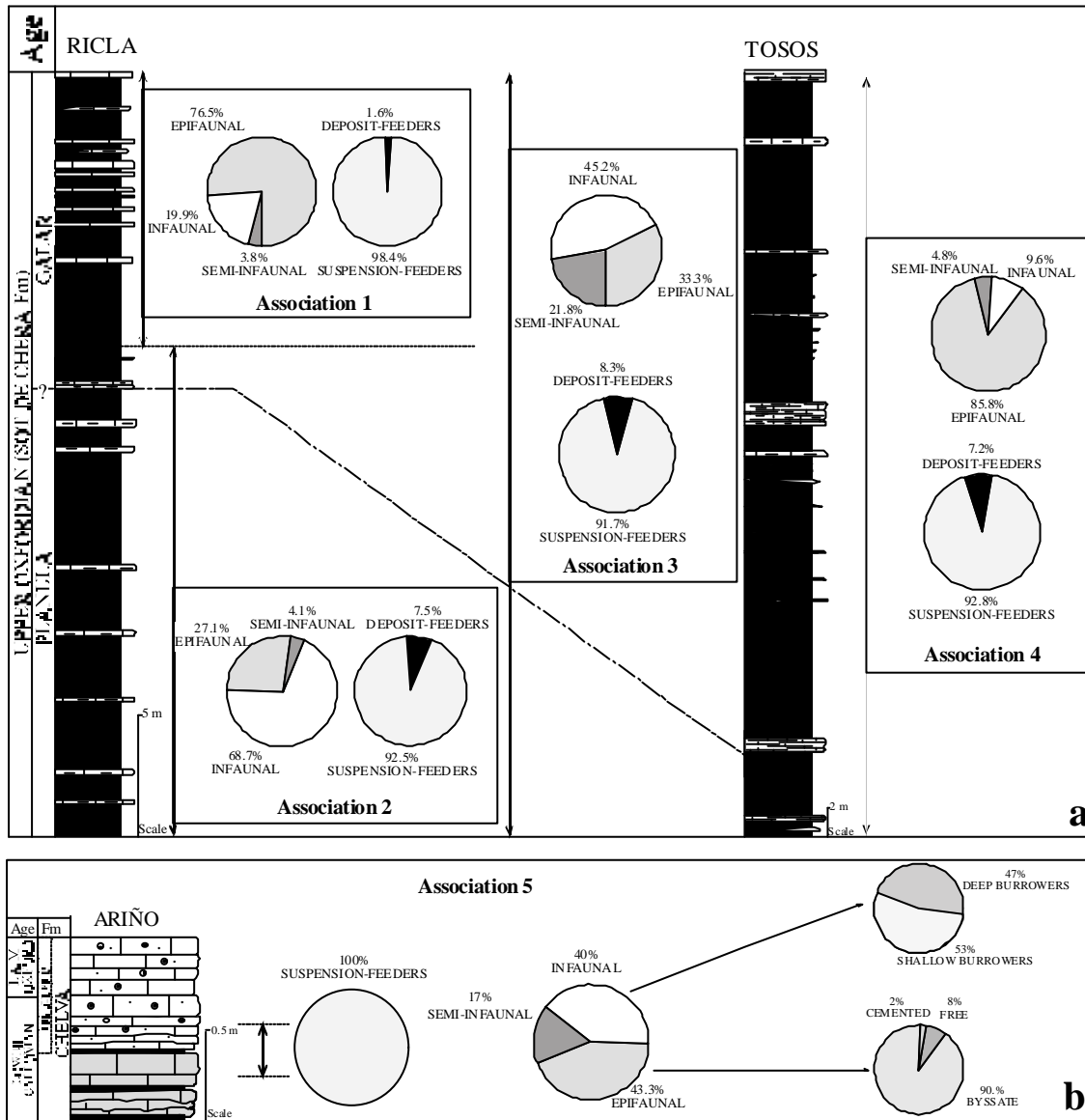


Fig. 62. Stratigraphic distribution of the five bivalve associations. **a:** Associations from the Sot de Chera Fm at Ricla and Tosos (province of Zaragoza). Association 1: *Nanogyra nana-Nicaniella (T.) carinata*; association 2: *Nicaniella (T.) carinata-Cingetolium*; association 3: *Nicaniella (T.) carinata-Gervillella aviculoides*; association 4: *Grammatodon (G.) concinnum-Cingetolium (C.) partitum*. **b:** Association 5: *Myoconcha (M.) rathieriana-Plagiostoma fuersichi* from the Chelva Fm at Ariño (province of Teruel).

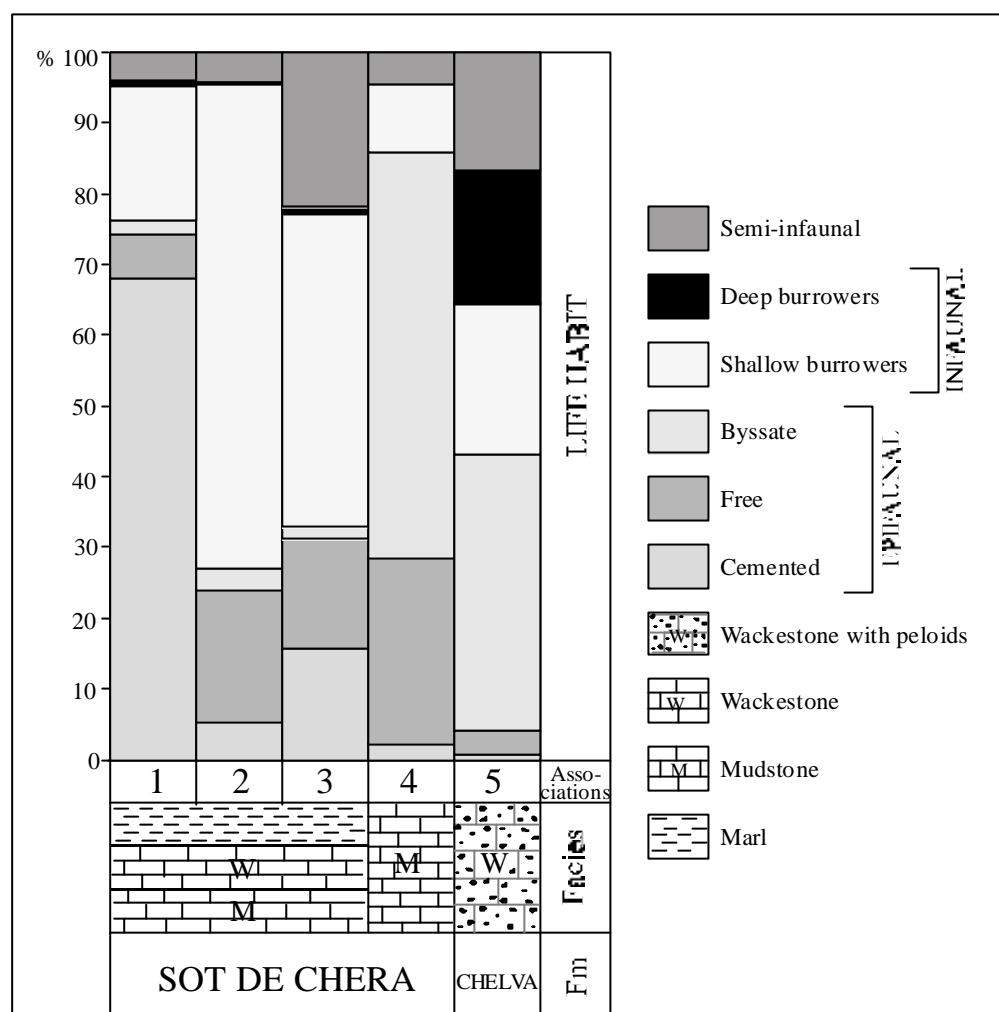


Fig. 63. Distribution of life habits of the five bivalve associations in the different types of substrates. 1: *Nanogyra nana-Nicaniella (T.) carinata* association; 2: *Nicaniella (T.) carinata-Cingetolium* association; 3: *Nicaniella (T.) carinata-Gervillella aviculoides* association; 4: *Grammatodon (G.) concinnum-Cingetolium (C.) partitum* association; 5: *Myoconcha (M.) rathieriana-Plagiostoma fuersichi* association.

