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Ana Mestre [a] & Susana Heredia [a]

[a] Conicet—Instituto de Investigaciones Mineras, Facultad de Ingeniería, Universidad Nacional de San Juan, Av. Libertador y Urquiza (5400) San Juan, Argentina

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ANA MESTRE AND SUSANA HEREDIA

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The Middle Ordovician successions in the Central Precordillera of Argentina are characterized by carbonate and fine mixed carbonate/siliciclastic deposits. Two middle Darriwilian sections spanning the *Eoplacognathus pseudoplanus* to *Eoplacognathus suecicus* Zones were sampled for conodonts, among which were found species of *Histiodella*. We revised the biostratigraphical distribution of these species in the Middle Ordovician of the Precordillera. This study confirms that the Darriwilian species of *Histiodella* present in the Argentine Precordillera have a similar distribution to those of equivalent age in Newfoundland, South China and the Baltic region. On the other hand, the overlap in the ranges of *H. holodentata* and *H. kristinae* seems to be restricted to a fairly short interval in the upper part of the *E. pseudoplanus* Zone. We also propose that the FAD of *H. kristinae* Stouge is accurately positioned in the upper part of the *E. pseudoplanus* Zone; thus this species should not be used to define the base of the *E. suecicus* Zone in the Ordovician biozonation of the Argentine Precordillera.

Ana Mestre [amestre@unsj.edu.ar] and Susana Heredia [sheredia@unsj.edu.ar], Conicet—Instituto de Investigaciones Mineras, Facultad de Ingeniería, Universidad Nacional de San Juan. Av. Libertador y Urquiza (5400) San Juan, Argentina. *Received 16.2.2011, revised 27.4.2011, accepted 13.5.2011.*

Key words: Conodonts, *Histiodella*, Ordovician, Darriwilian, biostratigraphy, Argentine Precordillera.

HISTIODELLA was established by Harris (1962) for a distinctive group of Middle Ordovician asymmetrical blade-like conodonts (Stouge 1984). Mound (1965) and Sweet *et al*. (1971) reviewed the species of *Histiodella* known to them and concluded that successively younger forms display increasing differentiation of the blade into fused denticles. Later, McHargue (1982) recognized several important evolutionary trends in *Histiodella* based on features of the spathognathodontiform elements (P elements). Those trends include development of serrations or denticles, decrease in height/length ratio and increasing abundance (relative to other components of the skeletal apparatus) for progressively younger species.

The stratigraphical distribution of *Histiodella* is important, because its evolutionary changes allowed establishment of a well-defined zonation of the Darriwilian in the North American Midcontinental Province, comprising the *H. sinuosa* Zone and *H. holodentata* Zone (Harris *et al*. 1979, Ethington & Clark 1981, Bauer 2010). Stouge (1984) proposed that the *Histiodella* species present in the Table Head Formation of Newfoundland represent further evolutionary branches of the genus. He defined three new species and phylozones, *H. tableheadensis* (=*H. holodentata*), *H. kristinae* and *H. bellburnensis*, with the inferred evolution expressed mainly in the spathognathodontiform elements. These species of *Histiodella* have been recognized in the Argentine Precordillera (Lehnert 1995, Heredia *et al*. 2005a,b), Baltica (Rasmussen 2001, Löfgren 2004), South China (Zhang 1998) and Australia (Zhen & Percival 2004, Zhen *et al*. 2009).

The Lower–Middle Ordovician carbonate succession of the Precordillera is developed along a meridional length of 400 km with a latitudinal width of 150 km. Several localities in the Central Precordillera have been well studied (Baldis & Chebli 1969); the Las Chacritas River (LCHA) section and Cerro La Chilca (LCHI) section are considered here as the most complete and well exposed for detailed analysis of Middle Ordovician conodont biostratigraphy (Fig. 1).

