

## *Protopleurobema*: a new genus of freshwater bivalve from the Lower Cretaceous of the Cameros basin (NW Spain)

*Protopleurobema*: un nuevo género de bivalvo de agua dulce del Cretácico Inferior de la Cuenca de Cameros (NO de España)

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Received: 12/05/09 / Accepted: 30/06/09

### Abstract

A new genus of fossil bivalve from the Lower Cretaceous of the Cameros Basin is described and designated *Protopleurobema*. As well as the type material of *Unio numantinus* (Palacios and Sánchez, 1885), we examined 805 specimens discovered in deposits comprising unit D of the lithological Urbión Group of Upper Barremian-Lower Aptian age. This new taxon is compared here to all the available closely related Mesozoic genera described in the literature.

A large number of juvenile and adult specimens of *Protopleurobema numantina* (Palacios and Sánchez, 1885) were found in what was interpreted as a palaeoecological association. The presence of bivalves (Unionoida) and gastropods of the genus *Viviparus* indicate the freshwater nature of the environment.

**Keywords:** Freshwater bivalves, Unionoida, *Protopleurobema numantina*, Lower Cretaceous, Spain.

### Resumen

Se describe un nuevo género de bivalvo de agua dulce del Cretácico Inferior en la Cuenca de Cameros que se ha denominado *Protopleurobema*. Además del material tipo de *Unio numantinus* (Palacios y Sánchez, 1885), se han estudiado 805 ejemplares que proceden de los materiales del Grupo Urbión (Unidad D), cuya edad es Barremiense Superior-Aptiense Inferior. Este nuevo taxón se compara con los géneros más similares del Mesozoico descritos en la bibliografía.

Se han encontrado un número elevado de ejemplares adultos y juveniles de *Protopleurobema numantina* (Palacios y Sánchez, 1885) que representan una asociación paleoecológica. La presencia de bivalvos (Unionoida) y gasterópodos del género *Viviparus* indican un ambiente de agua dulce.

**Palabras clave:** Bivalvos de agua dulce, Unionoida, *Protopleurobema numantina*, Cretácico Inferior, España.

### 1. Introduction

Palacios and Sánchez (1885) defined the species *Unio numantinus* in a study conducted by the *Spanish Geologi-*

*cal Map Commission* in the provinces of Logroño and Soria. A few years later, Palacios (1890) re-described and figured the species (using the same pictures) in a report on the geology of the province of Soria. The specimen

came from the Lower Cretaceous of Villarijo (San Pedro Manrique, province of Soria). Several years later, Mongin (1966: 50-51) cited "*Unio*" *numantinus* Palacios and Sánchez (1885) in the discussion of "*Unio*" cf. *porrectus* Sowerby and argued that both species from the Spanish Weald facies were very different.

Subsequently, the syntype of this taxon was identified and figured by Delvene (2005, lectotype, Plate 1, Figs. 3a and 3b) according to article 73.2 of the *International Code of Zoological Nomenclature (I.C.Z.N.)*.

Bermúdez-Rochas *et al.* (2006) reported a preliminary study of several sections of the Urbión Group (Lower Cretaceous) identifying the presence and high abundance of "*Unio*" *numantinus* coexisting with gastropods of the Viviparidae family in Valdeperillo (La Rioja province), a section very close to Villarijo. This was followed by a brief description by Delvene and Araujo (2008) of the species "*Unio*" *numantinus* including the original specimen of Palacios and Sánchez (1885) and specimens recorded in the Valdeperillo section. These authors described its most characteristic features and suggested its possible ascription to a new genus of the order Unionoidea, or naiads. Delvene and Araujo (2009) have also recently described other freshwater mussels from this same lithological group (Urbión Group). The abundant species *Margaritifera idubedae* (Palacios and Sánchez, 1885) recorded in Navajún (Camerós Basin, province of La Rioja, Spain) formed a monospecific bivalve association (Delvene *et al.*, 2006) in a fluvial environment. Another species of *Margaritifera* appears in lacustrine sediments of the Cameros Basin, and is common in the Weald sediments of England. Specimens of *Margaritifera valdensis* (Mantell, 1844) have been collected from the Enciso Group at Cornago in La Rioja province (Delvene and Araujo, 2009).

The present study describes a new bivalve association in the Urbión Group pertaining to the Lower Cretaceous of the Cameros Basin, whose main representative is "*Unio*" *numantinus*.

## 2. Geological framework

This paper focuses on the Cameros Basin, in the north-western Iberian Peninsula (Spain). The studied material originates from the Urbión Group, a lithostratigraphical unit divided into four subunits (A-D) corresponding to different depositional sequences of clearly fluvial characteristics. Bivalves were collected at the Valdeperillo site (Figs. 1, 2), La Rioja province, belonging to the subunit D of this lithological group. According to Mas *et al.* (2003),

this subunit D, also known as Urbión D, is included in a depositional sequence designated number seven and its age is Upper Barremian-Lower Aptian (Lower Cretaceous). It is interpreted as a braided fluvial system progressing to a meandering system eastwards with a well-developed floodplain (Barrenechea, 1993).

