

Rivista Italiana di Paleontologia e Stratigrafia	volume 116	no. 3	1 pl.	pp. 273-281	November 2010
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POLYGNATHUS ROSAE N. SP. (CONODONTA) AND ITS BIOSTRATIGRAPHICAL CORRELATION POTENTIAL (LOWER EMSIAN, LOWER DEVONIAN) IN THE SPANISH CENTRAL PYRENEES

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Received: February 3rd, 2010; accepted: October 11th, 2010

Key words: Polygnathids, Pragian/Emsian boundary, Lower Devonian, Spanish Central Pyrenees.

Abstract. The problems around the Pragian/Emsian (P/E) boundary have been widely discussed by several authors, who have pointed out that the present Global Stratotype Section and Point (GSSP) in the Zinzilban section (Kitab Reserve, Uzbekistan), is much older than the traditional German Siegenian-Emsian boundary, a fact that considerably reduces the duration of the traditional Pragian Stage. A comprehensive conodont study of two important sections (Isábena 1 and Baliera 6) demonstrates the presence of the conodont indexes for the P/E boundary in both senses (official and traditional) in the Spanish Central Pyrenees (SCP). Within the important conodont faunas registered, the presence of a new early polygnathid species *Polygnathus rosae* n. sp. stands out. Its stratigraphic range in the two sections is restricted to a short interval around the traditional beginning of the Emsian Stage. This particular distribution permits direct relation between both indexes, a better characterization of the P/E boundary in the traditional German sense and increases the palaeontological knowledge of this stratigraphic interval. Conodont records in the SCP suggest that *Po. rosae* n. sp. could be a good local index, too. In addition, *Po. rosae* n. sp. represents the last known step of the lineage *Po. pirenae* → *Po. rosae* n. sp., a new early polygnathid lineage that supports the early radiation of the genus around the P/E boundary.

Riassunto. I problemi stratigrafici intorno al limite Pragian/Emsiano (P/E) sono stati ampiamente discussi da diversi autori, i quali hanno messo in evidenza che l'attuale limite definito entro il Global Stratotype Section and Point (GSSP) nella sezione di Zinzilban (Riserva di Kitab, Uzbekistan), sia molto più antico del limite Siegeniano-Emsiano in Germania. Questo comporta una sensibile riduzione della durata del piano Pragian tradizionale. Lo studio della fauna a conodonti di due importanti sezioni nei Pirenei centrali spagnoli (SCP) (Isábena 1 e Baliera 6) ha evidenziato la presenza dei conodonti indice per il limite P/E sia che questo sia considerato in senso ufficiale che tradizionale. Entro l'importante fauna a conodonti rinvenuta, spicca la presenza di una nuova specie di polignatidi, *Polygnathus rosae* n. sp. La sua distribuzio-

ne stratigrafica nelle due sezioni è limitata ad un breve intervallo intorno all'inizio del Piano Emsiano, inteso in senso tradizionale. Questa specifica distribuzione permette una correlazione diretta tra entrambi gli indici, una migliore caratterizzazione del limite P/E nel senso germanico tradizionale ed aumenta la conoscenza paleontologica di questo intervallo stratigrafico. Inoltre, la documentazione dei conodonti nel SCP indica come *Po. rosae* n. sp. possa essere un buon indice locale. Infine, *Po. rosae* n. sp. rappresenta l'ultimo livello evolutivo della linea *Po. pirenae* → *Po. rosae* n. sp., nuova linea precoce che testimonia la radiazione precoce del genere intorno al limite P/E.

Introduction

The study of the early polygnathids faunas was undertaken because *Polygnathus* exhibits a rapid evolution and worldwide geographical distribution. Devonian polygnathids have been extensively used to establish conodont-based zones, as well as boundaries between different stages and substages. In this sense, the boundaries and biozones of the Emsian Stage in most schemes are based exclusively on the successive occurrence of different species of the genus *Polygnathus* (see, for example, Klapper & Johnson 1975; Klapper 1977; Weddige & Ziegler 1977; Lane & Ormiston 1979; Yolk-in et al. 1994). This shows the value of polygnathid species as biostratigraphical markers.

