Late middle Cambrian trilobites from El Totoral, Mendoza, Argentina

M. FRANCO TORTELLO

TORTELLO, M.F., 2011:12:23. Late middle Cambrian trilobites from El Totoral, Mendoza, Argentina. *Memoirs of the Association of Australasian Palaeontologists 42*, 115-136. ISSN 0810-8889.

Late middle Cambrian trilobites from open-shelf lithofacies of El Totoral, Precordillera of Mendoza, western Argentina, are described. The material belongs to the Ángel Borrello collections in the Museum of Natural Sciences of La Plata, Argentina. In addition, type specimens of the Carlos Rusconi collections in the Museum J.C. Moyano, Mendoza, are reillustrated. Biostratigraphically important agnostoids of the *Lejopyge laevigata* Zone [*Agnostus microcephalus* (Rusconi), *Ammagnostus beltensis* (Lochman), *Kormagnostus seclusus* Walcott, *Clavagnostus calensis* Rusconi, *Tomagnostella nepos* (Brøgger), *Lejopyge* sp.] are described from this locality for the first time, and the polymeroid faunas are fully revised. The latter include *Asaphiscus* cf. *lasherensis* (Rusconi), *Blountia socorrensis* Rusconi, *Elrathia oscelata* (Rusconi), *Talbotinella communis* Poulsen, *Modocia* sp., *Olenoides faldeanus* Rusconi and *Hysteropleura* (*Verditerrina*) *totoralensis* (Rusconi). As previously suggested by Borrello and Rusconi, the polymeroids have their closest affinities with faunas of North America (lower *Cedaria* Zone and equivalents).

M. Franco Tortello (tortello@.fcnym.unlp.edu.ar), Departamento Paleontología Invertebrados, Museo de Ciencias Naturales, Paseo del Bosque s-n°, 1900 La Plata, Argentina. *Received 13 July 2011.*

Keywords: middle Cambrian, trilobites, systematics, El Totoral, Mendoza, Argentina.

THE EL TOTORAL fossil locality is located in the southern Precordillera of western Argentina, about 25 km NW of Mendoza city. This classic site was discovered by Carlos Rusconi and Manuel Tellechea (Museum of Natural History of Mendoza) in the 1950s and consists of c. 20 m of dark limestones containing abundant and diverse trilobites, molluscs and brachiopods (Rusconi, 1956a). Rusconi (1956a, 1958) mentioned the presence of agnostoid trilobites and described several new genera and species of polymeroids from the succession, which was originally assigned to the "latest middle Cambrian?-earliest late Cambrian". Unfortunately most of these taxa were erected only on the basis of isolated pygidia and their descriptions were not accompanied by photographs, a fact that has hampered later taxonomic assessment of the faunas.

A few years after the pioneer work of Carlos Rusconi, Ángel Borrello (Museum of Natural Sciences of La Plata, Argentina) collected additional specimens of invertebrates from El Totoral. Based on the papers of Rusconi and preliminary observations made by himself, Borrello (1971) considered that the El Totoral section may include levels correlatable with the lower 'Dresbachian' zones of North America (*Cedaria* or *Crepicephalus* zones). He initiated the examination of his trilobite collections in collaboration with Pierre Hupé (Sorbonne, Paris), though detailed systematic study was not achieved (see Borrello 1965, p. 44; Tortello 2009).

A systematic study of the trilobites from the El Totoral locality is presented herein. The material examined consists of more than 400 specimens and numerous fragments from the Borrello collections, which are housed in the Museum of Natural Sciences of La Plata. In addition, selected type specimens of the Rusconi collections in the Museum J.C. Moyano, Mendoza, are reillustrated. Biostratigraphically important agnostoids are described from El Totoral for the first time, and the polymeroid faunas are strongly revised. As previously suggested by Rusconi (1956a, 1962) and Borrello (1965, 1971), the polymeroids have their closest affinities with faunas of North America (*Lejopyge laevigata* and lower *Cedaria* zones and equivalents).

STRATIGRAPHIC SETTING

The Cambrian of the southern Precordillera in Mendoza Province consists predominantly of

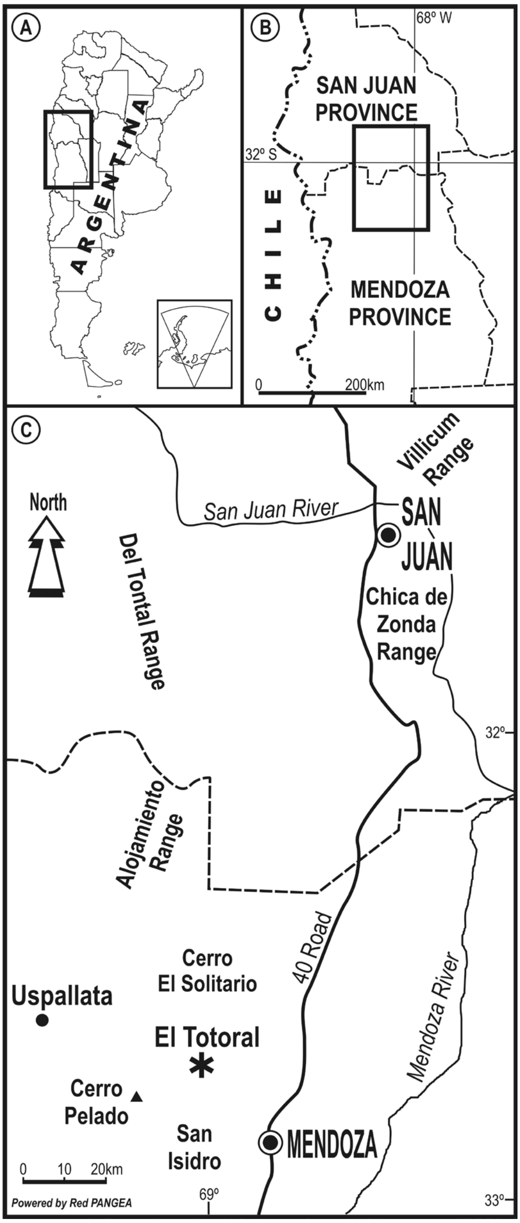

Figure 1. Location map of fossiliferous sites in northern Mendoza, western Argentina.

isolated carbonate blocks chaotically mixed within Middle to Upper Ordovician siliciclastic sequences (Heredia & Beresi 2004). These olistoliths range from centimeters to hundred of meters in thickness and represent shelf to upper slope environments containing diverse shelly faunas (e.g., Bordonaro 1992, 2003a, b; Bordonaro *et al*. 1993; Bordonaro & Liñán 1994; Heredia 1994, 1996; Bordonaro & Banchig 1996; Shergold *et al*. 1995; Tortello & Bordonaro 1997; Keller 1999; Heredia & Beresi 2004; Tortello 2009). The most classic fossil localities are San Isidro, Cerro El Solitario, and El Totoral (Fig. 1).

The San Isidro area is located 15 km W of Mendoza city. There, the carbonate-dominated San Martín, San Isidro and La Cruz Olistoliths, as well as other minor exotic blocks, are emplaced in Ordovician green and black shales of the Estancia San Isidro and Empozada formations (Beresi 2003; Heredia & Beresi 2004 and references therein). These allochthonous units contain trilobites, sponge spicules and chancellorid sclerites which are middle Cambrian (*Glossopleura* and *Oryctocephalus* zones) and Furongian (*Glyptagnostus reticulatus*, *Elvinia* and *Saukia* zones) in age (e.g., Rusconi 1956b; Bordonaro 2003b, fig. 2; Beresi 2003). The Cerro El Solitario locality is about 40 km NNW of Mendoza city, and consists of a medium-sized olistolith (Solitario Olistolith) partially covered by alluvial material. It is composed of open-shelf dark limestones and black shales containing trilobites of late middle Cambrian (*Lejopyge laevigata* Zone) age (Rusconi 1956b; Poulsen 1960; Bordonaro & Liñán 1994; Tortello & Bordonaro 1997; Bordonaro 2003b, fig. 2; Tortello 2009 and references therein).

El Totoral is 25 km NW of Mendoza city and 3.5 km SE of Puesto El Totoral (Fig. 1). Rusconi (1956a, 1958) provided a brief description of a 20 m thick succession of black limestones containing trilobites, brachiopods and molluscs which were originally assigned to the "latest middle Cambrian?-earliest late Cambrian". Rusconi (1956a, 1958) proposed the new genera *Epumeria*, *Pichunia* and *Pichynturia*, and the new species *Olenoides faldeanus*, *Blountia socorrensis*, *B. luanensis*, *B. complexa*, *B. multicostata*, *Epumeria lata*, *Pichunia indomita*, *Pichunia quadricostata*, *Pichynturia oscelata*, *Notocoryphe totoralensis* and *Hemirhodon puntanus* from the locality, all of which are revised below.

In the fifty years since the work of Rusconi, El Totoral has only been cited or briefly quoted in a few papers (Rusconi 1956b; Castellaro 1963; Borrello 1965, 1971; Bordonaro & Banchig 1995, 1996; Bordonaro 2003a, b; Cerdeño 2005). Borrello (1971) provided a succinct faunal list and pointed out the Laurentian aspect of the trilobites (cf. Rusconi 1962). Stratigraphically, the open-shelf limestones of the outcrop belong to the La Cruz Limestones *sensu* Keller (1999), and constitute an olistolith (assigned to "Olistoliths Totoral" by Bordonaro & Banchig 1996) mixed within the late Darriwilian shales of the Estancia San Isidro Formation (Heredia & Beresi 2004; Susana Heredia, personal communication 2007). The succession is tectonically emplaced in the

Silurian-Devonian shales of the Villavicencio Formation.

STRATIGRAPHIC AND PALAEOBIOGEOGRAPHIC IMPLICATIONS

In Cambrian successions, the geographical distribution of agnostoid faunas usually is wider than that of polymeroid trilobites (e.g., Öpik 1979; Robison 1988, 1994; Shergold *et al*. 1990; Ahlberg & Ahlgren 1996; Peng & Robison 2000; Axheimer *et al*. 2006; Høyberget & Bruton 2008). Thus, biozones based on agnostoids are very useful on an intercontinental scale, especially in deposits representing the neritic to oceanic transition (e.g., Robison 1976, 1984, 1988; Daily & Jago 1975). Most of the agnostoid genera and species identified from El Totoral [*Agnostus microcephalus* (Rusconi, 1950a), *Ammagnostus beltensis* (Lochman in Lochman & Duncan, 1944), *Kormagnostus seclusus* Walcott, 1884, *Clavagnostus calensis* Rusconi, 1950b, *Tomagnostella nepos* (Brøgger, 1878), *Lejopyge* sp.] occur in open-shelf lithofacies of different continents and therefore provide valuable biostratigraphic information. *Clavagnostus calensis* has been previously reported from the late middle Cambrian of China (*Lejopyge laevigata* to basal *Proagnostus bulbus* zones), Indian Himalaya (*Proagnostus bulbus* Zone), Tasmania, Antarctica and Cerro El Solitario (*Lejopyge laevigata* Zone) (Jago & Daily 1974; Jago & Webers 1992; Bordonaro & Liñán 1994; Tortello & Bordonaro 1997; Peng & Robison 2000 and references therein; Peng *et al*. 2009). In addition, *Ammagnostus beltensis* and *Agnostus microcephalus* are known from the *Lejopyge laevigata* Zone and the partially coeval *Cedaria minor* Zone of North America, Greenland and Cerro El Solitario (Poulsen 1960; Robison 1988; Pratt 1992; Bordonaro & Liñán 1994; Tortello & Bordonaro 1997). The widespread species *Tomagnostella nepos* has a stratigraphic range from the *Ptychagnostus punctuosus* to the lower *Proagnostus bulbus* and *Cedaria* zones, whereas *Kormagnostus seclusus* is known from the *L. laevigata* Zone to the *Glyptagnostus stolidotus* Zone (Robison 1988; Pratt 1992; Peng & Robison 2000 and references therein; Høyberget & Bruton 2008; Tortello 2009 and references therein).

Thus, the agnostoid assemblages from El Totoral indicate a late middle Cambrian age. They mostly resemble those described from the Cerro El Solitario outcrop, which has been assigned to the *Lejopyge laevigata* Zone (Poulsen 1960; Bordonaro & Liñán 1994; Tortello & Bordonaro 1997). Similarly, the association of *Tomagnostella nepos*, *Agnostus microcephalus*, *Kormagnostus seclusus*, *Ammagnostus beltensis* and *Lejopyge* is known from the *L. laevigata* Zone of North Greenland (Robison 1988).

The polymeroid trilobites described herein [*Asaphiscus* cf. *lasherensis* (Rusconi, 1950b), *Blountia socorrensis* Rusconi, 1956a, *Elrathia oscelata* (Rusconi, 1958), *Talbotinella communis* Poulsen, 1960, *Modocia* sp., *Olenoides faldeanus* Rusconi, 1956a and *Hysteropleura* (*Verditerrina*) *totoralensis* (Rusconi, 1958)] provide further evidence in favour of a late middle Cambrian age. In addition, they indicate Laurentian affinities, showing major similarities with faunas from the Marjum Formation of Utah (Robison 1964), the Nolichucky Formation of the southern Appalachians (e.g., Resser 1938; Rasetti 1965), the Holm Dal Formation of central North Greenland (Robison 1988), the Cow Head Group of the northern Appalachians (Westrop & Ludvigsen 2000), the Rabbitkettle Formation of northwest Canada (Pratt 1992), and the Solitario Olistolith of Cerro El Solitario, southern Precordillera (Rusconi 1950a, b; Poulsen 1960; Tortello 2009). *Asaphiscus* Meek, 1873, *Modocia* Walcott, 1924 and *Elrathia* Walcott, 1924 have been reported from the middle Cambrian of North America and Greenland (e.g., Palmer 1954a; Robison 1964, 1988; Schwimmer 1989; Pratt 1992). As noted below, *Modocia* sp. most closely resembles material from the Mackenzie Mountains (*Cedaria minor* Zone), North Greenland (lower and middle *Cedaria* Zone), and Cerro El Solitario, Mendoza (*Lejopyge laevigata* Zone), whereas *Elrathia oscelata* is particularly similar to material described from the upper *Bolaspidella* Zone of Utah, USA. On the other hand, *Talbotinella* Poulsen, as revised herein, is only known from the southern Precordillera (Poulsen 1960; Tortello 2009).

