Sephardiellinae, a new Middle Triassic conodont subfamily

Sephardiellinae, una nueva subfamilia de conodontos del Triásico Medio

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Abstract

Sephardiellinae (nov. subfam.) encompasses a Middle Triassic Gondolelloid lineage that originated in the Sephardic realm, westernmost shallow Neotethys, from where, in the course of the Ladinian and earliest Carnian, some of its species spread to the world oceans, before extinction as a result of the Carnian salinity crisis. It is composed of two genera, Sephardiella and Pseudofurnishius. Differential criteria in its septimembrate apparatus are the basal cavity structure of P1 element and morphological variations in the P2 and S3 elements.

Keywords: Conodonts, Middle Triassic, Sephardiellinae, Sephardic Realm, Neotethys.

1. Introduction

Lindström (1970) established the Triassic family Gondolellidae with a septimembrate apparatus, while Sweet, in Clark et al. (1981) established the seximembrate Xaniognathidae, annotated Pa, Pb, M, Sa, Sb, Sc elements. Hirsch (1981), after adding the missing P element in the later, discarded it as a family and distinguished two different stocks in Gondolellidae: a “xaniognathid-neogondolellid stock”, which included encompassing the genera Neospathodus, Neogondolella, Pseudofurnishius, Carinella and Epigondolella, and a “xaniognathid- gl-
adigondolellid stock” for the apparatus genus Gladi-gondolella, making both septimembrate apparatuses. Hirsch (1994) subsequently has subdivided Gondolellidae in the subfamilies Neogondolellinae and Gladigondolellinae, and included Pseudofurnishius and Sephardiella genus in Neogondolellinae. In this work we propose the new subfamily Sephardiellinae, encompassing this two genera and this will be based in the reconstruction of their apparatus.

Dealing with the reconstruction of multi-elements and clusters of Pseudofurnishius and Sephardiella, Ramovs (1977), Mietto (1982), Bagnoli et al. (1985) and Dzik (1991) created notations based on the form-taxonomic names for the elements of their apparatuses, described as pentamembrate or septimembrate types. Orchard and Rieber (1999), reassembled several loose form-taxonomic fragments into new multi-element units and set the base for the octomembrate apparatus of most subfamilies established by Orchard (2005) in Gondolellioidea. The question remains whether the reassignments of form-taxonomic fragments within the elements of an octomembrate apparatus are all justified. Related with Pseudofurnishius, Orchard (2005, p. 92-93) states that Ramovs (1977) has not differentiated any S₂ element and that his “Chi” element almost certainly represents a distal hindeodellid fragment (S₃-S₄), similar to element “Hi” in Ramovs’ stunning good material to justify a octomembrate apparatus in this genus. It can be said that the “de-jure” form-taxonomy, enables identification of the elements of the apparatus in the “de-facto” multi-element taxonomy; in other words, the correlation of apparatus elements to their original form-taxonomic name enables to keep track within the different multi-element notations proposed by authors (Fig. 1).

To propose Sephardiellinae we have studied the materials described by several authors from Jordan, Italy (Sicily), Israel and Spain, doing a re-interpretation of the observations carried out by Benjamini and Chepstow-Lusty (1986), Gullo and Kozur (1989, 1991), Sadeddin (1990), Sadeddin and Kozur (1992), March (1991), Hirsch (1966, 1994) and Márquez-Aliaga et al. (1996). On the other hand, we have studied new material from different outcrops, sited in Spain in the Catalonian Coastal Range (Colldejou and Benifallet-Rasquera) (Calvet and Marzo, 1994), the Iberian Range (Calanda, Libros and Henarejos) (López-Gómez et al., 1987; Márquez-Aliaga et al., 1989; Márquez-Aliaga et al. 1994), and the Betic Range (Espejeras and Cabo Cope) (López-Gómez et al., 1994; Pérez-López et al., 2003) (Fig. 2a) and of Israel, Negev (Makhtesh Ramon) (Benjamini and Chepstow-Lusty, 1986) (Fig. 2b).