The LCHA section was first studied by Espisúa (1968) and subsequently reviewed by Peralta & Baldis (1995). Astini (1994) and Carrera & Astini (1998) examined the sedimentology of this section, analyzing palaeoenvironmental changes and faunal turnover. Albanesi & Astini (1994) reported conodonts of the *Eoplacognathus suecicus* Zone at the top of the San Juan Formation in the LCHA section, and Lehnert (1995), who identified the *E. suecicus* and *Pygodus serra* zones from the uppermost levels of the San Juan

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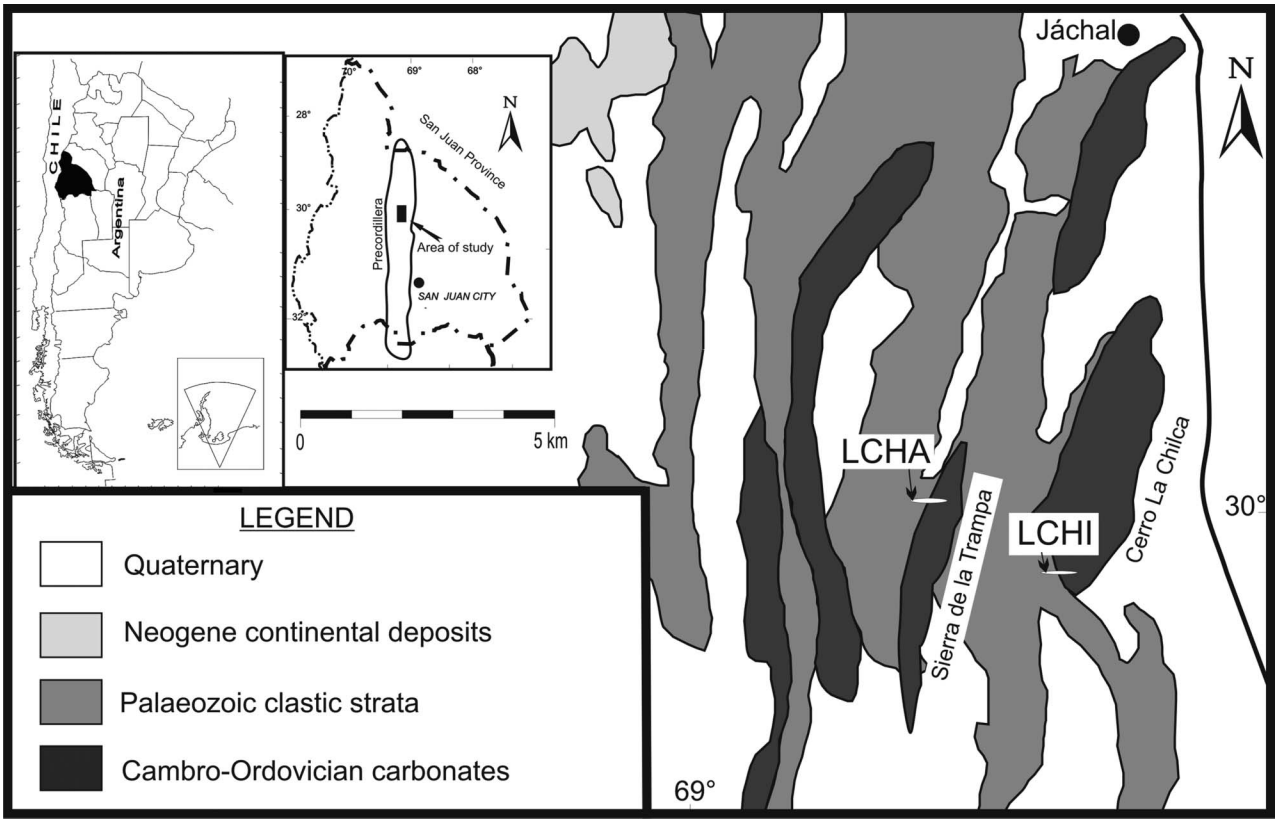

Fig. 1. Map showing the locations of sections mentioned in text.