Hysteropleura (*Verditerrina*) Robison, 1988 has been described from the late middle Cambrian (*Lejopyge laevigata* Zone and equivalents) of Greenland and the northern Appalachians (Robison 1988; Westrop & Ludvigsen 2000), so its occurrence in El Totoral also supports Laurentian affinities. In the same way, *Blountia* Walcott, 1916 is especially diverse in the latest middle Cambrian (*Cedaria* and *Crepicephalus* zones) of USA, Canada and Greenland, and is rare elsewhere (e.g., Jago & Webers 1992).

SYSTEMATIC PALAEONTOLOGY

The material studied is housed in the Museo de Ciencias Naturales de La Plata (MLP), Argentina. In addition, selected type specimens of the Rusconi collections at the Museo de Ciencias Naturales y Antropológicas “Juan Cornelio Moyano” (MCNAM), Mendoza, Argentina, are reillustrated in Figures 8 and 9.

Order AGNOSTIDA Salter, 1864
Superfamily AGNOSTOIDEA M'Coy, 1849
Family AGNOSTIDAE M'Coy, 1849
Subfamily AGNOSTINAE M'Coy, 1849

Agnostus Brongniart, 1822

Type species. Entomostracites pisiformis Wahlenberg, 1818.

Agnostus microcephalus (Rusconi, 1950a) (Fig. 2A, E)

Synonymy. See Tortello & Bordonaro (1997) and Tortello (2009).

Material. Ten cephala and four pygidia (MLP 32965, 32973, 32977, 33025, 33036, 33049, 33052, 33056, 33096, 33104, 33116, 33126, 33137) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. Rusconi (1958) mentioned the occurrence of *Agnostus microcephalus* (Rusconi) (=*A. exsulatus* Poulsen) from the El Totoral locality, although the material was not described or illustrated. Pratt (1992) provided a complete diagnosis of this species. Cephala from El Totoral clearly show a moderately developed preglabellar median furrow and a slightly pointed anteroglabella. Although the pygidia studied are not well preserved, they also exhibit diagnostic features of *A. microcephalus* such as a long, parallel-sided axis bearing effaced transverse furrows and a prominent terminal node.

This species has been previously described from the *Lejopyge laevigata* Zone of Cerro El Solitario, western Argentina (Rusconi 1950a, fig. 7; Poulsen 1960, pl. 1, figs 3, 4; Bordonaro & Liñán 1994, pl. 1, figs 1-3; Tortello & Bordonaro 1997, fig. 3.1; Tortello 2009, fig. 2.A-C), North Greenland (Robison 1988, figs 7.4-7.11), and the *Cedaria minor* Zone of northwestern Canada (Pratt 1992, pl. 1, figs 1-13).

Family AMMAGNOSTIDAE Öpik, 1967

Ammagnostus Öpik, 1967

Type species. Ammagnostus psammius Öpik, 1967.

Ammagnostus beltensis (Lochman in Lochman & Duncan, 1944) (Fig. 2B, D[bottom], F)

Synonymy. See Robison (1988), Pratt (1992), Tortello & Bordonaro (1997) and Tortello (2009).

Material. Four cephala and nine pygidia (MLP 32976, 32986, 33052, 33092-33094, 33097, 33115, 33146, 33149, 33152) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. A bipartite, posteriorly rounded glabella, a subcentral posteroglabellar node, simple basal lobes, confluent genae, a long, subcylindrical to weakly pyriform pygidial axis extending to the posterior border furrow, the presence of almost effaced pygidial ring furrows, a terminal secondary node, moderately wide cephalic and pygidial border furrows, and small posterolateral spines are characters of *Ammagnostus beltensis* (Lochman in Lochman & Duncan, 1944) (see diagnosis of Robison 1988; Peng & Robison 2000). The species is known from the *Lejopyge laevigata* and *Cedaria* zones of USA, Canada, Greenland and the Argentine Precordillera. The cephalon illustrated in Figure 2B shows faint indications of scrobicules, a fact that was also documented in material from Greenland (Robison 1988, fig. 10.2), Canada (Pratt 1992, pl. 3, fig. 5) and Cerro El Solitario (Tortello 2009, fig. 2.D).

Kormagnostus Resser, 1938

Type species. Agnostus seclusus Walcott, 1884, by synonymy with *Kormagnostus simplex* Resser, 1938 (see Robison 1988).

Kormagnostus seclusus Walcott, 1884 (Fig. 2C, D[top], G)

Synonymy. See Robison (1988), Pratt (1992) and Tortello & Bordonaro (1997).

Material. Two cephala and one pygidium (MLP 33093, 33103, 33119) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. Some ammagnostid cephala from El Totoral have a completely effaced anteroglabella and therefore are assignable to *Kormagnostus* Resser. These specimens exhibit a subrectangular outline (Figs 2C, D[top]), mostly resembling material of *K. seclusus* Walcott from the late middle Cambrian of North Greenland (Robison 1988, fig. 11.6,7).

In addition, a minute pygidium of the Borrello collection is characterised by having a wide, parallel-sided axis, a prominent median node, and a posterior lobe (M3) that is surrounded by well defined axial furrows (Fig. 2G). *Kormagnostus seclusus* typically shows effaced posterior axial furrows (e.g., Robison 1988); however, taking

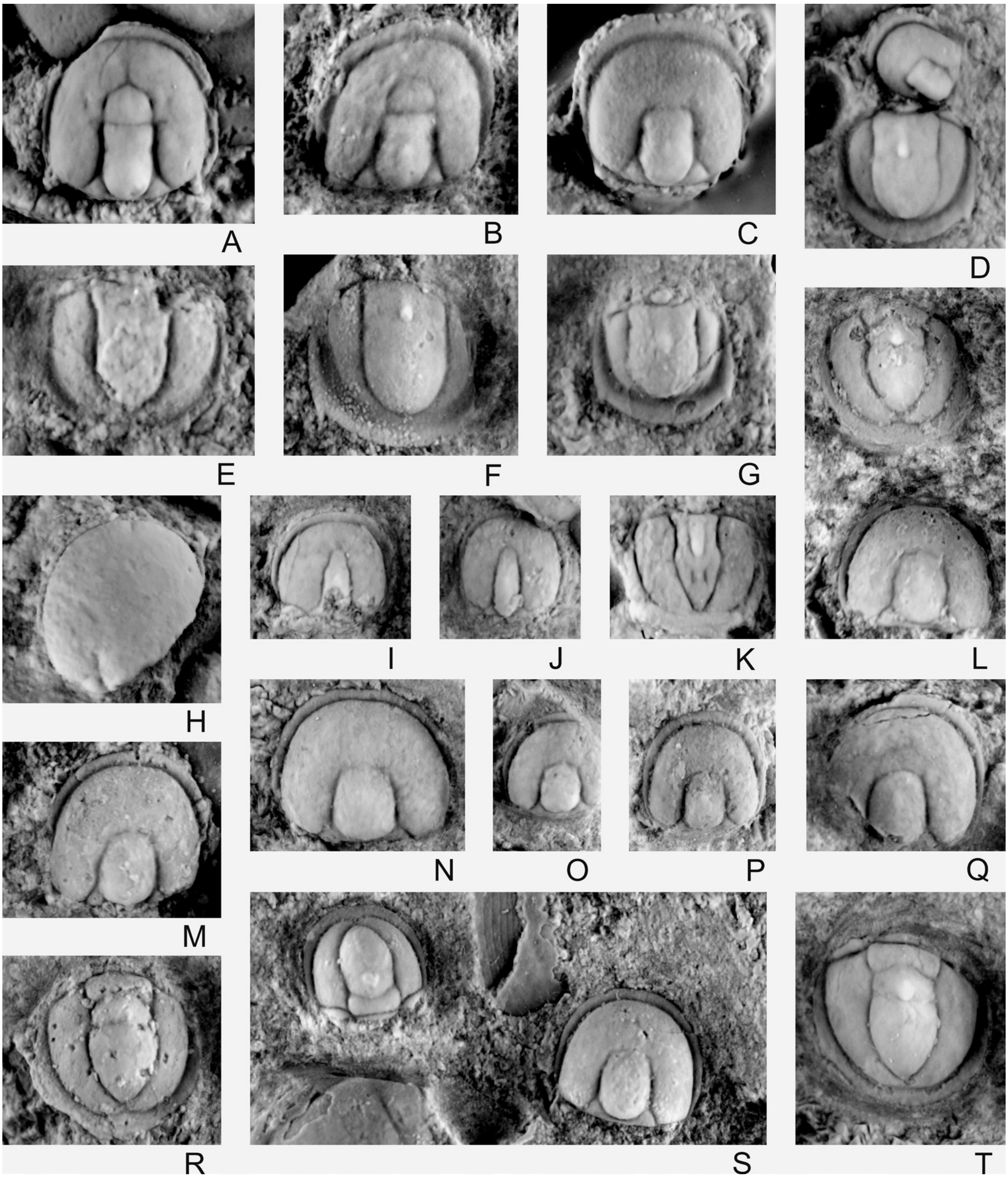

Figure 2. Agnostoid trilobites from El Totoral. **A**, **E**, *Agnostus microcephalus* (Rusconi, 1950a); **A**, cephalon, MLP 32965, x8.3; **E**, pygidium, MLP 33116, x9.2. **B**, **D**, **F**, *Ammagnostus beltensis* (Lochman in Lochman & Duncan, 1944); **B**, cephalon, MLP 32986, x10.4; **D**, pygidium -bottom-, associated to a cephalon -top- of *Kormagnostus seclusus*, MLP 33093, x8.6; **F**, pygidium, MLP 33094, x8. **C**, **G**, *Kormagnostus seclusus* Walcott, 1884; **C**, cephalon, MLP 33103, x8.5; **G**, small pygidium, MLP 33119, x10.5. **H**, *Lejopyge* sp., cephalon, MLP 33120, x7.4. **I**-**K**, *Clavagnostus calensis* Rusconi, 1950b; **I**, cephalon, MLP 33076, x8; **J**, cephalon, MLP 33044, x8.8; **K**, pygidium, MLP 33035, x6.8. **L**-**T**, *Tomagnostella nepos* (Brøgger, 1878); **L**, cephalon -bottom- and pygidium -top-, MLP 33162, x6; **M**, cephalon, MLP 32977, x7.6; **N**, cephalon, MLP 32983, x6.7; **O**, minute cephalon, MLP 32966, x6.8; **P**, cephalon, MLP 33115, x5.6; **Q**, cephalon, MLP 33102, x8.2; **R**, pygidium, MLP 32966, x7.6; **S**, cephalon -right- and pygidium -left-, MLP 33013, x6.3; **T**, pygidium, MLP 33127, x7.2.

into account that the degree of expression of this character shows a considerable change during ontogeny (e.g., Rasetti 1948; Palmer 1954b; Lochman & Hu 1960; Hu 1971; Robison 1988; Pratt 1992), this early holaspid specimen may be assigned to this species. Very similar small pygidia of *K. seclusus* were described by Robison (1988, fig. 11.9, 10) from North Greenland.

Family CLAVAGNOSTIDAE Howell, 1937

Clavagnostus Howell, 1937

Type species. Agnostus repandus Westergård in Holm & Westergård, 1930.

Clavagnostus calensis Rusconi, 1950b (Fig. 2I-K)

Synonymy. See Tortello & Bordonaro (1997) and Peng & Robison (2000).

Material. Three cephala and three pygidia (MLP 33031, 33035, 33044, 33076, 33081, 33117) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. The material studied includes two small cephala characterised by having moderately scrobiculate genae, a weak and incomplete median preglabellar furrow, a narrowly rounded to pointed anteroglabella, and short basal lobes (Fig. 2I-J). Peng & Robison (2000) documented a similar morphology in early holaspides of *Clavagnostus calensis* Rusconi from Hunan, China. In addition, a pygidium from El Totoral (Fig. 2K) shows a moderately constricted M2, a conspicuous median tubercle, a proportionally wide and ogival posteroaxis, narrow and elongate fossae, scrobiculate pleural fields, a medially widened border, and a pair of marginal spines. Therefore, it is assigned to *Clavagnostus calensis*.

This species has been reported from the late middle Cambrian of Cerro El Solitario (Rusconi 1950b, fig. 3; Bordonaro & Liñán 1994, pl. 1, figs 8-14; Tortello & Bordonaro 1997, figs. 4.22, 4.23; Tortello 2009, fig. 2F), Hunan and western Zhejiang, China (Lu & Lin 1989; Peng & Robison 2000 and references therein), Indian Himalaya (Peng *et al*. 2009), Tasmania (Jago & Daily 1974) and West Antarctica (Jago & Webers 1992).

Family PTYCHAGNOSTIDAE Kobayashi, 1939

Tomagnostella Kobayashi, 1939

Type species. Agnostus exsculptus Angelin, 1851.

Tomagnostella nepos (Brøgger, 1878) (Fig. 2L-T)

Synonymy. See Høyberget & Bruton (2008).

Material. 30 cephala and 32 pygidia (MLP 32966-32968, 32970, 32972, 32977, 32979, 32983, 32986-32990, 33013, 33015, 33019, 33026, 33033, 33034, 33045, 33049, 33055, 33056, 33059, 33065, 33070, 33072, 33076, 33079, 33080, 33095, 33099-33102, 33104, 33107, 33110, 33115, 33118, 33122, 33124, 33127-33129, 33150, 33151, 33153-33157, 33162) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. The specimens examined represent a *Tomagnostella* species with a smooth cephalic acrolobe, a distinct to partially effaced glabellar F3, small basal lobes, and a long and tumid pygidial axis. The glabella lacks indications of F1 and F2, whereas the pygidial axis shows a chevronate and moderately deep to shallow F1, and a shallow to effaced F2. Following the recent systematic revision of Høyberget & Bruton (2008), this material is assignable to *Tomagnostella nepos* (Brøgger, 1878). Although the cephalic acrolobe of the species is typically effaced, some specimens show very faint indications of scrobicules (Fig. 2N; see also Peng & Robison 2000, fig. 69.1).