2. Systematic Paleontology Discussion

The Spanish material is hosted in the “Museu de Geologia de la Universitat de Valencia”, sited in the Department of Geology. The Israeli material is hosted in the Department of Earth Sciences, Ben Gurion University of the Negev, Beersheba, Israel. We follow the element notation proposed by Purnell et al. (2000).

Order OZARKODINIDA Dzik, 1976
Superfamily Gondolellacea (Lindström, 1970)
Family Gondolellidae (Lindström, 1970)

Sephardiellinae nov. subfam.

Synonym: Pseudofurnishiidae Ramovs 1977
Novispathodinae Orchard 2005 pro parte

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<td>Pa</td>
<td>P₁</td>
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<td>Ozarkodina tortilis</td>
<td>Pa</td>
<td>Pb</td>
<td>P₂</td>
<td>Po (pollognathiform)</td>
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<tr>
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<td>Pb</td>
<td>Sb₁</td>
<td>S₂</td>
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<td>Roundya magnisideta</td>
<td>M</td>
<td>Sa</td>
<td>S₀ (hibbardellid)</td>
<td>Hib (hibbardelliform)</td>
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<td>Prioriodina mulieri</td>
<td>Sα</td>
<td>M</td>
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<td>Lonchodeilla kaitidenta</td>
<td>Sb</td>
<td>Sc₂</td>
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<td>Diplochella sp.indet.</td>
<td>Sc₁</td>
<td>S₃ (hibbardellid)</td>
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Fig. 1. - Element notations used for the apparatuses of Gondolellidae: *after Von Bitter and Merrill (1998); **after Purnell et al. (2000).

Fig. 1.- Denominación de los elementos utilizada para el aparato de Gondolellidae: *según Von Bitter y Merrill (1998); **según Purnell et al. (2000).
Derivation of the name: after the Sephardic realm (Hirsch, 1972).

Diagnose: Differential criteria of the sephardiellin septimembrate apparatus are the structure of the basal cavity in the \( P_1 \) element, the variable morphology of the \( P_2 \) (ozarkodiniform) element, and the simple \( S_3 \) (hindeodellid) element, devoid of a diplodellid bifid anterior process.

Description: Septimembrate apparatus composed of a pair of \( P_1, P_2, M, S_1, S_2 \), and \( S_3 \) elements, and a single \( S_0 \) element. The \( P_1 \) element develops several kinds of platforms in the course of its phylogeny; amygdaloidal basal cavity, with tendency of the basal pit to shift towards the posterior end of the unit in the course of advanced phylogeny; early platform naked, but ornamented by several kinds of denticles, that accuse the generic differences between \textit{Pseudofurnishius} and \textit{Sephardiella}. \( P_2 \) element is ozarkodiniform, with “pollognathid” variations in \textit{Pseudofurnishius}; \( S_3 \) element is devoid of diplodellid bifid anterior process.

Lineage: The earliest taxon of this subfamily known is \textit{Neospathodus shagami} Benjamini and Chepstone-Lust (1986), which was originally described from the \textit{Gevanites inflatus} beds that crosses the Illyrian - Fassanian boundary in Makhtesh Ramon (Israel) and in a correspondent level [Ab8] at Wadi Naur (Jordan). Its first biochronological appearance is, however, mentioned in an early Upper Anisian (Pelsonian) \textit{Trigonodus} bed [TJ17] at Wadi Siyala, Jordan (Sadeddin, 1990; Sadeddin and Kozur, 1992). The \( P_1 \) element of this taxon shows a typical sephardiellin basal cavity, and the slight curvature of the unit shows affinity to that of \textit{Pseudofurnishius}, justifying eventually our new assignment to that genus (Fig. 3). Junior synonyms of \textit{P. shagami} include \textit{Pseudofurnishius siyalaensis} Sadeddin and Kozur (1992) (which appears together with \textit{P. shagami} in Wadi Siyala) and the slightly different morphotype \textit{Pseudofurnishius priscus} Sadeddin (1990). \textit{Pseudofurnishius shagami} strongly resembles \textit{Pseudofurnishius sosioensis} Gullo and Kozur (1989) and may possibly directly precede the earliest Fassanian (Ladinian) \textit{Pseudofurnishius murcianus} Boogaard (1966), in the section of Ramon (Israel). In the sierra de Carrascoy (Murcia, Southern Spain), type locality of \textit{P. murcianus}, this taxon is preceded by \textit{Pseudofurnishius huddlei} Boogaard & Simon (1973), a taxon that may represent the transition between \textit{P. shagami} and \textit{P. murcianus}. The lineage of \textit{Pseudofurnishius} ranges from Upper Anisian to Early Carnian.