## 3. Systematic palaeontology

All the specimens examined are provisionally housed at the Museo Geominero (IGME, Madrid, Spain). The lectotype (Delvene, 2005) belongs to the collections of this museum and is coded by the letters MGM (Museo Geominero), followed by a number and the letter C (Cretaceous). Specimens whose designated codes start with the abbreviation for the outcrop Valdeperillo (VDPR) (La Rioja province) will be deposited at the end of this study in one of La Rioja's palaeontological centres.

Main measurements (height, length, thickness of shell, angle  $\alpha$ , convexity) were made on the best-preserved specimens (Fig. 3). All the figured specimens were coated with sublimated ammonium chloride. The asterisk indicates the type species.

Subclass Palaeoheterodonta Newell, 1965  
Order Unionoidea Stoliczka, 1871  
Superfamily Unionoidea Rafinesque, 1820

Genus *Protopleurobema* gen. nov.

*Derivatio nominis*

*Proto* (Greek,  $\pi\rho\omega\tau\omicron$ ) = First, Early

*Pleurobema* = A recent genus of Unionidae described by Rafinesque (1820) from North America.

*Type species*

*Unio numantinus* Palacios and Sánchez, 1885

*Diagnosis*

Shell trigonal, equivalve, inequilateral, gibbose, very tumid and posteriorly elongated to forming a slight wing. Lunule well developed. Hinge very strong. Right valve bears a massive pyramidal cardinal tooth with pronounced longitudinal grooves. Left valve presents two grooved cardinal teeth; anterior tooth flat and sharp and posterior massive. Lateral teeth run from the umbo parallel to the valve edge.