This taxon has a wide geographical distribution and a stratigraphic range from the *Ptychagnostus punctuosus* Zone to the lower *Proagnostus bulbus* Zone (Robison 1988; Pratt 1992; Peng & Robison 2000 and references therein; Høyberget & Bruton 2008 and references therein). In the Precordillera of Mendoza, it has been reported from Cerro El Solitario (*Lejopyge laevigata* Zone) (Bordonaro & Liñán 1994; Tortello & Bordonaro 1997; Tortello 2009) and San Isidro (Tortello & Bordonaro 1997).

Lejopyge Hawle & Corda, 1847

Type species. Battus laevigatus Dalman, 1828.

Lejopyge sp. (Fig. 2H)

Material. One cephalon (MLP 33120) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. This incomplete cephalon has an elongate outline, a narrow border, a nonscrobiculate acrolobe, and distally effaced axial furrows. In addition, it shows indications of a preglabellar median furrow, clearly defined, short basal lobes, and a posterolateral border lacking spines. The presence of distally effaced axial furrows and well defined basal lobes suggests morphological correspondence with *Lejopyge laevigata* (Dalman, 1828) (Westergård 1946; Daily & Jago 1975; Robison 1984; Laurie 1989; Peng & Robison 2000; Axheimer *et al*. 2006; Høyberget & Bruton 2008). However, until the corresponding pygidium becomes available for analysis, this specimen is left in open nomenclature.

Order PTYCHOPARIIDA Swinnerton, 1915
Suborder PTYCHOPARIINA Swinnerton, 1915
Family ASAPHISCIDAE Raymond, 1924
Subfamily ASAPHISCINAE Raymond, 1924

Asaphiscus Meek, 1873

Type species. Asaphiscus wheeleri Meek, 1873.

Asaphiscus cf. lasherensis (Rusconi, 1950b) (Figs 3A-F, G[top and left], H-O, 5H[right])

cf. 1950b *Canotiana lasherensis*; Rusconi, p. 75, 76, fig. 7.
cf. 2009 "*Canotiana*" *lasherensis* Rusconi; Tortello, fig. 9D, G.

Material. 136 cranidia and 46 pygidia (MLP 32966, 32967, 32970, 32972-32975, 32977, 32978, 32981, 32984-32986, 32991, 32993-33002, 33007, 33009, 33010, 33013-33019, 33021, 33023, 33029-33032, 33037, 33039, 33040, 33044, 33046, 33050-33052, 33054, 33056, 33057, 33060-33062, 33064, 33073-33076, 33082, 33086, 33089, 33090, 33093, 33104, 33108, 33110, 33111, 33113, 33114, 33121, 33122, 33127, 33130, 33132-33134, 33136, 33138-33140, 33143, 33145-33147, 33157, 33158, 33160-33163, 33165, 33168-33170, 33173, 33174) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Description. Cranidium slightly convex, with well rounded anterior margin and downsloping fixed cheeks; glabella large, unfurrowed, moderately elevated above genal region, slightly tapered and broadly rounded anteriorly, surrounded by narrow and shallow axial furrows; it occupies about 69-72% of the total length of the cranidium; occipital ring with rounded posterior margin, smooth or with a small median node; occipital furrow very shallow, straight or slightly bowed backwards, marked medially; frontal area subequally divided by narrow and faint border furrow having moderate forwards curve; anterior border little upturned, constant in width; anterior facial suture somewhat divergent; palpebral area of the fixigena moderately wide (tr.), 0.5 to 0.6 width of adjacent glabella; palpebral lobe about one-sixth length of cranidium, little elevated above fixigena, forwards of glabellar midpoint; palpebral furrow usually not developed; eye ridge very weak or indistinct; posterior facial suture strongly divergent, sinuous; posterior fixigena relatively wide (tr.), with a broad and shallow border furrow and a narrow (exsag.) posterior border. The internal mould illustrated in Figure 3I exhibits internal features such as vascular prosopon running forward on the preglabellar field, and four pairs of muscle scars on the glabella.

Pygidium semicircular in outline, somewhat convex, width about twice length, posterior margin entire; axis elevated above level of pleural fields, smooth, evenly and moderately tapering backwards, rounded at posterior end, extending to posterior border; length of axis about 75-80% of that of pygidium on sagittal line; pleural field smooth, only slightly downsloping; border furrow weak, poorly defined; border wide, fairly convex to flat, becoming a little wider posterolaterally.

Remarks. The material described above is characterised by having a tapered, unfurrowed, anteriorly rounded glabella, a forwardly curved anterior border, a moderately wide ocular area of the fixigena, a large and downsloping posterior fixigena, and a semicircular pygidium with an unfurrowed, tapered axis which extends to the posterior border, and smooth pleural fields. Therefore, it is consistent with the definition of *Asaphiscus* Meek, 1873 (see diagnosis of Palmer 1954a; Schwimmer 1989). The specimens resemble *A. lasherensis* (Rusconi, 1950b), a taxon based on poorly preserved material from the late middle Cambrian of Cerro El Solitario (Tortello 2009, fig. 9G), but differ in having a slightly longer (sag.) preglabellar field and a pygidium that is semicircular rather than subrectangular in outline.

Asaphiscus cf. *lasherensis* differs from the type species *A. wheeleri* Meek, 1873, from the middle Cambrian of North America (Palmer 1954a, pl. 16, fig. 7, and references therein; Robison 1964, pl. 86, figs 1-3; McNamara & Rudkin 1984, figs 6, 7), in having a wider palpebral area of the fixigena, shallower marginal furrows, and pleural fields with no traces of segmentation. It is distinguished from *A. laeviceps* (Walcott, 1884), from the latest middle Cambrian of North America (Palmer 1954a, pl. 16, figs 4, 6), because the latter possesses poorly defined cephalic dorsal furrows, a narrower ocular area of the fixigena, a convex pygidial border, and a postaxial ridge that extends onto the posterior border of the pygidium.

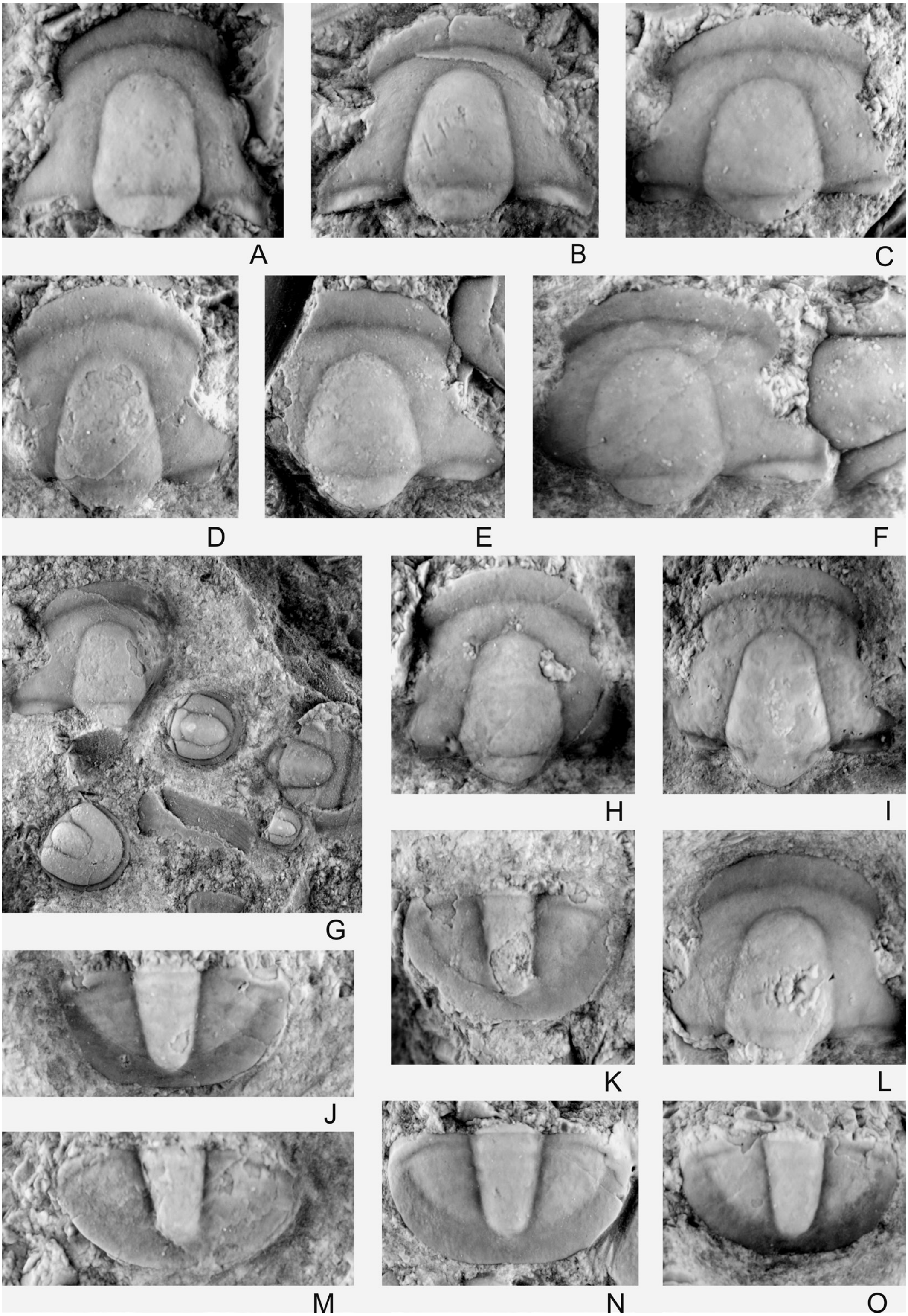

Figure 3. *Asaphiscus* cf. *lasherensis* (Rusconi, 1950b); **A**, cranidium, MLP 32978, x6.8; **B**, cranidium, MLP 33002, x5.3; **C**, cranidium, MLP 32967, x8.2; **D**, cranidium, MLP 33074, x6; **E**, cranidium, MLP 33009, x5.8; **F**, distorted, transverse cranidium, MLP 33018, x7.5; **G**, cranidium (top and left) (*continued opposite*)

Asaphiscus gregarius Walcott, 1916, from the late middle Cambrian of USA (Resser 1938, pl. 9, fig. 7; Schwimmer 1989, pl. 3, figs. 10, 12, 15) differs from *A*. cf. *lasherensis* mainly in having a less effaced pygidium and a narrower pygidial border. *Asaphiscus* cf. *villavicencis* (Rusconi, 1950b), from the late middle Cambrian of Cerro El Solitario (Tortello 2009, fig. 8A-D, G), can be differentiated by its more developed anterior cranidial border, its perceptible eye ridges and its subrectangular pygidium.

Asaphiscus cf. *lasherensis* (Rusconi, 1950b) is the most abundant polymeroid in the collections studied. Rusconi (1958) also noted the presence of *Asaphiscus* (=*Canotiana*, see Tortello 2009, p. 264) in the El Totoral locality on the basis of "numerous cranidia and pygidia" (Rusconi 1958, p. 106) that were not originally described or illustrated. The latter are probably conspecific with the material described herein.

Subfamily BLOUNTIINAE Lochman in Lochman & Duncan, 1944

Blountia Walcott, 1916

Type species. Blountia mimula Walcott, 1916.

Remarks. Westrop (1992) tentatively assigned *Blountia* Walcott, 1916 to the Family Kingstoniidae on the basis of similarities between the occipital ring of this genus and that of *Kingstonia* Walcott, 1924 and its allies. However, Stitt & Perfetta (2000) retained *Blountia* in the Subfamily Blountiinae (Family Asaphiscidae) because of the presence of an inflated glabella that rises above genal region, as well as a defined anterior border, anterior border furrow and preglabellar field. Pratt (1992) (see also Stitt & Perfetta 2000) regarded *Maryvillia* Walcott, 1916 as a junior synonym of *Blountia*, and this is followed herein.

Blountia socorrensis Rusconi, 1956a (Figs 4A-B, D-F, 8A-D)

1956a *Blountia socorrensis*; Rusconi, p. 117, 118, fig. 3.
1956a *Blountia luanensis*; Rusconi, p. 118, fig. 4.

Material. Three cranidia and ten pygidia (MLP 32968, 32971, 33011, 33056, 33066, 33068, 33091, 33175, MCNAM 19970, 19974, 19975) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Diagnosis. Cranidium with long, conical, inflated, broadly rounded glabella; anterior border wide (sag.), length about three times that of preglabellar field, clearly delimited by a shallow anterior border furrow; palpebral lobe proportionally long (exsag.) and wide (tr.), slightly forwards of glabellar midpoint; pygidial axis with faint indications of 7 or 8 axial rings and a terminal piece that extends onto the posterior border of the pygidium; pygidial border weakly convex.

Description. Cranidium convex, with downsloping fixed cheeks; glabella proportionately long, inflated, conical in outline and rounded anteriorly, unfurrowed, surrounded by shallow and narrow axial furrows, occupying about 80% of the total length of the cranidium; occipital furrow poorly defined and slightly backwardly bowed; occipital ring narrow (sag. and exsag.), bowed posteriorly, with faint indications of a median node; anterior cranidial margin evenly rounded; anterior border convex, sagittal length about three times that of preglabellar field, clearly delimited by a shallow border furrow; preglabellar field slightly convex, with lateral margins moderately divergent; palpebral area of fixigena somewhat wide; palpebral lobe proportionally long (exsag.) and wide (tr.), slightly forwards of glabellar midpoint; eye ridge indistinct; posterior fixigena subtriangular, with a shallow posterior border furrow and a transverse and very narrow (exsag.) border.

