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The conodont apparatus of *Zieglerodina eladioi* (Valenzuela-Ríos, 1994)

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KEY WORDS - Taxonomy, Apparatus reconstruction, Conodonts, Přídolí, Lochkovian.

ABSTRACT - Zieglerodina eladioi *(Valenzuela-Ríos) is a small ozarkodinid from the latest Přídolí (Silurian) and the Lochkovian (Lower Devonian), up to now documented only in areas of North Gondwana. Material from Morocco, the Carnic Alps, and Sardinia provide the basis for the seximembrate reconstruction of this conodont species' apparatus (consisting of P1, P2, M, S0, S1, and S2 elements). The ramiform elements of* Zieglerodina eladioi *are characterised by an alternate denticulation with spike-like denticles, further confirming the attribution of the species to the genus* Zieglerodina.

RIASSUNTO - [L'apparato del conodonte *Zieglerodina eladioi* (Valenzuela-Ríos, 1994)] - Zieglerodina eladioi *(Valenzuela-Ríos) è una specie di conodonti ozarkodinidi documentata dalla parte più alta del Přídolí (Siluriano superiore) al Lochkoviano medio (Devoniano Inferiore). La specie è stata istituita nei Pirenei spagnoli e fino a ora è documentata in diverse aree del nord Gondwana (Marocco, Alpi Carniche, Sardegna, Repubblica Ceca e Turchia). L'apparato di* Zieglerodina eladioi *viene ricostruito basandosi su ritrovamenti in Marocco, Sardegna e nelle Alpi Carniche; esso comprende sei elementi (P1, P2, M, S0, S1 e S2) in cui gli elementi ramiformi sono caratterizzati da una denticolazione alternata con denticoli aghiformi. La morfologia dell'apparato conferma l'attribuzione della specie al genere* Zieglerodina.

INTRODUCTION

Zieglerodina eladioi is a small ozarkodinid documented from latest Silurian and Lower Devonian rocks of various Mediterranean and central European regions. The species was established by Valenzuela-Ríos (1994) as *Ozarkodina eladioi* from the Lochkovian of central Spanish Pyrenees, based solely on the P1 element. Corriga (2007) suggested that the taxon may belong to genus *Zieglerodina* Murphy et al. on the basis of a few poorly preserved ramiforms collected in the Perda s'Altari II section, in southwestern Sardinia. Thanks to various samples from Morocco, the Carnic Alps and Sardinia (Fig. 1) we are able to reconstruct the complete apparatus of *Z. eladioi*, which is composed of six elements (P1, P2, M, S0, S1 and S2), and herein we describe this species' apparatus for the first time.

MATERIAL

This work is predominantly based on one sample from Morocco collected by Professor O.H. Walliser in the '990s, which is stored in the "Walliser conodont collection" at the Geoscience Centre, Georg-August University, Göttingen, Germany, under reference collection number GZG 1612. This sample is labelled "Wa3715" and was collected from a loose block near the Atrous 3 section, southeastern Tafilalt (Fig. 1b). For more information on the locality and stratigraphic data refer to Corriga et al. (2014a, b).

The sample yielded a rich population represented by *Zieglerodina eladioi*, *Ancyrodelloides carlsi* (Boersma, 1973) and *Pseudooneotodus beckmanni (*Bischoff & Sannemann, 1958), together with rare elements of *Belodella resima* (Philip, 1965) and *Icriodus angustoides* cf. *alcolae* Carls, 1969. The ramiform elements can be easily subdivided into two groups: one is represented by large and robust elements, belonging to *Ancyrodelloides*, and the other, smaller and with a characteristic denticulation with spike like denticles are attributed to *Z. eladioi*. Also, the differentiation between the two groups was even easier since the apparatus of *Ad. carlsi* is already known, having been reconstructed by Slavík (2011).

Zieglerodina eladioi is also present in our collections from Sardinia and the Carnic Alps. In Sardinia poorly preserved elements of *Z. eladioi* are documented from the Perda s'Altari (Corriga, 2007; Corriga & Corradini, 2008) and Mason Porcus (Corriga, 2011) sections (Fig. 1c).