Even though the Emsian boundaries and their subdivision in conodont zones are relatively well established, there are some problems concerning the location of the actual lower boundary (see Carls et al. 2008); this has become one of the main objectives of the Subcommittee on Devonian Stratigraphy (SDS). The problem concerning the Pragian/Emsian boundary (P/E) has

been widely discussed by several authors (see especially, Carls 1987, 2001; Carls & Valenzuela-Ríos 1993, 1997, 1998, 1999, 2000, 2007; Mawson 1995; Carls et al. 2008, 2009; Martínez-Pérez & Valenzuela-Ríos 2005; Valenzuela-Ríos 1997, 2001a, b; Valenzuela-Ríos & Carls 1991; Valenzuela-Ríos & Martínez-Pérez 2004). Many proposals of these authors have been recently “updated” and summarised in Carls et al. (2008). According to above-authors, the position of the formal lower Emsian boundary, which is marked by the first entry of *Polygnathus kitabicus* after Yolkin et al. (1994), is much older than the traditional German Siegenian-Emsian boundary (Carls 1999, 2009; Carls & Valenzuela-Ríos 1993, 2002, 2007; Carls et al. 2009); being able to correlate this level with middle parts of the traditional lower Siegenian (Carls et al. 2008). Thus, an important part of the current lower Emsian overlaps with the original Pragian, reducing considerably the duration of the latter stage. Consequently, Carls et al. (2008) suggest that the P/E boundary should be placed as closely as possible to the traditional beginning of the Emsian Stage, defined in the SE Eifel Hills, Germany (Mittmeyer 1974; Fuchs 1974). This level seems to be very close to the first occurrence of *Po. excavatus* ssp. 114, taxon that appears 114 m above the *kitabicus* boundary in the Zinzilban

Gorge sections. This taxon was originally identified by Yolkin et al. (1994) as *Po. excavatus gronbergi* (including *Po. gronbergi* as a subspecies of *Po. excavatus*) and considered as the index for the Middle *excavatus* Subzone (Yolkin et al. 1994). However, as Carls & Valenzuela (2002) commented, the elements that Yolkin et al. (1994) recognized as *Po. excavatus gronbergi* are morphologically different and older than *Po. gronbergi*, proposing, in consequence, the establishment of the new taxon *Po. excavatus* ssp. 114 to include these morphologies. In the present paper, we have followed the proposals of Carls et al. (2008), using *Po. excavatus* ssp. 114 to approximate the beginning of the Emsian Stage in the traditional German sense, as well as to indicate the base of the Middle *excavatus* Subzone as proposed by Yolkin et al. (1994).

Given this scenario, we have started a comprehensive conodont research of two important sections (Isábena 1 and Baliera 6) from the Spanish Central Pyrenees. These sections had already been studied by Valenzuela-Ríos (1994, 2001a) who demonstrated the presence of the P/E boundary in both senses, and, hence, it is possible to directly analyse the discrepancy between both concepts. Therefore, the purposes of this paper are to describe a new polygnathid species, to discuss its