Pygidium sub-semicircular in outline, gently to moderately convex transversely and longitudinally, with length about three quarters of width; axis very long, gently tapering, slightly elevated above level of pleural fields, occupying almost the total pygidial length, surrounded by narrow axial furrows; exfoliated surface shows a semicircular articulating half-ring, 7 or 8 axial rings and a terminal piece, which are almost invisible on the outer surface of the exoskeleton; the terminal piece of the axis is pointed and extends across most of the posterior pygidial border; pleural fields slightly convex, unfurrowed on outer surface and either unfurrowed or crossed by 4 to 5 weak, slightly oblique pleural furrows on internal mould; border faintly convex, of uniform width, demarcated by a shallow border furrow.

Remarks. Rusconi (1956a) originally described

associated to a cephalon (bottom and left) and a pygidium (centre) of *Tomagnostella nepos*, and a small cranidium (right) of *Elrathia oscelata*, MLP 33013, x4.4; **H**, cranidium, MLP 33056, x6; **I**, cranidium showing indications of muscle scars, MLP 33162, x5.2; **J**, pygidium, MLP 32977, x6.3; **K**, pygidium, MLP 33061, x7.2; **L**, cranidium, MLP 33064, x6.2; **M**, pygidium, MLP 33032, x8.3; **N**, pygidium, MLP 32970, x4.8; **O**, pygidium, MLP 32966, x8.

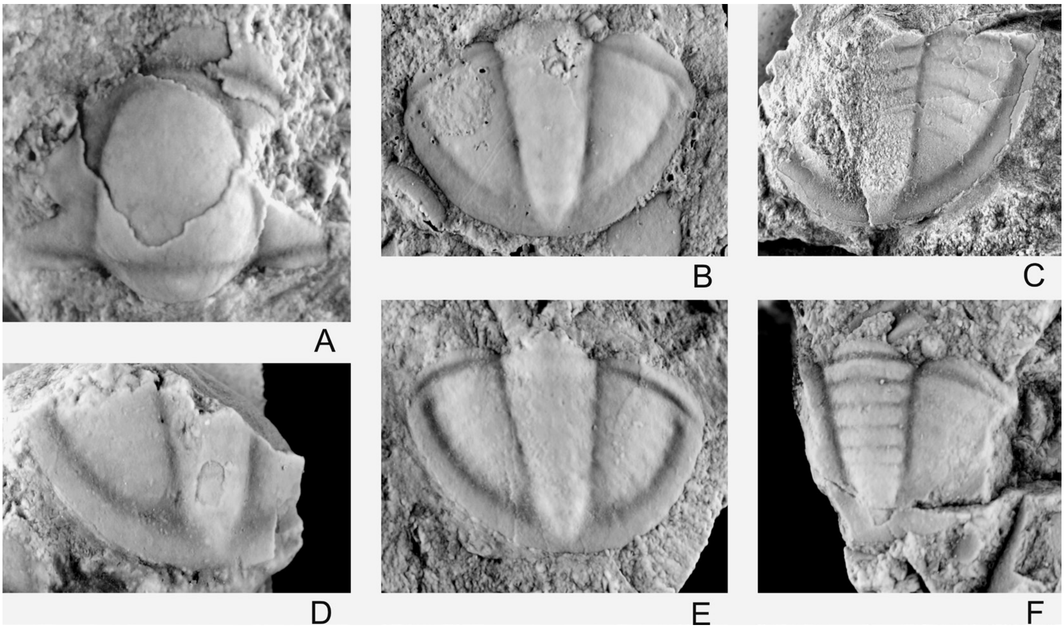

Figure 4. **A-B**, **D-F**, *Blountia socorrensis* Rusconi, 1956a; **A**, cranidium, MLP 33175a, x8; **B**, slightly distorted pygidium, latex cast, MLP 33175c, x5.1; **D**, fragmentary pygidium, MLP 33011, x6; **E**, slightly distorted pygidium, MLP 32971, x6.4; **F**, incomplete, exfoliated pygidium, MLP 33175b, x7.2. **C**, *Blountia complexa* Rusconi, 1956a, pygidium, MLP 32969, x3.

Blountia socorrensis on the basis of five pygidia from El Totoral. The cranidium and the pygidia from the Borrello collections illustrated in Figure 4A, B and F occur together in the sample MLP 33175, so they could be conspecific. At first glance, the described material superficially conforms in several features with the diagnosis of *Asaphiscus* Meek, 1873 (Palmer 1954a, p. 73), showing some correspondence with *A. laeviceps* (Walcott, 1884) (Palmer 1954a, pl. 16, figs 4, 6). However, the former exhibits a well defined, strongly convex glabella, a fact that supports a closer relationship with *Blountia* Walcott, 1916 (see diagnosis of Palmer 1962, p. 22).

Blountia socorrensis compares most closely with species of *Blountia* that combine a proportionally large palpebral lobe that is only a little forward of the glabellar midpoint, and a discernible occipital furrow. The cranidium of *B. glabra* (Walcott, 1916), from the lower upper Cambrian of the southern Appalachians (Resser 1938, pl. 12, fig. 31), possesses a relatively long (exsag.) palpebral lobe and a well defined, posteriorly bowed occipital ring. However, the palpebral lobe of the Argentinian species is much wider (tr.).

Blountia socorrensis closely resembles *Blountia widnerensis* (Resser, 1938), from the lower upper Cambrian of Virginia, USA (Resser 1938, pl. 13, fig. 1), but differs primarily in having a narrower (sag.) anterior border furrow and a wider (sag.) anterior border on the cranidium. *Blountia alberta* (Resser, 1942) from Montana (Resser 1942, pl. 13, figs 1-4; Lochman 1950, pl. 48, figs 22, 23) is also characterised by having eyes that are slightly larger than usual for the genus. However, this species is easily distinguished from *B. socorrensis* by its shorter pygidial axis and its much wider pygidial border. The cranidium of *Blountia aequa* (Duncan in Lochman & Duncan, 1944), from the *Crepicephalus* Zone of Montana (Lochman & Duncan 1944, pl 4, fig. 24, 25), differs in having an uninflated glabella, a wider (tr.) palpebral area of the fixigena, and a broader (sag.) anterior border furrow.

Palmer (1962) pointed out that representatives of *Blountia* typically show dorsal furrows that are nearly effaced on the external surface of the exoskeleton, but are weakly developed on internal moulds. These variations are well documented, for example, in faunas from the Mackenzie Mountains (Pratt 1992, pl. 24, figs 10, 11), Quebec (Rasetti 1946, pl. 67, figs 9, 10), Tennessee (Rasetti 1965, pl. 9, figs 24-26; pl. 10, figs 6, 7), as well as in specimens from El Totoral. The partially exfoliated cranidium of Figure 4A exhibits axial furrows that are slightly better defined on the internal surface of the exoskeleton. Similarly, the pygidia studied include exoskeletons and internal moulds that show variations in the degree of expression of the axial ring furrows and pleural furrows (Fig. 4B, D-F). The type materials of *B. socorrensis* (Fig. 8A, B) and *B. luanensis* Rusconi (1956a, p. 118, fig. 4) (Fig. 8C, D) from El Totoral are considered herein to belong to a single species.

On the basis of pygidia from El Totoral, Rusconi (1958) assigned two other species to *Blountia*. *Blountia complexa* Rusconi (1958, p. 105, fig. 11) (Fig. 8E, F) is very similar to *B. socorrensis* and may be conspecific, although the holotype of the former (Fig. 8E) exhibits a little narrower, less tapering axis, 9 axial rings, and well defined ring and pleural furrows on both the outer and the internal surface. "*Blountia*" *multicostata* Rusconi (1958, p. 105, 106, fig. 12) (Fig. 8G-J) differs mainly in showing a wider, shorter axis, and pleural fields having broad and shallow pleural furrows as well as narrow, delicate interpleural lines.

Family ALOKISTOCARIDAE Resser, 1939 emend. Sundberg, 1999

Elrathia Walcott, 1924

1958 *Pichynturia*; Rusconi, p. 102.

Type species. Conocoryphe (*Conocephalites*) *kingii* Meek, 1870.

Remarks. Walcott (1925), Palmer (1954a) and Robison (1964) provided complete diagnoses of *Elrathia* Walcott, 1924, pointing out the presence of a slightly tapered glabella with a broadly to bluntly rounded anterior margin; shallow axial furrows; superficial or absent glabellar furrows; an occipital furrow that is deepest laterally and shallow on midline; a spineless occipital ring; a frontal area having a flat or gently convex border, a shallow marginal furrow and a distinct preglabellar field; a slightly divergent anterior facial suture; weak eye ridges; and palpebral lobes anterior to glabellar midpoint, well defined by shallow palpebral furrows. These features agree with those of *Pichynturia* Rusconi, a monospecific genus (type species *P. oscelata*) that was proposed by Rusconi (1958, p. 102) on the basis of cranidia from the El Totoral locality (Fig. 9A-C). Therefore, *Pichynturia* is suppressed here as a subjective junior synonym of *Elrathia*.

Elrathia oscelata (Rusconi, 1958) (Figs 5A-G, H[left], I-P, 9A, B, ?C)

1958 *Pichynturia oscelata*; Rusconi, p. 102, fig. 8.
?1964 *Elrathia alapyge*; Robison, p. 541, 542, pl. 85, figs 14-19.

Material. 46 cranidia and 20 pygidia (MLP 24392a, 24392b, 32968, 32974, 32975, 32980, 32992, 32999, 33000, 33003, 33007, 33008, 33013, 33014, 33016, 33020, 33021, 33025, 33029, 33043, 33046, 33048, 33050, 33053, 33069, 33071, 33076, 33077, 33083-33085, 33087-33091, 33096, 33105, 33106, 33109, 33114, 33122, 33123, 33125, 33131, 33141, 33144, 33146, 33154, 33160, 33164, 33166, MCNAM 21308-21310) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Description. Cranidium slightly convex, with broadly rounded anterior margin; glabella large, elevated above genal region, slightly tapered forwards and broadly to sharply rounded anteriorly, surrounded by narrow and shallow axial furrows, occupying about 72-78% of the total length of the cranidium; well preserved specimens show indications of three pairs of lateral furrows on the glabella; S1 strongly oblique backwards, sinuous, adaxially bifurcated; S2 and S3 shallow, straight to slightly curved, oblique backwards; occipital furrow straight, deepest laterally and shallow on midline; occipital ring with a tiny median node and rounded posterior margin; anterior cranidial border faintly convex, subequal in length (sag.) to a little shorter than preglabellar field, delimited by a shallow, straight to slightly curved forwards border furrow; anterior facial suture somewhat divergent; eye ridge weak, oblique backwards, confluent with palpebral lobe; palpebral area of fixigena half width of adjacent glabella; palpebral lobe about one-fifth length of cranidium, slightly elevated above fixigena, forwards of glabellar midpoint; palpebral furrow shallow but distinct; posterior fixigena having shallow posterior border furrow and relatively narrow (exsag.) posterior border.

Pygidium alate, length about one fourth maximum width; axis convex, elevated above pleural fields, anterior width one fourth maximum width of pygidium, subparallel sided to slightly tapered backwards, broadly rounded posteriorly, extended almost to posterior pygidial margin; it is composed of a short (sag.) articulating half ring, 3 or 4 axial rings, and a rounded terminal piece; articulating and first ring furrows better defined than posterior ring furrows; pleural field slightly convex, crossed by three or four sets of pleural furrows and delicate interpleural lines; distal parts of pleural furrows curving backwards and terminating just inside of pygidial margin; first pleural furrow deeper than other furrows of pleural field; border furrow indistinct; anterolateral corners of the pygidium posteriorly located; posteromedian margin having a well defined indentation. Largest pygidia seem to have posterior and posterolateral areas relatively more

