



## Presence of *Naraoia* Walcott, 1912 (Nektaspida, Arthropoda) in the middle Cambrian of Europe (Murero, NE Spain)

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### ABSTRACT

The genus *Naraoia* Walcott, 1912, a Burgess Shale-type fossil known from the lower and middle Cambrian of British Columbia (Canada), Idaho and Utah (USA), as well as from Yunnan and Guizhou provinces (China), is now reported from the middle Cambrian of Murero (Zaragoza, Spain), which is the first record in the Acadobaltic province. The only fragmented specimen found is determined as *Naraoia* sp., its age being *Pardailhania multispinosa* Zone (Drumian Stage). This new datum reinforces the hypothesis of the existence of a cosmopolitan faunal substrate in early Cambrian times, which is to some extent reflected in the mid Cambrian by faunal groups of low evolutionary potential as the family *Naraoiidae* and other soft-bodied fossil taxa.

**Keywords:** Systematics, Arthropoda, Drumian (Cambrian Series 3), palaeobiogeography.

### RESUMEN

El género *Naraoia* Walcott, 1912, es un fósil de tipo Burgess Shale, conocido en el Cámbrico inferior y medio de la Columbia Británica (Canadá), Idaho y Utah (EE.UU.), así como en las provincias chinas de Yunnan y Guizhou. Este hallazgo en Murero (Zaragoza, España) supone el primer registro del género en la provincia Acadobáltica. Sólo se ha encontrado un espécimen fragmentado que se ha determinado como *Naraoia* sp., en la Zona de *Pardailhania multispinosa* (Piso Drumense). Este nuevo dato refuerza la hipótesis de la existencia de faunas cosmopolitas durante el Cámbrico temprano, que se extenderían hasta el Cámbrico medio en algunos grupos faunísticos con baja tasa evolutiva, como es el caso de la familia *Naraoiidae* y otros taxones fósiles de organismos de cuerpo blando.

**Palabras clave:** Sistemática, Arthropoda, Drumense (Serie 3 del Cámbrico), paleobiogeografía.

## 1. INTRODUCTION

The Family Naraoiidae is an arthropod group represented by commonly non-mineralized taxa. They are abundant and well preserved in the Burgess Shale (British Columbia, NW Canada) and Chengjiang (Yunnan, S China) *Lagerstätten* (Whittington, 1977; Hou *et al.*, 2004; Zhang *et al.*, 2007). They have also been found in the lower and middle Cambrian of Idaho and Utah (western USA) (Robison, 1984) and in the Kaili and Balang faunas in Guizhou (S China) (Zhao *et al.*, 2005; Peng *et al.*, 2012). Herein, we describe the first non-calcified nektaspid arthropods found in Murero (Spain), which is also the first record of the family Naraoiidae in Europe, as well as in the Acadobaltic province (*sensu* Sdzuy, 1972; Sdzuy *et al.*, 1999).