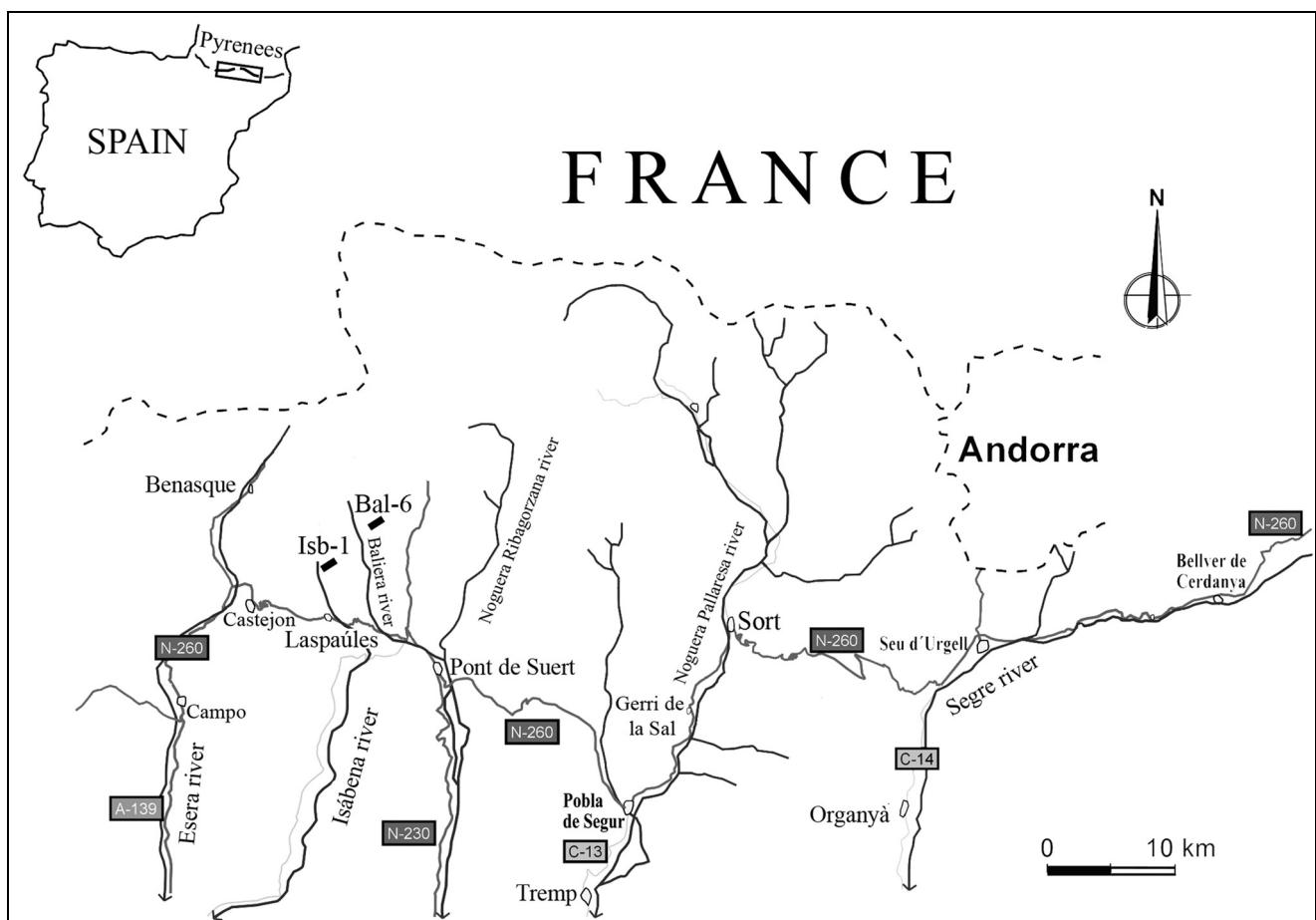


Fig. 1 - Geographical setting of the studied area with indication of the location of the Isábena 1 and Baliera 6 sections.

biostratigraphical value for local correlation and to show the polygnathid conodont record around the P/E boundary in two selected Pyrenean sections.

Geological and Geographical Setting

In the Devonian of the Pyrenees, four main facies-areas can be distinguished (the southern, central, western and northern facies-areas), all of which can be further subdivided into smaller subfacies-areas (see Mey 1967a, b, 1968; Hartevelt 1970). The material studied herein comes from two sections (Isábena 1 and Baliera 6) described in the Baliera subfacies-area (Southern facies-area) of Mey (1967b).

Four geological formations have been identified in the Lower Devonian of the Baliera subfacies (Mey 1967b, 1968): Rueda Fm. (with the Aneto and Gelada Members), Basibé Fm. (with the Ponferrat, San Silvestre and Llaviero Members), Fonchanina Fm. and Mañanet Fm. The Isábena 1 and Baliera 6 sections are exclusively composed by strata attributed to the Llaviero Mbr. of the Basibé Fm.

The Isábena 1 Section (Isb-1) is located in the upper part of the Isábena river valley; about 6 km north of the village of Laspaúles (Province of Huesca) (Fig. 1). Section Isb-1 (Fig. 2), partially exposes strata of the Llaviero Mbr. (Basibé Fm.) (late Pragian-early Emsian), and consists of 18 metres of grey platy limestone, thick-bedded limestone and dolostone with some interbedded shale (Valenzuela-Ríos 1994, 2001a). The Baliera 6 section (Bal-6) has been described in the upper part of the Baliera river valley, located at about 5 km northeast of the Isb-1 Section (Fig. 1). This section exposes almost completely the Llaviero Mbr. (Basibé Fm.) (late Pragian-early Emsian) and consists of about 28 metres of blue-grey platy limestone with intercalations of thick-bedded limestone, arenitic and marly limestone, and shale (Valenzuela-Ríos 1994, 2001a) (Fig. 2).

Both sections were sampled for conodonts and other microfossils with an average weight of 6.5 kg per sample and up to 10-15 kg weight in those levels around the P/E boundaries. The position of the samples in the section is shown in Figure 2 (black dots) beside the ranges of selected conodont taxa.

Systematic Palaeontology

All conodonts studied herein appear as isolated elements after the dissolution of carbonate rocks with formic acid (5-10%). The material is housed in the Museum of Geology at the University of Valencia, and is identified by the MGUV initials followed by their related museum number.