Formation and the 'Transfacies' ('transfacies calcáreo-peliticas' in the sense of Baldis & Beresi 1981), also reported the presence of *H. kristinae* and *H. holodentata* at this level. The occurrence of the *Lenodus variabilis* Zone (Albanesi *et al.* 1998) in the carbonate succession was first mentioned by Peralta *et al.* (1999a) and was documented by Peralta *et al.* (1999b). Albanesi & Astini (2000) reported the occurrence of the *Eoplacognathus pseudoplanus* Zone in the LCHA section. Heredia *et al.* (2005a) documented the distribution of the conodont taxa and analyzed the relationship between lithostratigraphy and biostratigraphy within the LCHA section. Heredia *et al.* (2005b) argued that the first occurrence of *H. kristinae* is at the base of the *E. suecicus* Zone following the proposal of Lehnert (1995).

The graptolite fauna of the LCHI section was studied by Cuerda (1986). Lehnert (1995) mentioned the first conodont fauna from LCHI and registered the presence of *Histiodella*, but provided confused sampling details. Mestre (2010) defined the *E. pseudoplanus* Zone for the uppermost metre of the San Juan Formation in this section, and observed elements of *H. kristinae* and *H. holodentata* in the recovered conodont association. Here we review the stratigraphical distribution of Darriwilian species of *Histiodella* in the Argentine Precordillera, and discuss their biostratigraphical value.

Geological setting and stratigraphy

The Ordovician carbonates exposed in the LCHA and LCHI sections are composed of medium to dark grey limestone, marls and mixed carbonate/siliciclastic sediments deposited in a ramp setting (Peralta & Baldis 1995, Carrera 1997, Peralta *et al.* 1999a, b, Mestre 2010). Each section begins with the Lower–Middle Ordovician San Juan Formation, composed mainly of fossiliferous limestone and marly limestone. Its base is concealed by faulting, but the exposed part is 340 m thick in the LCHA section and 325 m thick in the LCHI (Keller 1999). The San Juan Formation is conformably overlain by 55 m of thin- to medium-bedded marly limestone and black shale of the Las Aguaditas/Los Azules Formation of Middle to Late Ordovician age. These latter units consist of tabular, thin- to medium-bedded, dark mudstone, nodular fossiliferous wackestone to packstone, black shale and sparse thin beds of bentonite.

The contact between the San Juan and Las Aguaditas/Los Azules Formations is transitional, the first level of black shale being used as the arbitrary boundary between these units.

Our stratigraphical and biostratigraphical study focuses on the upper part of the San Juan Formation and the lower members of Las Aguaditas (LCHA section) and Los Azules (LCHI section) formations (Fig. 2). In the LCHA section, the top of the San Juan Formation is characterized by dark grey grainstones and bioclastic packstones, with plates of crinoids, brachiopods, trilobites and nautiloids. A hardground is developed at the contact with Las Aguaditas Formation. The lowest level of Las Aguaditas Formation consists of unfossiliferous marly mudstones (Fig. 2), but crinoids, brachiopods, trilobites and conodonts occur 2 m above.