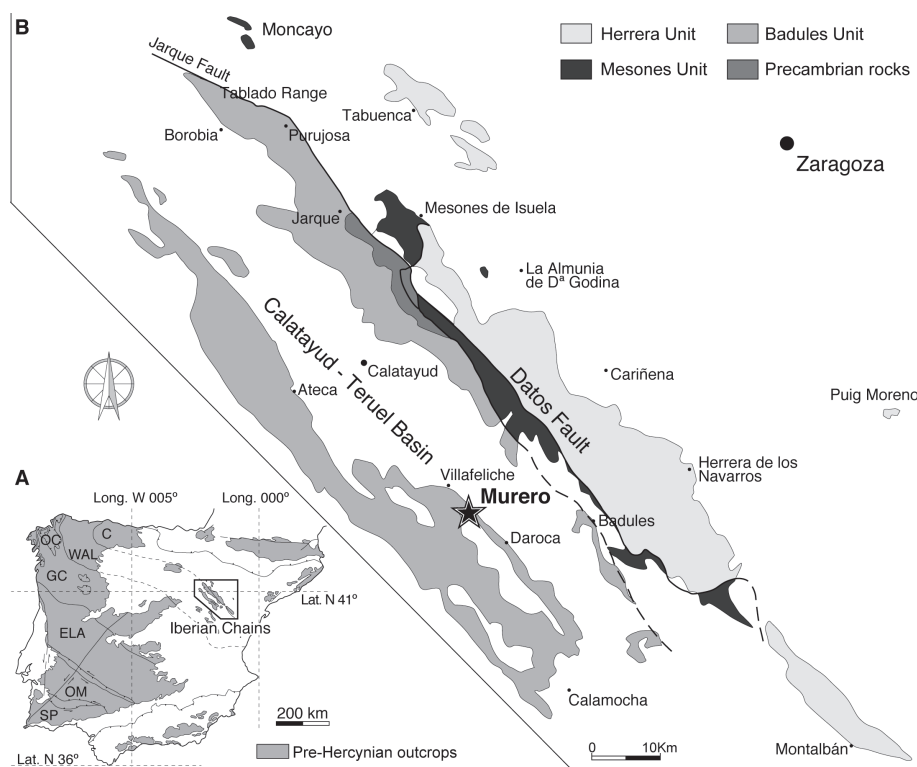
The lower and middle Cambrian Murero *Lagerstätte* is a 195 m-thick, marine monofacial stratigraphic succession, deposited in a sublittoral environment under a subtropical climate. It has yielded arthropods, represented by more than 80 trilobite species (Liñán & Gozalo, 1986; Liñán *et al.*, 1996, 2008) and some bradoriids (Gozalo *et al.*, 2004), up to 6 species of brachiopods (Liñán & Mergl, 2001), up to 15 taxa of echinoderms, including eocrinoids, edrioasteroids, and cinctans (Zamora, 2011), and hyoliths. Burgess Shale-type fossils include chlorophytic and phaeophytic algae (Liñán *et al.*, 2012), sponges (García-Bellido *et al.*, 2007, 2011), palaeoscolecid ecdysozoans (Conway Morris & Robison, 1986; Gámez Vintaned, 1995; Zhuravlev *et al.*,

2011) and xenosian lobopods (Gámez Vintaned *et al.*, 2011). Twenty ichnotaxa have been described in Murero (Gámez Vintaned & Mayoral, 1992, 1995). Thus, the Cambrian site of Murero represents an exceptional geological site in order to research the global events affecting the planet during the early-mid Cambrian transition and mid Cambrian times (recorded in rocks of the Cambrian Series 2 and 3).

## 2. GEOLOGICAL AND STRATIGRAPHICAL SETTINGS

The village of Murero is located by the Jiloca river, near the historic city of Daroca, 80 km southwards from Zaragoza (Aragón, NE Spain). Murero is framed in the Western Iberian Chain (Badules Unit), in the heart of the Iberian Mountains (Fig. 1). The fossiliferous strata near Murero are located in the Villafeliche block (Gozalo *et al.*, 1993), cropping out in a normal succession dipping SW and being affected by normal faults. The Cambrian strata are exposed to the north of Murero along the rambla de Valdemedes (Valdemedes gully). Among the several stratigraphic sections studied, the rambla de Valdemedes 1 section (RV1) is located on the right bank of the gully (Liñán & Gozalo, 1986; Liñán *et al.*, 2008).

In general, the depositional environment of the Cambrian of Murero is interpreted as a low-to-moderate



**Figure 1.** Geographical and geological setting of the study area in Murero. The star indicates the location of the studied section RV1 (modified from Gozalo & Liñán, 1988; Liñán *et al.*, 2008).

energy, open sublittoral (infralittoral) shelf located at a subtropical latitude.

The fossil specimen described herein was found at the base of level 15 of section RV1, corresponding to the middle part of the Murero Formation. The fossil assemblage associated to *Naraoia* sp. is composed of the following taxa: 1) the trilobites *Peronopsis acadica*, *Diplagnostus planicauda*, *Eccaparadoxides sequerosi*, *E. rouvillei*, *Pardailhania hispida*, *P. multispinosa*, *Conocoryphe (Parabailiella) languedocensis*, *C. (C.) heberti*, *Ctenocephalus (Hartella) antiquus* and *Agraulos longicephalus* (see Liñán & Gozalo, 1986; Liñán *et al.*, 2008), and 2) the brahiopods *Redlichiella cf. bohémica* and *Dyctionina radioplicata* (Liñán & Mergl, 2001). This fossil assemblage belongs to the *Pardailhania multispinosa* Biozone of the middle Caesaraugustan regional Stage, which is correlated with the Drumian Stage (Gozalo *et al.*, 2011).