In the Carnic Alps (Fig. 1d) the complete apparatus of *Z. eladioi* was recovered from two beds (samples RMW 4B and RMW 9) at the Rio Malinfier West section (Corriga, 2011; Corradini et al., 2012, 2019a; Corriga et al., 2017b), whereas only scattered elements have been collected from other levels of the section (Corradini et al., 2019a, fig. 9). The taxon, either the more common P1 element or its rarer ramiforms, is documented from various other sections in the region (e.g., Monte Cocco II: Corriga & Corradini, 2009; Rio Malinfier: Corriga et al., 2012, 2017a; Cellon: Corradini et al., 2015; Corriga et al., 2016; Rauchkofel Boden: Schönlaub et al., 2017b; Freikofel South II: unpublished). Also, we observed the presence of elements of *Z. eladioi* in collections stored at the Austrian Geological Survey in Vienna (Oberbuchach Ib: Schönlaub & Corradini, 2017; Oberbuchach II: Schönlaub et al., 2017a; Oberbuchach IV: unpublished; Rauchkofel Boden: Schönlaub et al., 2017b; Rauchkofel South: unpublished).

The studied material includes a few dozen elements and is stored at the Geoscience Centre of Georg-August University Göttingen (GZG), Museo Friulano di Storia Naturale (MFSNgp), Museo di Paleontologia "Domenico

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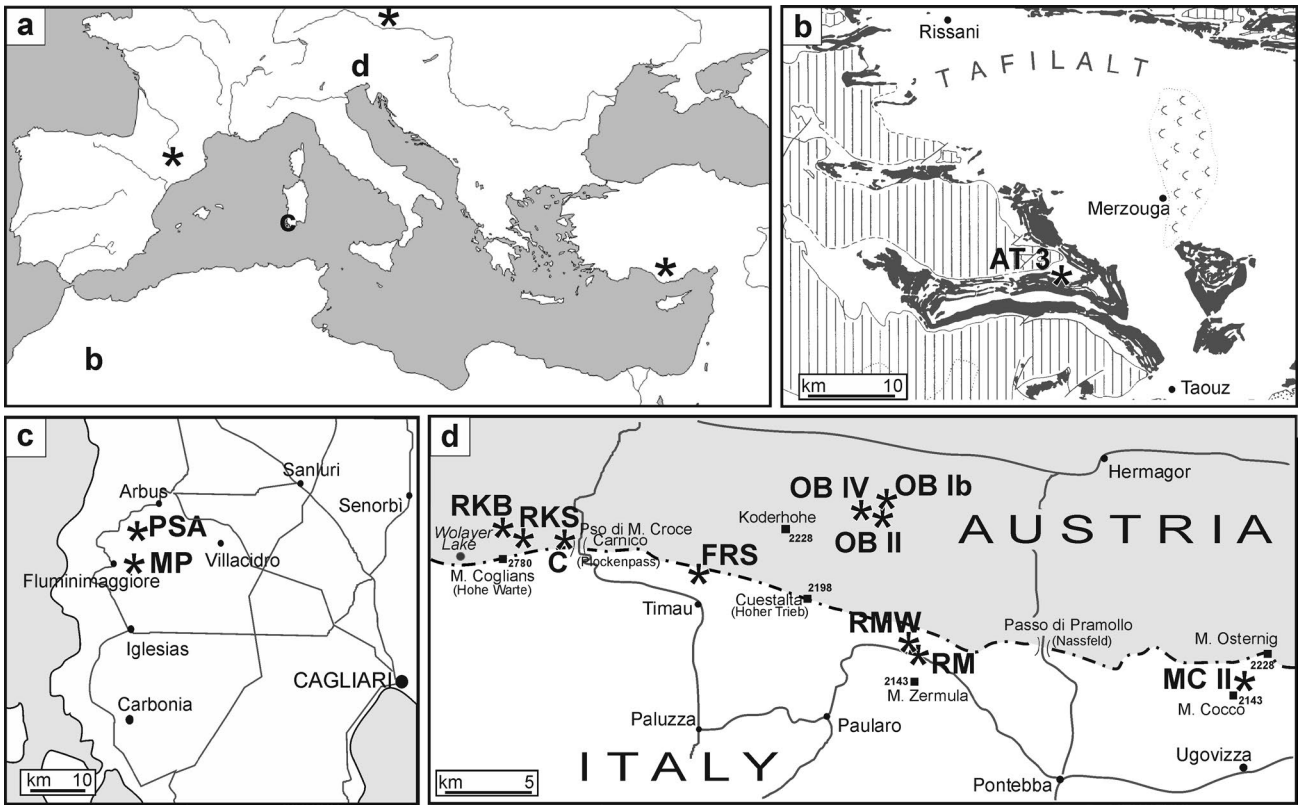