*Protopleurobema numantina* (Palacios and Sánchez, 1885)  
Figures 4, 5

\*1885 *Unio numantinus* Palacios and Sánchez: 137, plate 7a, figures 6, 6a-6d

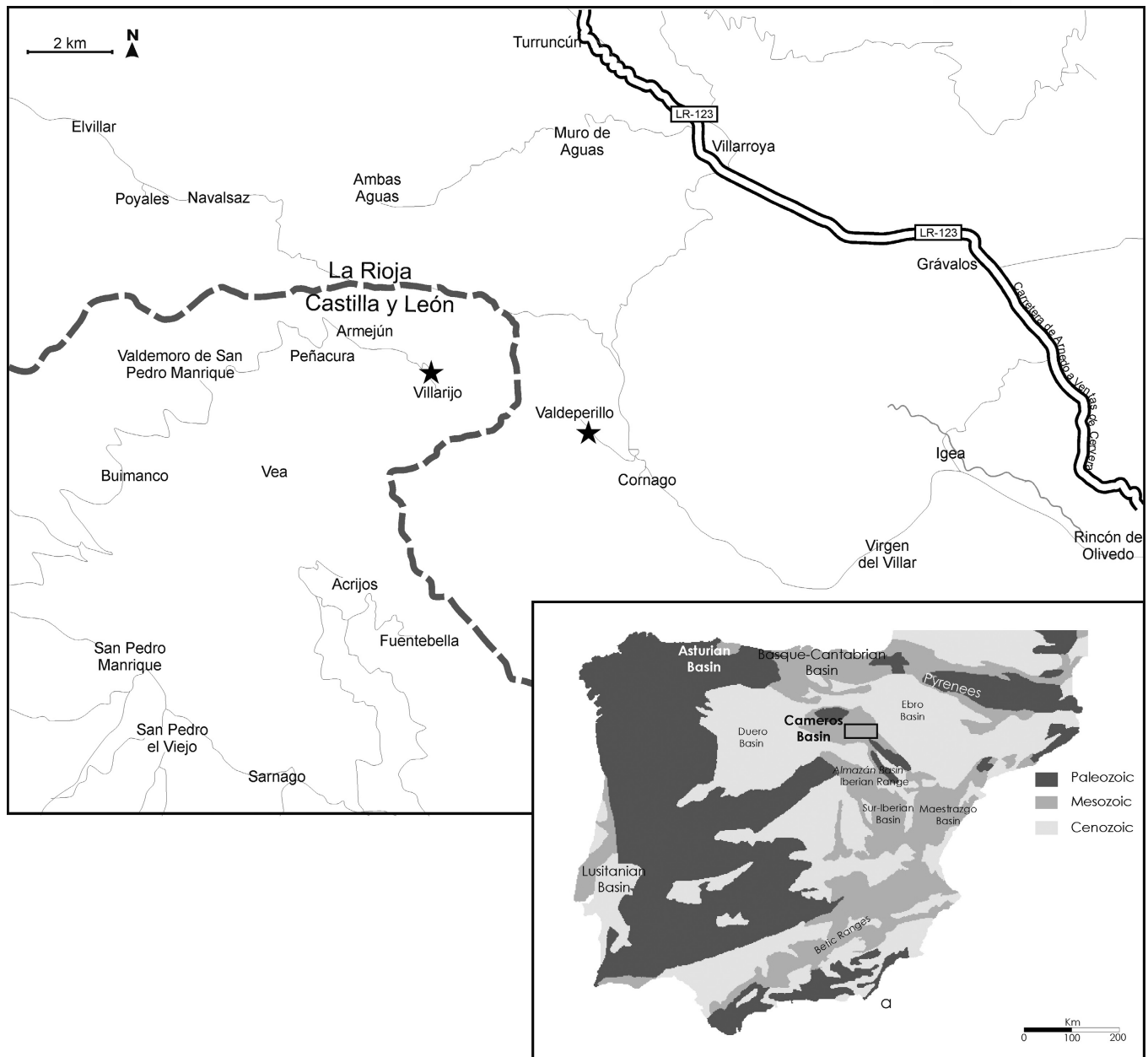


Fig. 1. Simplified geological map of the Iberian Peninsula showing the location of the Cameros Basin stressing the studied geographic area. The stars correspond to the main fossiliferous sites: Villarijo (Soria province) and Valdeperillo (La Rioja province).

Fig. 1. Mapa geológico simplificado de la Península Ibérica mostrando la Cuenca de Cameros, resaltando el área geográfica de estudio. Las estrellas indican los principales afloramientos fosilíferos: Villarijo (provincia de Soria) y Valdeperillo (provincia de La Rioja).

1890 *Unio numantinus* Palacios and Sánchez Lozano - Palacios: 284, plate 6a, figures 1-5

2005 "*Unio*" *numantinus* Palacios and Sánchez - Delvene: 169, plate 1, figures 3a-3b

2008 "*Unio*" *numantinus* Palacios and Sánchez - Delvene and Araujo: 37, figures 1a-1b

#### Material

Lectotype: Right valve with posterior region broken (MGM1781C), (Fig. 4.1). Type locality: Peña de las Huecas, Villarijo (Soria, Spain).

The lectotype figured by Delvene (2005) (plate 1, figs. 3a, 3b) is housed at the Museo Geominero (Instituto Geológico y Minero de España). This specimen had been figured by Palacios and Sánchez (1885: plate 7a, figs. 6, 6a-c) and Palacios (1890: plate 6a, figs. 1-4) and belongs to the collection *Invertebrados y Plantas Fósiles de España*, which is one of the Museo Geominero's main collections. The other specimen figured by Palacios and Sánchez (1885: plate 7a, fig. 6d) and Palacios (1890: plate 6a, fig. 5), supposedly a left valve, was not found in