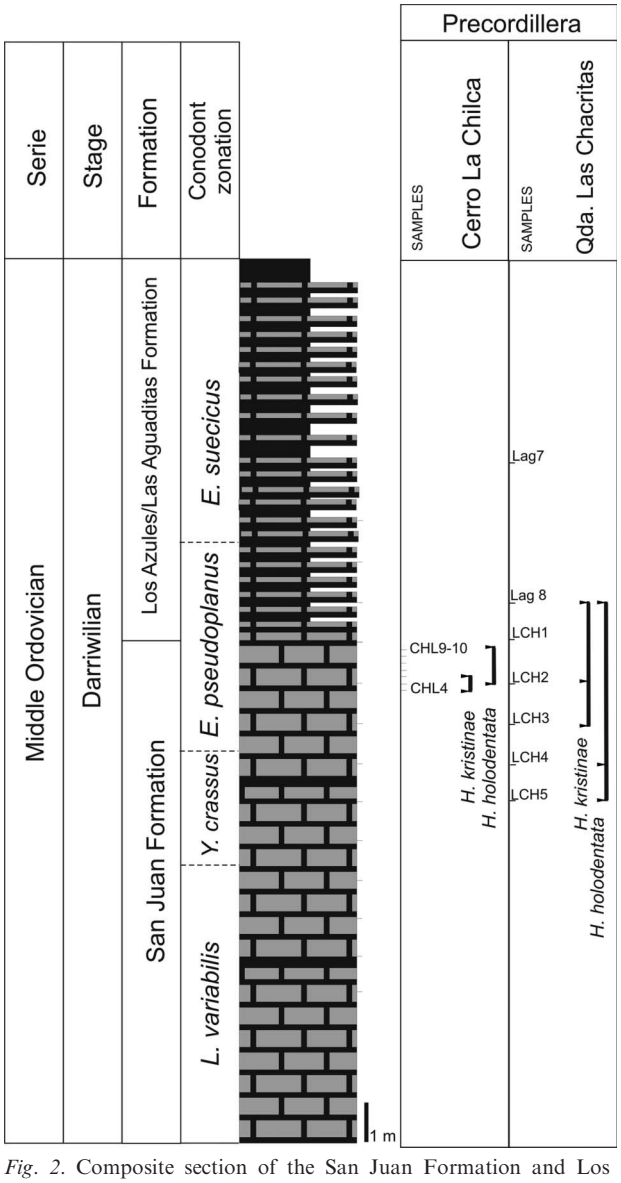

Fig. 2. Composite section of the San Juan Formation and Los Azules /Las Aguaditas formations represented at the Sierra de la Trampa (Las Chacritas River section) and Cerro la Chilca (Cerro La Chilca section).

In the LCHI section, the top of San Juan Formation consists of light greenish-grey wackestones, bioclastic packstones and marly carbonates. The lowest bed in this section is an intraclastic breccia and is overlain by bioclastic wackestones–mudstones with crinoids, brachiopods and trilobites. The progressive increase in mud instills a nodular structure to the marly limestone. Trilobites are the only fossils present in these beds. Strata overlying the San Juan Formation include several coquinas composed of trilobites and brachiopods between grey barren mudstones. The lower levels of Los Azules Formation consist of black shales and dark mudstones (Fig. 2).

Methodology

Conodont samples were collected from limestone beds at 10–15 cm intervals from the uppermost part of the San Juan Formation at La Chilca and 1 m intervals at the Las Chacritas River section (Fig. 2). Initially, 1–2 kg of each sample was dissolved in dilute formic acid with additional material processed if needed. The insoluable fraction of each sample was picked for conodonts resulting in recovery of *ca* 4100 identifiable conodont elements. All elements have a colour alteration index of 2–3 (60–200°C) (Epstein *et al*. 1977). The conodonts are housed in the collection of the INGEO at the Universidad Nacional de San Juan, under the code-MP and the INSUGEO at the Facultad de Ciencias Naturales e Instituto Miguel Lillo, under the code CML-C.

Systematic palaeontology

Although this paper focuses on *Histiodella*, the composition of the remainder of the middle Darriwilian conodont fauna especially that of the *E. pseudoplanus* Zone, of the LCHA and LCHI sections, is also of interest. This consists of *Ansella jemtlandica* Löfgren, *Baltoniodus medius* Dzik, *'Bryantodina'* sp. aff. *B. typicalis* (Stauffer), *Drepanodus gracilis* Branson & Mehl, *Drepanoistodus basiovalis* (Sergeeva), *Drepanoistodus bellburnensis* Stouge, *Drepanoistodus pitjanti* Cooper, *Dzikodus hunanensis* Zhang, *Dzikodus tablepointensis* Stouge, *Eoplacognathus pseudoplanus* (Viira), *Erraticodon balticus* (Dzik), *Fahraeusodus marathonensis* (Bradshaw), *Histiodella kristinae* Stouge, *Histiodella holodentata* Ethington & Clark, *Microzarkodina* sp. cf. *M. ozarkodella*

Lindström, *Paltodus? jemtlandicus* Löfgren, *Parapaltodus simplicissimus* Stouge, *Paroistodus horridus* Barnes & Poplawski, *Periodon aculeatus zgierzensis* (Dzik), *Polonodus clivosus* Viira, *Polonodus galerus* Albanesi, *Protopanderodus calceatus* Bagnoli & Stouge, *Protopanderodus graeai* (Hamar), *Rossodus barnesi* Albanesi, *Scolopodus oldstockensis* Stouge, and *Spinodus spinatus* (Hadding). *Eoplacognathus suecicus* Bergström occurs in Las Aguaditas Formation (sample Lag 7) and denotes the presence of the *E. suecicus* Zone (see Figs 3, 4 for selected conodonts). *Histiodella* has a low relative abundance with slightly more than 0.5%.

