

# New bradorid arthropods from the Lower Cambrian of Spain

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**ABSTRACT:** Lower Early Cambrian rocks of the Pedroche Formation in the Sierra de Córdoba consist of well-exposed mixed facies with abundant fossil assemblages showing long stratigraphical ranges. These assemblages include diverse Ovetian archaeocyaths, trilobites, small shelly fossils, calcimicrobia, trace fossils, and stromatolites. For the ostracod-like Cambriidae it is the first record from the Iberian Peninsula.

*Cordubiella pedrochensis* n.gen. n.sp. comes from two sections of the lower Pedroche Formation: the Arroyo de Pedroche 1 section, and the Arroyo Pedroche 2 section. The material was collected in the zone of *Lemdadella perejoni*, of lower Ovetian age and below the *Eoredlichia* FAD. It supplements both biostratigraphic and palaeobiogeographic distribution of the Cambriidae, which may be an important tool for the international correlation in the middle Lower Cambrian.

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## INTRODUCTION

The Lower Cambrian age of strata in the Sierra de Córdoba was first recognized by Hernández Pacheco (1907) with the discovery of archaeocyaths from Cerro de las Ermitas within the lower part of the Pedroche Formation. During the following years new fossiliferous localities were found and studied providing archaeocyaths, crustaceans, stromatolites, small shelly fossils, brachiopods, trilobites, and trace fossils (see Perejón et al. 1996; Liñán et al. 2005; Gámez Vintaned et al. 2006). Because of the alternance of numerous levels of archaeocyaths and trilobites (Liñán et al. 1982), the Sierra de Córdoba is considered as a classic area for biostratigraphical studies on the lower Lower Cambrian (Liñán et al. 1993, 2002).

The aim of this work is to study the cambriid record in Member I of the Pedroche Formation at two sections (text-fig. 1). Representatives of the family Cambriidae belong to the Order Bradorida, a group of bivalved arthropods that preceded ostracod evolution. Cambriids have fairly large carapaces, which are characterized by a distinct anterior-dorsal downslope and a typical surface sculpture that consists of nodes and ridges. Their discovery in Spain adds to their known records from different parts of the world such as North America, Greenland (Siveter et al. 1996), France (Vannier et al. 2005), Siberia, and Southwest China (e.g., Hou et al. 2002).

In the well-known and highly fossiliferous Spanish Cambrian, findings of bradorids are, however, scarce. Until now, only representatives of the family Hipponicharionidae have been documented from this region (Gozalo and Hinz-Schallreuter 2002; Gozalo et al. 2004).

## GEOLOGICAL AND STRATIGRAPHY SETTING

The Cambrian rocks of the Sierra de Córdoba are defined by a syncline trending NW-SE and dipping to the SE. The northern flank of this syncline is interrupted by the Cerro Muriano fault while the southern part connects to an anticline whose core is made up of Precambrian rocks of the Volcanic-Sedimentary Complex. This structure is covered by scarce Triassic outcrops, widespread Miocene materials and Quaternary terraces of the Guadalquivir River (text-fig. 1). For summary of the stratigraphy see Liñán Guijarro (1978), Perejón et al. (1996), and Liñán et al. (2002, 2005).

The Pedroche Formation is composed of limestone and shale, with scarce sandstone and dolostone, and contains archaeocyaths, trilobites (cf. *Bigotinella* sp., *Bigotina bivallata* Cobbold 1935, *Lemdadella linaresae* Liñán and Szdzy 1978, *L. aff. linaresae* Liñán and Szdzy 1978, *L. perejoni* Liñán et al. 2005, *Serrania verae* Liñán Guijarro 1978, *Eoredlichia* cf. *ovetensis* Szdzy in Liñán and Szdzy 1978, and Neoredlichiiidae sp. indet.), bivalved arthropods (*Isoxys carbonelli* Richter and Richter 1927), brachiopods (*Paterina*), algae, calcimicrobes, small shelly fossils, bradorids, hyolithids, stromatolites (*Charaulachia cordubensis* Schmitt 1983, and *Vetella* cf. *safartiae* Schmitt 1979; both defined at the Arroyo de Pedroche 1 section) and trace fossils (*Bergaueria*, *Cochlichnus*, *Dactyloidites*, *Monocraterion*, *Palaephycus*, *Phycodes*, *Planolites*, *Psammichnites*, *Rusophycus*, *Torrowangea*, *Treptichnus* and *Skolithos*). Archaeocyath localities are numerous but the most important are Las Ermitas and Arroyo de Pedroche. These palaeontological assemblages suggest an Early Ovetian age for the Pedroche Formation (Liñán Guijarro 1978; Perejón et al. 1996; Liñán et al. 2002, 2005).

The fossils studied belong to two sections located in Member I of the Pedroche Formation (Figs. 2, 3). The Arroyo de Pedroche section (AP1) was studied by Liñán and Dabrio (1974), Liñán et al. (1982; 2005), Fernández Remolar (1996) and Gámez Vintaned et al. (2006). It is the type section of the Pedroche Formation. The section begins in the crossroads between the new Badajoz-Córdoba road and the right side of the Arroyo Pedroche. It follows the abandoned road of the Córdoba-Cerro Muriano which is located at the left side of the Arroyo de Pedroche. The Arroyo de Pedroche 2 section (AP2) which has been studied by Liñán et al. (2005) and Gámez Vintaned et al. (2006), is located near the Club Asland Córdoba and runs parallel to the Arroyo de Pedroche 1 section.

## BIOSTRATIGRAPHIC IMPLICATIONS

Based on archaeocyaths (Perejón 1994), the Lower Ovetian of Sierra Morena has been subdivided into three biozones, of which Zone III has been recently subdivided into three trilobite biozones by Liñán et al. (2005): the *Bigotina bivallata* biozone, *Lemdadella linaresae* biozone and *Lemdadella perejoni* biozone. The cambriids studied herein came from the *L. perejoni* biozone (text-figs. 2, 3), from a horizon below the first documented appearance of the genus *Eoredlichia*.

The *Lemdadella perejoni* biozone contains the trilobites *Lemdadella perejoni*, *L. linaresae* (only in the lower part) and Neoredlichidae indet., undetermined archaeocyaths, the brachiopod *Paterina* sp., the trace fossils *Planolites montanus* and *Torrowangea* ichnosp., as well as the bradorid *Cordubiella pedrochensis* n. gen., n. sp.

The *Lemdadella linaresae* and *Lemdadella perejoni* biozones correspond to the upper part of the archaeocyath Zone III at section AP1 (Perejón 1989). The two guide species of these biozones are close to *Lemdadella spectabilis* and *Lemdadella tioutensis* (see Liñán et al. 2005), respectively from Zone 0 and Zone I (*Fallotaspis tazemmoutensis* zone) of Morocco (Sdzuy 1978, 1981; Liñán and Sdzuy 1978). Liñán et al. (2005) correlated the *Bigotina bivallata* and *Lemdadella linaresae* biozones with Zone 0 of Morocco, and the *Lemdadella perejoni* biozone with Zone I (*Fallotaspis tazemmoutensis* zone). These three biozones probably correspond with part of the lower Atdabanian stage in Siberia, the East European Platform, and Antarctica.