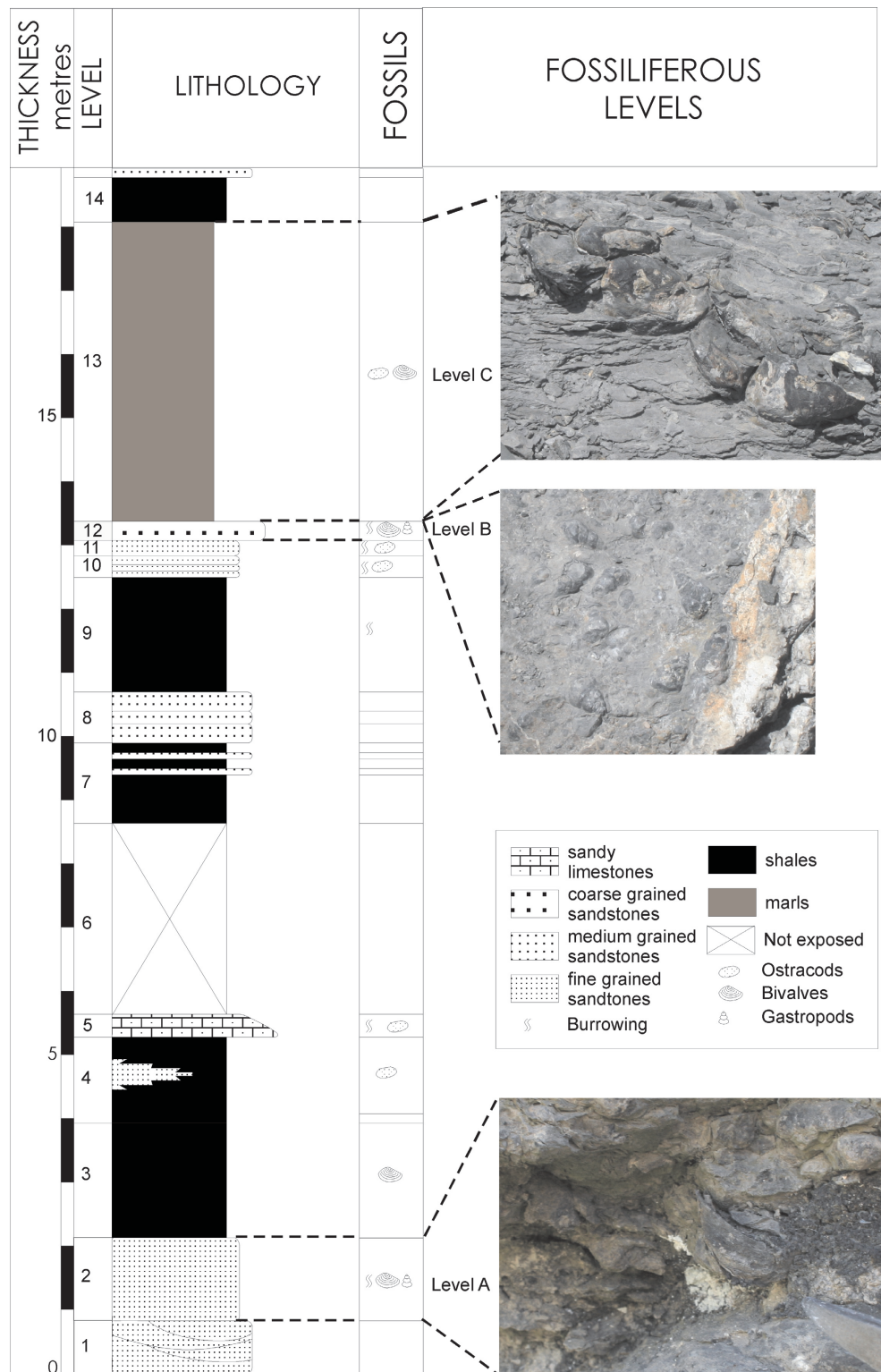


Fig. 2. Stratigraphical section of Valdeperillo site (La Rioja province) showing the main fossiliferous levels.

Fig. 2. Sección estratigráfica del afloramiento de Valdeperillo (provincia de La Rioja), mostrando los principales niveles fosilíferos.

this museum. If this specimen eventually appears, it will be considered a paralectotype.

Recently collected specimens: 805 specimens from the Valdeperillo site (La Rioja province), coded VDPR-A-1-125 (26 articulated specimens, 46 right valves, 53 left valves) and VDPR-C-1-680 (26 articulated specimens,

322 right valves, 332 left valves) from the levels A y C respectfully.

*Description*

The material examined differs from any other known fossil bivalve. Shell medium-sized to large (88.2 mm of

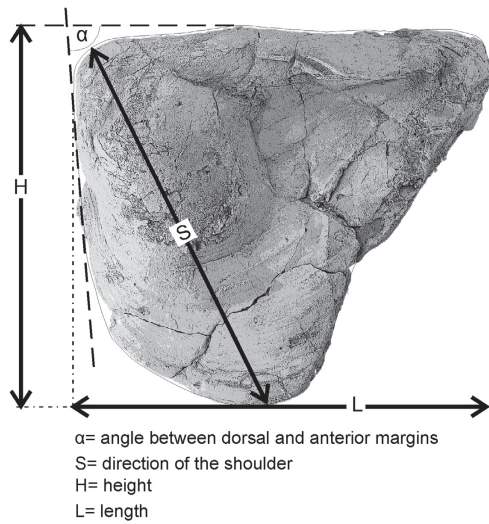


Fig. 3. Biometric parameters used for measuring *Protopleurobema numantina*.

Fig. 3. Parámetros biométricos para medir los ejemplares de *Protopleurobema numantina*.

maximum shell height and 120 mm of maximum shell length), equivalve, inequilateral, gibbose and very tumid. Outline completely trigonal with a very acute prosogyrous umbo. Sculpture of the umbones absent. Lunule well developed, flat and wide, ornamented with smooth striae. Both valves exceptionally convex with a marked anterior-medial shoulder (Fig. 3); this shoulder builds the thickest part of the shell, which attains a thickness of 12.6 mm in the largest specimens. The ligament pit, straight and narrow (Fig. 4.5 a-b), marks the dorsal margin of the valve. Ligament external and opisthodontic. The dorsal margin forms a variable angle coded  $\alpha$  (Fig. 3, Table 1) with the anterior margin at the level of the umbo, being a right angle in some specimens. Anterior and dorsal margins joined by a rounded ventral border that continues into a posterior slight wing, very visible in the best-preserved specimens.

Hinge very strong and distinctive with two plates that diverge from the umbo: the anterior short and wide bearing the cardinals, and the posterior, large and straight, bearing the laterals. Right valve shows a massive pyramidal cardinal tooth with pronounced longitudinal grooves. This tooth is flanked by two deep sockets, the posterior socket being larger and grooved. Besides this socket, the straight lateral tooth, which starts just below the umbo, enlarges as it runs parallel to the posterior border. The left

Table 1. Measurements of the biometric parameters of the best-preserved specimens, expressed in mm.

Tabla 1. Medidas de los parámetros biométricos de los ejemplares mejor conservados, expresadas en mm.