### 3. SYSTEMATIC PALAEOONTOLOGY

Order NEKTASPIDA Raymond, 1920

Family *Naraoiidae* Walcott, 1912

Genus *Naraoia* Walcott, 1912

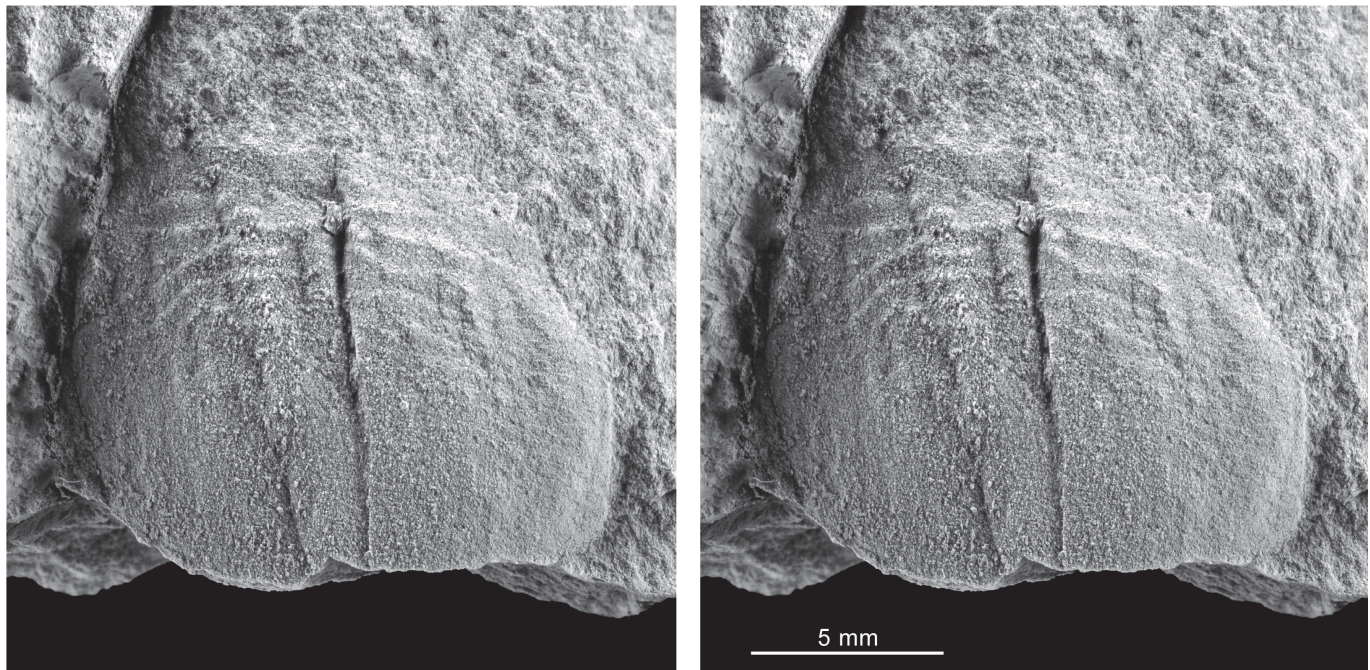
Type species *Naraoia compacta* Walcott, 1912, by original designation.

**Other species.** *Naraoia spinifer* Walcot, 1931; *N. halia* Simonetta & Delle Cave, 1975; *N. spinosa* Zhang & Hou, 1985; *N. bertensis* Caron *et al.*, 2004; *N. taijiangensis* Peng, Zhao & Sun, 2012.

*Naraoia* sp.  
(Fig. 2)

**Material.** One incomplete posterior shield preserved as internal mould. It is deposited at the Collection of Type Fossils of the Museo de Ciencias Naturales de la Universidad de Zaragoza (Canudo, 2017) under repository MPZ-2018/29. Morphological terms used in this description are after Zhang *et al.* (2007).

**Description.** Slightly distorted posterior shield, broken and incomplete on its posterior area. Its outline is rounded, and it shows a doublure or narrow band around the margin. The surface is slightly convex, gradually flattening laterally and divided longitudinally by a convex axial lobe. The anterior part is located in a lower plane with respect to the majority of the surface and, probably, it represents the overlapping portion between both shields (see Whittington, 1977, p. 420). The axis is raised as a convex ridge along its length, which is highlighted by two straight lateral furrows tapering backward; the axis is also narrow, its width being less than one-fourth of the posterior shield width. The anterior part of the posterior shield shows a branching pattern of gut caeca, with seven transverse branches which



**Figure 2.** Stereopair pictures of *Naraoia* sp. Internal mould of posterior shield. Rambla de Valdemedias 1 section, Level 15. Specimen MPZ 2018/29.