In strata of similar age of \textit{P. huddlei} (Fassanian) in Northern Spain, Sardinia and Provence (Southern France), \textit{Sephardiella truempyi} (Hirsch, 1971) occurs,
this is the earliest taxon of the genus *Sephardiella*. The lineage of *Sephardiella* also includes, *Sephardiella manggoensis* (Diebel, 1956), *Sephardiella hungarica* (Kozur and Vegh, 1972), *Sephardiella japonica* (Hayashi, 1968) and *Sephardiella diebeli* (Kozur and Mostler, 1970), ranging from Early Ladinian to Early Carnian.

All these forms, originally described either as Neosphathodus, *Pseudofurnishius*, *Polygnathus*, *Gondolella*, *Metapolygnathus*, *Epigondolella*, *Tardogondonella*, *Carinella*, *Sephardiella* and *Budurovignathus*, belong into the new subfamily *Sephardiellinae*. All species of the lineage display an almost identical amygdaloid basal cavity in $P_1$ element. During ontogeny, more advanced forms of *Sephardiella manggoensis* (Diebel, 1956) may display an inclination that suggests a tendency towards the formation of a bifid posterior end of the basal cavity.

**Discussion:** According to Orchard (2005), Novispathodinae developed from Neogondolellinae through loss of bifurcation in the $S_4$ and growth of the anterior edge of $S_2$, while $S_3$ is non-bifid. However, it is necessary to consider the fundamental differences of the $P_1$ and $P_2$ elements in Early Triassic and Early Anisian forms of this subfamily. Therefore Sephardiellinae (n. subfam.) is erected to distinguish a group of Late Anisian to earliest Carnian forms that share very particular features of the $P_1$ element, while their $P_2$ element is clearly distinct from other Novispathodinae taxa. The inclusion of *Mosherella newspasensis* (Mosher, 1968) as a taxon apparently derived from *Pseudofurnishius*, is, at this stage, not sufficiently substantiated.

**Genus *Pseudofurnishius*** Van den Boogaard, 1966

**Type Species:** *Pseudofurnishius murcianus* Van den Boogaard, 1966.

The genus *Pseudofurnishius* was established by Boogaard (1966), and its apparatus has subsequently been well described by Ramo (1977). Benjamini and Cheptow-Lusty (1986) have also illustrated elements of the apparatus of *P. shagami* in which the element $P_1$, $S_3$ (hindeodelliform) and $S_2$/$M$ (cypridodelliform) elements can be identified. March (1991) described for *Pseudofurnishius murcianus* an apparatus composition that we re-interpreted in this work as follows: $P_1$ element, $P_2$ element, and $S_3$ element.
Fig. 4.- Apparatus of Pseudofurnishius murcianus (van den Boogaard). Bar = 50 µ. P₁. Right element, upper view. CLD2703, Calanda; P₂. Left Element, inner view. HE1802P2, Henarejos; S₀. Left element, inner view. LI801, Libros; S₁. Left element, inner view. ESP3104S, Espejeras; S₂. Left element, inner view. ESP3102S; S₃. Right element, inner view. ESP3106S, Espejeras; M. Right element, inner view. ESP3105S, Espejeras. Ladinian.

Fig. 4.- Aparato de Pseudofurnishius murcianus (van den Boogaard). Barra = 50 µ. P₁. Elemento derecho, vista superior. CLD2703, Calanda; P₂. Elemento izquierdo, vista interior. HE1802P2, Henarejos; S₀. Elemento izquierdo, vista interior. LI801, Libros; S₁. Elemento izquierdo, vista interior. ESP3104S, Espejeras; S₂. Elemento izquierdo, vista interior. ESP3102S, Espejeras; S₃. Elemento derecho, vista interior. ESP3106S, Espejeras; M. Elemento derecho, vista interior. ESP3105S, Espejeras. Ladiniense.
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(Ozarkodina tortilis), M (Prioniodina muelleri), S₁ (Diplododella magnidentata), S₂ (Enanthiognathus ziegleri), S₃ (Prioniodina muelleri var or Cypridodella mediocris) and S₄ (Hindeodella suevica + Hindeodella triassica + Lonchodina latidentata). Re-evaluation of March’s illustrations and additional element study of new collections allow us to do the following re-assessment of the *Pseudofurnishius* apparatus (Fig. 4).