Fig. 1 - Geographic distribution of *Zieglerodina eladioi* (Valenzuela-Ríos, 1994). a) Occurrence of the species: letters indicate the areas of origin of the collections studied in this paper (b: Tafilalt, Morocco; c: Sardinia; d: Carnic Alps); asterisks indicate the other regions where the species is documented (from west to east: Spanish Pyrenees, Bohemia, Turkey). b) Sketched location map of the Atrous 3 (AT 3) locality in Morocco (after Corriga et al., 2014b, mod.). c) Sketched location map of the sections bearing *Z. eladioi* in southwestern Sardinia (MP = Mason Porcus; PSA = Perda s'Altari). d) Sketched location map of the sections bearing *Z. eladioi* in the Carnic Alps (C = Cellon; FRS = Freikofel South II; MC II = Monte Cocco II; OB Ib = Oberbuchach Ib; OB II = Oberbuchach II; OB IV = Oberbuchach IV; RKB = Rauchkofel Boden; RKS = Rauchkofel South; RM = Rio Malinfier; RMW = Rio Malinfier West).

Lovisato" of Cagliari University (MDLCA), Museo di Paleontologia of Modena and Reggio Emilia University (IPUM) and Austrian Geological Survey. Precise information and repository numbers of illustrated elements are reported in the caption of Fig. 3.

SYSTEMATIC PALAEONTOLOGY

Class Conodonta Pander, 1856
Order Ozarkodinida Dzik, 1976
Family Spathognathodontidae Hass, 1959

Genus *Zieglerodina* Murphy, Valenzuela-Ríos & Carls, 2004
Type species *Spathognathodus remscheidensis* Ziegler, 1960

Zieglerodina eladioi (Valenzuela-Ríos, 1994) (Figs 2-3)

1980 *Ozarkodina remscheidensis remscheidensis* (Ziegler) - Schönlaub, pl. 1, fig. 20/29; pl. 2, fig. 3/44; pl. 3, fig. 20 (only).
1980 *Ozarkodina remscheidensis eosteinhornensis* (Walliser) - Schönlaub, pl. 3, fig. 13 (only).
1985 *Ozarkodina remscheidensis remscheidensis* (Ziegler) - Schönlaub, pl. 1, fig. 20 (only).
1994 *Ozarkodina eladioi* n. sp. Valenzuela-Ríos, p. 59-63, pl. 5, figs 1-35.
non 2000 *Ozarkodina eladioi* Valenzuela-Ríos - Göncüoğlu & Kozur, fig. 7.1.
2004 *Ozarkodina* sp. - Göncüoğlu et al., fig. 4.10, ?4.12.
2004? *Ozarkodina eladioi* Valenzuela-Ríos - Göncüoğlu et al., fig. 4.17, 4.18.
2006 "*Ozarkodina*" *eladioi* Valenzuela-Ríos - Sanz-López et al., fig. 5.14, 5.15.
2007 *Zieglerodina eladioi* (Valenzuela-Ríos) - Corriga, p. 84-86, pl. 2, figs 1-3, 5, 7; pl. 3, figs 1-3 (only).
2011 *Zieglerodina eladioi* (Valenzuela-Ríos) - Corriga, p. 123, pl. 6, fig. 2; pl. 11, fig. 4.
2012 *Zieglerodina eladioi* (Valenzuela-Ríos) - Corriga et al., fig. 5.1.
2016 *Zieglerodina eladioi* (Valenzuela-Ríos) - Corriga et al., p. 266, fig. 5A-5B.
2017b *Zieglerodina eladioi* (Valenzuela-Ríos) - Schönlaub et al., pl. 3, fig. 2.
2017a *Zieglerodina eladioi* (Valenzuela-Ríos) - Corriga et al., fig. 4.2.
2019b *Zieglerodina eladioi* (Valenzuela-Ríos) - Corradini et al., fig. 12C.

Emended diagnosis - A small species of *Ziegerodina* with an apparatus of six elements (P1 carminate, P2 angulate, M dolabrate, S0 alate, S1 digyrate, S2

bipennate), whose ramiforms are characterised by an alternate denticulation with spike-like denticles.

Description - The seximembrate apparatus of *Zieglerodina eladioi* is composed of P1, P2, M, S0, S1 and S2 elements.

The P1 element is a carminate pectiniform with a short posterior blade bearing three-four denticles of different sizes, two of which are bigger than the others. The anterior blade bears up to six denticles of slightly different dimension. The cusp is only a little larger than the other denticles. The basal cavity, which is relatively wide and somewhat asymmetrical, is located a bit posterior than the centre of the elements.

The P2 element is an angulate pectiniform with a gently arched lower profile. The anterior process is higher than the posterior, and bears closely spaced subtriangular denticles increasing in height towards the cusp. The posterior process, a little longer than the anterior, bears closely spaced denticles. The cusp is high and robust and in lateral view has a subtriangular shape. The small basal cavity extends as a narrow groove under both processes.