5.5.3. DISTRIBUTION OF ORGANIC MATTER

The distribution of organic matter is strongly related to the turbulence level. Under relatively high turbulence conditions (dominance of epifauna) available organic matter is kept in suspension and the main trophic group are suspension-feeders (association 1). In contrast, when the water energy is low (dominance of infauna), organic matter accumulates in the sediment, and allows development of deposit-feeders (Nuculacea) and of microcarnivorous organisms such as scaphopods (association 2). The increase of deposit-feeders from association 1 (1.6%) to associations 2 and 3 (>7%) reflects the decreasing water energy. Although it is evident that the water energy in association 1 was higher than other associations, it was still comparatively low as is demonstrated by the presence of deposit-feeders. The organic matter content in sediments of associations 4 and 5 was explained above.

5.6. SPATIAL AND TEMPORAL DISTRIBUTION PATTERN OF BIVALVES

5.6.1. TEMPORAL DISTRIBUTION

The five bivalve associations show a very clear temporal distribution pattern. The first four associations occur in the Upper Oxfordian Sot de Chera Fm (Fig. 62a). At Ricla, association 2 (most likely Planula Biozone and part of Galar Biozone) occurs stratigraphically below association 1 (attributed to Galar Biozone). This is true of both sections in the Ricla area (Ri₄ and Ri₈). Association 3 however, occurs at the same stratigraphic level as the previous ones, but also below or above them, apparently reflecting slight fluctuations of the energy level. Association 4 occurs in sediments of the Planula and Galar biozones of the Tosos area. Association 5 comes from levels of the Chelva Fm attributed to the Lower Callovian (Fig. 62b).

5.6.2. SPATIAL DISTRIBUTION PATTERN

Comparing all sections, a general decrease of bivalves is observed from NW to SE, except for Callovian bivalves.

The thickness of the Sot de Chera Fm progressively decreases along the Aragonian Branch from NW to SE. Maximum abundance of bivalves (Tables 9-11, Fig. 62a) is where the formation is thick as in the Ricla area, closest place to the shore and decreases progressively in SE direction. This decrease is noticeable even within short distances such as between Ricla and Tosos. In Tosos, bivalves are abundant (Table 12), but their percentage of the total macrobenthos decreases compared to Ricla although still being the main benthic group. It seems clear that the controlling factor of this spatial distribution pattern is the availability of nutrients whose source must be the nearest landmass.

Another example where this trend can be demonstrated, although less clearly, is the Loriguilla Fm. Fossils are rare in this formation, and so are bivalves. However, when we compare the section of Valmadrid (Fig. 15) located more centrally on the platform with the section of La Cañada de Verich (Fig. 36), located in the distal-most part, we then can observe that bivalves decrease considerably in this direction. The most likely explanation of the distribution pattern is again the availability of larger amounts of nutrients in the more proximal areas of the platform.

Callovian bivalves exhibit a different tendency. In the Ricla-Tosos area (NW) and in Calanda-La Cañada de Verich (SE), rocks of Callovian age are characterized by their low content of bivalves. The only area where bivalves are abundant is at Ariño (Table 13, Fig. 62b). This area has been interpreted as a palaeogeographic high (MELÉNDEZ *et al.* 1997, see references therein). Availability of nutrients around this palaeogeographic high may have been high and the energy level medium to high. Although representing a different situation, the geographic distribution of bivalves was possibly controlled by the availability of nutrients also during the Callovian.

6. CONCLUSIONS

A review of previous work on Middle and Upper Jurassic bivalves from the Iberian Range reveals the scarcity of data, partly due to the poor preservation, partly due to the low abundance of this group in the study area. 14 sections studied in detail supplemented by five additional outcrops give a general idea of the composition and distribution of bivalves during Middle and Upper Jurassic sediments of the Iberian Range. The northwestern area (especially Ricla and Tosos, province of Zaragoza) and the "Sierra de Arcos" area (Ariño-Oliete sector, province of Teruel) are richest in bivalves. The first is represented by occurs in rocks of the Sot de Chera Fm (Upper Oxfordian) and the second one by rocks of the Chelva Fm (Callovian).

A detailed taxonomic study of the bivalve fauna resulted in the description of 83 species belonging to 46 genera and subgenera. One species is new: *Plagiostoma fuersichi* from the Chelva Fm (Callovian). Bivalves belong to the subclasses Palaeotaxodonta (3.9%), Pteriomorphia (67.9%), Isofilibranchia (0.9%), Palaeoheterodonta (0.4%), Heterodonta (22.8%) and Anomalodesmata (4.5%). The most abundant families of the Pteriomorphia are Entoliidae and Gryphaeidae, the latter due to the large abundance of *Nanogyra nana* (J. SOWERBY) which accounts for more than 25% of the total bivalve fauna.

Analysis of the palaeoautecology show that 3.9 % were deposit-feeders (Palaeotaxodonta), the rest suspension-feeders. Deposit-feeders are almost restricted to the Sot the Chera Fm, only in section To₃ deposit-feeders occur in some levels of the Yátova Fm.

The sections richest in bivalves were selected for a quantitative palaeoecological analysis of the bivalve fraction of the macrobenthos. They are the sections Ri₄, Ri₈, To₃ and BE which yielded 49 quantitative samples and 70 species. Five bivalve associations and two assemblages were recognized with the help of a Q-mode hierarchical cluster analysis (Ward method) The assemblages occur in the Yátova Fm (Tosos, Ariño). Four of the associations occur in the Sot de Chera Fm, three of them at Ricla and one at Tosos. The fifth association comes from the Chelva Fm at Ariño. Environmental factors that control the distribution of the bivalve associations are substrate, water energy and distribution of the organic matter, which are all interrelated.

With respect to substrate, associations 1, 2 and 3 occur in marl, mudstone and wackestone. Association 4 only occurs in mudstone, and association 5 in wackestone with peloids. Where epifauna dominates over infauna (associations 1, 4), the substrate was probably firm and stable. In contrast, where infauna dominates (association 2) it was soft enough for burrowing bivalves. Association 3 represents slight fluctuations of the energy level between that of associations 1 and 2.

The presence of Nuculacea reflects a low turbulence level and a high organic matter content of the substrate. The water energy level was not very high in the four first associations, as the presence of members of the Nuculacea and the dominance of shallow burrowers over deep ones demonstrate.

In association 5 all bivalves are suspension-feeders, epifauna and infaunal occur in equal proportion, and semi-infaunal bivalves are well represented demonstrating that the substrate was relatively firm and the water energy level high.

The bivalves exhibit a distinct spatial and temporal distribution pattern. Associations 1-4 occur in the Upper Oxfordian and association 5 in the Callovian. In the Sot de Chera Fm the abundance of bivalves decreases from NW to SE, from the Ricla area, closest place to the shore line towards the distal-most part of the basin. Bivalves from the Callovian are more abundant in the Ariño area, interpreted as a palaeogeographic high. The spatial distribution pattern of bivalves might have been largely controlled by the availability of nutrients.

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Plate 1

Figs. 1-2. *Palaeonucula calliope* (D'ORBIGNY 1850)

1. Articulated specimen, right valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/750.
2. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/740.