Finally, the FAD of the genus *Eoredlichia* marks the top of the *Lemdadella perejoni* biozone. The presence of that genus permits a good correlation with the former Qiongzhusian stage of South China; these levels are included now in the Nangaoian Stage (see Peng and Babcock 2001; Peng 2003).

According to Siveter et al. (1996), Hou et al. (2002) and Vannier et al. (2005) the family Cambriidae comprises the following genera: *Cambria* Neckaya and Ivanova 1956, *Shangsiella* Lee 1975, *Auriculatella* Tan 1980, *Petrianna* Siveter et al. 1996, and *Monceretia* Vannier and Williams in Vannier et al. 2005. Their regional and biostratigraphic occurrences are given in text-figure 4.

The Siberian species *Cambria melnikovi* Ivanova 1964 was recorded from the Tyaser Formation, Atdabanian Stage (see Melnikova et al. 1997), while *C. sibirica* Neckaya and Ivanova 1956, and *C. egorovae* Melnikova 1983 came from the Lena-Aldan region, the lithostratigraphic provenance for both

species is not clear, they may be from the Pestrotsvet Formation, also Atdabanian Stage (see Melnikova et al. 1997).

In China four genera of Cambriidae with several species had been recorded (see Hou and Shu 1985). Recently, Hou et al. (2002) revised the systematics of Chinese bradorids, assigning all Chinese Cambriidae to only two species: *Shangsiella elongata* Lee 1975, and *Auriculatella typica* Tan 1980. Both species came from the Qiongzhusi Formation but not from the same sections, although all localities are placed in the named western subprovince by Hou et al. (2002). The biostratigraphical record of *Shangsiella elongata* refers to upper *Abadiella* to middle *Eoredlichia*-*Wutingapis* trilobites biozones, while the distribution of *Auriculatella typica* is restricted to the the upper part of *Abadiella* biozone. Both biozones belong to the former Qiongzhusian Stage which corresponds, in part, with the Nangaoian Stage (Peng and Babcock 2001; Peng 2003).

*Petrianna fulmenata* Siveter, Williams, Peel and Siveter 1996 from the Buen Formation of Greenland comes from top of the *Nevadella* zone or bottom of the *Bonnina-Olenellus* zone, while *Petrianna*? sp. A, from the same formation, was discovered in the *Bonnina-Olenellus* zone (see Siveter et al. 1996).

Recently, Vannier and Williams in Vannier et al. 2005 introduced *Cambria danvizcainia* and *Monceretia erisylvia* from the Montagne Noire (France), both species coming from the basal Pardaillan Formation; this formation contains archaeocyaths and trilobites of upper Ovetian age.

Already Melnikova et al. (1997) stated that “Cambriids are amongst the oldest bradorids, characterising approximately coeval rocks in Russia (Atdabanian), South China (Qiongzhusian) and North Greenland (*Nevadella-Bonnina* to *Olenellus* zone, top of Montezuman)”. The new findings from Montagne Noire (Vannier et al. 2005) and Córdoba are Ovetian in age, and supplement this biochronological record (text-fig. 4).

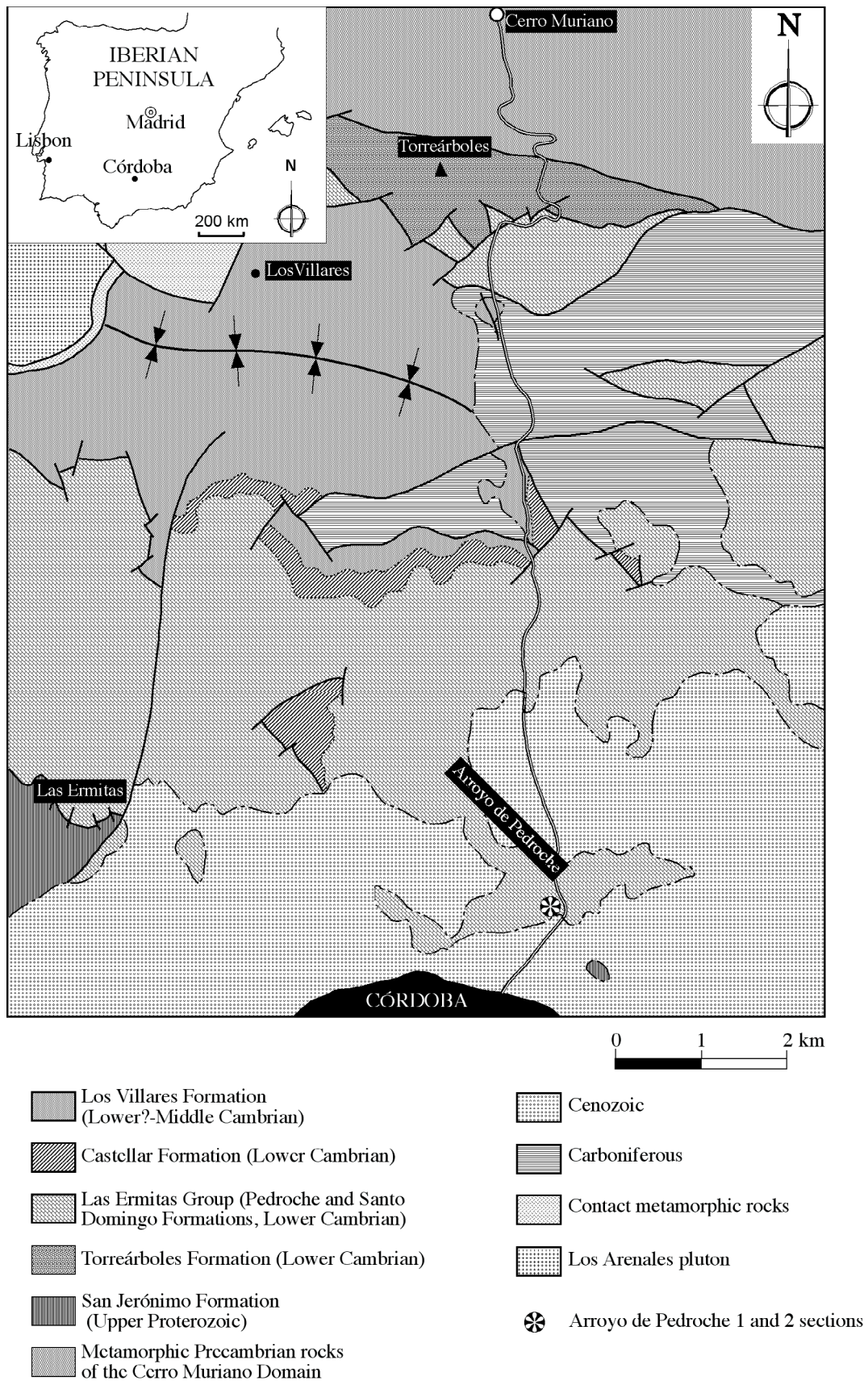
Cambriids belong to the oldest yet recorded bradorids and appear contemporaneously with or slightly later than the first trilobites. With regard to their regional distribution, this family can be used as biostratigraphic correlation tool (comp. Siveter et al. 1996; Vannier et al. 2005).