Phylum **Chordata** Balfour, 1880

Subphylum **Vertebrata** Cuvier, 1812

Class **Conodonta** Eichenberg, 1930

Order **Ozarkodinida** Dzik, 1976

Family Polygnathidae Bassler, 1925

Genus *Polygnathus* Hinde, 1879

Type species: *Polygnathus dubius* Hinde, 1879

Polygnathus rosae n. sp.

Pl. 1, Figs 1-4.

Etymology: In honour of Rosa María Lara Fernández.

Holotype: MGUV-21.079. Element illustrated in Pl. 1, Fig. 1.

Paratypes: MGUV-21.080 to MGUV-21.083, MGUV- 21.302 to MGUV-21.305 and MGUV-21.330 to 21.333 (Elements MGUV-21.080, MGUV-21.082 and MGUV-21.302 figured in Pl. 1, Figs. 2-4).

Type locality and age: Isábena 1 Section, Province of Huesca (Spanish Central Pyrenees). Llaviero Mbr. of the Basibé Fm., late Pragian-early Emsian in age.

Stratum typicum: Bed 10M.

Material: 14 elements of the following sections and beds: Bal 6/Bed 8(1) (MGUV-21.081), Bal 6/Bed 12(1) (MGUV-21.082), Isb 1/Bed 10M(10) (MGUV-21.079, MGUV-21.083, MGUV- 21.302 to MGUV-21.305 and MGUV-21.330 to MGUV-21.333), Isb 1/Bed 12(1) (MGUV-21.301) and Isb 1/Bed 13F(1) (MGUV-21.080). The figures in brackets represent the number of elements in each sample.

Diagnosis: The Pa elements of *Polygnathus rosae* n. sp. have a very characteristic long and straight platform, with a marked constriction in the anterior outer third, and an asymmetric long, narrow and shallow, but not inverted basal cavity.

Description. The free blade is short, representing approximately one fourth of the total length of the element (Pl. 1, Fig. 3a, b). The platform is long, straight, narrow, and curved slightly inwardly in the posterior third. The platform surface is flat, with weak adcarinal troughs equally developed in the anterior part of the platform. The element is slightly asymmetric with the presence of a characteristic constriction in the outer anterior third of the platform. The lateral flanks are slightly elevated with respect to the central part of the element, with an inner platform margin more or less rectilinear. The inner and the outer anterior platform margins join the free blade almost at the same positions and at angles greater than 90° (Pl. 1, Fig. 4a). In lateral view the platform is practically straight, and it is slightly bent aborally in the posterior region.

The posterior carina reaches the end of the element and is placed in a central position with, at least, 8-10 rounded or slightly laterally flattened denticles that are isolated posteriorly and partly to totally fused anteriorly. The platform margins are ornamented by small ribs that are arranged perpendicularly to the carinae, although some small and rounded denticles can be identified in the inner margin (Pl. 1, Fig. 2c). The ribs in the outer margin are more numerous.