Figs. 3-4, 6. *Palaeonucula menkii* (ROEMER 1836)

3. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/760.
4. Articulated specimen. a: right valve view; b: posterior view; c: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 3.5. - MPZ 00/761.
6. Left valve. Sot de Chera Fm (Tosos, prov. Zaragoza); x 2. - MPZ 00/803.

Fig. 5. *Palaeonucula monnadi* CHAVAN 1952

- Left valve. Sot de Chera Fm (Tosos, prov. Zaragoza); x 2. - MPZ 00/816.

Fig. 7. *Palaeonucula* sp.

- Articulated specimen. a: right valve view; b: dorsal view. Yátova Fm (Tosos, prov. Zaragoza); x 4.5. - MPZ 00/818.

Fig. 8. *Nuculana (Praesaccella) venusta* (SAUVAGE & RIGAUX 1871)

- Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 4.5. - MPZ 00/841.

Fig. 9. *Dacryomya roederi* (DE LORIO 1897)

- Left valve. a: left valve view; b: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 4. - MPZ 00/843.

Fig. 10. *Grammatodon (Grammatodon) concinnum* (PHILLIPS 1829)

- Composite mould of right valve. Loriguilla Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 3. - MPZ 00/889.

Fig. 11. *Barbatia (Barbatia) tenuitexta* (MORRIS & LYCETT 1853)

- Articulated specimen. a: right valve view; b: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.1. - MPZ 00/854.

Fig. 12. *Grammatodon (Cosmetodon) elongatum* (J. DE C. SOWERBY 1824)

- Right valve. a: external view; b: internal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/897.

Figs. 13-14. *Gervillella aviculoides* (J. SOWERBY 1814)

13. Left valve of articulated specimen. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/900.
14. Right valve of articulated specimen. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/970.

Fig. 15. *Pinna (Pinna) cf. socialis* D'ORBIGNY 1850

- Articulated specimen. a: external mould; b: composite mould of articulated specimen. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/1018.

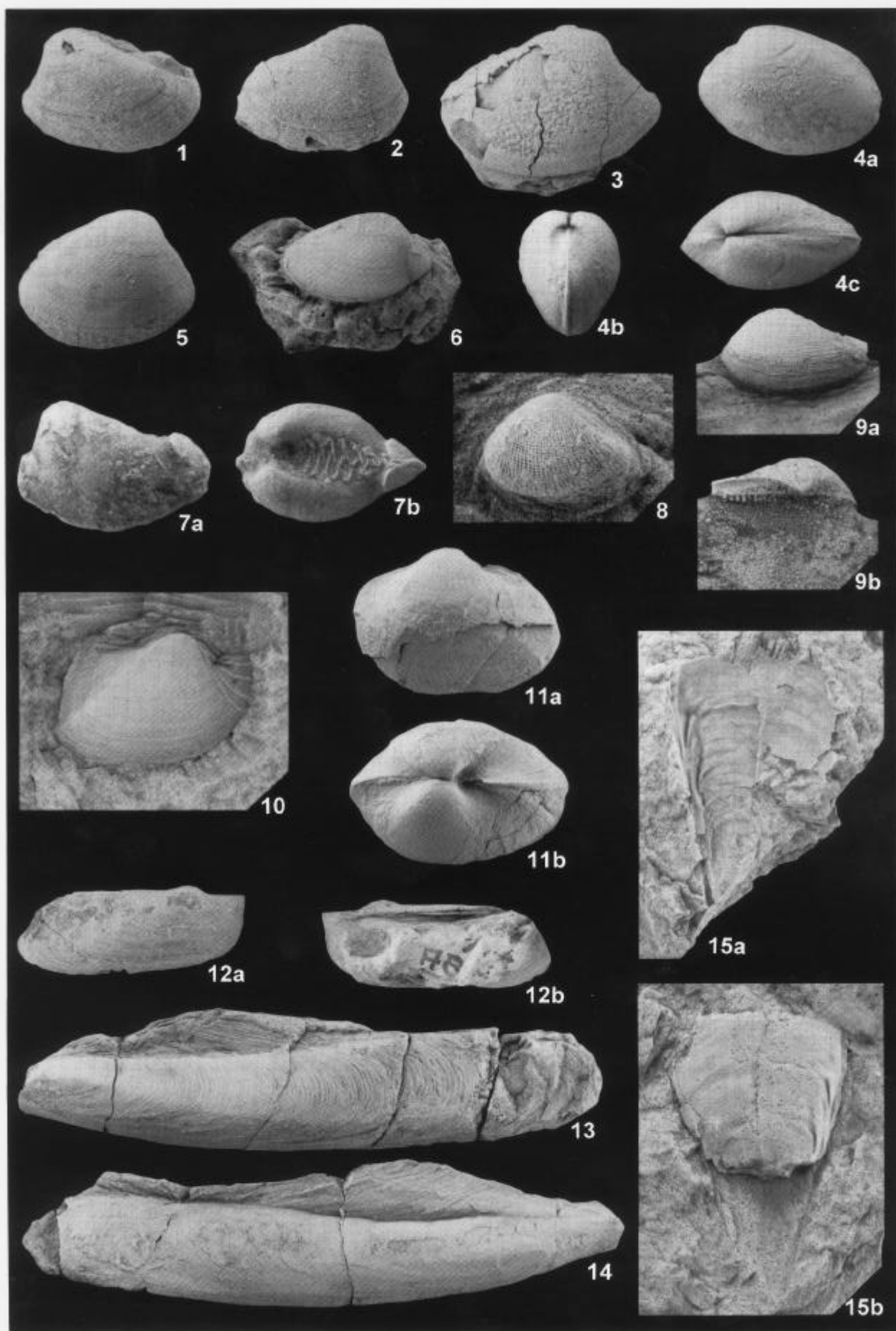


Plate 2

Fig. 1. *Plagiostoma fuersichi* sp. nov.

Right valve. Chelva Fm (Aguilón, prov. Zaragoza); x 1. - MPZ 98/117 (paratype).

Figs. 2-3. *Ctenostreon proboscideum* (J. SOWERBY 1820)

2. Right view of articulated specimen. Yátova Fm (Ventas de San Pedro, Oliete, prov. Teruel); x 1. -MPZ 97/48.

3. Right view of articulated specimen. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. -MPZ 97/49.

Fig. 4. *Plagiostoma oepybolum* (WHIDBORNE 1883)

Left valve. Yátova Fm (Moneva, prov. Zaragoza); x 1. - MPZ 97/165.

Fig. 5. *Isognomon* (*Isognomon*) cf. *promytiloides* ARKELL 1933

Right valve of articulated specimen. Sot de Chera Fm (Ricla, prov. Zaragoza); x 0.6. - MPZ 00/1009.