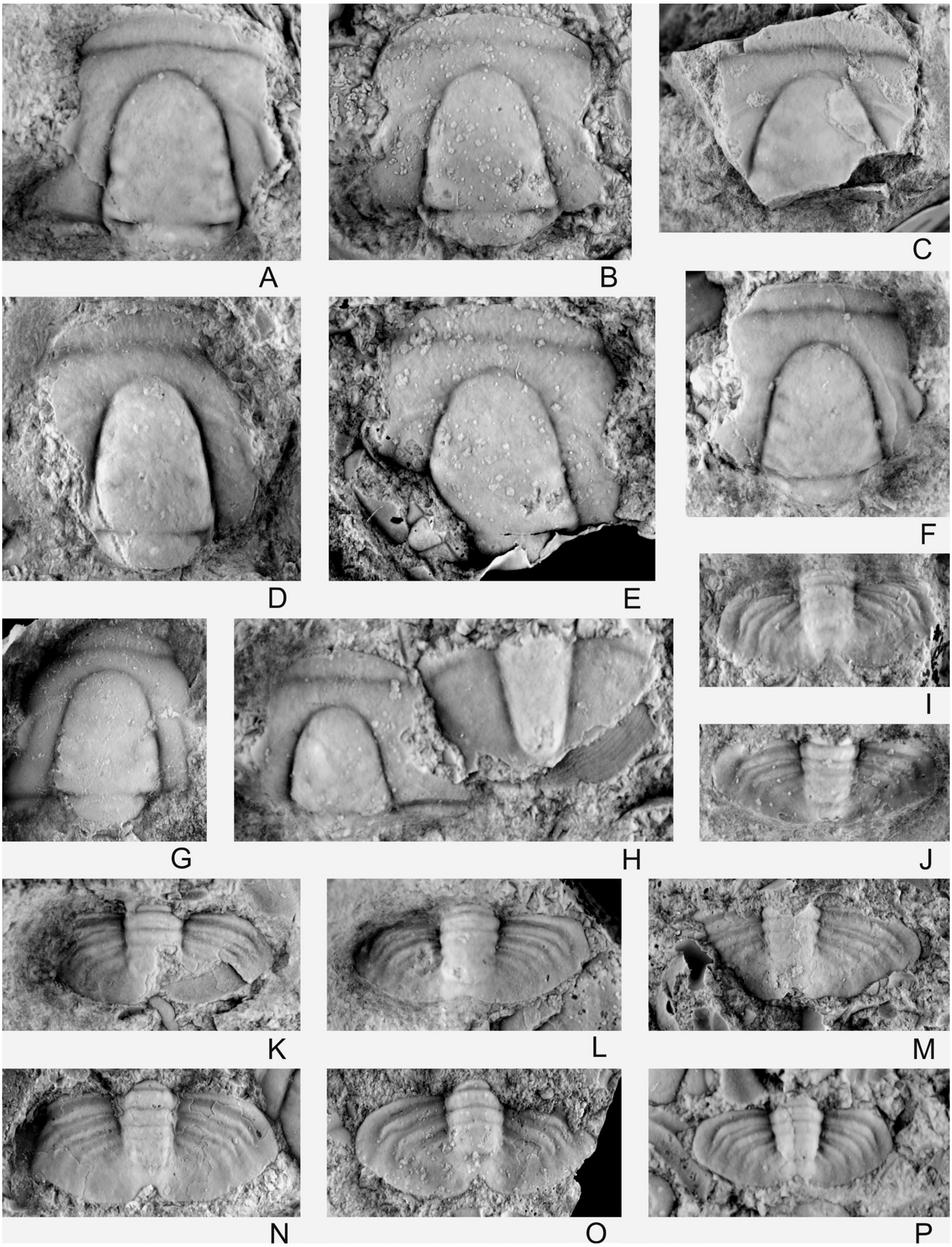

Figure 5. *Elrathia oscelata* (Rusconi, 1958); **A**, cranidium, MLP 32992, x5.6; **B**, cranidium, MLP 33003a, x3.8; **C**, incomplete cranidium, MLP 33053, x3.2; **D**, longitudinally elongated cranidium, MLP 33091, x3.8; **E**, cranidium, latex cast, MLP 33003b, x4.1; **F**, cranidium, MLP 33016, x6; **G**, cranidium, latex cast, MLP 33154, x4.2; **H**, cranidium (left) associated to a pygidium of *Asaphiscus* cf. *lasherensis* (right), MLP 33021, x7.7; **I**, pygidium, MLP 33164, x5.6; **J**, pygidium, MLP 33014, x5.2; **K**, pygidium, MLP 32980, x4.3; **L**, pygidium, MLP 33007, x3.9; **M**, pygidium, latex cast, MLP 24392a, x3.5; **N**, pygidium, MLP 33076, x3.7; **O**, pygidium, latex cast, MLP 33114, x4.2; **P**, pygidium, MLP 24392b, x6.6.

developed (Fig. 5N).

Remarks. The type material of *Elrathia oscelata* (Rusconi, 1958) is illustrated in Figure 9A-C, whereas additional specimens from the Borrello collections are shown in Figure 5. The anterior glabellar margin of the studied cranidia ranges from broadly (Fig. 9A) to sharply rounded (e.g., Figs 5A, 9B), an intraspecific variation that has also been reported in other species of the genus such as *E. kingii* (Meek, 1870) (see Bright 1959, pl. 17) and *E. omega* Robison (1988, pl. 26).

The pygidium of *E. oscelata*, which is described herein for the first time, provides relevant information about the affinities of this species. The presence of an alate outline and a distinctive indentation on the posterior margin indicates high correspondence with *E. alapyge* Robison, 1964 and *E. omega* Robison, 1988, from the upper middle Cambrian of the Great Basin (Nevada and Utah) and Greenland, respectively (Robison 1964, pl. 85, figs 14-19; Robison 1988, fig. 26.1-10). *Elrathia oscelata* hardly differs from *E. alapyge* by showing posteriorly located anterolateral corners of the pygidium and distal pleural furrows curving backwards, differences that may lack crucial taxonomic value. *Elrathia omega* has, in addition, a pair of deflections on the anterior border furrow of the cranidium, larger palpebral lobes, and 4 or 5 axial rings on the pygidium.

The adequate state of preservation of the holotype and the paratype MCNAM 21309 of *E. oscelata* (Fig. 9A, B) reveals a complex pattern of furrows and lobes on the glabella, which is characterised by a bifurcated S1 and a subquadrate L2. A similar arrangement is shown by well preserved specimens of *E. kingii* (Meek, 1870) and *E. antiquata* (Salter, 1859), from the upper middle Cambrian of Utah (see Robison 1964, pl. 85, fig. 4) and the southern Appalachians (Schwimmer 1989, fig. 3.1), although these species are distinguished from *E. oscelata* in having larger palpebral lobes, as well as a non-alate pygidium.

Elrathia marjumi Robison, from the upper middle Cambrian of Utah (Robison 1964, pl. 85, figs 6-13, 20), differs from *E. oscelata* in possessing a sharply upturned anterior cranidial border, a subtriangular pygidium, and a longer pygidial axis. *Elrathia hornensis* (Rusconi), from the *Lejopyge laevigata* Zone of Cerro El Solitario (Rusconi 1951, fig. 28; Tortello 2009, figs 6F-H, 9F), can be differentiated mainly by its more laterally expanded pygidium. *Elrathia* sp. from the middle Cambrian of Greenland (Babcock 1994, fig. 25) is distinguished by having larger palpebral lobes, a deeper occipital furrow, a longer pygidial axis, and a weaker indentation on the posterior pygidial margin.

Tortello (2009) pointed out the affinity of "*Talbotinella*" *rusconii* Poulsen, from Cerro El Solitario (Poulsen 1960, pl. 2, figs 13-15), with *Elrathia*. However, since that species was originally proposed on a single, fragmentary cranidium, its analysis is difficult. "*Talbotinella*" *rusconii* may be a junior synonym of *E. oscelata*, but additional material is needed in order to establish its relationships with other *Elrathia* species.

Family MARJUMIIDAE Kobayashi, 1935

Talbotinella Poulsen, 1960

Type species. Talbotinella communis Poulsen, 1960.

Remarks. Although Tortello (2009) tentatively assigned *Talbotinella* to the Family Alokistocaridae, the presence of a well developed anterior border, a tapered and anteriorly rounded glabella with extremely faint lateral furrows, and a short, relatively wide and blunty terminated pygidial axis indicates a closer relationship with the Marjumiidae (Robison 1964, 1988). Thus, *Talbotinella* is here relocated to that family.

Talbotinella communis Poulsen, 1960 (Fig. 6A-J)

1960 *Talbotinella communis*; Poulsen, p. 24, 25, pl. 2, figs 2-8, pl. 3, fig 2.
2009 *Talbotinella communis* Poulsen; Tortello, p. 260, 262, figs 6I-M, 7A, ?B, C, D, ?E, F, H, 9E (cum syn.).

Material. 30 cranidia and two pygidia (MLP 24392c, 32970, 32973, 32976, 32995, 33012, 33015, 33027, 33028, 33032, 33038, 33039, 33041, 33046, 33050, 33051, 33056, 33067, 33075, 33089, 33104, 33110, 33113, 33114, 33130, 33148, 33151, 33161, 33170) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. Diagnoses of *Talbotinella* and *Talbotinella communis* have been given by Poulsen (1960) and Tortello (2009) on the basis of material from the type locality Cerro El Solitario (Poulsen 1960, pl. 2, figs 2-8, pl. 3, fig 2; Tortello 2009, figs 6I-M, 7A, ?B, C, D, ?E, F, H, 9E). Because specimens from El Totoral have a tapered, raised and granulose glabella with very faint lateral furrows, a well developed preglabellar field, moderately wide palpebral

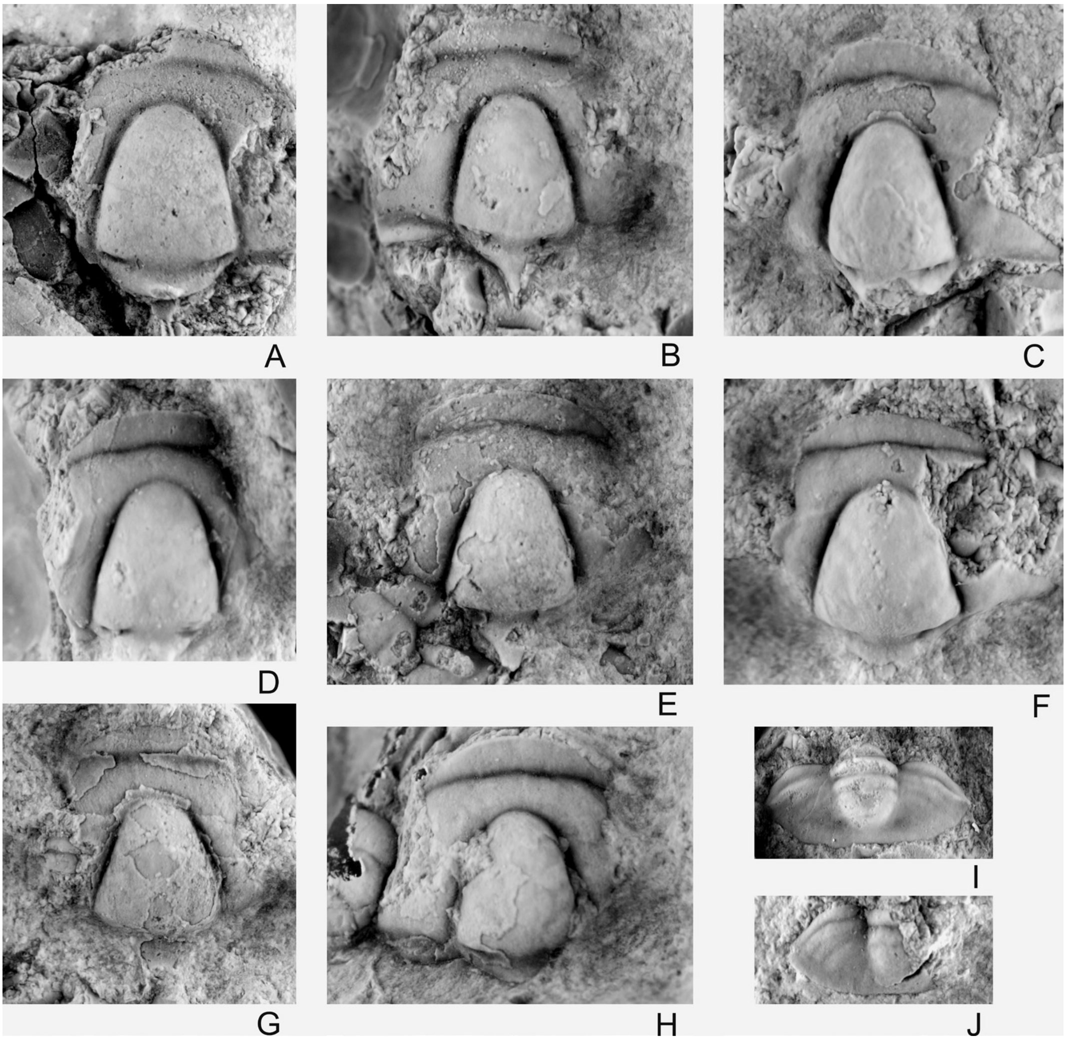

Figure 6. *Talbotinella communis* Poulsen, 1960; **A**, cranidium, MLP 33012, x3.5; **B**, cranidium, MLP 33104, x5.5; **C**, cranidium, MLP 33051, x7.7; **D**, cranidium, MLP 33050, x7.3; **E**, cranidium, MLP 33056, x5.3; **F**, cranidium, MLP 33015, x6.2; **G**, cranidium, MLP 33161a, x5; **H**, cranidium, MLP 33161b, x5.5; **I**, pygidium, latex cast, MLP 33041, x5.2; **J**, pygidium, MLP 24392c, x4.4.

areas of fixigenae, a deep occipital furrow, a prominent occipital spine and a short pygidium with posteriorly located anterolateral corners, they conform in all fundamental features with those diagnoses. Although the studied specimens differ slightly from material from Cerro El Solitario by lacking well defined pustules on the anterior cranidial border and caecal marking on the preglabellar field, these variations may be in part preservational and are not accorded taxonomic significance.

Bentley *et al*. (2009, fig. 8A-F) recently described a set of ptychopariid cranidia from the late middle Cambrian of northern Victoria Land, Antarctica, that was referred to *Talbotinella* sp. This material is characterised by having well marked axial furrows, an adaxially bifurcated S1, and a moderately wide (sag.), smooth to slightly caecate preglabellar field, but it lacks several diagnostic features of *Talbotinella* such as an extremely tapered and granulose glabella, very faint glabellar furrows, a proportionately wide (sag.) anterior border, and an occipital spine. Therefore, it is probably not assignable to this genus.

Modocia Walcott, 1924

Type species. *Arionellus* (*Crepicephalus*) *oweni* Meek & Hayden, 1861.