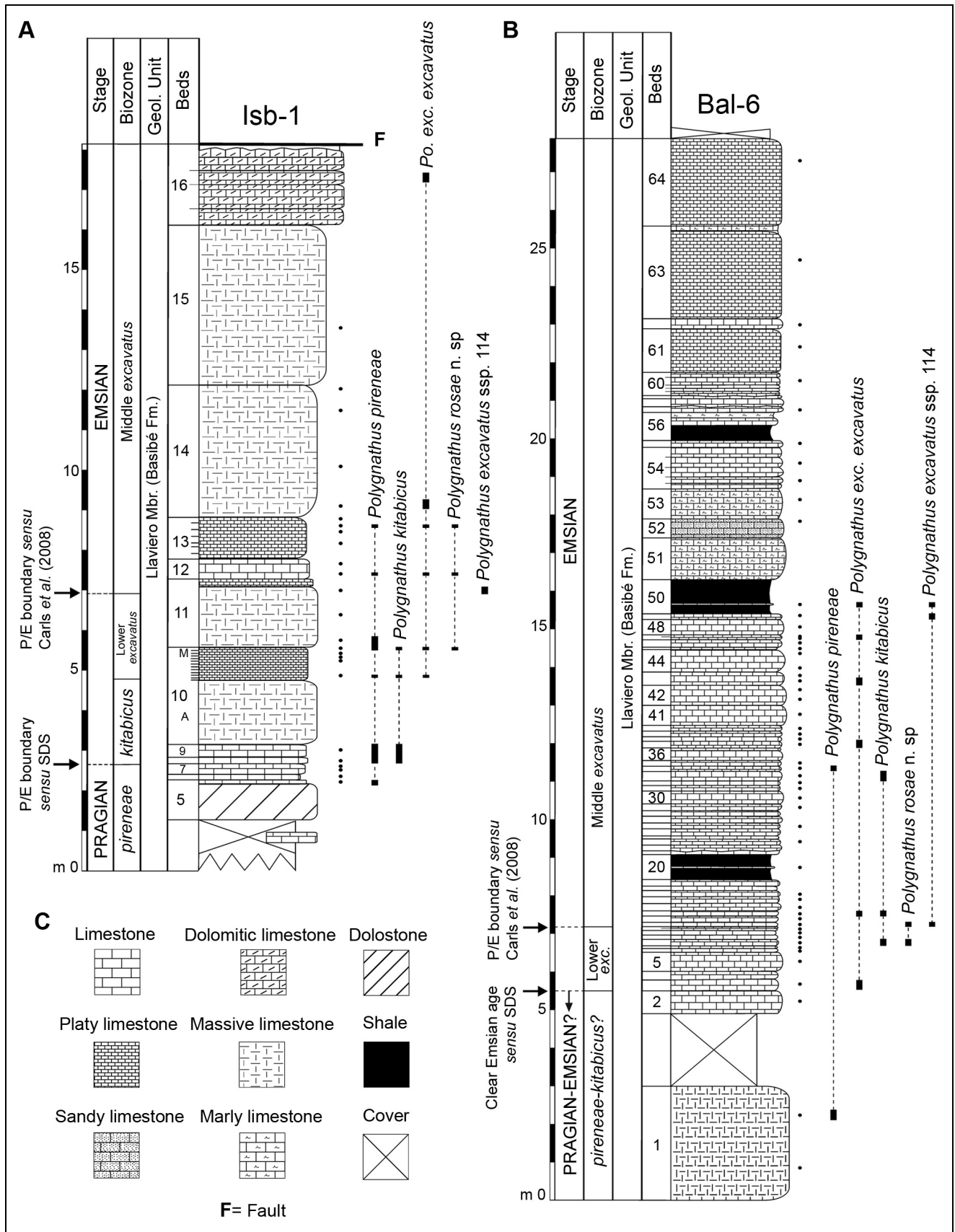


Fig. 2 - Stratigraphic column of the Isábena 1 (A) and Baliera 6 (B) sections showing the location of the level sampled for conodont (black dots) and ranges of selected conodont taxa with biostratigraphical relevance around the P/E boundaries (see main text).

The basal asymmetrical cavity (broader outer expansion) is long, relatively narrow and shallow but not inverted, with the basal pit positioned in the centre. It is always restricted to the platform limits.

Remarks. The specimens studied are characterised by the following combination of features: 1) elongated platform, 2) marked constriction in the outer anterior third of the element, 3) well developed, but relatively shallow, adcarinal troughs, and 4) a shallow, long and relatively narrow asymmetrical basal cavity. Although, relatively, few specimens were found, their diagnostic features cannot be assigned to any other known species of *Polygnathus*. In addition, the specimens do not seem to be pathological elements or extreme morphologies of other related species. Neither they can be interpreted as an artefact of tectonic stress; as the specimens come from different Beds and sections, it is unlikely that the conodont elements were deposited on the sea floor in the exactly same orientation through time and space, so that the deformation response to structural deformation produced the identical form in all specimens. Therefore, we have assigned these 14 specimens to the new species *Polygnathus rosae* n. sp.

The large basal cavity, the shallow but well developed adcarinal troughs, and the joining of the inner and the outer anterior platform margins with the free blade at angles greater than 90° are features shared with the primitive polygnathid. However, *Po. rosae* n. sp. differs clearly from other related taxa, as *Po. pireneae*, *Po. kitabicus* and *Po. excavatus* as follows. *Po. pireneae* has a large basal cavity, a flat surface platform with very poorly developed adcarinal troughs, and its platforms is characteristically ornamented by hemispheric denticles. These features differ from *Po. rosae* n. sp. in that it has a shallow, long and relatively narrow basal cavity, a well developed adcarinal troughs and a platform ornamented by short ribs. *Po. rosae* n. sp., shows a much more elongated platform than *Po. kitabicus*, with the

characteristic constriction of the outer platform in its anterior third that is absent in the latter. *Po. excavatus* differs basically from *Po. rosae* n. sp. because the former displays much more developed adcarinal troughs, of which, the outer one is deeper and more excavated, and because the carina is characteristically located near the inner platform margin.