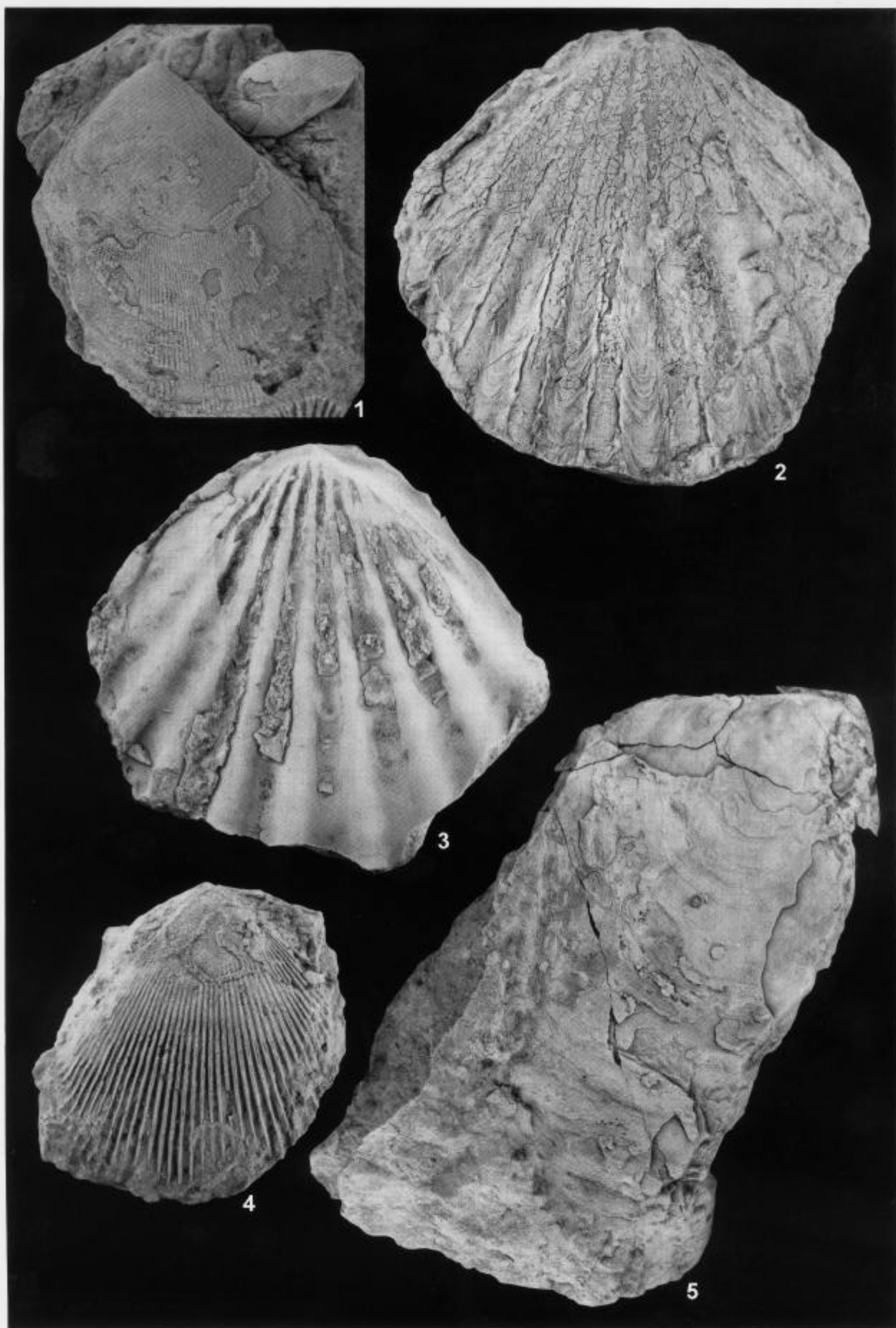


Plate 3

Fig. 1. *Plagiostoma laeviusculum* J. SOWERBY 1822

Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 97/157.

Figs. 2-3. *Plagiostoma buckmani* COX 1943

2. Right valve. Chelva Fm (Tía Chula, Oliete, prov. Teruel); x 1.5. - MPZ 97/160.

3. Left valve. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 97/163.

Fig. 4. *Plagiostoma pratzi* (BOEHM 1881)

Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 97/170.

Fig. 5. *Pseudolimea duplicata* (J. DE C. SOWERBY 1827)

Left valve. Yátova Fm (Foz Calanda, prov. Teruel); x 1.5. - MPZ 97/192.

Figs. 6-7. *Plagiostoma fuersichi* sp. nov.

6. Right view of articulated specimen. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 98/121 (paratype).

7. Left view of articulated specimen. Chelva Fm (Ventas de San Pedro, Oliete, prov. Teruel); x 1. - MPZ 98/118 (holotype).

Figs. 8, 14. *Actinostreon* cf. *solitarium* (J. DE C. SOWERBY 1824)

8. ? Right valve. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1.7. - MPZ 97/272.

14. ? Right valve. Chelva Fm (Barranco de la Peñisquera, Lécera, prov. Zaragoza); x 1.5. - MPZ 97/263.

Figs. 9, 13. *Actinostreon gregareum* (J. SOWERBY 1815)

9. Ventral view of articulated specimen. Yátova Fm (Moneva, prov. Zaragoza); x 1. - MPZ 97/240.

13. Right valve. Yátova Fm (Foz Calanda, prov. Teruel); x 1.3. - MPZ 97/243.

Fig. 10. *Gryphaea* (*Bilobissa*) *dilatata* J. SOWERBY 1816

Left valve. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 97/304.

Fig. 11. *Liostrea dubiensis* (CONTEJEAN 1860)

Interior view of right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 97/301.

Fig. 12. *Atreta* cf. *lepis* (EUDES-DESLONGCHAMPS 1858)

Interior view of right valve. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 2.5. - MPZ 97/204.