Specimen	Height (H)	Length (L)	Thickness shell	Angle $\alpha$	Convexity
VDPR-C-7	-	-	6	85	-
VDPR-C-8	50	-	-	80	41.4
VDPR-C-9	-	-	4.9	87	-
VDPR-C-10	-	-	6.4	78	-
VDPR-C-11	58	-	8.4	79	-
VDPR-C-12	36.4	-	-	90	-
VDPR-C-13	49.6	-	-	-	-
VDPR-C-14	-	-	7.6	84	-
VDPR-C-15	32	-	-	79	-
VDPR-C-16	17.9	-	-	78	-
VDPR-C-17	18.2	-	-	73	-
VDPR-C-18	39.6	-	6.8	88	-
VDPR-C-19	46.5	-	9	-	-
VDPR-C-20	53.9	-	9.6	-	-
VDPR-C-21	-	-	8.9	75	-
VDPR-C-22	35.8	-	-	90	18.7
VDPR-C-23	57	-	-	80	37
VDPR-C-24	-	-	-	65	-
VDPR-C-25	30.4	-	-	81	18.3
VDPR-C-26	-	-	5.2	86	-
VDPR-C-27	29.3	+34	-	81	29.6
VDPR-C-28	-	-	10.8	86	-
VDPR-C-29	+57.4	+53.5	9.7	75	-
VDPR-C-30	53.6	-	6.8	73	-
VDPR-C-31	27.8	-	5.8	87	-
VDPR-C-32	46.6	-	-	77	-
VDPR-C-33	15.3	+9.6	2	75	-
VDPR-C-34	31.4	-	-	85	-
VDPR-C-35	51.4	-	6.8	90	-
VDPR-C-36	-	-	9.2	75	-
VDPR-C-37	17.6	-	2.4	-	-
VDPR-C-38	-	-	-	82	-
VDPR-C-39	-	-	-	-	-
VDPR-C-40	12.2	-	-	83	-
VDPR-C-41	19.4	-	-	72	-
VDPR-C-42	44	+37	6.8	88	-
VDPR-C-43	46.4	-	6.7	80	-
VDPR-C-44	-	-	-	78	-
VDPR-C-45	-	-	-	70	-
VDPR-C-46	41.1	-	-	79	-
VDPR-C-47	49	-	12.6	-	-
VDPR-C-48	52.5	-	-	-	-
VDPR-C-49	-	-	-	86	-
VDPR-C-50	-	-	-	80	-
VDPR-C-51	41.3	57.4	9	-	-
VDPR-C-52	-	-	9	79	-
VDPR-C-53	42.8	+34.4	9.5	79	-
VDPR-C-54	49.5	+35.5	4.1	-	-
VDPR-C-55	-	-	5.4	72	-
VDPR-C-56	-	-	6	78	-
VDPR-C-57	-	-	6.3	78	-
VDPR-C-59	54	+45.5	8	80	-
VDPR-C-60	-	-	8.5	77	-
VDPR-A-1	64.2	68.3	-	81	37.7
VDPR-A-4	88.2	120	-	-	-
VDPR-A-5	64.2	72	-	89	-
VDPR-A-6	54.5	59.8	-	88	-
VDPR-A-7	65.5	82.2	-	83	-

valve presents two grooved cardinal teeth, which fit in the two opposite sockets. Anterior cardinal flat and sharp, height variable (Fig. 5. 4a-c) and joined to the anterior border of the valve. Posterior cardinal massive, pyramidal and similar to the one in the right valve. Sockets between the two cardinals very grooved. Two straight lateral teeth run from the umbo parallel to the valve edge.

Anterior adductor muscle impression very deep and close to the shell margin. In the right valve (Fig. 4. 6a; 5. 2b), the retractor pedal muscle scar, posterior to the adductor scar, is circular; while the protactor one, posterior and mostly ventral to the adductor muscle scar, is oval. Posterior adductor muscle impression unknown.

### Discussion

The external and internal morphological features of “*Unio*” *numantinus* are obviously not characteristic of the genus *Unio* as defined by its authors. Thus, in view of the lack of any known genus (recent or fossil) that could accommodate the species, we here define the new genus *Protopleurobema*.

According to the fossil mussel’s trigonal outline, freshwater habitat and above mentioned hinge characters (opisthodontic external ligament, and hinge consisting of two strong cardinal teeth in the left valve and one in the right), *Protopleurobema numantina* may be included in the order Unionoida. Moreover, the presence of lateral teeth and their shape in these specimens suggest the inclusion of the genus *Protopleurobema* in the superfamily Unionoidea (Cox *et al.*, 1969). Although this designation

seems clear, the number of characters is insufficient for its ascription at the family level, but it could be assigned to the family Unionidae as *Pleurobema*, since our specimens resemble the members this genus more than those of any other known genus, as we discuss below.

The genera *Pachycardia*, *Hadrodon*, and *Pleurobema* are the only known closely related Mesozoic genera described in the literature:

*Pachycardia* Hauer (1857) is a European genus of the Middle to Upper Triassic record. Its main similarity to *Protopleurobema* is the general shape of the shell, which is markedly trigonal; another shared characteristic is the presence of a wide and easily distinguished lunule. However, the hinge in *Pachycardia* is less strong and massive. In effect, this genus was formerly included in the Cardiniidae family (Heterodonta Subclass) (Cox *et al.*, 1969: N468). Owing to the hinge not really being heterodont, it was transferred to the Palaeoheterodonta Subclass, but its hinge is not as thick and strong as that of the members of the genera in the Unionoidea superfamily bearing cardinal and lateral teeth.