Po. rosae n. sp. represents the last known step of the new lineage *Po. pireneae* → *Po. kitabicus* → *Po. rosae* n. sp. (Fig. 3). This lineage is represented by taxa that share primitive characteristics within the genus, for instance, weak developed adcarinal troughs (either absent or at a very early state of development in *Po. pireneae*) and a large basal cavity (occupying almost the entire element in lower view). This lineage has a clear morphological trend that is characterised by the development of weak adcarinal troughs, the reduction of the basal cavity, an ornamentation change from nodules to ribs, and the characteristic elongation of their platforms. In addition, this new early Polygnathid lineage supports the Yolkin et al.'s proposal (1994, 2008) of an evolutionary radiation of the genus around the P/E boundary, which is also shown by other important unpublished data from the Pyrenees.

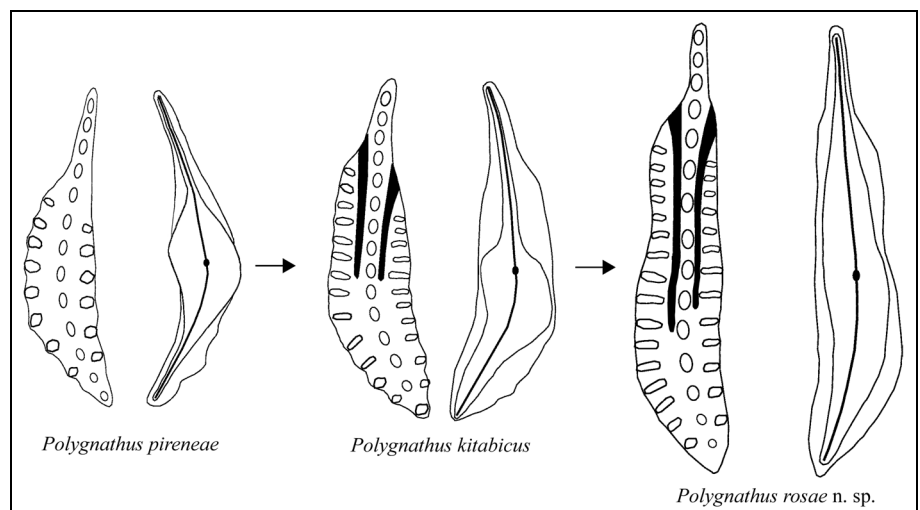
Stratigraphical and geographical distribution.

The distribution of *Po. rosae* n. sp. in the two studied sections is restricted to a short interval around the Lower and Middle *excavatus* Subzones (lower Emsian *sensu* Yolkin et al. 1994 or late Pragian/early Emsian *sensu* Carls et al. 2008) (Fig. 4). *Po. rosae* n. sp. has been recorded exclusively in the Spanish Central Pyrenees.

Discussion

Although an important conodont fauna has been recovered from the two sections (Isb-1 and Bal-6), only those conodonts with biostratigraphical relevance

Fig. 3 - *Polygnathus pireneae* → *Polygnathus rosae* n. sp. lineage. This new lineage has a clear morphological trend that is characterised by the development of adcarinal troughs, the reduction of the basal cavity, a change in its ornamentation from nodules to ribs, and the elongation of their platforms. Draws based on the original type-material of *Po. pireneae* (Boersma 1973: Pl. 2, figs. 1-3), *Po. kitabicus* (Yolkin et al. 1994: Pl. 1, figs. 1-2) and *Po. rosae* n. sp. Elements not to scale but preserving their relative sizes.



Stage Taxa	Pragian		Emsian		
	<i>pireneae</i>	<i>kitabicus</i>	<i>excavatus</i>		<i>nothoperbonus</i>
			Lower	Middle	
<i>Po. pireneae</i>	-----	—————	—————		
<i>Po. kitabicus</i>		—————	—————		
<i>Po. exc. excavatus</i>			—————	—————	
<i>Po. rosae</i> n. sp.			———	———	
<i>Po. excavatus</i> ssp. 114				—————	

Fig. 4 - Distribution chart of relevant Pyrenean polygnathid species.

around the P/E boundary have been shown in Figure 2. Among these conodonts we point out the occurrence of different early *Polygnathus* species (*Po. pireneae*, *Po. kitabicus*, *Po. excavatus excavatus*, *Po. excavatus* ssp. 114 and the new species described herein *Po. rosae* n. sp.), all of which, are important biostratigraphic markers (Fig. 2 and Fig. 4). According to these findings, we have identified the P/E boundary in both senses in the Isábena 1 section; the Baliera 6 section also shows the discrepancy between the two concepts of this boundary (see below). In addition, the main important zones and subzones of the late Pragian and early Emsian have also been recognized: the upper part of the *pireneae* Zone, and the early Emsian zones of Yolkin et al. (1994): the *kitabicus* Zone, the Lower *excavatus* Subzone and the Middle *excavatus* Subzone (see Fig. 2).