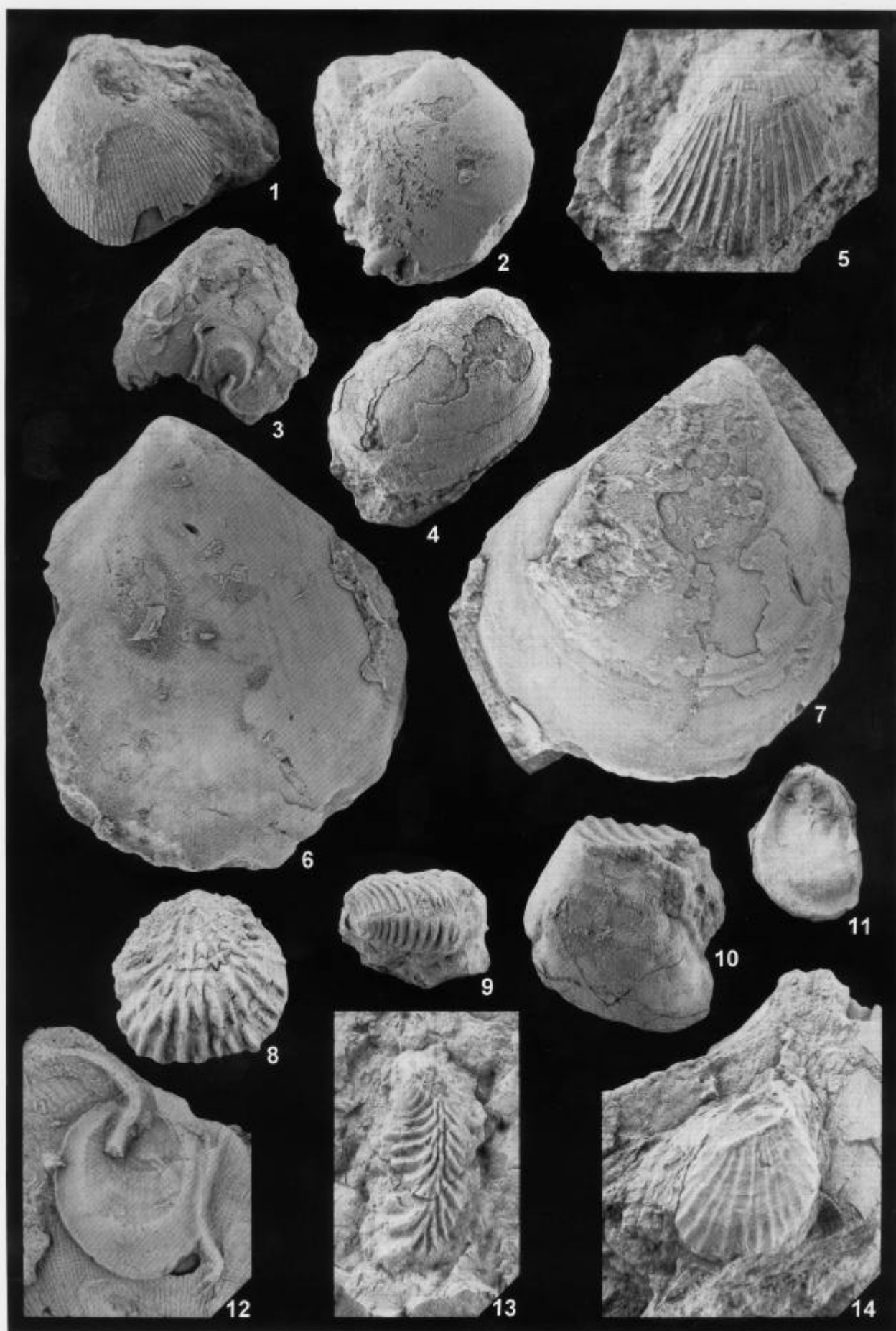


Plate 4

Figs. 1-2, 6-7. *Nanogyra nana* (J. SOWERBY 1822)

1. Internal view of right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 2. - MPZ 97/339.
2. Internal view of right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 2. - MPZ 97/365.
6. External view of left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 97/354.
7. External view of left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 97/330.

Fig. 3. *Meleagrinnella braamburensis* (PHILLIPS 1829)

Right valve. Yátova Fm (Mirambueno, Muniesa, prov. Teruel); x 1. - MPZ 00/1700.

Figs. 4, 8. *Chlamys (Chlamys) textoria* (SCHLOTHEIM 1820)

4. ? Left valve. Yátova Fm (Barranco de la Peñisquera, Lécera, prov. Zaragoza); x 1. - MPZ 00/1752.
8. External mould of right valve. Yátova Fm (Mirambueno, Muniesa, prov. Teruel); x 1. - MPZ 00/1744.

Fig. 5. *Camptonectes (Camptonectes) auritus* (SCHLOTHEIM 1813)

Single valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/1708.

Fig. 9. *Eopecten velatus* (GOLDFUSS 1833)

Left valve. Yátova Fm (Moyuela, prov. Zaragoza); x 1. MPZ 00/1761.

Fig. 10. *Radulopecten sigmaringensis* (ROLLIER 1915)

Left valve view of articulated specimen. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/1776.

Fig. 11. *Spondylopecten (Plesiopecten) subspinosus* (SCHLOTHEIM 1820)

Single valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 3. - MPZ 00/1812.

Figs. 12, 14-15. *Spondylopecten (Spondylopecten) subpunctatus* (MÜNSTER 1833)

12. Single valve. Yátova Fm (Barranco de la Peñisquera, Lécera, prov. Zaragoza); x 3.5. - MPZ 00/1781.
14. Articulated specimen, ? left valve view. Yátova Fm (Tosos, prov. Zaragoza); x 5. - MPZ 00/1788.
15. Right valve. Yátova Fm (Tosos, prov. Zaragoza); x 5. - MPZ 00/1787.

Fig. 13. *Radulopecten scarburgensis* (YOUNG & BIRD 1822)

External mould, ? valve view. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1.5. - MPZ 00/1771.

Fig. 16. *Radulopecten fibrosus* (J. SOWERBY 1816)

External mould. Yátova Fm (Ventas de San Pedro, Oliete, prov. Teruel); x 1.5. - MPZ 00/1764.

Fig. 17. *Radulopecten inequicostatus* (YOUNG & BIRD 1822)

External mould. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/1770.

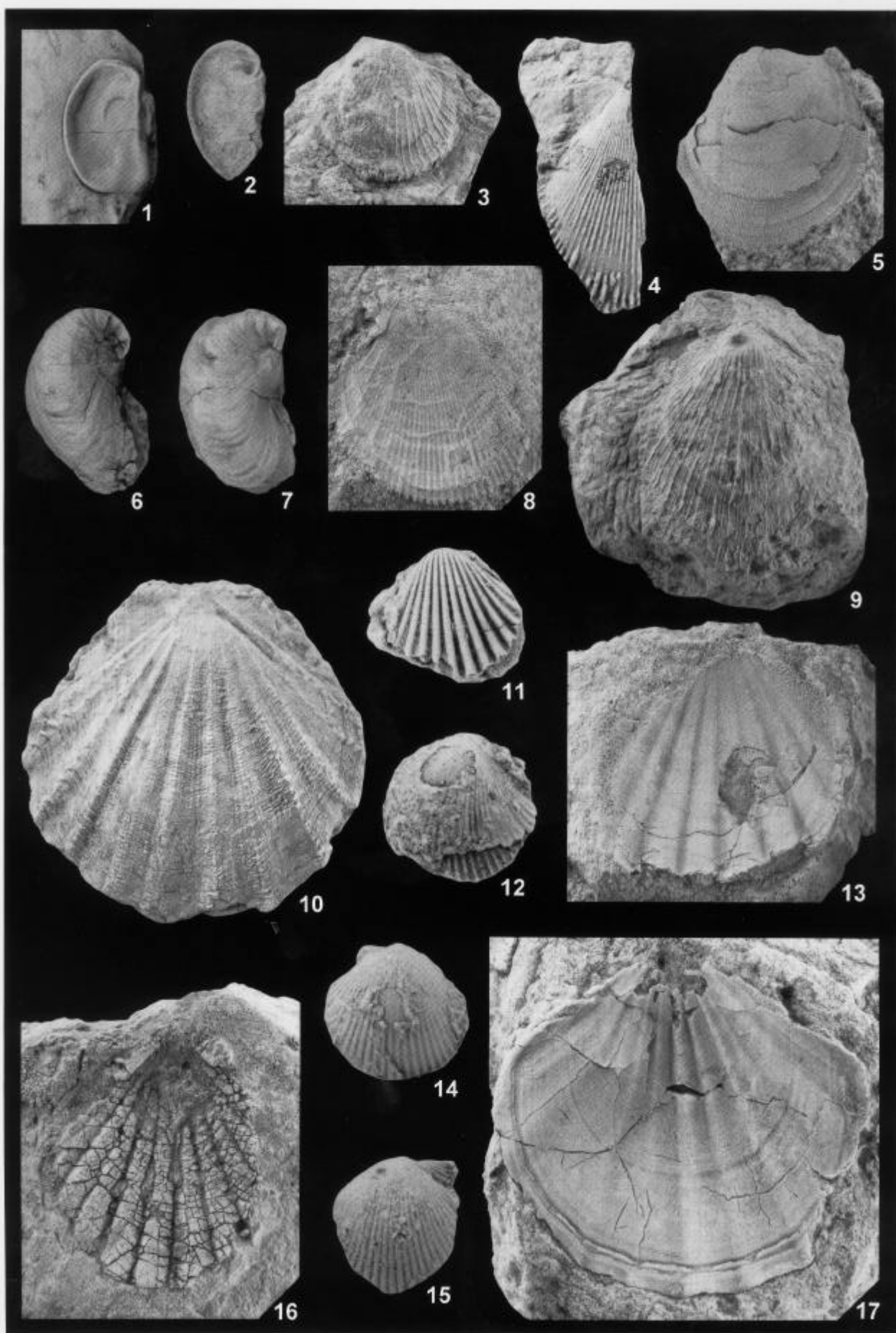


Plate 5

Figs. 1, 4, 7b. *Cingentolium (Cingentolium) cingulatum* (GOLDFUSS 1835)

1. Several articulated specimens in pavement preservation. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/1962-1964.

4. Internal mould. Chelva Fm (Tía Chula, Oliete, prov. Teruel); x 2. - MPZ 00/1985.

7b. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/1987.