The genus *Hadrodon* Yen (1952) appears in the Jurassic of North America. Its members exhibit a strong hinge with a massive pyramidal cardinal tooth, which is very similar to the tooth observed in *Protopleurobema*. Although species of *Hadrodon* also present a wing-like posterior slope, its conspicuously undulated external surface distinguishes it very clearly from that found in *Protopleurobema*.

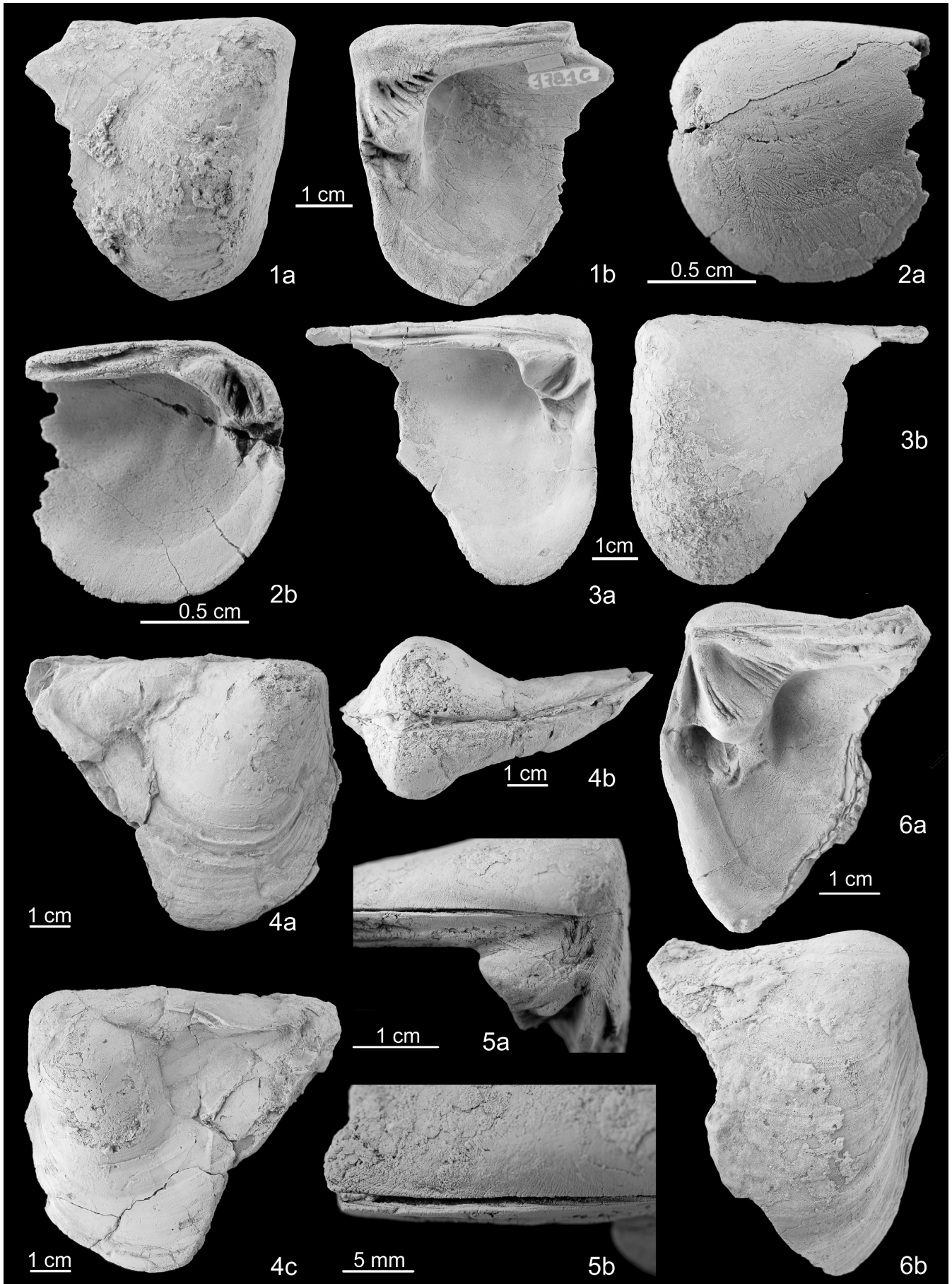
Whitfield (1907: 624) described *Unio pyramidatoides*, a *Pleurobema*-like species from the Cretaceous of Mon-

Fig. 4. *Protopleurobema numantina* (Palacios and Sánchez, 1885) (opposite page)

1. Right valve; a: External view; b: Internal view. Lower Cretaceous at Peña de las Huecas, Villarijo (Soria, Spain). Lectotype. MGM1781C. Figured by Delvene (2005: plate 1, figures 3a and 3b) and Delvene and Araujo (2008, figures 1a-1b).
2. Left valve of a juvenile specimen; a: External view; b: Internal view. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-1.
3. Left valve; a: Internal view; b: External view. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-2.
4. Articulated specimen; a: Right view, b: Dorsal view; c: Left view. Lower Cretaceous at level A of Valdeperillo site (La Rioja province). VDPR-A-1.
5. a: Detail of left valve; b: Magnification of the ligament pit. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-3.
6. Right valve; a: Internal view; b: External view. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-4.