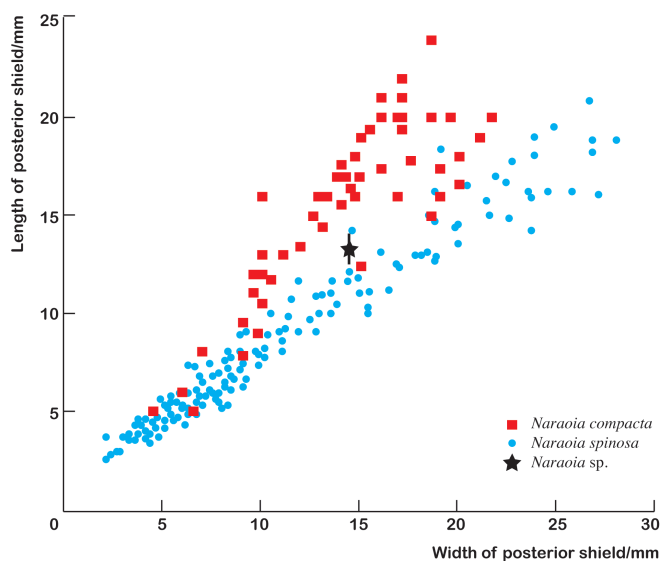


fade away in the lateral area of the shield. The caeca fade in the posterior part of the posterior shield too.

The maximum transverse width of the specimen is 14.5 mm, while the minimum sagittal length is 11.2 mm, because the posterior part is broken; the possible sagittal length range from 13 to 15 mm. This size indicates that the specimen was an adult (see Zhang *et al.*, 2007).

**Remarks.** Naraoiid arthropods are clearly defined as nektaspids with the dorsal exoskeleton divided by a single articulation into an anterior and a posterior shield (Zhang *et al.*, 2007, p. 19). The anterior portion of the rounded posterior shield studied herein is interpreted as the overlap portion between both shields; thus our specimen is identified as belonging to the family Naraoiidae. Only two genera are known in the family, namely *Naraoia* Walcott, 1912, and *Misszhouia* Chen, Edgecombe & Ramsköld, 1997. The main character of the latter is the elongated posterior shield (Zhang *et al.*, 2007, p. 31). Thus, in conclusion, we classify the Spanish specimen as *Naraoia*.

The morphology of the study specimen of *Naraoia* sp. is close to *Naraoia compacta* Walcott, 1912 and the morph B of *Naraoia spinosa* Zhang & Hou, 1985. Zhang *et al.* (2007, p. 19) commented that the outline of morph B of *N. spinosa* is similar to that of *N. compacta*, and that the difference lies in the shape of anterior shield. Figure 3 shows a graph of measurements of posterior shield of *N. compacta* and *N. spinosa*, redrawn, respectively, from Whittington (1977, fig. 2.d) and Zhang *et al.* (2007, fig. 17.2), and the *Naraoia* specimen from Murero. The position of the Spanish specimen is, more or less, in the



**Figure 3.** Graphs of measurements, in millimetres, of posterior shield of *Naraoia compacta* Walcott, 1912 (*sensu* Whittington, 1977, fig. 2.d), *Naraoia spinosa* Zhang & Hou, 1985 (*sensu* Zhang *et al.*, 2007, fig. 17.2) and *Naraoia* sp. from Murero.

middle of both species distribution. Thus, and also because of the lack of the anterior shield, we prefer to classify the specimen in open nomenclature.

*Naraoia* sp. differs mostly from *N. spinifer* Walcott, 1931 and morph A of *N. spinosa* Zhang & Hou, 1985 in that it has no marginal spines in the posterior shield. *Naraoia halia* Simonetta & Delle Cave, 1975 has a posterior shield, with an almost straight anterior margin. Finally, *Naraoia bertiensis* Caron *et al.*, 2004, from the late Silurian, does not have a marked axis in the posterior shield.

Previously, *Naraoia* sp. had been cited in South Australia (Nedin, 1999). This material is now classified as *Emucaris*, a genus defined by Paterson *et al.* (2010) showing a more elongated posterior shield and an axis with polygonal ornament on the dorsal surface, some features that are not present in the Murero specimen.

**Occurrence.** Base of level 15 of the rambla de Valdemiedes-1 section (RV1/15; Liñán & Gozalo, 1986, fig. 9), middle part of the Murero Formation, *Pardailhanian multispinosa* Biozone (middle Caesaraugustan regional Stage); Drumian Stage in the standard chronostratigraphy.

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