Remarks. The generic diagnosis of Robison

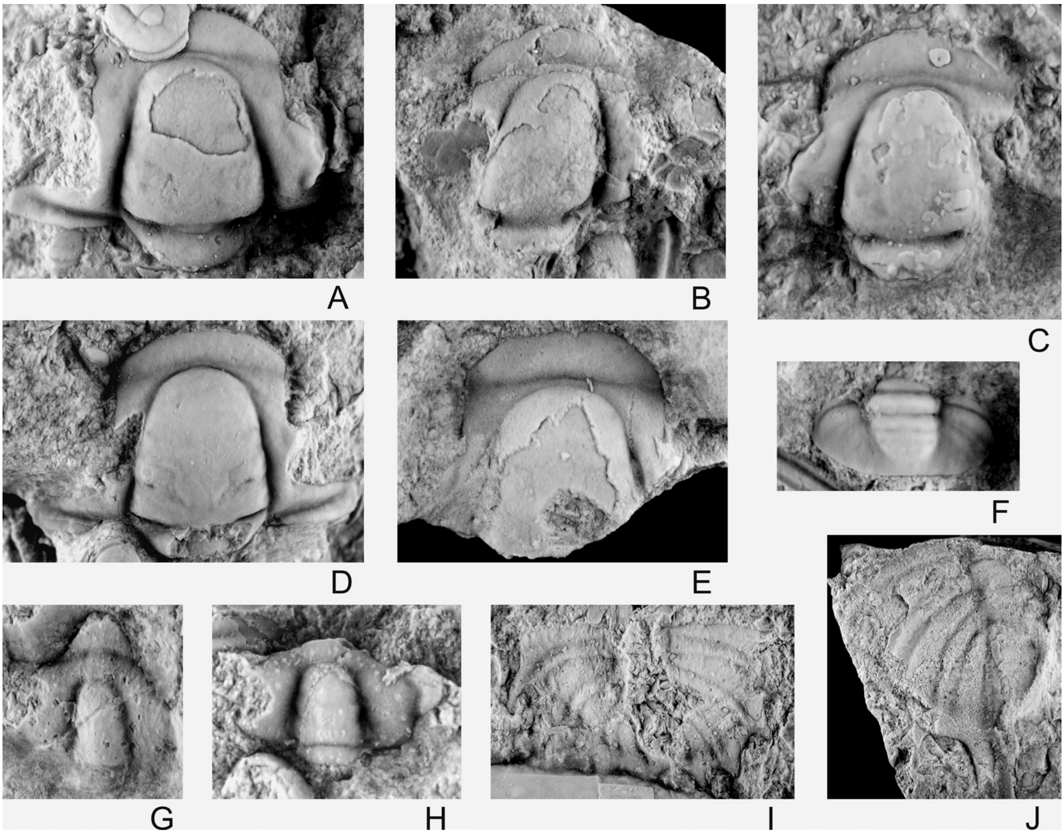

***Figure** 7*. **A**-**F**, *Modocia* sp.; **A**, cranidium, MLP 32965a, x4.2; **B**, cranidium, MLP 33142, x4.6; **C**, cranidium, MLP 33003, x5.5; **D**, cranidium, MLP 32965b, x3.3; **E**, fragmentary cranidium, MLP 32974a, x5; **F**, pygidium, MLP 32974b, x5.2. **G**-**H**, *Hysteropleura* (*Verditerrina*) *totoralensis* (Rusconi, 1958); **G**, distorted, elongate cranidium, MLP 33058, x3.7; **H**, incomplete cranidium, MLP 33013, x7.2. **I**-**J**, *Olenoides faldeanus* Rusconi, 1956a, fragmentary pygidia; **I**, MLP 32982, x2.1; **J**, MLP 33022, x1.7.

(1964), slightly emended by Robison (1988), is followed here.

Modocia sp. (Fig. 7A-F)

Material. 24 cranidia and one pygidium (MLP 32965, 32974, 32975, 32980, 33003, 33006, 33009, 33017, 33042, 33047, 33048, 33113, 33125, 33135, 33142, 33158, 33167, 33171, 33172, 33175) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Description. Cranidium moderately convex, with an evenly rounded anterior margin and downsloping fixed cheeks; glabella large, proportionately long, somewhat elevated above genal region, slightly tapered forwards and broadly rounded anteriorly, delimited by deep axial furrows, lacking lateral furrows; it occupies about 80% of the total length of the cranidium; axial furrow deeper than preglabellar furrow; occipital ring lacking median node or occipital spine, with rounded posterior margin; occipital furrow very deep, slightly bowed backwards; frontal area unequally divided by a shallow, curved forward medially border furrow; preglabellar field very short, approximately 20% length (sag.) of anterior border; anterior facial suture somewhat divergent; eye ridge extremely faint or absent, oblique backwards; palpebral area of the fixigena moderately wide (tr.), about 0.4 width of adjacent glabella; palpebral lobe long, about 30% length of cranidium, slightly elevated above fixigena, slightly anterior of glabellar midpoint; palpebral furrow shallow; posterior facial suture strongly divergent, sinuous; posterior fixigena with deep posterior border furrow and relatively narrow (exsag.), convex posterior border.

Pygidium semicircular, transverse maximum width about twice sagittal length; axis broad, convex, elevated above pleural fields, anterior width 40% maximum width of pygidium, slightly tapered backwards and broadly rounded posteriorly, occupying 85% of the total pygidial

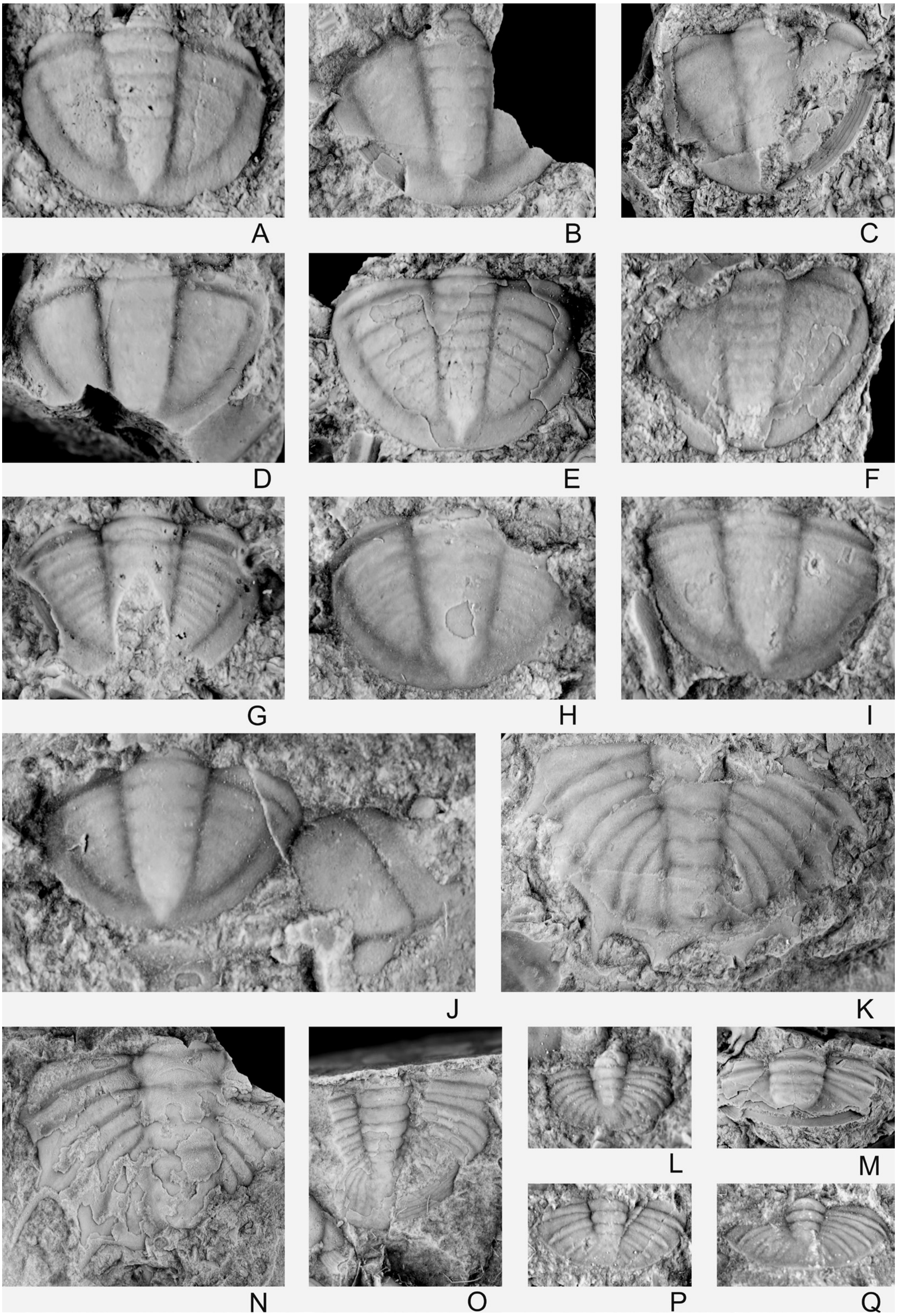

Figure 8. Type specimens of selected species from El Totoral described by Rusconi (1956a, 1958). **A**-**D**, *Blountia socorrensis* Rusconi, 1956a, pygidium; **A**, MCNAM 19970, holotype, x5.8; **B**, MCNAM 19974, paratype, x4.2; **C**, MCNAM 19975, *Blountia luanensis* Rusconi, 1956a, holotype, x3.5; (*continued opposite*)

length (excluding articulating half-ring), with 3 axial rings and a rounded terminal piece; anterior ring better defined than posterior rings; pleural field slightly convex, crossed by a deep anterior pleural furrow and a very delicate second pleural furrow; border furrow indistinct; posteromedian margin of pygidium with a weak, broad indentation.

Remarks. The only pygidium described is recorded in association with the cranidium 377a. *Modocia* sp. is characterised by having a wide (sag.) anterior border, a very short preglabellar field, a long and slightly tapered glabella, an occipital ring lacking median node or occipital spine, and faint pleural furrows on the pygidium. Therefore, it mostly resembles *Modocia* sp., from the *Cedaria minor* Zone of the southern Mackenzie Mountains, Canada (Pratt 1992, pl. 20, figs 11-18) (?= *Marjumia spinosa* Robison, from the upper middle Cambrian of Greenland; Robison 1988, fig. 20.4[bottom], 8-12; see Pratt 1992, p. 60); the latter slightly differs by having a prominent occipital spine and a slightly narrower (tr.) palpebral area of the fixigena. Pratt (1992) noted a possible relationship between *Modocia* sp. from Canada and "*Prometeoraspis*" *canotensis* Poulsen (1960, pl. 1, figs 16, 17) from Cerro El Solitario. The latter was described on the basis of an incomplete, fragmentary cranidium which, although seemingly lacking a wide (sag.) anterior border, has a close affinity with the material described herein.

Although *Modocia* sp. and *Modocia planata* Robison, from the late middle Cambrian of Greenland, both show a slightly tapered, elongate glabella and a short preglabellar field, *M. planata* differs in having a low convexity, a narrower (sag.) anterior cranidial border, and a wider palpebral area of the fixed cheek.

Modocia dubia (Resser, 1938), from the *Cedaria* Zone of Tennessee, USA, and the southern Mackenzie Mountains, Canada (Rasetti 1965, pl. 1, figs 22-26; Pratt 1992, pl. 20, figs 1, 2), differs from *Modocia* sp. in having a more tapered glabella, a shorter (exsag.) palpebral lobe that is situated well in advance of the glabellar midpoint, and deeper pleural furrows on the pygidium. Other *Modocia* species from the late middle Cambrian of North America (e.g., *M. nucaspina* Robison, 1988; *M. crassimarginata* Rasetti, 1965; *M. punctata* Rasetti, 1967) are distinguished mainly by showing an anterior cranidial border and a preglabellar field subequally developed. *Modocia brevispina* Robison, 1988, *M. laevinucha* Robison, 1988, *M. nevadensis* Palmer, 1954a, *M. metisensis* (Walcott) (Rasetti 1963) and *Modocia* cf. *oweni* (Meek & Hayden, 1861) have, in addition, a more tapered glabella.

Family DORYPYGIDAE Kobayashi, 1935

Olenoides Meek, 1877

Type species. Paradoxides? *nevadensis* Meek, 1877.

Olenoides faldeanus Rusconi, 1956a (Figs 7I, J; 8K, N)

1956a *Olenoides faldeanus*; Rusconi, 116, 117, fig. 2.

Material. Six pygidia (MLP 32982, 33022, 33024, 33063, MCNAM 19978, 19979) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Remarks. Olenoides faldeanus was originally described by Rusconi (1956a) on the basis of two large pygidia from El Totoral which are characterised by having a sharp anterolateral angle; a long, subparallel-sided to slightly tapered axis having five axial rings and a terminal piece; four oblique backwards pleural furrows and three interpleural furrows; a narrow border; and four pairs of delicate, subequally spaced marginal spines (Fig. 8K, N). Additional pygidia from the Borrello collections are illustrated in Figure 7I, J, but unfortunately they are poorly preserved, and associated cranidia were not found.

The specimens studied most closely resemble *Olenoides metisensis* Rasetti, from late middle Cambrian boulders of Quebec (Rasetti 1948, pl. 51, figs 1-4), but the latter differs by possessing more conspicuous pleural and interpleural furrows, and unequally spaced marginal spines. *Olenoides* sp., from the *Bolaspidella* Zone of eastern North America (Rasetti 1967, pl. 11, figs

D, MCNAM s/n, *Blountia luanensis* Rusconi, 1956a, paratype, x3.8. **E-F**, *Blountia complexa* Rusconi, 1958, pygidium; **E**, partially exfoliated specimen, MCNAM 21827, holotype, x3.6; **F**, MCNAM 21828, paratype, x4.4. **G-J**, "*Blountia*" *multicostata* Rusconi, 1950, pygidium; **G**, MCNAM 21831, holotype, x7; **H**, MCNAM 21833, paratype, x5.6; **I**, MCNAM 21834, paratype, x7; **J**, MCNAM 21832, paratype, x11.2. **K**, **N**, *Olenoides faldeanus* Rusconi, 1956a; **K**, pygidium, MCNAM 19978, holotype, x1.7; **N**, pygidium, MCNAM 19979, paratype, x1.7. **L**, *Pichunia indomita* Rusconi, 1958, pygidium, MCNAM 21317, holotype, x6.6. **M**, *Epumeria lata* Rusconi, 1958, pygidium, MCNAM 21295, holotype, x3.4. **O**, "*Hemirhodon*" *puntanus* Rusconi, 1958, pygidium, MCNAM 21323, holotype, x4. **P-Q**, *Pichunia quadricostata* Rusconi, 1958, pygidium; **P**, MCNAM 21851, holotype, x4.4; **Q**, MCNAM 21852, paratype, x4.4.