## BIOGEOGRAPHIC IMPLICATIONS

Bradorids include cosmopolitan taxa such as the presumably pelagic *Eremos* Moberg and Segerberg 1906, endemic representatives like the Oepikalutidae that are restricted to South China and Australia (Hinz-Schallreuter 1999), and examples of provincialism such as the genus *Hipponicharion*, which is apparently confined to the Acadobaltic Province (sensu Sdzuy; see Gozalo and Hinz-Schallreuter 2002).

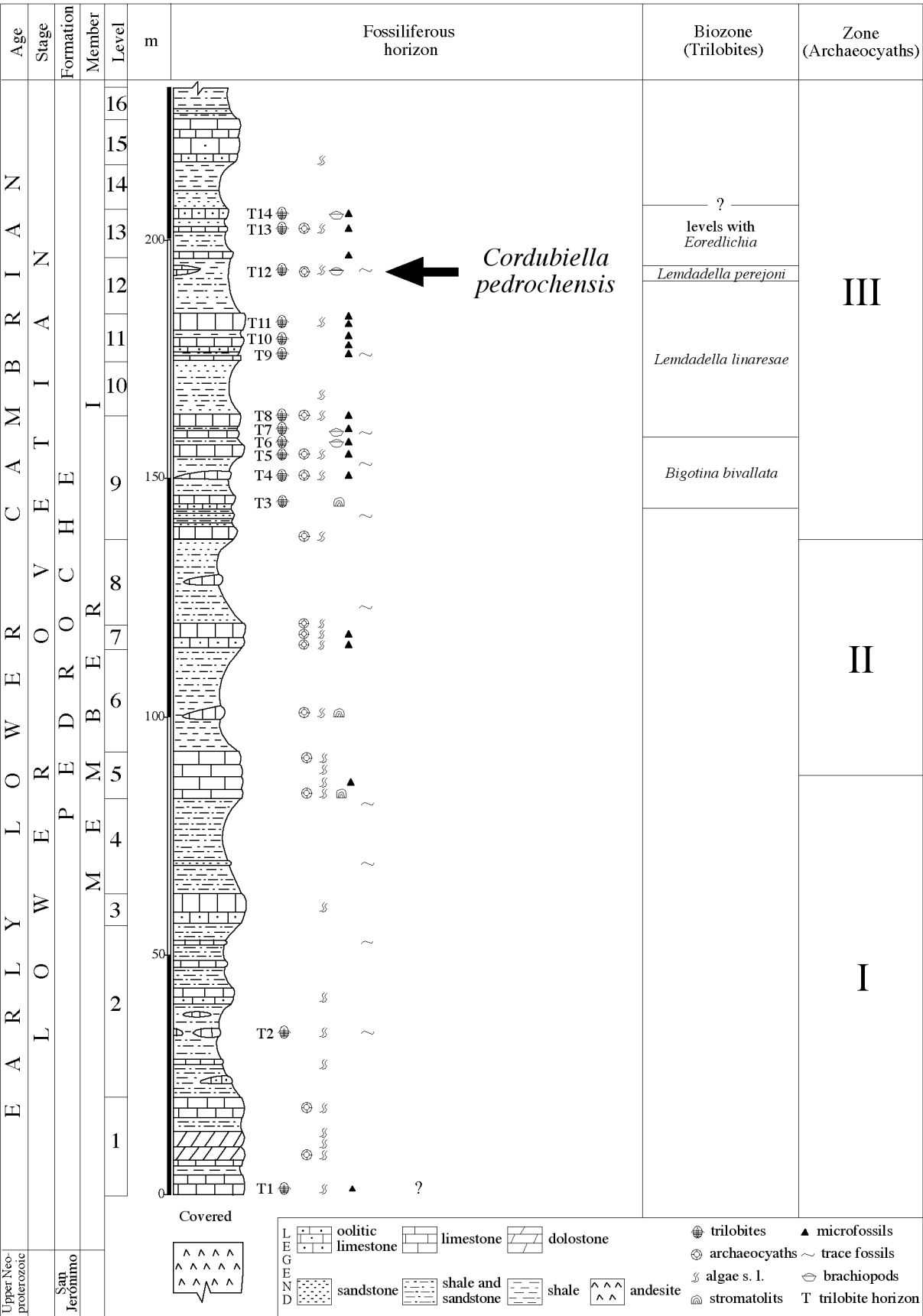
Representatives of the family Cambriidae are fairly large-sized arthropods with a bivalved, ostracod-like carapace. Cambriids are restricted to Lower Cambrian mainly shallow marine environments. Only the genus *Petrianna*, the youngest yet known member from Greenland came from offshore sediments (Williams and Siveter 1997). However, all taxa occur in an equatorial belt up to 30° northern and southern latitude, a warm water realm which is confirmed by the presence of archaeocyaths.

From a palaeobiogeographic point of view the Cambriid occurrences are widespread longitudinally, spanning parts of the Redlichiid, Olenellid and Bigotiniid trilobites realms (sensu Pillola 1990, and McKerrow et al. 1992), but are apparently re-