The M element is dolabrate with the vaguely arched posterior process bearing closely spaced small denticles; very small spike-like denticles alternate with relatively larger and rounded in cross section denticles. Anterior process absent. The cusp is high and straight, but relatively narrow. The basal cavity is small and limited in expanse to just below the cusp.

The S0 element is alate, with two processes forming an angle of about 90° to 100°. The processes are straight and bear closely spaced denticles, and often one or two smaller spike-like denticles alternate with larger ones. The cusp is higher and stronger than the other denticles. The basal cavity is small below the cusp, and slightly enlarged in the inner side of the element.

The S1 element is digyrate with the posterior process longer and a bit higher than the anterior one. The processes form an angle of about 160°. Both bears closely spaced posteriorly reclined spike-like denticles, a few of them are slightly larger and alternate with the smaller denticles, generating the characteristic alternate denticulation. The cusp is small, only a little larger than the adjacent denticles. The small basal cavity is located below the cusp and expands a little towards in the inner margin of the element.

The S2 element is bipennate with a long, straight posterior process and a short anterior process that is bowed inward and downward. Both processes bear small, closely spaced denticles, with smaller spike-like denticles alternating with slightly larger ones. The prominent cusp is somewhat inclined posteriorly. The basal cavity is narrow.

Remarks - Drygant (2010) and Drygant & Szaniawski (2012) considered *Z. eladioi* (Valenzuela-Ríos) as a junior synonym of *Z. mashkovae* (Drygant, 1984), arguing that the P1 elements "do not differ significantly in morphology and stratigraphic range from *Zieglerodina mashkovae* (Drygant, 1984)" (Drygant & Szaniawski, 2012, p. 854). However, the two species are clearly different because the P1 element of *Z. mashkovae* is characterised by the straight upper and lower margins of the element, a high cusp that is definitively bigger than the other denticles that are more or less equal in height, and a symmetrical basal cavity approximately in a central position (Corriga et al., 2016).

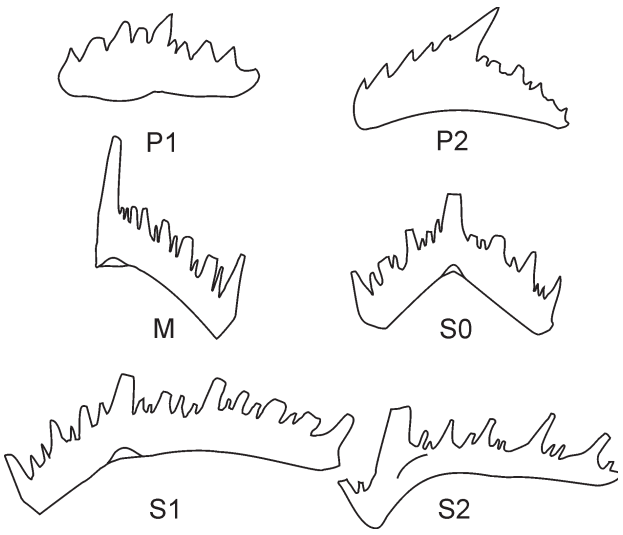

Fig. 2 - Sketched drawings of the elements of the apparatus of *Zieglerodina eladioi* (Valenzuela-Ríos, 1994). Letters indicate the position in the apparatus. All elements are illustrated at the same enlargement; for scale see Fig. 3. For description see the text.

The only ramiform elements that we attribute to *Z. eladioi* that have been figured until now are the S1 and S2 element illustrated as *Ozarkodina* sp. by Göncüoğlu et al. (2004, figs 4.10, 4.12?) from southern Turkey.

Stratigraphic distribution - From the uppermost Přídolí to the middle Lochkovian: from the upper part of the Upper *Oul el. detortus* Zone to the *Ad. trigonicus* Zone (Corradini & Corriga, 2012). In the Carnic Alps the species enters in the latest Silurian beds, at the same level of the first occurrence of *Z. remscheidensis* (Corradini & Corriga, 2017; Corradini et al., 2019b), and can be used for approximating the Silurian/Devonian boundary. In other regions (e.g., Spain, Valenzuela-Ríos, 1994) the species is documented only from the Devonian.

Geographic distribution - Up to now, the species has been documented only from peri-Gondwana regions: Spanish central and eastern Pyrenees (Valenzuela-Ríos, 1994; Garcia Alcalde et al., 2002; Sanz-López et al., 2002, 2006), Carnic Alps (e.g., Corriga et al., 2016 and references therein), Sardinia (Corriga, 2007, 2011), Bohemia (Slavík et al., 2012), Turkey (Göncüoğlu et al., 2004) and Morocco (this paper).