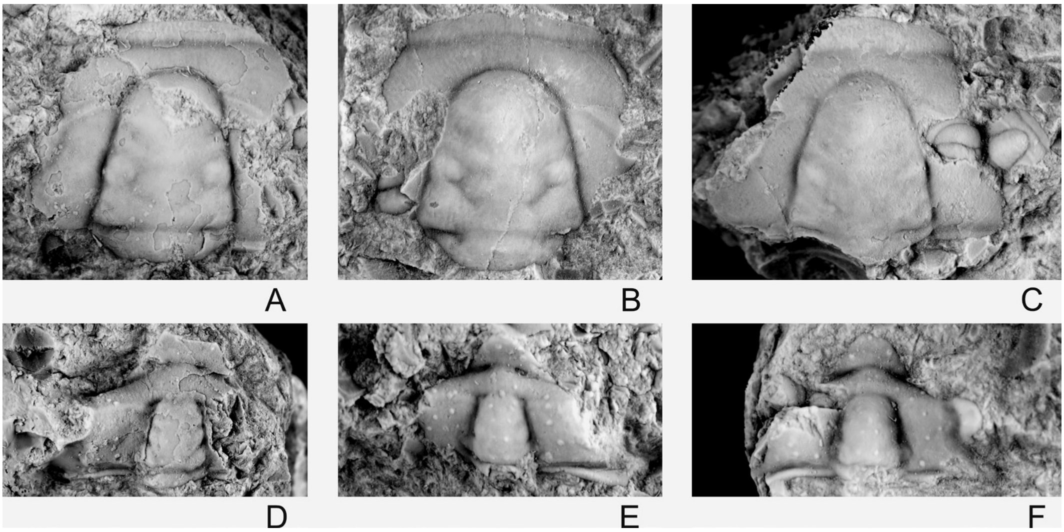

Figure 9. Type specimens of selected species from El Totoral described by Rusconi (1958). **A**-**B**, *Elrathia oscelata* (Rusconi, 1958), cranidium; **A**, MCNAM 21308, holotype, x2.9; **B**, MCNAM 21309, paratype, x3.4. **C**, ?*Elrathia oscelata* (Rusconi, 1958) MCNAM 21310, *Pichynturia oscelata* Rusconi, 1958, paratype, x3.4. **D**-**F**, *Hysteropleura* (*Verditerrina*) *totoralensis* (Rusconi, 1958), cranidium; **D**, MCNAM 21301, holotype, x3; **E**, MCNAM 21302, paratype, x5.2; **F**, MCNAM 21304, paratype, x5.

20-22), is distinguished by its shorter axis and its wider pleural furrows.

Family MENOMONIIDAE Walcott, 1916

Hysteropleura Raymond, 1937

Type species. Hysteropleura macgerriglei Raymond, 1937.

Hysteropleura (Verditerrina) Robison, 1988

Type species. Verditerrina lacinia Robison, 1988.

Hysteropleura (Verditerrina) totoralensis (Rusconi, 1958) (Figs 7G, H, 9D-F)

1958 *Notocoryphe totoralensis*; Rusconi, p. 102-104, fig. 9.

Material. Seven cranidia (MLP 32982, 33013, 33058, 33112, MCNAM 21301, 21302, 21304) from El Totoral, Mendoza, Argentina, upper middle Cambrian.

Description. Cranidium of small size, subtriangular in dorsal view and moderately convex; glabella slightly tapered forwards, truncate or broadly rounded anteriorly, surrounded by a pair of deep axial furrows and a shallow preglabellar furrow, smooth or with faint indications of three oblique lateral furrows, occupying about 60% of the total length of the cranidium; occipital furrow straight, shallow and narrow; occipital ring lacking a spine; anterior cranidial margin strongly rounded; anterior border medially broad (sag.), gently convex, subequal in length (sag.) to preglabellar field; border furrow conspicuous, curved forwards medially, deepest at sides and shallow on midline; palpebral area of fixigena (excluding palpebral lobe) about equal in width to adjacent glabella; palpebral lobe large, about one-third length of cranidium, elevated above fixigena, opposite to anterior third of glabella, delimited by a distinct palpebral furrow; posterior section of facial suture strongly divergent, sinuous; posterior fixigena having a deep posterior border furrow and a narrow (exsag.), convex posterior border; cranidial surface with small tubercles on the glabella, anterior border and fixed cheek.

Remarks. Rusconi (1958) originally assigned this menomoniid trilobite from El Totoral to *Notocoryphe* Rusconi (=*Bolaspidella*), and pointed out the presence of a prominent, medially broad (sag.) anterior border, a pair of deep pits on the anterior border furrow, a well defined preglabellar field, three weak glabellar furrows, a large and elevated palpebral lobe, and a granulose surface. However, the material described above undoubtedly differs from most species of *Bolaspidella* Resser, 1937 (see generic diagnosis of Palmer 1954b; Robison 1964) by its strongly curved anterior cephalic margin, its medially broad (sag.) anterior border, and its conspicuous anterior border furrow. Only

Bolaspidella burnetensis (Walcott), from the upper middle Cambrian (*Bolaspidella* Zone) of Texas (Lochman 1938, pl. 17, fig. 29; see Palmer 1964b, pl. 83, figs 10, 12, 13), has a similar frontal area, but its fixigena is much narrower (tr.).

The presence of an anteriorly expanded anterior cranidial border and very wide interoccular fixigenae indicates stronger affinities with *Hysteropleura* (*Verditerrina*) Robison, 1988, from the upper middle Cambrian of Greenland and western Newfoundland (Robison 1988; Westrop & Ludvigsen 2000). Therefore, the cranidia described above are assigned to this subgenus. *Hysteropleura* (*Verditerrina*) *totoralensis* (Rusconi) differs from the type species *H.* (*V.*) *lacinia* Robison, from the Holm Dal Formation of Greenland (Robison 1988, fig. 27.11, 12), primarily by having a spineless occipital ring. *Hysteropleura* (*Verditerrina*) *adraini* Westrop & Ludvigsen, 2000, *H.* (*V.*) *edgecombei* Westrop & Ludvigsen, 2000 and *H.* (*V.*) *ramskoldi* Westrop & Ludvigsen, 2000, from the Marjuman of the northern Appalachians, show, in addition, a smooth external surface of the exoskeleton.

Other material

Besides the taxa described above, Rusconi (1958) described a series of new genera and species from El Totoral (*Epumeria*, *E. lata*; *Pichunia*, *P. indomita*, *P. quadricostata*; and *Hemirhodon puntanus*) on the basis of rare, small pygidia whose affinities are difficult to verify. The holotypes of these species are reillustrated in Figure 8L-M, O-P. Following the original description of Rusconi, the pygidium of *Epumeria lata* Rusconi (1958, p. 100, fig. 5) (Fig. 8M) is more than twice as wide as long, and it is characterised by having a wide (tr.) and slightly tapered axis containing 3 rings and a rounded terminal piece, three pleural furrows, and a narrow border. Although the holotype is highly damaged, *Epumeria* seems to represent a marjumiid trilobite (Robison 1964, p. 547) of *Modocia*/*Marjumia* type.

Pichunia Rusconi (1958, p. 100-101) (Fig. 8L, P, Q) was based on tiny pygidia that are characterised by their subelliptic outline, short and tapered axis of 3 or 4 rings, and 3 or 4 pairs of pleural and interpleural furrows. The anterior interpleural furrow reaches lateral pygidial margin, whereas other furrows of the pleural field terminate short of outer margin. These specimens show some resemblance to those of *Conopolus* Robison, from the late middle Cambrian of Greenland, Texas and Quebec (Robison 1988, fig. 27.6-10), although *Conopolus* shows more radial and separated posterior pleural furrows. *Pichunia indomita* Rusconi (1958, p. 101, fig. 6) (Fig. 8L) was based on an immature specimen which may prove to be conspecific with *P. quadricostata* Rusconi (1958, p. 101, fig. 7; = *P. quadrispina* Rusconi, 1958, figure caption of fig. 7, *nomen nudum*) (Fig. 8P, Q). "*Hemirhodon*" *puntanus* Rusconi (1958, p. 104, fig. 10) (Fig. 8O) seems to be closely related to *Pichunia*, but differs in showing a more subcircular outline. However, further material is necessary to warrant a systematic revision of these forms.

ACKNOWLEDGEMENTS

Carlos Cingolani, Marta Alfaro (Museo de Ciencias Naturales de La Plata), Susana Devincenzi, Clara Abal, and Álvaro Sacchi (Museo de Ciencias Naturales y Antropológicas "Juan Cornelio Moyano", Mendoza) are thanked for making the material available for study. This paper was improved by helpful comments from John Laurie and two anonymous reviewers. Susana Heredia kindly shared unpublished geologic information on the El Totoral locality. Figure 1 was produced by Mario Campaña. This research was supported by the CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas), the Universidad Nacional de La Plata, and the Instituto Superior de Correlación Geológica (Universidad Nacional de Tucumán - CONICET), Argentina.

REFERENCES

Ahlberg, P. & Ahlgren, J., 1996. Agnostids from the Upper Cambrian of Västergötland, Sweden. *GFF 118*, 129-140.

Angelin, N.P., 1851. *Palaeontologia Suecica. Pars I: Iconographia Crustaceorum Formationis Transitionis*. Weigel, Lund, 24 p.

Axheimer, N., Eriksson, M.E., Ahlberg, P. & Bengtsson, A., 2006. The middle Cambrian cosmopolitan key species *Lejopyge laevigata* and its biozone: new data from Sweden. *Geological Magazine 143*, 447-455.

Babcock, L.E., 1994. Systematics and phylogenetics of polymeroid trilobites from the Henson Gletscher and Kap Stanton formations (Middle Cambrian), North Greenland. *Bulletin Grønlands Geologiske undersøgelse 169*, 79-127.

Bentley, C.J., Jago, J.B. & Cooper, R.A., 2009. An *Acmarhachis typicalis* Zone trilobite fauna from the Cambrian of northern Victoria Land, Antarctica. *Memoirs of the Association of Australasian Palaeontologists 37*, 165-197.

Beresi, M.S., 2003. Cambrian sponge spicules and chancelloriid sclerites from the Argentine Precordillera: A review. *Geologica Acta 1*, 73-84.

Bordonaro, O.L., 1992. El Cámbrico de Sudamérica. 69-84 in Gutiérrez Marco, J.C., Saavedra, J. & Rábano, I. (eds), *Paleozoico Inferior de Ibero-*

América. Universidad de Extremadura, España.

Bordonaro, O.L., 2003a. Review of the Cambrian Stratigraphy of the Argentine Precordillera. *Geologica Acta 1*, 11-21.

Bordonaro, O.L., 2003b. Evolución paleoambiental y paleogeográfica de la cuenca cámbrica de la Precordillera argentina. *Revista de la Asociación Geológica Argentina 58*, 329-346.

Bordonaro, O.L. & Banchig, A.L., 1995. Trilobites lauréntícos en el Cámbrico de la Precordillera argentina. *6° Congreso Argentino de Paleontología y Bioestratigrafía (Trelew), Actas*, 59-65.

Bordonaro, O.L. & Banchig, A.L., 1996. Estratigrafía de los olistolitos Cámbricos de la Precordillera argentina. *13º Congreso Geológico Argentino y 3º Congreso de Exploración de Hidrocarburos (Buenos Aires), Actas 5*, 471-479.

Bordonaro, O.L., Beresi, M. & Keller, M., 1993. Reinterpretación estratigráfica del Cámbrico del área de San Isidro, Precordillera de Mendoza. *12° Congreso Geológico Argentino y 2° Congreso de Exploración de Hidrocarburos (Mendoza), Actas 2*, 12-19.

Bordonaro, O.L. & Liñán, E., 1994. Some Middle Cambrian agnostoids from the Precordillera argentina. *Revista Española de Paleontología 9*, 105-114.

Borrello, A.V., 1965. Sobre el desarrollo bioestratigráfico del Cámbrico de la Precordillera. *Acta Geológica Lilloana 7*, 39-46.

Borrello, A.V., 1971. The Cambrian of South America. 385-438 in Holland, C. (ed.), *Cambrian of the New World*. Wiley Interscience, London.

Bright, R.C., 1959. A paleoecologic and biometric study of the Middle Cambrian trilobite *Elrathia kingii* (Meek). *Journal of Paleontology 33*, 83-98.

Brøgger, W.C., 1878. Om Paradoxidesskifrene ved Krekling. *Nyt Magazin for Naturvidenskaberne 24*, 18-88.

Brongniart, A., 1822. Les trilobites. 1-65 in Brongniart, A. & Desmarest, A.G. (eds), *Histoire naturelle de crustacés fossils, sous les raports zoölogiques et géologiques*, Lavrault, Paris.

Castellaro, H.A. 1963. Faunas cámbricas. 13-37 in Amos, A.J., Camacho, H.H., Castellaro, H.A. & Menéndez, C.A. (eds), *Guía Paleontológica Argentina*. Publicación del Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina), Buenos Aires.

Cerdeño, E., 2005. La colección de Paleontología del Museo de Ciencias Naturales y Antropológicas "J. C. Moyano" (Mendoza) y sus ejemplares tipo. *Contribuciones del Museo Argentino de Ciencias Naturales 2*, 61 p.

Daily, B. & Jago, J.B., 1975. The trilobite *Lejopyge* Hawle and Corda and the Middle-Upper Cambrian boundary. *Palaeontology 18*, 527-550.

Dalman, J.W., 1828. Årsberättelse om nyare zoologiska arbeten och upptäcker. *Kongliga Svenska Vetenskaps-Akademiens Handlingar*, 138 p.

Heredia, S., 1994. *Conodontes y Bioestratigrafía del Cámbrico Superior de Cerro Pelado y San Isidro, Provincia de Mendoza, Argentina*. Unpublished Ph.D. dissertation, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, 285 p.

Heredia, S., 1996. El Cámbrico y Ordovícico de la Cuchilla del cerro Pelado, Precordillera de Mendoza, Argentina. *13° Congreso Geológico Argentino y 3° Congreso de Exploración de Hidrocarburos (Buenos Aires), Actas 1*, 591-600.