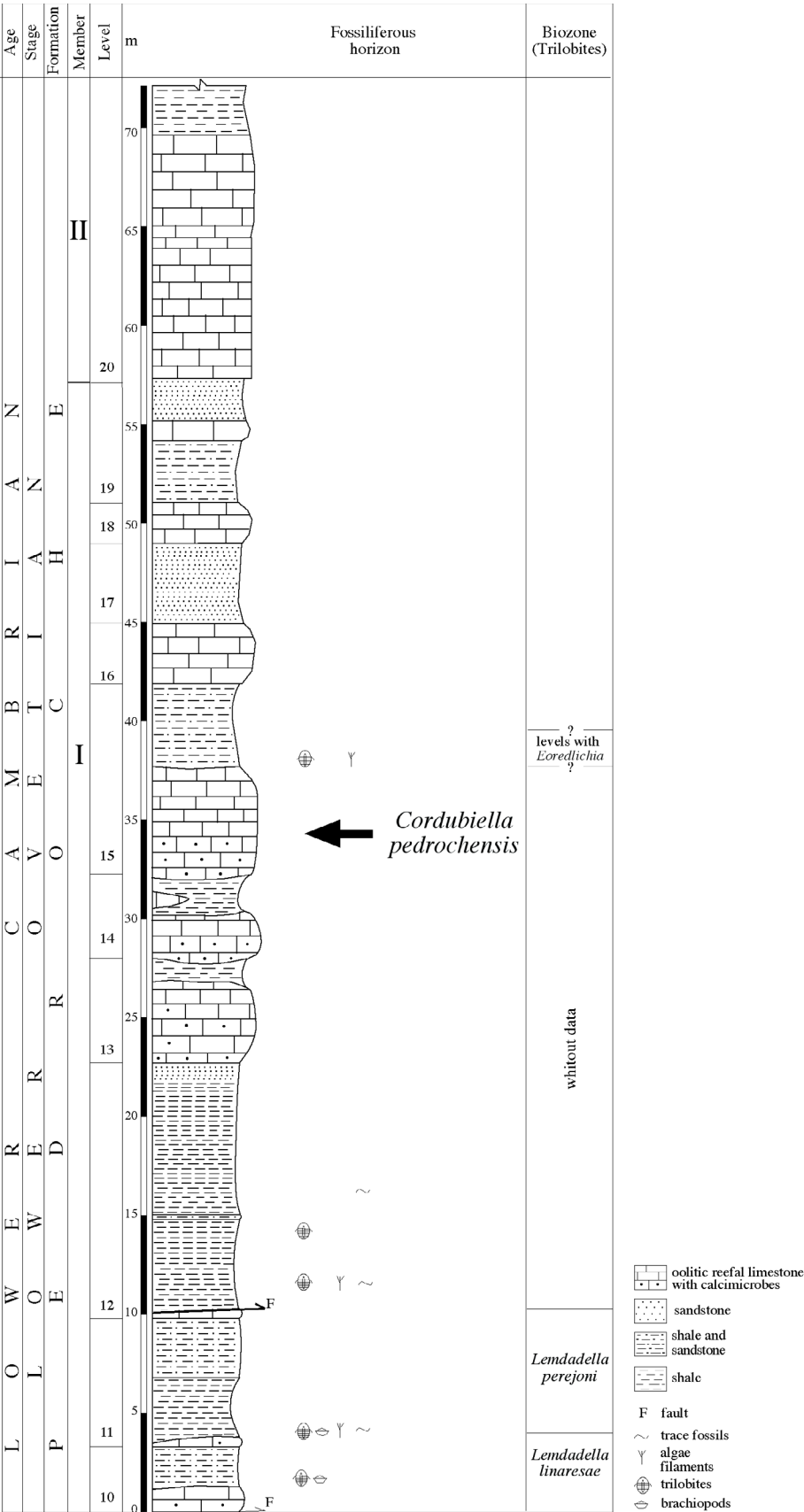


TEXT-FIGURE 1  
Geological setting of the studied sections (after Liñán Guijarro in Perejón et al. 1996).










TEXT-FIGURE 2  
Arroyo de Pedroche 1 (AP1) section (after Liñán and Dabrio, 1974, and Liñán et al. 2005).



TEXT-FIGURE 3  
Arroyo de Pedroche 2 (AP2) section (after Liñán et al 2005).

SOUTH CHINA	LAURENTIA	SIBERIA	IBERIA and FRANCE
DUYUNIAN (pars)	DYERAN (pars) 	BOTOMAN 	MARIANIAN
NANG-AOAN 	MONTEZUMAN	AITDA-BANIAN 	OVETIAN 
MEISHUCUNIAN (pars)	unnamed	TOMMOTIAN (pars)	CORDUBAN (pars)

TEXT-FIGURE 4

Stratigraphic distribution of Cambriidae (indicated by icon and arrow), modified from Siveter et al. (1996) and Vannier et al. (2005). The correlation has been established based on Geyer (1990), Liñán and Gámez (1993), Zhuravlev (1995), Geyer and Shergold (2000, 2003); the stages nomenclature for South China in accordance with the proposal of Peng and Babcock (2001) and Peng (2003).

stricted to tropical and subtropical regions after Siveter et al. (1996). Similar conclusions were drawn by Vannier et al. (2005) and this paper (text-fig. 5). The Spanish cambriids belong to the Bigotiniid realm, which is considered to be subtropical because of the presence of archaeocyaths. We therefore, conclude, that the distribution of the family was controlled by tropical climatic factors, similar to the interpretation proposed for the distribution of oryctocephalid trilobites (Shergold 1969; Gozalo et al. 2003) and the poriferan genus *Leptomitius* (García-Bellido et al., in press).

## SYSTEMATIC PALEONTOLOGY

The material studied herein is housed in the Museo Paleontológico de la Universidad de Zaragoza-Gobierno de Aragón at Zaragoza, Spain, under references MPZ 2006/337 to MPZ 2006/343. Casts of the respective specimens are housed under the indicated IGG numbers at the Institute of Geography and Geology, University of Greifswald.

Order BRADORIDA Raymond 1935

Family CAMBRIIDAE Lee 1975

Type genus: *Cambria* Neckaja and Ivanova 1956

*Diagnosis (emend.):* Large-sized ostracod-like bivalved arthropods, up to 1.75cm length and equivalved carapaces of subovate to sub-semicircular outline with distinct retrol swing. Dorsal margin angular, being composed of straight “hinge-line” and downslope between anterior cardinal and anterodorsal corners. Free margin with adventral rim. Lobation consisting of anterior and posterior lobes that may be confluent via a connecting lobe. Additional lobes, particularly in the dorsal region, may be present. Outer surface smooth to granular.

*Comments:* The first descriptions of cambriids date back to 1956 when Neckaja and Ivanova introduced *Cambria sibirica*, the type species and type genus of the family. Two further records from Russia followed by Ivanova (1964) and Melnikova (in Grigorieva et al. 1983), but a great many cambriids have been reported from China by various authors (see Tab. 1). According to Lee (1975), Huo and Shu (1985) and Shu (1991) eight genera with a total of 32 species and subspecies belong to the family Cambriidae: *Antihipponicharion*, *Auriculatella*, *Cambria*, *Chuanbeieila*, *Guangyuanella*, *Nanchengella*,

*Paracambria* and *Shangsiella*. However, only *Auriculatella*, *Cambria*, *Shangsiella* and the Greenlandian genus *Petrianna* seem to represent unequivocal cambriids as well as the latest records of *Monceretia* Vannier and Williams in Vannier et al. 2005 and *Cordubiella* n.gen. The Chinese *Paracambria*, *Chuanbeieila* and perhaps *Antihipponicharion* were regarded as junior synonyms of *Shangsiella*, and *Guangyuanella* was suggested to be restricted to the type specimen for preservational reasons (Hou et al. 2002). *Nanchengella* which was originally assigned to the family Shangsiellidae by Lee (1975) was referred to as a kunmingellid by Hou et al. (2002) for differences in lateral lobation.