In the Isb-1 section, the actual GSSP for the Emsian Stage has been identified with the first occurrence of *Po. kitabicus* in Bed 8, whereas the P/E boundary *sensu* Carls et al. (2008) can be recognised 135 cm above the base of Bed 11 with the first record of *Po. excavatus* ssp. 114, that, as we have commented above, indicates according to Yolkin et al. (1994) the base of the Middle *excavatus* Subzone (see Carls et al. 2008). The new taxon, *Po. rosae* n. sp., occurs in Bed 10M, Bed 12 and Bed 13F, thus its total range spans a short interval across the Lower-Middle *excavatus* Subzones.

The section Bal-6 has also provided an important conodont assemblage. At the base of the section, the first level that yielded relevant conodonts was Bed 1B with *Po. pireneae*. Thus, without any other information, this level can correspond to either the late Pragian or the early Emsian (the *pireneae* or *kitabicus* Zones, respectively). In Bed 3, the first occurrence of *Po. exc. excavatus* indicates the beginning of the Lower *excavatus* Subzone, hence a clear Emsian age *sensu* Yolkin et al. (1994). A little above, Bed 8 yielded the first records of *Po. rosae* n. sp. and *Po. kitabicus* (delayed). The next level with significant records corresponds to Bed 12, with the last occurrence of *Po. rosae* n. sp. and the first *Po. excavatus* ssp. 114, which is indicative of the beginning of the Middle *excavatus* Subzone. As already discussed, this taxon is the biostratigraphic marker used to

approximate the base of the traditional Emsian in the classic German sense, as suggested by Carls et al. (2008). These records show that the stratigraphic range of *Po. rosae* n. sp. is restricted to a short interval around the boundary between the Lower and Middle *excavatus* Subzones in the section Baliera 6 as well.

Conclusions

Two important sections (Isábena 1 and Baliera 6) from the Lower Devonian (late Pragian-early Emsian in age) of the Spanish Central Pyrenees have been studied for conodonts in an attempt to analyse contrasting opinions regarding the P/E boundary. An important conodont fauna, including the new species *Po. rosae* n. sp. has been recovered from the two sections, although only the ranges of those polygnathids of biostratigraphical relevance around the P/E boundary have been depicted. According to these records, we have identified the P/E boundary in both senses (traditional German that lies close to the potential new GSSP and the current GSSP) and the main important zones and subzones of the late Pragian and early Emsian: the upper part of the *pireneae* Zone, the *kitabicus* Zone, the Lower *excavatus* Subzone and the Middle *excavatus* Subzone.