Fig. 4 *Protopleurobema numantina* (Palacios y Sánchez, 1885) (página opuesta)

1. Valva derecha; a: Vista externa; b: Vista interna. Cretácico Inferior en Peña de las Huecas, Villarijo (Soria, Spain). Lectotipo. MGM1781C. Figurado por Delvene (2005: lámina 1, figuras 3a y 3b) y Delvene y Araujo (2008, figures 1a-1b).
2. Valva izquierda de un ejemplar juvenil; a: Vista externa; b: Vista interna. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-1.
3. Valva izquierda; a: Vista interna; b: Vista externa. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-2.
4. Ejemplar articulado; a: Vista derecha, b: Vista dorsal; c: Vista izquierda. Cretácico Inferior del yacimiento de Valdeperillo (nivel A), (provincia de La Rioja). VDPR-A-1.
5. a: Detalle de una valva izquierda; b: Aumento de la inserción ligamentaria. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-3.
6. Valva derecha; a: Vista interna; b: Vista externa. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-4.



tana. Although this is the species that most resembles *Protopleurobema numantina*, several important features differentiate the two. In *U. pyramidatoides*, the lunule is quite small or nearly obsolete and the posterior region is straight and has a very pronounced ridge, while *P. numantina* displays a large patent lunule. The former species also lacks a posterior wing.

The stratigraphical record of the North American genus *Pleurobema* Rafinesque (1820) spans the Upper Cretaceous to recent times. Of all the known genera, this is the genus that most resembles the new *Protopleurobema*. The main difference between the two lies in the shape of the shell, which is much more equilateral in *Pleurobema* than in *Protopleurobema*. The clearly recognized slight posterior wing makes the outline of the *Protopleurobema* shell very inequilateral. The hinges are nevertheless very similar in both, with cardinal teeth that are markedly pyramidal.

#### 4. Palaeoecological environment

After detailed sampling of a 40-metre section of subunit D of the Urbión Group, we identified 3 thick levels (A, B and C) of bivalves (Fig. 2). Lithologies varied from red sandstones of very fine grain size to grey marls, in which a greater abundance of well-preserved specimens was observed. Gastropods appeared throughout this section and coexisted with the bivalves in some levels. These were large gastropods belonging to the family Viviparidae that could be ascribed to the genus *Viviparus*, though their species identification remains unclear. What is clear is that they point to a freshwater environment. As described above, the sedimentologic features of the section also indicate a freshwater environment represented by a fluvial

system (Barrenechea, 1993).

The taphonomic characteristics of this bivalve association such as the high number of specimens (805), the presence of both juvenile and adult specimens, and the preserved articulated valves indicate it should be interpreted as a palaeoecological association. The “butterfly position” was relatively frequent among articulated specimens, especially in level A of the outcrop. The bivalve association is almost exclusively comprised of the species *Protopleurobema numantina*. The level B contains a large number of specimens but it is very difficult to remove them from the matrix.

According to the available literature, the order Unionoida only inhabits freshwater environments. Thus, the presence of this palaeoecological community confirms the freshwater nature of the palaeoenvironment. As are all known naiads, this type of bivalve would have been a filter feeder that lived burrowed in the substrate.

#### Acknowledgements

This work is a contribution to project CGL2006-10380/BTE. Photographs were prepared by the *Servicio de Fotografía Paleontológica* of the *Universidad de Zaragoza* (Spain). Support was received from the SYNTHESYS Project (<http://synthesys.info/>) financed by European Community Research Infrastructure Action under the FP6 “Structuring the European Research Area” programme. The authors thank the Dirección de Educación y Cultura del Gobierno de La Rioja (Spain) for permission to collect and analyze the fossil material. We also thank reviewers A. Bogan and A. Márquez Aliaga for their comments. Ana Burton reviewed the English.