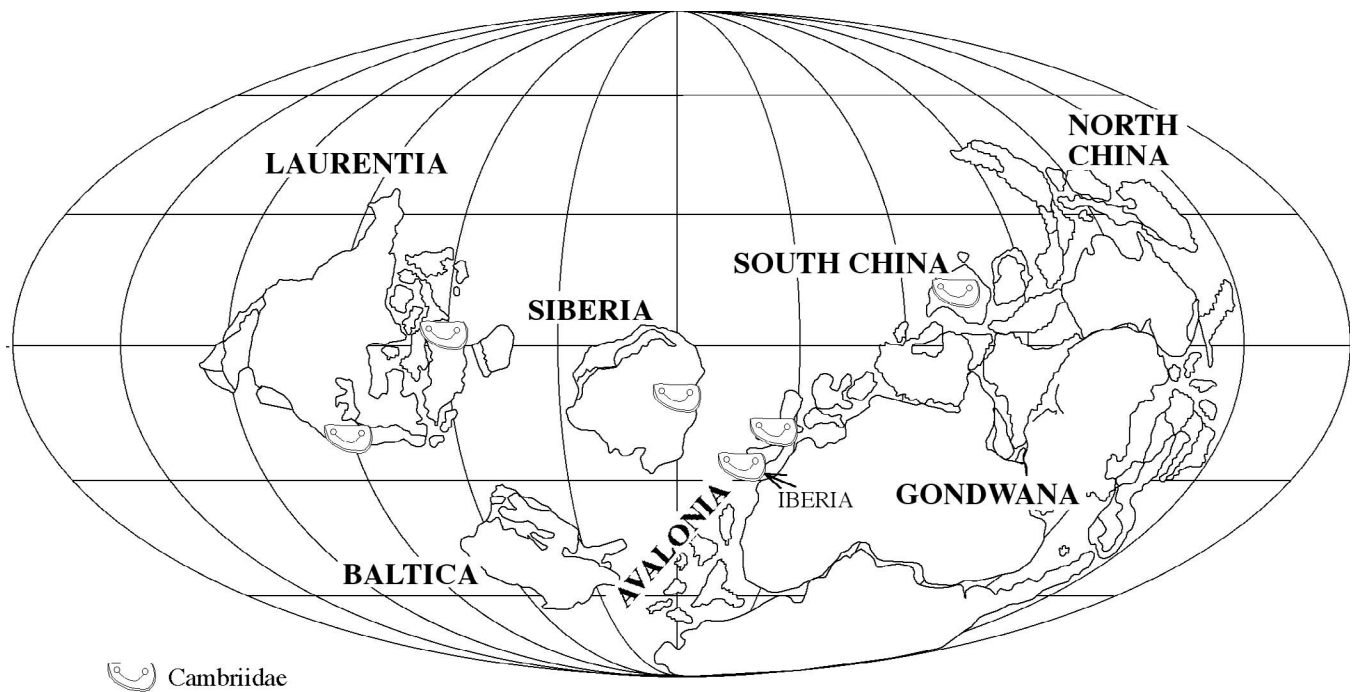
*Remarks:* Except for the genus *Matthoria* Siveter and Williams 1997 which is not regarded as member of the family Cambriidae, the latter comprise six genera of which three are presently monotypic (Tab. 1). They are distributed on four continents. A comparison on the species level revealed that morphological differences, even within the genus *Cambria* (e.g., *C. sibirica*, *C. melnikovi*, *C. egorovae*) may be bigger than between different genera (e.g., *Cambria sibirica* and *Auriculatella zhaanxiensis*) as was already noted by Williams et al. (1994). Only *Shangsiella*, although showing all characteristics of cambriids, is different to all other representatives particularly in the extension of the connecting lobe which does, however, not question its assignment to Cambriidae. We follow here the concept of Siveter and Williams (1997) in establishing a new cambriid genus for the first record of this family in Spain based on specimens with the characteristics outlined below.

## Morphological terminology and orientation

The term dorsal cusp introduced by Williams et al. (1994) and subsequently used by, e.g., Siveter et al. (1996), Hou et al. (2002) and Vannier et al. (2005) may be easily confused with “cusp” in the sense of Martinsson (1962), which means a lobe projecting beyond the dorsal margin unlike the situation in cambriids. Moreover, the suggested cusp in cambriids is reinterpreted as anterior cardinal corner passing into a more or less abrupt anterior-dorsal downslope which terminates at the anterodorsal corner (text-fig. 6).

Moreover, we consider the dorsal margin to consist of two portions: a straight “hinge-line” and an anterior-dorsal downslope with the latter not belonging to the “articulation axis”. Unlike a number of illustrated single valves (e.g., Siveter et al. 1996: fig. 6 a-d, f, g; Hou et al. 2001: figs. 2e 16a, b; Vannier et al. 2005: fig. 4b) we suggest to orient the “hinge-line” horizontally comparable to other lower Palaeozoic bradorids as well as of straight-hinged palaeocope and leperditioCOPE ostracods. Regarding the downsloping anterior-dorsal portion as part of the “hinge-line” would cause severe mechanical problems particularly in the process of carapace opening.

The excellently illustrated material of *Petrianna* in Siveter et al. (1996) reveal that the valves of the widely opened carapace (op. cit.: fig. 6j) are deformed. Similar illustrations from other taxa were provided by Hou et al. (2001: 376), and Vannier et al. (2005: text-fig. 4b). The valves are shifted underneath each other along the anterior-dorsal half and in order to create a supposed horizontal axis of “articulation” along the entire dorsal margin. In their figure explaining the function of a cambriid carapace with dorsal “cusp” Vannier et al. (2005) referred, however, to a straight dorsal margin.



TEXT-FIGURE 5

Palaeogeographical distribution of cambriids in the Early Cambrian (Atadabanian to Botoman) reconstruction after Mckerrow et al (1992) and modified from Siveter et al. (1996).

**Remarks.** Although Williams et al. (1996) sketched species of the Cambrian bivalved arthropod *Isoxys* with dorsal cusp in their figure 3 to show its stratigraphical, geological and palaeogeographical distribution, they did not include a dorsal “cusp” in their figure 4 illustrating the morphological terms. Furthermore, their high quality photographs of *Isoxys volucris* from Greenland (o.c.) clearly show a wrinkled surface of the strongly laterally compressed carapaces, which suggests that these specimens must have had a rather flexible shell. This might have been also the reason why the dorsal margin is differently developed in all illustrated specimens, ranging from straight to variably uneven, but none exposing a “cusp” comparable to cambriids. Williams et al. (1996) also illustrated other *Isoxys* species from North America, Australia and Southwest China. The best preserved specimen, which comes from China has a straight dorsal margin and confirms doubts about the primary nature of a dorsal “cusp” in *Isoxys*.

Genus ***Cordubiella*** Hinz-Schallreuter, Gozalo and Liñán **n. gen.**

Type species: *Cordubiella pedrochensis* n. sp.

**Etymology:** Corduba (latin) after its occurrence in the Córdoba city, Spain.

**Diagnosis:** Cambriid with very small anterior node and ridge-like posterior lobe joined by a connecting lobe. Adventral rim entire between anterodorsal and posterior cardinal angles.

**Comparison:** *Cordubiella* differs from *Cambria* mainly in the development of anterior and posterior lobes, that are more pronounced in *Cambria* with its prominent rounded anterior lobe and a sickle-shaped posterior lobe. A third, anterodorsal lobe or inflation is, however, not developed in *Cordubiella*. Furthermore, the adventral ridge in *Cambria* is confluent with the

valve margin anteriorly instead of being entire between anterodorsal and posterior-cardinal angles. From *Auriculatella*, the new genus differs in the less prominent connecting ridge and in the development of the adventral ridge which is very similar in *Auriculatella* and *Cambria* in being confluent with the valve margin anteriorly. The new genus lacks, however, the third lobe of *Auriculatella*. *Petrianna* also has a distinct connecting ridge and an entire adventral ridge like *Cordubiella*, but differs in having both lobes developed as nodes rather than as node and ridge. Both lobes are closer to each other in *Petrianna* than in *Cordubiella*. The ridge-like connection between anterior lobe and dorsal rim is also lacking in *Cordubiella*. In *Shangsiella*, anterior and posterior lobes are not connected. The anterior lobe is fused with the anterior part of the connecting ridge to form a sickle-shaped sculpture. The posterior portion of the connecting ridge is lacking and thus, isolating the node-like posterior lobe. Contrary to Vannier et al. (2005) the genus *Matthoria* Siveter and Williams 1997 is not regarded as cambriid representative herein. It has a totally different valve outline in being much higher than long, and lacks the typical lobation consisting of anterior and posterior lobes as well as a connecting lobe. Furthermore, the dorsal margin is gently rounded in the type species of *Matthoria*, which was originally referred to the family Svealutidae by Siveter and Williams (1997) although the authors noted a similarity to cambriids in the development of the dorsal margin, which is gently rounded in the type species rather than abruptly downsloping and forming a “cusp”.