PLATE 1

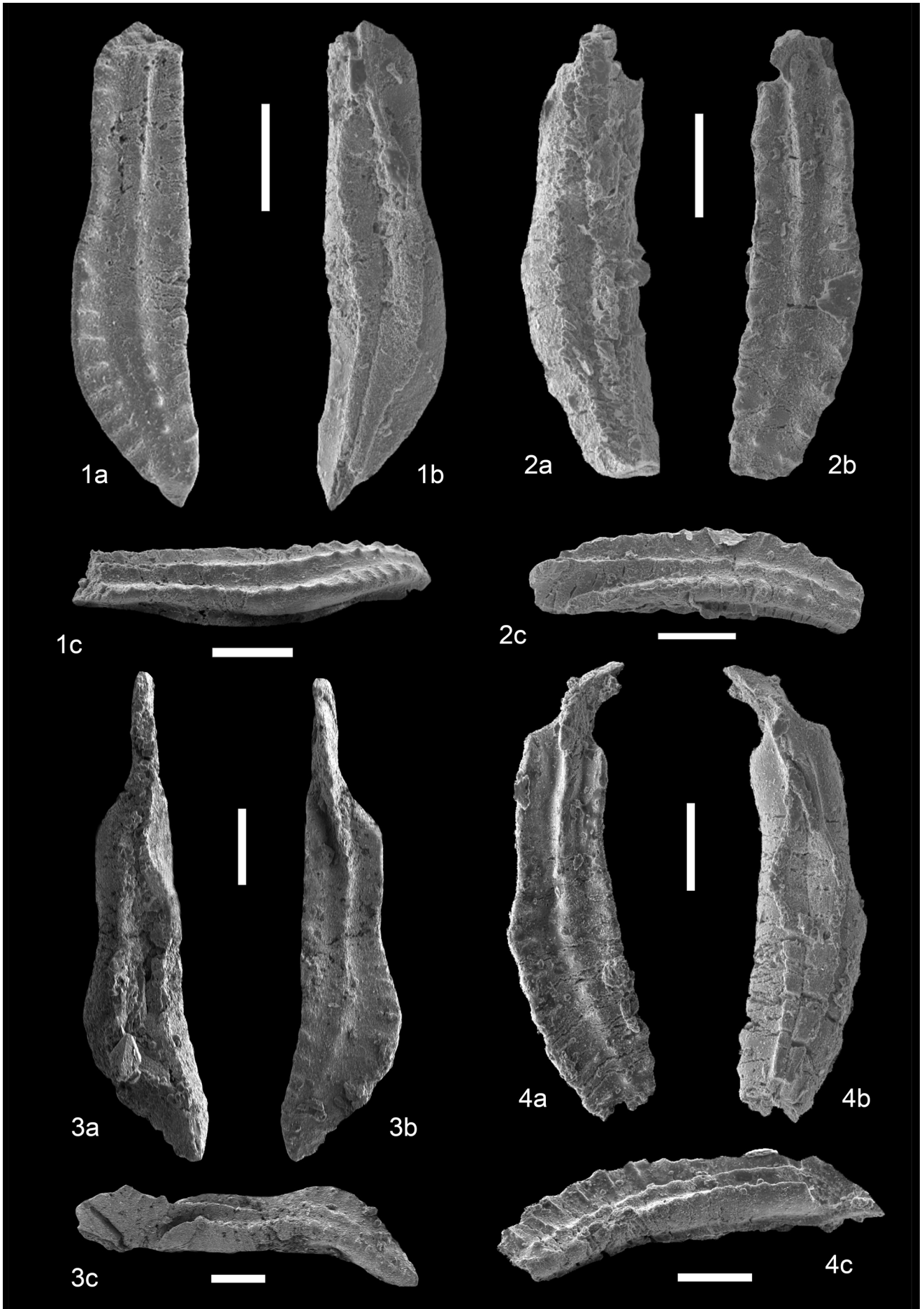
All scale bars represent 200 μ m.

Figs. 1a-c - *Polygnathus rosae* n. sp.; holotype, 1a) upper view, 1b) lower view, 1c) lateral view; Isábena 1 section, Bed 10M; MGUV-21.079.

Figs. 2a-c - *Polygnathus rosae* n. sp.; paratype, 2a) lower view, 2b) upper view, 2c) lateral view; Isábena 1 section, Bed 13F; MGUV-21.080.

Figs. 3a-c - *Polygnathus rosae* n. sp.; paratype, 3a) lower view, 3b) upper view, 3c) lateral view; Isábena 1 section, Bed 10M; MGUV-21.302.

Figs. 4a-c - *Polygnathus rosae* n. sp.; paratype, 4a) upper view, 4b) lower view, 4c) lateral view; Baliera 6 section, Bed 12; MGUV-21.082.



The particular and consistent distribution in these two Pyrenean sections suggests that *Po. rosae* n. sp. could be a good local index to characterize an interval around the P/E boundary *sensu* Carls et al. (2008) in the Spanish Central Pyrenees and, therefore, help to increase the palaeontological knowledge of this stratigraphic interval, which spans the boundary between the Lower and Middle *excavatus* Subzones.

In addition, *Po. rosae* n. sp. represents the final step of the new early Polygnathid lineage *Po. pirenae* → *Po. rosae* n. sp., that supports Yolkin et al.'s proposal

(1994, 2008) of an early radiation of the genus around the P/E boundary.

Acknowledgements. This work represents a contribution to the UNESCO/IGCP project No. 499 “Devonian land-sea interaction: evolution of ecosystems and climate” (DEVEC). We thank Jau-Chyn Liao for the enormous help in the field campaigns, specially in geological discussions on tectonics and stratigraphy. We also thank Ruth Mawson, Carlo Corradini, R. Thomas Becker and Navas Parejo for their comments and suggestions. We thank the Technical support of the SCSIE (Servicio Central de Soporte a la Investigación Experimental), University of Valencia, too. CM-P is grateful to the V Segles Fellowship that allowed him to carried out this research.

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