CONCLUSION

Based on collections from Morocco, Sardinia and the Carnic Alps, the reconstructed apparatus of *Zieglerodina eladioi* (Valenzuela-Ríos, 1994) is seximembrate, consisting of six elements. The morphology of the P2 and ramiform elements validates Corriga's (2007) previous suggestion that the species be assigned to the genus *Zieglerodina*.

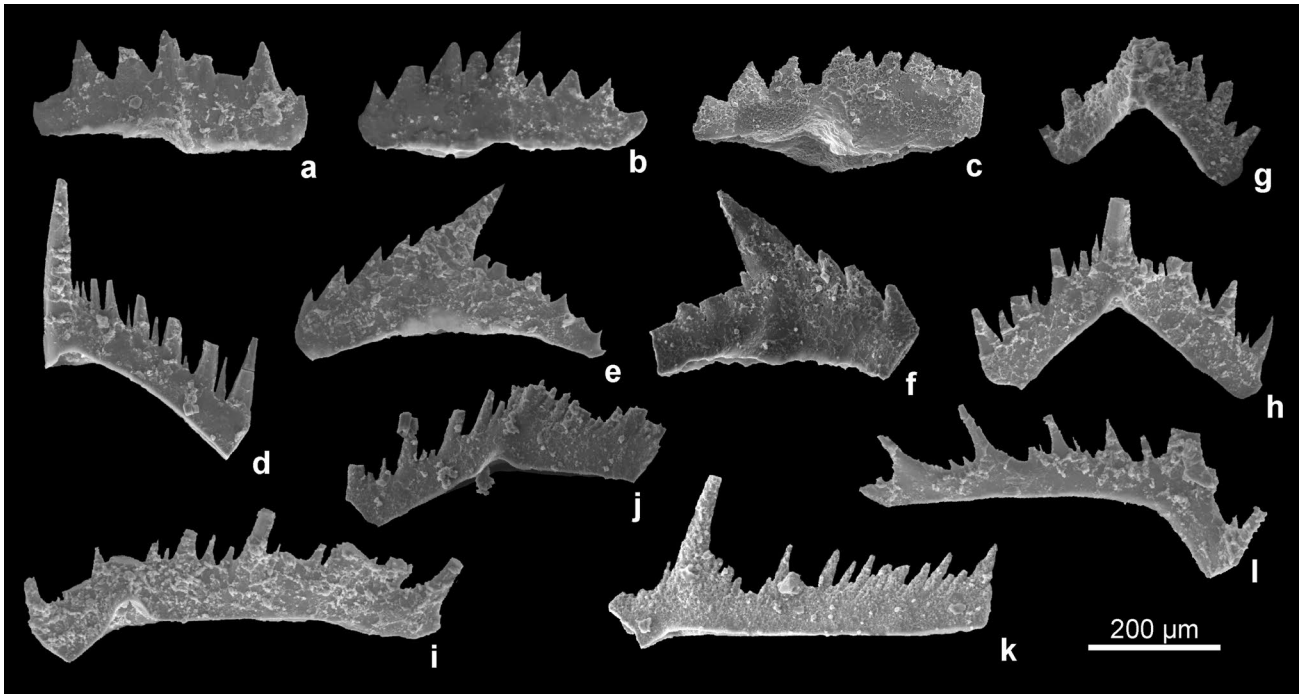

Fig. 3 - *Zieglerodina eladioi* (Valenzuela-Ríos, 1994). a) P1 element GZG 1612-477-3715-1, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone. b) P1 element MDLCA 30351, Rauchkofel South section, sample 13, *Ad. carlsi* Zone. c) P1 element MDLCA 30188, Rio Malinfier section, sample RM 13, *Ad. transitans* Zone. d) M element GZG 1612-477-3715-2, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone. e) P2 element GZG 1612-477-3715-3, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone. f) P2 element MFSNgp 48365, Rio Malinfier West section, sample RMW 9, *Icr. hesperius* Zone. g) S0 element MFSNgp 48368, Rio Malinfier West section, sample RMW 9, *Icr. hesperius* Zone. h) S0 element GZG 1612-477-3715-4, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone. i) S1 element GZG 1612-477-3715-5, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone. j) S1 element MFSNgp 48370, Rio Malinfier West section, sample RMW 9, *Icr. hesperius* Zone. k) S2 element MFSNgp 48372, Rio Malinfier West section, sample RMW 9, *Icr. hesperius* Zone. l) S2 element GZG 1612-477-3715-6, El Atrous 3 locality, sample Wa 3715, *Ad. carlsi* Zone.

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