Range: Upper Anisian – Early Carnian.

Genus *Sephardiella* March, Budurov, Hirsch and Márquez-Aliaga, 1988

Figure 5, 6

Type Species: *Sephardiella mungoensis* (Diebel, 1956)

Diagnosis: as for *Sephardiella* (March et al., 1990) including all stages from juvenile to fully mature development.

Description: The multi-element reconstruction of *S. truempyi* (Hirsch, 1971) has been depicted by Bagnoli et al. (1985, Plate 1, p. 314; figure 5), and we considered

Fig. 5 - Apparatus of *Sephardiella truempyi* (Hirsch) elements, reproduced of Bagnoli et al. (1985). Bar = 50 μ. 3a-c, 4a-b: P₁; 5, 6: M (prioniodiniform); 7: S₃⁻⁴ (hindeodelliform); 8: P₂ (ozarkodiniform); 9: S₁ (cypridodelliform); 10, 11: S₂ (enantiognathiform); 12, 13: S₀ (diplodelliform).

Fig. 5 - Aparato de *Sephardiella truempyi* (Hirsch) reproducido de Bagnoli et al. (1985). Barra = 50 μ. 3a-c, 4a,b: P₁; 5, 6: M (prioniodiniforme); 7: S₃⁻⁴ (hindeodelliforme); 8: P₂ (ozarkodiniforme); 9: S₁ (cypridodelliforme); 10, 11: S₂ (enantiognathiforme); 12, 13: S₀ (diplodelliforme).
Fig. 6. - Apparatus of Sephardiella mungoensis (Diebel). Elements $P_1$, $P_2$, $S_0$, $S_1$, $M$, bar = 50 µ. Elements $S_0$, $S_2$, $S_3$, reproduced of March (1991), bar = 100 µ. $P_1$. Left element, upper view. 963401A, Cabo Cope; $P_2$. Right? element, inner view. CRB104M, Benifallet-Rasquera; $S_1$. Isolated element, inner view. CCO-13, Colldejou; $S_0$. Right? element, inner view. CRB101M, Benifallet-Rasquera; $S_2$. Left element, inner view. CCO-13, Colldejou; $S_3$. Right element, inner view. CCO-13, Colldejou; $M$. Right element, inner view. CRB103M, Benifallet-Rasquera. Ladinian.

Fig 6. Aparato de Sephardiella mungoensis (Diebel). Elementos $P_1$, $P_2$, $S_0$, $S_1$, $M$, barra = 50 µ. Elementos $S_0$, $S_2$, $S_3$, reproduccidas de March (1991), barra = 100 µ. $P_1$. Elemento izquierdo, vista superior. 963401A, Cabo Cope; $P_2$. Elemento derecho?, vista interior. CRB104M, Benifallet-Rasquera; $S_0$. Elemento único, vista interior. CCO-13, Colldejou; $S_1$. Elemento derecho?, vista interior. CRB101M, Benifallet-Rasquera; $S_2$. Elemento izquierdo, vista interior, CCO-13, Colldejou; $S_3$. Elemento derecho, vista interior, Colldejou; $M$. Elemento derecho, vista interior. CRB103M, Benifallet-Rasquera. Ladiniiense.
Fig. 7.- Elements identified by Bagnoli et al. (1985) as “Epigondolella” truempyi and Ramovs (1977) as Pseudofurnishius murcianus.

Fig. 7.- Elementos identificados por Bagnoli et al. (1985) como “Epigondolella” truempyi y Ramovs (1977) como Pseudofurnishius murcianus.

this specie as an early taxon of the Sephardiella genus.