Fig. 2. *Entolium (Entolium) corneolum* (YOUNG & BIRD 1828)

Single valve. Yátova Fm (Barranco de la Peñisquera, Lécera, prov. Zaragoza); x 1. - MPZ 00/2328.

Figs. 3, 5-7a. *Cingentolium (Cingentolium) partitum* (J. DE C. SOWERBY 1840)

3. ? Left valve. Chelva Fm (Moneva, prov. Zaragoza); x 1.5. - MPZ 00/2060.

5. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/2110.

6a, b. Articulated specimen right and left valve views. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/2026.

7a. Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/2151.

Figs. 8-10. *Inoperna perplicata* (ÉTALLON 1863)

8. Articulated specimen, right valve view. Loriguilla Fm (Valmadrid, prov. Zaragoza); x 1. -MPZ00/2351.

9. Articulated specimen, right valve view. Loriguilla Fm (Longares, prov. Zaragoza); x 1. -MPZ00/2352.

10. Articulated specimen, right valve view. Loriguilla Fm (Longares, prov. Zaragoza); x 1. -MPZ00/2353.

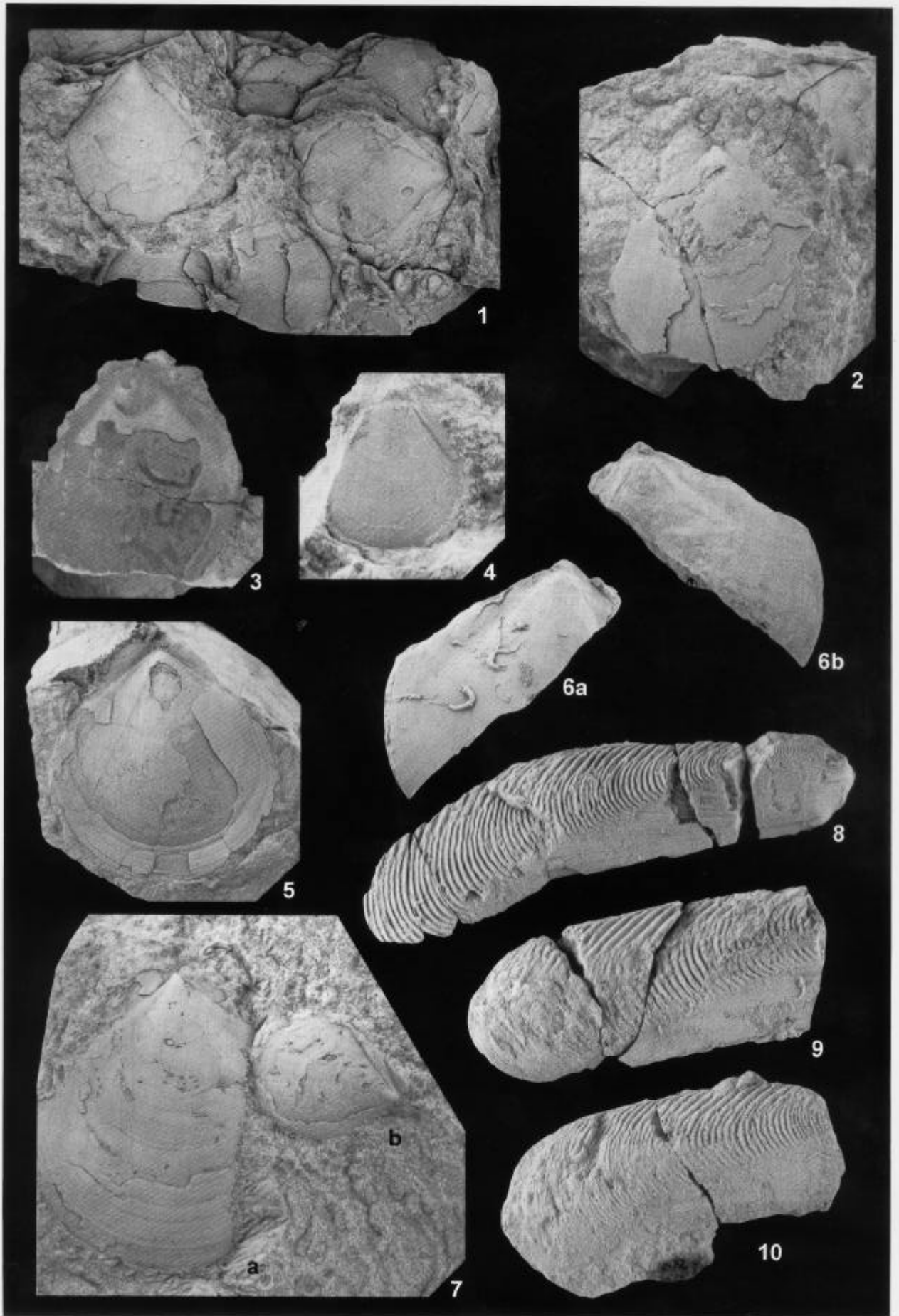


Plate 6

Fig. 1. *Trigonia (Trigonia) cf. reticulata* AGASSIZ 1840

Articulated specimen, left valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/2378.

Fig. 2. *Anisocardia (Anisocardia) cf. isocardioides* (BLAKE & HUDLESTON 1877)

Internal mould of articulated specimen, right valve view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/2393.

Figs. 3, 6, 8. *Rollierella tenuidentata* WELLNHOFER 1964

3. Articulated specimen, right valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/2410.

6. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/2408.

8. Right valve, hinge. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/2414.

Fig. 4. *Corbulomima suprajurensis* (D'ORBIGNY 1850)

a: Right valve, side view; b: oblique ventral view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 4.5. - MPZ 00/2389.

Fig. 5. *Modiolus (Modiolus) bipartitus* J. SOWERBY 1818

Articulated specimen. a: left valve view; b: dorsal view. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1.3. - MPZ 00/2374.

Fig. 7. *Anisocardia (Anisocardia) cf. choffati* DE LORIO 1904

Articulated specimen, left valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.4. - MPZ 00/2392.

Fig. 9. *Rollierella laubei* (ROLLIER 1913)

Articulated specimen, a: right valve view; b: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/2401.

Figs. 10-11, 13. *Nicaniella (Trautscholdia) carinata* (PHILLIPS 1829)

10. Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 3.5. - MPZ 00/2705.

11. Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 3.5. - MPZ 00/2843.

13. Articulated specimen. a: anterior view; b: right valve view; c: posterior view; d: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 3.5. - MPZ 00/2596.

Fig. 12. *Nicaniella (Nicaniella) cf. phillis* (D'ORBIGNY 1850)

Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 2.4. - MPZ 00/2446.

Figs. 14-15. *Myoconcha (Myoconcha) rathieriana* D'ORBIGNY 1850

14. Articulated specimen, right valve view. Chelva Fm (Tía Chula, Oliete, prov. Teruel); x 1. - MPZ 00/2422.

15. Internal mould of articulated specimen, left valve view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/2421.

Fig. 16. *Prorokia problematica* (BUVIGNIER 1852)

Composite mould of right valve. Chelva Fm (Tía Chula, Oliete, prov. Teruel); x 3. - MPZ 00/3019.

Fig. 17. *Prorokia aff. moriceana* (DOLLFUS 1863)

Right valve. a: external view; b: internal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/3009.