***Cordubiella pedrochensis*** Hinz-Schallreuter, Gozalo and Liñán **n. sp.**

**Etymology:** After its occurrence in the Lower Cambrian Pedroche section.

TABLE 1

Synopsis of cambriid taxa with regard to synonymy on the generic level suggested by Hou et al. (2002). The authorship of *Chuanbeiella* and its listed species was given as Huo and Peng in Huo and Shu (1985: 155-157) and was accordingly cited by various authors (e.g., by Siveter et al. (1996:116), or Hou et al. (2002: 375) . However, since Peng was not co-author of the monograph by Huo and Shu (1985) all taxa newly established in this work have to be referred to the latter authors according to the ICZN article 50.1 together with recommendations 50A and 51E.

Genera	Species (*Type species)
<i>Auriculatella</i> Tan 1980	* <i>Auriculatella typica</i> Tan 1980 <i>A. typical shaanxiensis</i> Huo and Shu 1985 <i>A. acuta</i> Huo and Shu 1985 <i>A. allocate</i> Huo and Shu 1985
<i>Cambria</i> Neckaja and Ivanova 1956	* <i>Cambria sibirica</i> Neckaja and Ivanova 1956 <i>C. chinensis</i> Huo and Shu 1985 <i>C. egorovae</i> Melnikova 1983 <i>C. melnikovi</i> Ivanova 1964 <i>C. sichuanensis</i> Huo and Shu 1985 ( <i>C. danvizcainia</i> Vannier et al. 2005)
<i>Cordubiella</i> n. gen. Hinz-Schallreuter et al.	* <i>Cordubiella pedrochensis</i> n.sp. Hinz-Schallreuter et al.
<i>Monceretia</i> Vannier et al. 2005	* <i>Monceretia erisylvia</i> Vannier et al. 2005
<i>Petrianna</i> Siveter et al. 1996	* <i>Petrianna fulmenata</i> Siveter et al. 1996
<i>Shangsiella</i> Lee 1975  (= <i>Chuanbeiella</i> Huo and Shu 1985  = <i>Paracambria</i> Huo and Shu 1985  = ? <i>Antihipponicharion</i> Huo and Shu 1985)	* <i>Shangsiella elongata</i> Lee 1975 <i>S. changjianggouensis</i> Huo and Shu 1985 <i>S. hypsita</i> Lee 1975 * <i>Chuanbeiella distincta</i> Huo and Shu 1985 <i>C. alata</i> (Lee 1975) <i>C. gigantea</i> Huo and Shu 1985 <i>C. guangyuanensis</i> Huo and Shu 1985 * <i>Paracambria typica</i> Huo and Shu 1985 <i>P. longa</i> Huo and Shu 1985 <i>P. zhaoi</i> Huo and Shu 1985 * <i>Antihipponicharion navis</i> Huo and Shu 1985

**Holotype:** MPZ 2006/337, text-figure 7.1

**Type Locality:** Arroyo de Pedroche Section (AP1) between Arroyo Pedroche and the Badajoz-Córdoba former road.

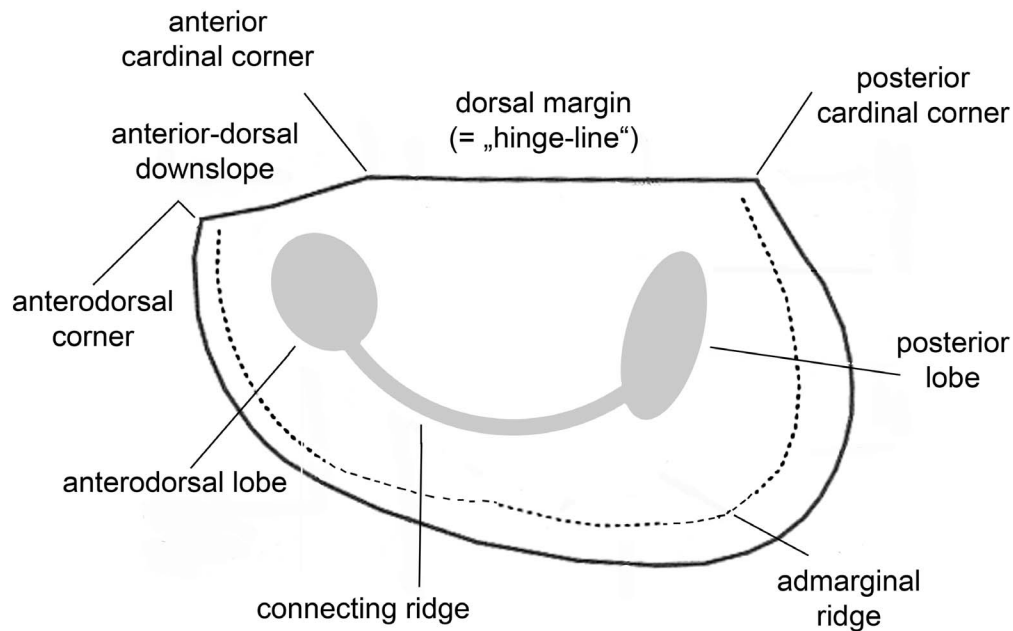
**Type Horizon:** *Lemdadella perejoni* Biozone, Lower Ovetian.

**Material:** More than 20 single valves and 1 carapace embedded in rock and preserved as steinkerns and external moulds. The material is partly incomplete (length or height measurable) or fragmentary (not measurable).

**Stratigraphical distribution and biochronology:** Arroyo de Pedroche 1 section, horizons T12b and probably T14. Arroyo de Pedroche 2 section, horizon T15. *Lemdadella perejoni* biozone (Lower Ovetian, Lower Cambrian); level T14 contains the trilobite *Eoredlichia*.

**Diagnosis:** Length at least up to 7.00mm. Length of anterior downslope slightly shorter than “hinge-line”. Nodular anterior lobe located at inner margin of anterodorsal field, posterior lobe ridge-like and extending from posterodorsal to central field. Connecting lobe distinct. Adventral ridge entire and parallel to free margin.





TEXT-FIGURE 6  
Generalized cambriid morphology.

**Description:** Large-sized, equivalved carapaces. Subamplate with sub-semicircular outline and distinct retrai swing. Maximum length at about mid-height. Dorsal margin with distinct anterodorsal downslope by approximately 30°. “Hinge-line” straight, not corresponding to entire dorsal margin and only slightly longer than anterodorsal downslope. Anterior cardinal angle more obtuse than posterior cardinal angle. Free margin evenly developed and paralleled by a prominent adventral ridge, which is continuous between anterodorsal and posterior cardinal angles and nearly equal in width. Lobation consists of a small nodular anterior lobe, that is situated at the inner margin of the anterodorsal field without connection to the dorsal margin. It may indistinctly pass into the connecting lobe. The ridge-like posterior lobe runs from near posterodorsal margin towards the central field. In some specimens the posterior lobe appears almost vertical. The posterior lobe raises towards its centrally located end. Both lobes are joined by a distinct connecting lobe, that is of about the same width as the posterior lobe. The outer shell surface is not preserved.