March (1991) has emphasized that the apparatus of Sephardiella and Pseudofurnishius are widely identical but we have noted differences at the level of the P2 element (figures 4 and 6). Besides this point, the Sephardiella apparatus composition follows the same element position of Pseudofurnishius. That could mean strong phylogenetic links that connect Sephardiella to Pseudofurnishius. One aspect in discussion, however, is that while Cypridodella (Metalonchodina) mediocris Tatge (1956) was included in the variability of P. muelleri by Kozur and Mostler (1972), it became restored by Orchard and Rieber (1999) as their element S2. We cannot currently decide which is correct and we can only express the discrepancy in the table of the elements recognized by Bagnoli et al. (1985) and by Ramovs (1977) (Fig. 7).

Range: Early Ladinian to Early Carnian

Remarks: Notwithstanding the oral statement of Dr. Heinz Kozur to Dr. Kriril Budurov and Dr. Francis Hirsch (ECOS V-Meeting, Frankfurt/Main 1988) that he would acknowledge the generic name Sephardiella, the name Budurovignathus Kozur was maintained in ECOS V Proceedings Volume I (Kozur, 1989) on the base of page priority in the 1988 ECOS V-symposium abstract volume (Kozur, pages 244-245; March et al., page 247) while the ECOS V Proceedings Volume II that contains the contribution of March et al. appeared a year later (1990).

However, Sudar (1989) has made clear that Sephardiella should be chosen as generic name instead of Budurovignathus in accordance with (ICZN) International Code of Zoological Nomenclature (1961), paragraph 24 (a) ‘Names published simultaneously’. Although the name published by Kozur (1989) is in accordance with ICZN paragraph 13 (a)(iii), it is in disagreement with ICZN ‘Code of Ethics’, appendix A, paragraph 3 as well as with the ICZN ‘General recommendations’, appendix E, paragraph 23. It may also be reminded that ICZN of 1947 (in Keen and Muller, 1948), in case of homonymy, the ‘Code of Ethics’ states that the proper action, from a standpoint of professional etiquette, is to notify an author of the facts of a case, and to give said author ample opportunity to propose a substitute name.

3. Conclusions

The Triassic radiation of Gondolellacea has followed the ups and downs of global sea-level changes that happened during this time (Hirsch et al., 1987; Hirsch and Márquez-Aliaga, 1988; Hirsch, 1994). From Early Triassic, the step by step rising relative eustatic sea level (Haq et al., 1987) resulted in the appearance of new environmental niches, creating breathing grounds for speciation and radiation of new taxa, and among them, Sephardiellinae (nov. subfam.) species, that range from Late Anisian to Early Carnian when extreme low stand and a substantial salinity crisis brought its extinction.

In Upper Anisian and Early Ladinian, Sephardiellinae is restricted to the Sephardic Realm. During the Ladinian, Pseudofurnishius is mono-specifically confined to shallower or slightly hypersaline intervals of the Sephardic realm and the Southern Alps, and Sephardiella has a worldwide distribution in more open marine environments (Hirsch et al., 1987; Budurov et al., 1993). Thus, the hypothesis may be advanced that not only their spatial distribution but also the morphological variability within their apparatus may depend of facial conditions, like depth, salinity, trophic resources and possibly variations of the calcium-phosphate levels in the water.

Differential criteria in its septimembrate apparatus, the basal cavity structure of P1 element and morphological variations in the P2 and S3 elements defined the Sephardiellinae (nov. subfam.), which encompass a Middle Triassic Gondolelloid lineage that originated in the Sephardic realm, westernmost shallow Neotethys, from where, in
the course of the Ladinian and earliest Carnian, some of its species spread to the world oceans, before extinction as a result of the Carnian salinity crisis.

Acknowledgments

This paper does homage to Professor Carmina Virgili for the outstanding role she has played for half a century in the service of scientific research. Without her discovery of Middle Triassic (early Ladinian) red beds, straightening out the Triassic stratigraphy of the Iberian Peninsula, it would have taken long to unravel the superposition of Anisian and Ladinian carbonate sequences. It is thanks to this pioneering work that one of the authors of this paper was able to correctly sample in stratigraphic sequence the materials in which the first conodonts in the NE part of the Iberian Peninsula were found (Hirsch, 1966).

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