Heredia, S. & Beresi, M.S., 2004. La Formación Empozada y su relación estratigráfica con la Formación Estancia San Isidro (nom. nov.), Ordovícico de la Precordillera de Mendoza. *Revista de la Asociación Geológica Argentina 59*, 178-192.

Hawle, I. & Corda, A.J.C., 1847. Prodom einer Monographie der böhmischen Trilobiten. *Abhandlungen der Kongligischen Bohemischen Gessellschaft der Wissenschaften 5*, 1-176.

Holm, G. & Westergård, A.H., 1930. A Middle-Cambrian fauna from Bennet Island. *Zapiski Akademii Nauk soyuza SSR, po Otdeleniyu Fiziko-Matematicheskikh Nauk 21(8)*, 25 p.

Howell, B.F., 1937. Cambrian *Centropleura vermontensis* fauna of northwestern Vermont. *Geological Society of America Bulletin 48*, 1147-1210.

Høyberget, M. & Bruton, D.L., 2008. Middle Cambrian trilobites of the suborders Agnostina and Eodiscina from the Oslo Region, Norway. *Palaeontographica A 286*, 1-87, pls 1-12.

Hu, C.-H., 1971. Ontogeny and sexual dimorphism of lower Paleozoic Trilobita. *Palaeontographica Americana 7(44)*, 27-155.

Jago, J.B. & Daily, B., 1974. The trilobite *Clavagnostus* Howell from the Cambrian of Tasmania. *Palaeontology 17*, 95-109.

Jago, J.B. & Webers, G.F., 1992. Middle Cambrian trilobites from the Ellsworth Mountains, West Antarctica. 101-124 in Webers, G.F., Craddock, C. & Splettstoesser, J.F. (eds), *Geology and Paleontology of the Ellsworth Mountains, West Antarctica*. Geological Society of America, Memoir 170.

Keller, M., 1999. Argentine Precordillera. Sedimentary and plate tectonic history of a Laurentian crustal fragment in South America. *Geological Society of America, Special Paper 341*, 131 p.

Kobayashi, T., 1935. The Cambro-Ordovician formations and faunas of South Chosen. Paleontology. Part 3. *Journal of the Faculty of Science, Imperial University of Tokyo, Section II 4(2)*, 49-344.

Kobayashi, T., 1939. On the agnostids. Part 1. *Journal of the Faculty of Science, Imperial University of*

Tokyo, Section II 5, 69-198.

Laurie, J.R., 1989. Revision of species of *Goniagnostus* Howell and *Lejopyge* Corda from Australia (Agnostida, Cambrian). *Alcheringa 13*, 175-191.

Lochman, C., 1938. Upper Cambrian faunas of the Cap Mountain Formation of Texas. *Journal of Paleontology 12*, 72-85.

Lochman, C., 1950. Upper Cambrian faunas of the Little Rocky Mountains, Montana. *Journal of Paleontology 24*, 322-349.

Lochman, C. & Duncan, D., 1944. Early Upper Cambrian faunas of Central Montana. *Geological Society of America Special Paper 54*, 181 p.

Lochman, C. & Hu, C.-H., 1960. Upper Cambrian faunas from the northwest Wind River Mountains, Wyoming. Part 1. *Journal of Paleontology 34*, 793-834.

Lu, Y-H. & Lin, H.-L., 1989. The Cambrian trilobites of western Zhejiang. *Palaeontologia Sinica 178, new series B, 25*, 287 p.

Mcnamara, K.J. & Rudkin, D.M., 1984. Techniques of trilobite exuviation. *Lethaia 17*, 153-173.

M'Coy, F., 1849. On the classification of some British fossil Crustacea with notices of some new forms in the University collection at Cambridge. *Annals and Magazine of Natural History, series 2, 4*, 161-179, 330-335, 392, 414.

Meek, F.B., 1870. Descriptions of fossils collected by the U.S. Geological Survey under the charge of Clarence King, esq. *Proceeding of the Academy of Natural Science, Philadelphia, series 2, 14*, 56-64.

Meek, F.B., 1873. Preliminary palaeontology report, consisting of list and descriptions of fossils, with remarks on the age of the rocks in which they are found. *Annual Report of the United States Geological Survey of Territories 6*, 429-518.

Meek, F.B., 1877. Paleontology. *U.S. Geological Exploration of the 40th Parallel 4(1)*, 1-17.

Meek, F.B. & Hayden, F.V., 1861. Descriptions of new Lower Silurian (Primordial), Jurassic, Cretaceous and Tertiary fossils collected in Nebraska by the exploring expedition under the command of Capt. Wm. F. Reynolds, U.S. Top. Engrs; with remarks on the rocks from which they were obtained. *Proceedings of the Academy of Natural Science, Philadelphia 2, 5*, 415-447.

Öpik, A.A., 1967. The Mindyallan fauna of north-western Queensland. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics 74*, vol. 1, 404 p., vol. 2, 167 p.

Öpik, A.A., 1979. Middle Cambrian agnostids: systematics and biostratigraphy. *Bulletin of the Bureau of Mineral Resources, Geology and Geophysics 172*, vol. 1, 188 p., vol. 2, 67 pls.

Palmer, A.R., 1954a. An appraisal of the Great Basin Middle Cambrian trilobites described before 1900. *U.S. Geological Survey Professional Paper 264-D*, 55-86, pls 13-17.

Palmer, A.R., 1954b. The faunas of the Riley Formation in central Texas. *Journal of Paleontology 28*, 709-786.

Palmer, A.R., 1962. *Glyptagnostus* and associated trilobites in the United States. *U.S. Geological Survey Professional Paper 374-F*, 1-49, pls 1-6.

Peng, S., Hughes, N.C., Heim, N.A., Sell, B.K., Zhu, X., Myrow, P.M. & Parcha, S.K., 2009. Cambrian trilobites from the Parahio and Zanskar Valleys, Indian Himalaya. *Journal of Paleontology 83 (supplement)*, 95 p.

Peng, S. & Robison, R.A., 2000. Agnostid biostratigraphy across the middle-upper Cambrian boundary in Hunan, China. *Journal of Paleontology 74 (supplement)*, 104 p.

Poulsen, C., 1960. Fossils from the late Middle Cambrian *Bolaspidella* Zone of Mendoza, Argentina. *Matematisk-fysiske Meddelelser, Det Kongelige Danske Videnskabernes Selskab 32(11)*, 42 p.

Pratt, B.R., 1992. Trilobites of the Marjuman and Steptoean stages (Upper Cambrian), Rabbitkettle Formation, southern Mackenzie Mountains, northwest Canada. *Palaeontographica Canadiana 9*, 179 p.

Rasetti, F., 1946. Early Upper Cambrian trilobites from western Gaspé. *Journal of Paleontology 20*, 442-462.

Rasetti, F., 1948. Middle Cambrian trilobites from the conglomerates of Quebec (exclusive of the Ptychopariidea). *Journal of Paleontology 22*, 315-339.

Rasetti, F., 1963. Middle Cambrian ptychoparioid trilobites from the conglomerates of Quebec. *Journal of Paleontology 37*, 575-594.

Rasetti, F., 1965. Upper Cambrian trilobites faunas of northeastern Tennessee. *Smithsonian Miscellaneous Collections 148(3)*, 1-127, pls 1-21.

Rasetti, F., 1967. Lower and Middle Cambrian trilobite faunas from the Taconic sequence of New York. *Smithsonian Miscellaneous Collections 152(4)*, 1-111, pls 1-14.

Raymond, P.E., 1924. New Upper Cambrian and Lower Ordovician trilobites from Vermont. *Proceedings of the Boston Society of Natural History 37*, 389-466.

Raymond, P.E., 1937. Upper Cambrian and Lower Ordovician Trilobita and Ostracoda of northwestern Vermont. *Geological Society of America Bulletin 48*, 1079-1146.

Resser, C.E., 1937. Third contribution to nomenclature of Cambrian trilobites. *Smithsonian Miscellaneous Collections 95(3)*, 29 p.

Resser, C.E., 1938. Cambrian System (restricted) of the southern Appalachians. *Geological Society of America Special Paper 15*, 140 p.

Resser, C.E., 1939. The *Ptarmigania* Strata of the Northern Wasatch Mountains. *Smithsonian Miscellaneous Collections 98*, 1-72, pls 1-14.

Resser, C.E., 1942. New Upper Cambrian trilobites. *Smithsonian Miscellaneous Collections 103(5)*, 136 p.

Robison, R.A., 1964. Late Middle Cambrian faunas from western Utah. *Journal of Paleontology 38*, 510-566.

Robison, R.A., 1976. Middle Cambrian trilobite biostratigraphy of the Great Basin. *Brigham Young University Geology Studies 23*, 93-109.

Robison, R.A., 1984. Cambrian Agnostida of North America and Greenland, Part 1, Ptychagnostidae. *University of Kansas Paleontological Contributions 109*, 59 p.

Robison, R.A., 1988. Trilobites of the Holm Dal Formation (late Middle Cambrian), central North Greenland. *Meddelelser om Grønland, Geoscience 20*, 23-103.

Robison, R.A., 1994. Agnostoid trilobites from the Henson Gletscher and Kap Stanton formations (Middle Cambrian), North Greenland. *Bulletin Grønlands geologiske Undersøgelse 169*, 25-77.

Rusconi, C., 1950a. Nuevos trilobitas y otros organismos del Cámbrico de Canota. *Revista del Museo de Historia Natural de Mendoza 4*, 85-94.

Rusconi, C., 1950b. Trilobitas y otros organismos del Cámbrico de Canota. *Revista del Museo de Historia Natural de Mendoza 4*, 71-84.

Rusconi, C., 1951. Más trilobitas cámbricos de San Isidro cerro Pelado y Canota. *Revista del Museo de Historia Natural de Mendoza 5*, 3-30.

Rusconi, C., 1956a. Fósiles cámbricos al sud del Totoral Mendoza. *Revista del Museo de Historia Natural de Mendoza 9*, 115-119.

Rusconi, C., 1956b. Lista de los géneros y especies fundadas por Carlos Rusconi. *Revista del Museo de Historia Natural de Mendoza 9*, 121-156.

Rusconi, C., 1958. Nuevos fósiles cámbricos de El Totoral, Mendoza. *Revista del Museo de Historia Natural de Mendoza 11*, 93-107, pl. 1.

Rusconi, C., 1962. Correlación de organismos Cambro-Ordovícicos de varias localidades de Mendoza. *Revista del Museo de Historia Natural de Mendoza 14*, 85-97.

Salter, J.W., 1859. On fossils of the *Lingula* flags or “zone primordiale”. *Quarterly Journal of the Geological Society, London 15*, 551-555.

Salter, J.W., 1864. A monograph of British trilobites. Part 1. *Monograph of the Palaeontographical Society*, 1-80, pls 1-6.

Schwimmer, D.R., 1989. Taxonomy and biostratigrahic significance of some middle Cambrian trilobites from the Conasauga Formation in western Georgia. *Journal of Paleontology 63*, 484-494.

Shergold, J.H., Bordonaro, O.L. & Liñán, E., 1995. Late Cambrian agnostoid trilobites from Argentina. *Palaeontology 38*, 241-257.

Shergold, J.H., Laurie, J.R. & Sun Xiaowen, 1990. Classification and review of the trilobite Order Agnostida Salter, 1864: an Australian perspective. *Bureau of Mineral Resources, Geology and Geophysics, Report 296*, 1-93.

Stitt, J.H. & Perfetta, P.J., 2000. Trilobites, biostratigraphy, and lithostratigraphy of the *Crepicephalus* and *Aphelaspis* zones, lower Deadwood Formation (Marjuman and Steptoean stages, Upper Cambrian), Black Hills, South Dakota. *Journal of Paleontology 74*, 199-223.

Sundberg, F., 1999. Redescription of *Alokistocare subcoronatum* (Hall and Whitfield, 1877), the type species of *Alokistocare*, and the status of Alokistocaridae Resser, 1939b (Ptychopariida: Trilobita, Middle Cambrian). *Journal of Paleontology 73*, 1126-1143.

Swinnerton, H.H., 1915. Suggestions for a revised classification of trilobites. *Geological Magazine (New Series) 6*, 487-496, 538-545.

Tortello, M.F. 2009. Systematic revision of the latest Middle Cambrian trilobites from Cerro El Solitario, Mendoza, Argentina. *Memoirs of the Association of Australasian Palaeontologists 37*, 247-272.

Tortello, M.F. & Bordonaro, O.L., 1997. Cambrian agnostoid trilobites from Mendoza, Argentina: a systematic revision and biostratigraphic implications. *Journal of Paleontology 71*, 74-86.

Wahlenberg, G., 1818. Petrificata Telluris Svecanae. *Nova Acta Regiae Societatis Scientiatum Upsaliensis 8*, 1-116.

Walcott, C.D., 1884. The paleontology of the Eureka district, Nevada. *United States Geological Survey Monograph 8*, 298 p.

Walcott, C.D., 1916. Cambrian geology and paleontology III, Nº 5, Cambrian trilobites. *Smithsonian Miscellaneous Collections 64(5)*, 303-456.

Walcott, C.D., 1924. Cambrian geology and paleontology V, Nº 2, Cambrian and lower Ozarkian trilobites. *Smithsonian Miscellaneous Collections 75(2)*, 53-60.

Walcott, C.D., 1925. Cambrian geology and paleontology V, Nº 3, Cambrian and lower Ozarkian trilobites. *Smithsonian Miscellaneous Collections 75(3)*, 61-146.

Westergård, A.H., 1946. Agnostidea of the Middle Cambrian of Sweden. *Sveriges Geologiska Undersokning, Series C, 477*, 141 p.

Westrop, S.R., 1992. Upper Cambrian (Marjuman-Steptoean) trilobites from the Port au Port Group, western Newfoundland. *Journal of Paleontology 66*, 228-255.

Westrop, S.R. & Ludvigsen, R., 2000. The Late Cambrian (Marjuman) trilobite genus *Hysteropleura* Raymond from the Cow Head Group, western Newfoundland. *Journal of Paleontology 74*, 1020-1030.