**Ontogeny:** The new species is represented by specimens ranging between 4.9 and 7.00mm in length. Whether or not the largest valves represent adult stages is unclear as yet. In the largest available stages, two different developments of the posterior lobe are observable. In one type, the posterior lobe is a simple ridge while the other type exhibits a bifurcated sculpture (text-fig. 7a-c). However, this particular specimen seems to be a carapace with view onto the left valve, while the underlying right valve had been slightly but obliquely shifted dorsally and posteriorly. Therefore, the posterior lobe of the underlying right valve may have produced the bifurcated lobe if this phenomenon is not interpreted as sculptural dimorphism. However, an interpretation as preservational feature seems to us the most plausible explanation on the basis of the yet available material.

**Comparison:** The genus *Cordubiella* is presently monotypic. Similarities to other taxa refer to single characteristics of cer-

tain species, such as the entire comarginal adventral ridge of, e.g., *Petrianna* and *Shangsiella* and the comparably small node-like anterior lobe in *Auriculatella shaanxiensis*. *Cambria egorovae* shows closest affinities to the new species with regard to the nodular anterior lobe. The posterior lobe seems to be ridge-like, but there is not a distinct connecting lobe. Also, the adventral ridge parallels the valve margin and extends between anterodorsal and posterior cardinal angles in *C. egorovae*, but is apparently not as set off from the marginal rim as in the new species. From *Cambria sibirica*, *Cordubiella pedrochensis* differs in the development of both anterior and posterior lobes. The anterior lobe is much stronger in *Cambria sibirica* and the posterior lobe of the latter species is sickle-shaped, while it runs straight in *Cordubiella pedrochensis*. *Cambria sibirica* has an adventral ridge running horizontally and thus, divergent to the valve margin in the ventral region where it is also most prominent. *C. pedrochensis* has a comparably evenly developed prominent adventral ridge that parallels the valve margin instead of being confluent with part of the valve margin like in *C. sibirica*. Moreover, the ratio of “hinge-line” to anterodorsal downslope differs in both species. In *C. sibirica* and also *Auriculatella* the “hinge-line” is distinctly longer than the downslope. *Petrianna* shows approximately equal length of both dorsal portions and resembles *Cordubiella pedrochensis* in this respect. From *Cambria danvizcainia* it differs in the development of the anterior lobe, that is U-shaped in *C. danvizcainia* and in the adventral ridge does not reach the cardinal corners but may join up with the posterior lobe ventrally (Vannier et al. 2005: 9).

#### Sexual dimorphism in Cambrian ostracod-like arthropods

As was stated by Vannier et al. (2005) sexual dimorphism until now is only documented from phosphatocopes. The authors referred to Zhang (1987) who assumed sexual dimorphism in his accordingly named *Phaseolella dimorpha*. However, as was already pointed out by Hinz-Schallreuter (1993: 345) the extremely early sexual differentiation in juveniles of only 0.2mm

length suggests two species rather than dimorphism. This assumption is supported by the fact, that the two dimorphs were not etched from the same sample. By contrast, Hinz-Schallreuter (1993) noted sexual dimorphism expressed as sculptural dimorphism in the phosphatocope *Bidimorpha bidimorpha*. Müller (1964) previously recorded sexual dimorphism in the phosphatocope *Vestrogothia spinata* which was confirmed and supplemented by subsequent investigations of the genus *Vestrogothia* by Hinz-Schallreuter (2000: 864, 867). In *Vestrogothia spinata* secondary sexual characters occur particularly in the development of an additional long postero-ventral spine on the left heteromorphic valve. *Vestrogothia herrigi* Hinz-Schallreuter 1998 and *Vestrogothia minilaterospinata* Hinz-Schallreuter 1998 have also been regarded as dimorphs of one species (o.c.). Both originally separated species show the same stop-peg-like sculpture and differ mainly in the development of the ventral spine which is much stronger in *V. herrigi*.

Concerning bradorids, records of sexual dimorphism are much rarer. Shu et al. (1999) illustrated a *Kunmingella* with preserved soft integument and attached spherical bodies that were interpreted as eggs which makes sexual dimorphism likely, although morphometric analyses have not been carried out, yet. A second, but questionable example of bradorid dimorphism was mentioned by Vannier et al. (2005) referring to their new species *Monceretia erisylvia*. As the authors noted, the material is tectonically deformed and prevents any reliable statements. Also, the newly established *Cordubiella pedrochensis* is a questionable candidate in this respect, because it shows two different developments of the posterior lobe. To solve this question, more material is required that gives precise information about size-range and clear documentation of true sculptural differentiation caused by sexual dimorphism.

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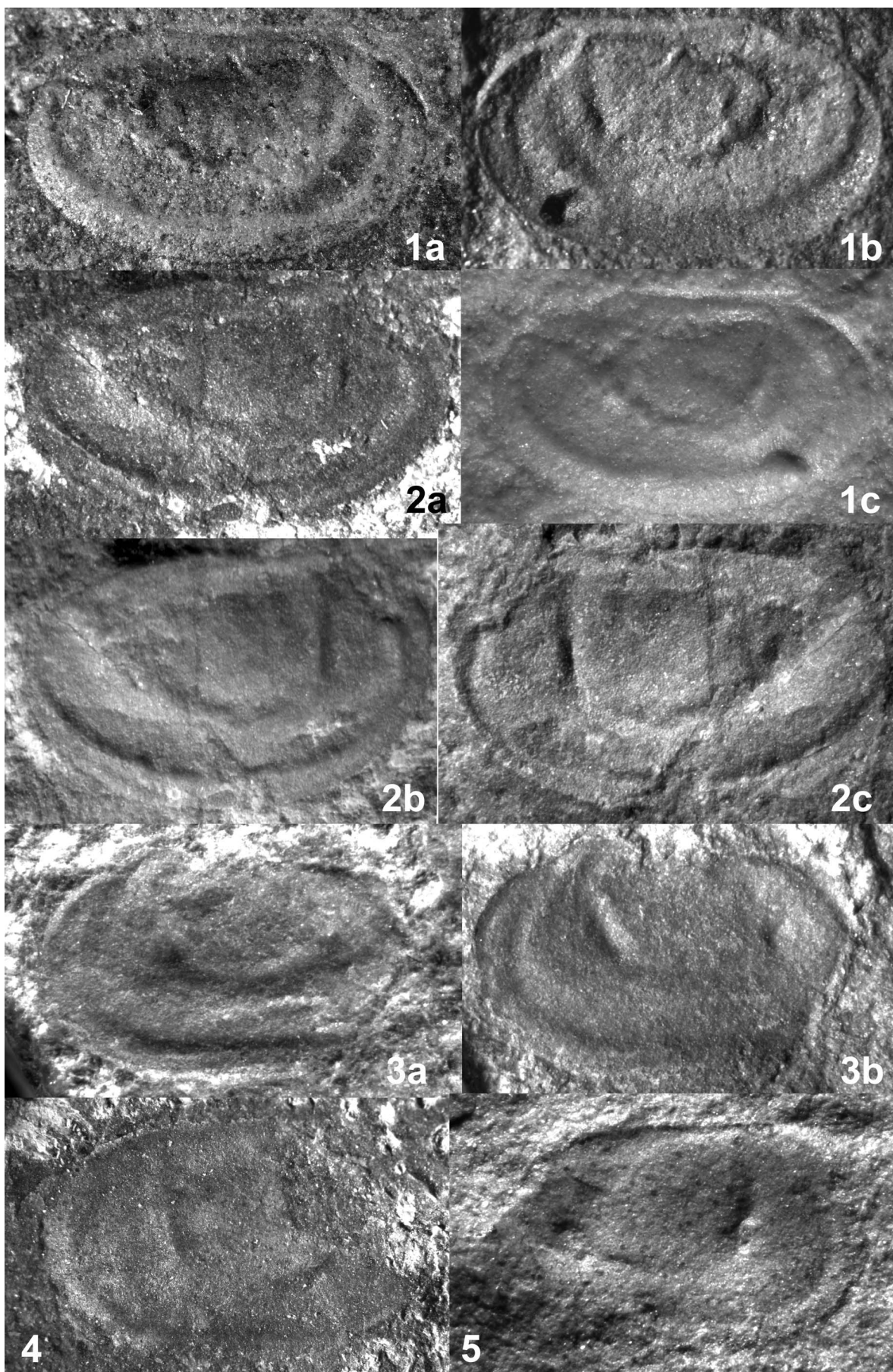
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## TEXT-FIGURE 7