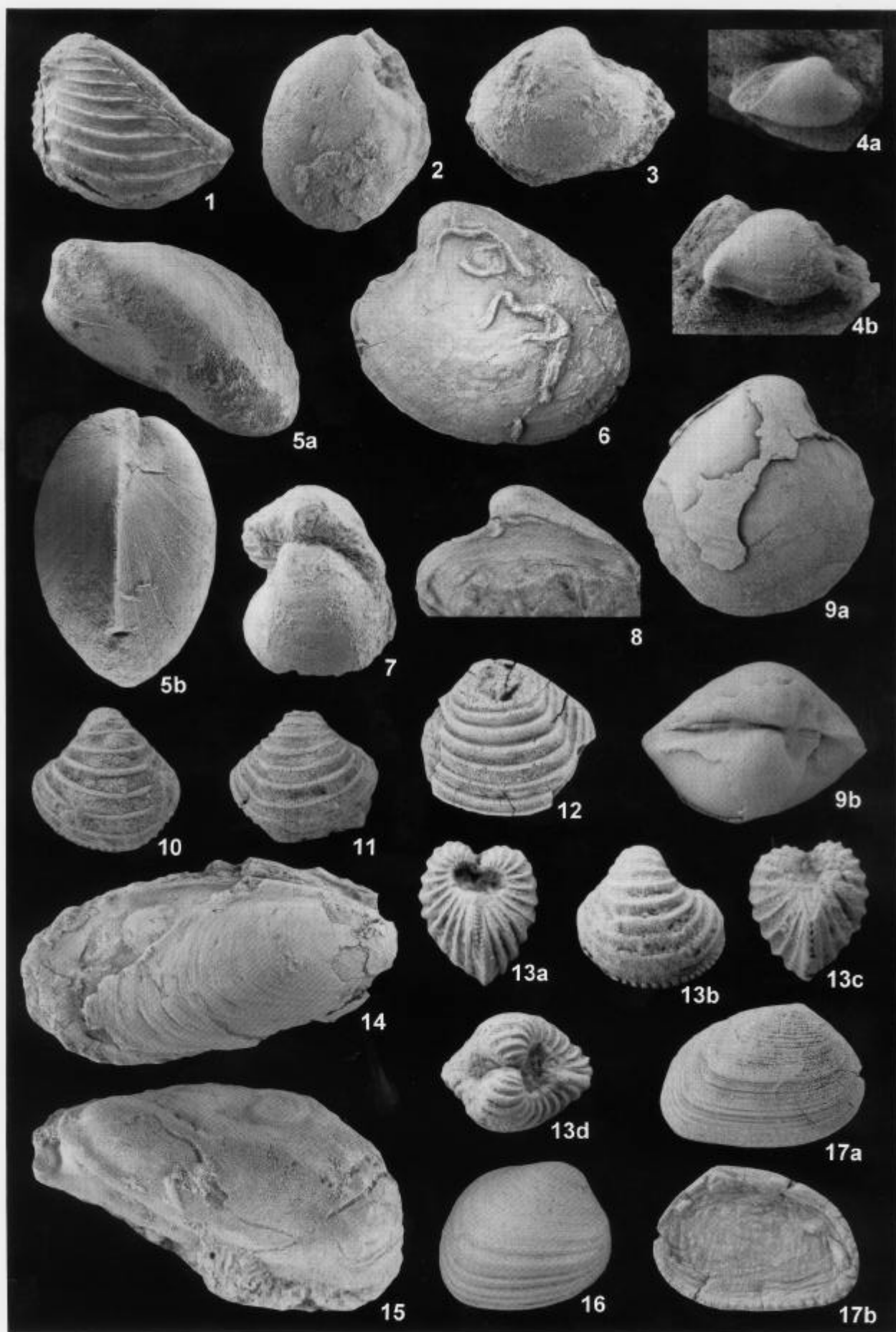


Plate 7

Fig.1. *Coelopsis (Coelopsis)* sp.

Right valve. Yátova Fm (Tosos, prov. Zaragoza); x 2.2. - MPZ 00/3020.

Fig. 2. *Mactromya globosa* AGASSIZ 1843

Articulated specimen. a: left valve view; b: dorsal view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.3. - MPZ 00/3029.

Fig .3. *Mactromya ovalis* (D'ORBIGNY 1850)

Left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.3. - MPZ 00/3034.

Fig. 4. *Mactromya aequalis* AGASSIZ 1843

Composite mould of articulated specimen, left valve view. Sot de Chera Fm (Ricla, prov. Zaragoza), x 1.2. - MPZ 00/3027.

Fig. 5. *Unicardium aceste* D'ORBIGNY 1850

Composite mould of articulated specimen, left valve view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/3039.

Fig. 6. *Unicardium angulatum* BOEHM 1883

Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.2. - MPZ 00/3041.

Fig. 7. *Unicardium bernardinum* D'ORBIGNY 1850

Articulated specimen in "butterfly position". a: posterior view; b: right valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.5. - MPZ 00/3044.

Fig. 8. *Unicardium exiguum* DE LORIOLO 1904

Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 2.4. - MPZ 00/3046.

Fig. 9. *Unicardium* aff. *tombecki* DE LORIOLO 1872

Articulated specimen in "butterfly position", left valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.3. - MPZ 00/3051.

Fig. 10. *Unicardium* sp. A

Articulated specimen, left valve view. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.6. - MPZ 00/3052.

Fig. 11. *Unicardium josephense* DE LORIOLO 1888

Right valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1.4. - MPZ 00/3047.

Fig. 12. *Goniomya (Goniomya) trapezicostata* (PUSH 1837)

Composite mould of articulated specimen, left valve view. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/3075.

Figs. 13-14. *Pholadomya (Pholadomya) acuminata* HARTMANN 1830

13. Composite mould of articulated specimen. a: left valve view; b: anterior view. Sot de Chera Fm (Aguilón, prov. Zaragoza); x 1.5. - MPZ 00/3077.

14. Composite mould of articulated specimen, left valve view. Loriguilla Fm (La Cañada de Verich, prov. Teruel); x 1.5. - MPZ 00/3076.

Fig. 15. *Pholadomya (Pholadomya) kachchhensis* PANDEY, FÜRSICH & HEINZE 1996

Internal mould of articulated specimen, right valve view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/3081.