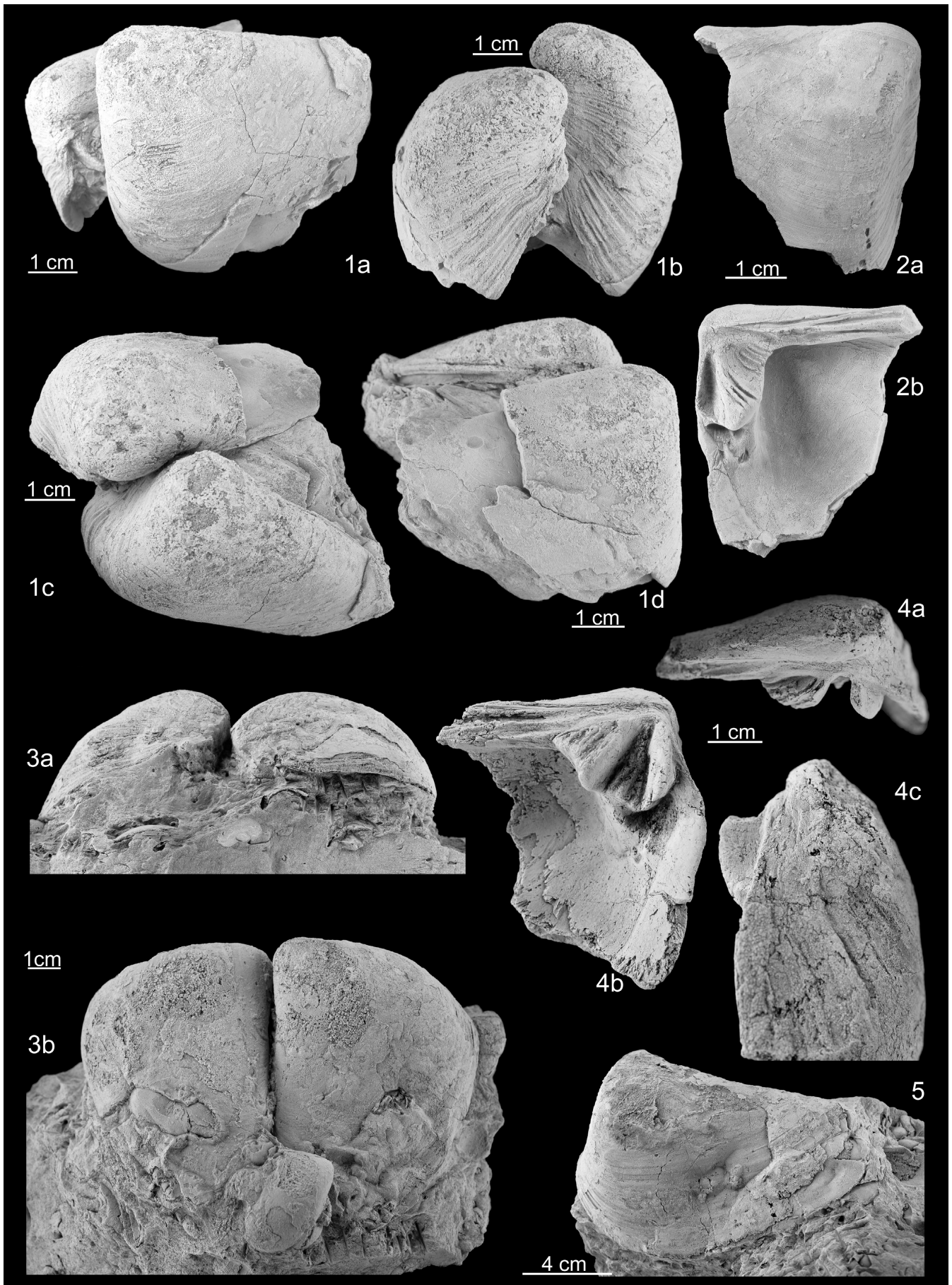
Fig. 5. *Protopleurobema numantina* (Palacios and Sánchez, 1885)

1. Articulated specimen; a: Left view, b: Posterior view; c: Dorsal view; d: Right view. Lower Cretaceous at level A of Valdeperillo site (La Rioja province). VDPR-A-2.
2. Right valve; a: External view; b: Internal view. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-5.
3. Articulated specimen; a: Anterior view; b: Both valves in “butterfly position”. Lower Cretaceous at level A of Valdeperillo site (La Rioja province). VDPR-A-3.
4. Left valve showing the flat and sharp anterior tooth; a: dorsal view; b: Internal view; c: Posterior view. Lower Cretaceous at level C of Valdeperillo site (La Rioja province). VDPR-C-6.
5. Left valve of articulated specimen of great size. Lower Cretaceous at level A of Valdeperillo site (La Rioja province). VDPR-A-4.

Fig. 5. *Protopleurobema numantina* (Palacios y Sánchez, 1885)

1. Ejemplar articulado; a: Vista izquierda, b: Vista posterior; c: Vista dorsal; d: Vista derecha. Cretácico Inferior del yacimiento de Valdeperillo (nivel A), (provincia de La Rioja). VDPR-A-2.
2. Valva derecha; a: Vista externa; b: Vista interna. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-5.
3. Ejemplar articulado; a: Vista anterior; b: Vista de las dos valvas en “posición mariposa”. Cretácico Inferior del yacimiento de Valdeperillo (nivel A), (provincia de La Rioja). VDPR-A-3.
4. Valva izquierda mostrando el diente posterior, plano y afilado; a: Vista dorsal; b: Vista interna; c: Vista posterior. Cretácico Inferior del yacimiento de Valdeperillo (nivel C), (provincia de La Rioja). VDPR-C-6.
5. Valva izquierda de ejemplar articulado de gran tamaño. Cretácico Inferior del yacimiento de Valdeperillo (nivel A), (provincia de La Rioja). VDPR-A-4.





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