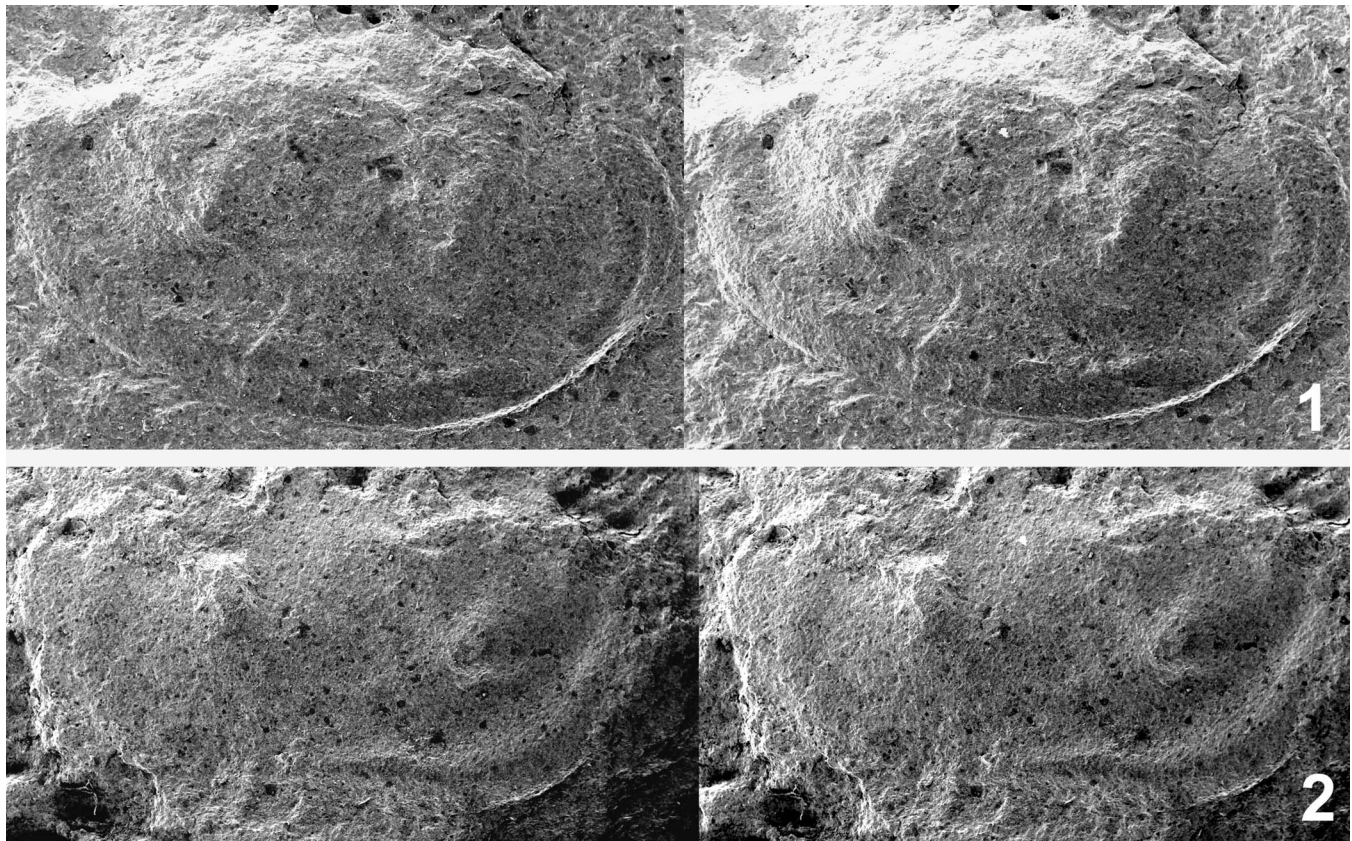
*Cordubiella pedrochensis* n. gen. n. sp.

- 1a-c MPZ 2006/3 37, holotype, complete carapace with the valves being separated along "hinge-line" and slightly shifted against each other, l = 5.7mm. AP1-Section (0 type section) of the Arroyo Pedroche Formation, Córdoba region. a) Internal mould with view onto the left valve. Note underlying right valve which is slightly obliquely shifted beyond "hinge-line" of left valve. Bifurcated posterior lobe may be the result of preservation with the two valves tightly pressed upon each other or the result of sculptural dimorphism. b) External mould of left valve. c) Latex cast of external mould showing the bifurcated posterior lobe.
- 2a-c MPZ 2006/33 8, paratype, left valve, l = 7.0mm. AP2-Section, parallel to AP1-Section of the Pedroche Formation. a) Internal mould. b) Same specimen different light conditions to focus on the anterodorsal downslope. c) External mould of the same specimen.
- 3a,b MPZ 2006/339, paratype, right valve, l = 5.1mm. AP2-Section parallel to Pedroche type-section. a) Internal mould. Note well-developed connecting lobe. b) Same specimen under different light conditions, showing that the posterior lobe is ridge-like contrary to text-fig. 7g) where it looks node-like.
- 4 MPZ 2006/340, paratype, internal mould of anteriorly incomplete right valve, l > 5.8mm, h = 3.2mm. AP2-Section of Pedroche Formation
- 5 MPZ 2006/341, paratype, external mould of anteriorly incomplete right valve, l > mm, h = mm. Type-section of Pedroche Formation (AP1).









TEXT-FIGURE 8  
*Cordubiella pedrochensis* n. gen. n. sp.

1 MPZ 2006/3 42, paratype, stereopair of an internal mould of a dorsally incomplete left valve, l = 4.9mm, h = 2.6mm. Type-section of Pedroche Formation (AP1).

2 MPZ 2006/343, paratype, stereopair of an internal mould of a dorsally incomplete left valve, l = 6.2mm, h = 3.2mm. Type-section of Pedroche Formation (AP1).

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