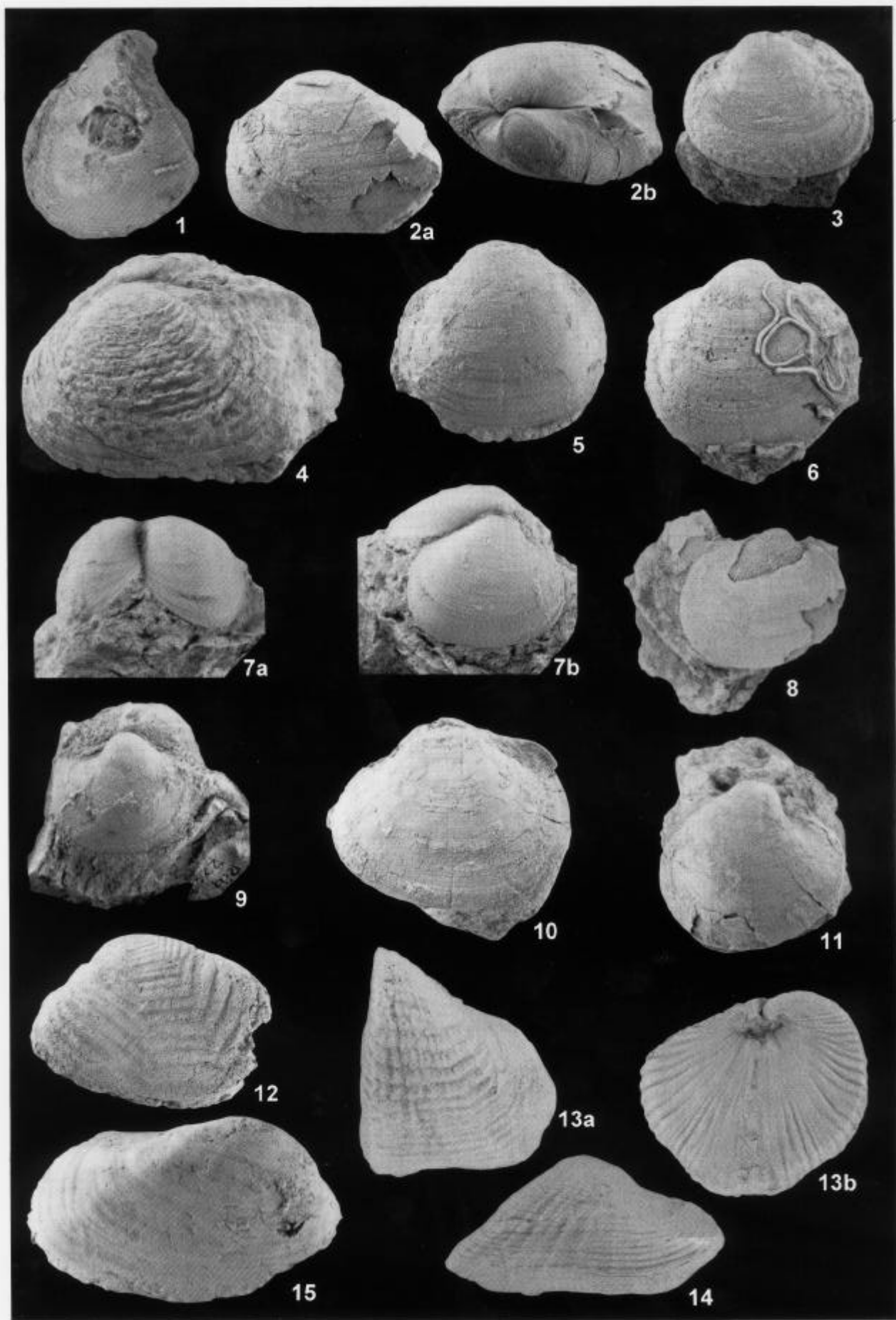


Plate 8

Figs. 1, 4-5. *Pholadomya (Bucardiomya) protei* (BRONGNIART 1821)

1. Composite mould of articulated specimen, right valve view. Yátova Fm (Ventas de San Pedro, Oliete, prov. Teruel); x 0.8. - MPZ 00/3101.
4. Composite mould of articulated specimen. a: left valve view; b: anterior view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 0.8. - MPZ 00/3134.
5. Composite mould of articulated specimen. a: right valve view; b: anterior view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 0.8. - MPZ 00/3151.

Figs. 2-3. *Pleuromya alduini* (BRONGNIART 1821)

2. Composite mould of left valve. Sot de Chera Fm (Ricla, prov. Zaragoza); x 1. - MPZ 00/3167.
3. Composite mould of left valve. Loriguilla Fm (Valmadrid, prov. Zaragoza); x 1.5. - MPZ 00/3173.

Figs. 6-7. *Pleuromya uniformis* (J. SOWERBY 1813)

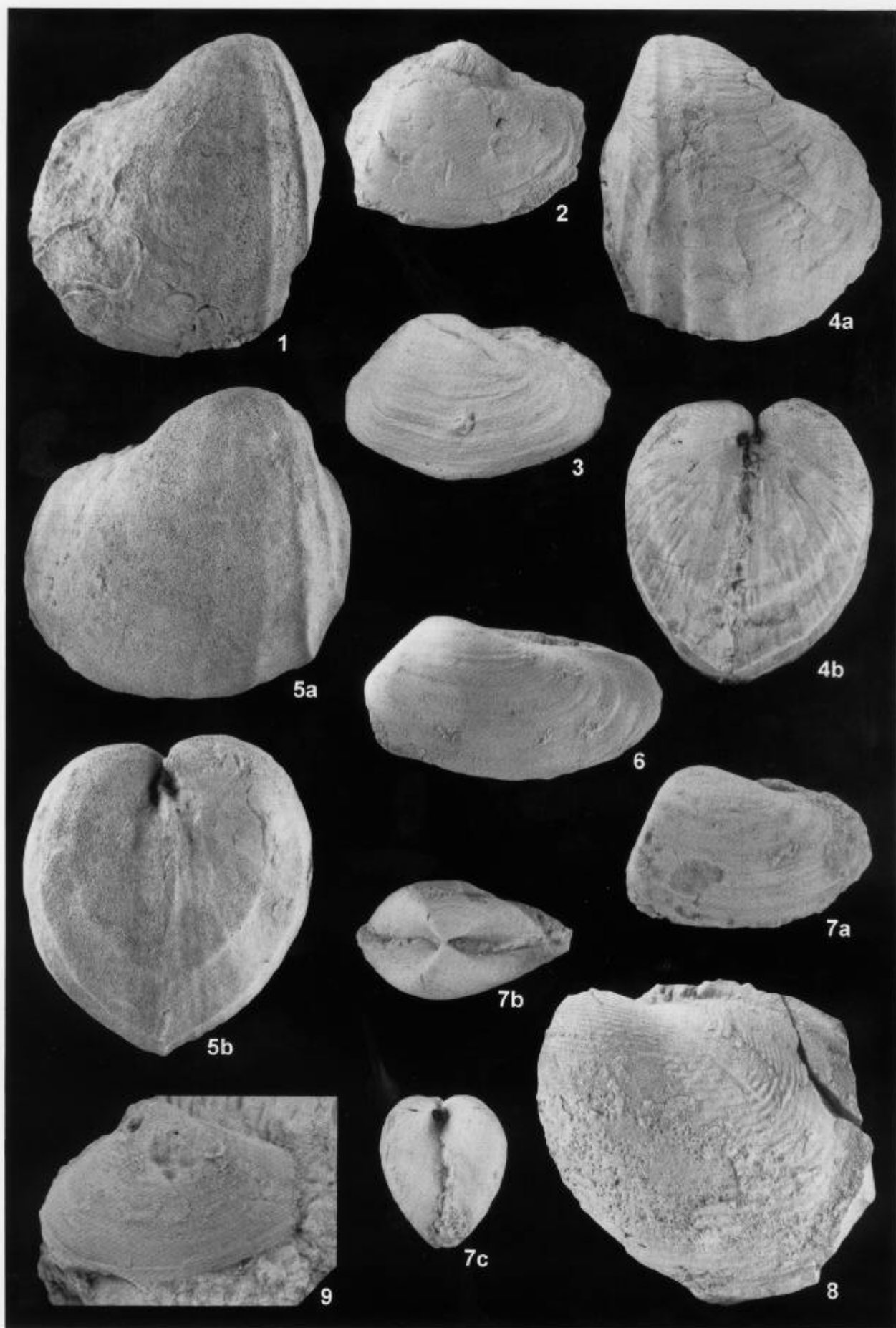
6. Composite mould of articulated specimen, left valve view. Yátova Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/3178.
7. Composite mould of articulated specimen. a: left valve view; b: dorsal view; c: anterior view. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1. - MPZ 00/3191.

Fig. 8. *Ceratomya excentrica* (ROEMER 1836)

Composite mould of articulated specimen, left valve view. Loriguilla Fm (Valmadrid, prov. Zaragoza); x 1. - MPZ 00/3200.

Fig. 9. *Thracia (Thracia) depressa* (J. de C. SOWERBY 1823)

Left valve. Chelva Fm (Barranco de las Estacas, Ariño, prov. Teruel); x 1.5. - MPZ 00/3201.



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Hiermit erkläre ich, daâ ich die vorliegende Arbeit selbständig und nur unter Verwendung der genannten Quellen und Hilfsmittel angefertigt habe.