The *Histiodella* apparatus was reconstructed by McHargue (1982) to comprise bryantodiniforms, ramiforms and an oistodontoform element. Stouge (1984) supported this reconstruction, recognizing six morphologically distinct elements. Recently, Bauer (2010) described the apparatus using the P, S and M notation, and defined *Histiodella labiosa* Bauer from the early Darriwilian of southern Oklahoma.

Previous authors investigating this genus have used diverse criteria to differentiate between species. McHargue (1982) determined that the spathognathodontiform elements show the development of serrations or denticles, decrease in height/length ratio, and increasing abundance of P elements (relative to other components of the skeletal apparatus) in progressively younger species. Stouge (1984) established the relationship of height and width of the cusp on the anterior denticles in the spathognathodontiform (P) elements as a specific diagnostic criterion. Zhen & Percival (2004) used the height/length ratio to differentiate *H. kristinae* from *H. holodentata*; *H. kristinae* has a more elongate outline (height/length ratio of 0.50–0.58), and *H. holodentata* is rectangular in outline and has a height/length ratio varying from 0.67 to 0.7. However, the trend of decreasing height/length ratio (McHargue 1982) for spathognathodontiform P elements does not hold true and is not useful for differentiating species.

This raises the question as to which criteria serve to distinguish *H. holodentata* from *H. kristinae*, and a review of the literature suggests that the characters currently used are vague and arbitrary. However, the concept (originally proposed by Stouge 1984) that the relative size and height of the cusp might be a more reliable means of distinguishing *H. holodentata* from *H. kristinae* is applied herein to identify specimens recovered from the San Juan Formation.

The Darriwilian species of *Histiodella* present in the Argentine Precordillera are described and illustrated herein, but a complete apparatus of this genus was not recovered from the two sections studied; only spathognathodontiform elements are present.

The synonymy lists are condensed, containing only taxonomically significant records of the species. In the descriptions, we have used the conventional orientational terms—anterior, posterior and lateral—noting that these do not relate to the anatomical orientation of elements (see Purnell *et al*. 2000).

Class CONODONTA Pander, 1856
Order OZARKODINIDA Dzik, 1976
Suborder PLECTODINIDA Dzik, 1991
Superfamily OISTODONTACEA Lindström, 1970
Family OISTODONTIDAE Lindström, 1970

Histiodella Harris, 1962

Type species. *Histiodella altifrons* Harris, 1962.

Histiodella holodentata Ethington & Clark, 1981 (Fig. 3A, B)

1981 *Histiodella holodentata*, Ethington & Clark, p. 47, pl. 4, figs 1, 3, 4, 16 (cum syn.).
1995 *Histiodella holodentata* Ethington & Clark, Lehnert, pl. 8, fig. 7, 10.
1998 *Histiodella sinuosa* Graves & Ellison; Albanesi, p. 162, pl. 4, fig. 26.
1998 *Histiodella tableheadensis* Stouge; Zhang, p. 72, pl. 9, figs 14, 15 (cum syn.).
2000 *Histiodella holodentata* Ethington & Clark; Zhao *et al*., p. 205, pl. 27, figs 12, 1.
2001 *Histiodella kristinae* Stouge; Rasmussen, p. 82, pl. 7, figs 18, 19.
2002 *Histiodella tableheadensis* Stouge, Albanesi & Ortega, pl. 1, fig. 4.
2004 *Histiodella kristinae* Stouge; Zhen *et al*., p. 97–98, fig. 14A–L. [2004a].
2005 *Histiodella sinuosa* Graves & Ellison; Heredia *et al*., pl. 3, fig. N. [2005a].
2005 *Histiodella holodentata* Ethington & Clark; Du *et al*., p. 365, pl. 1, figs 22–26, 28.
2007 *Histiodella holodentata* Ethington & Clark; Percival & Zhen, p. 391, pl. 1, figs 22, 23.
2009 *Histiodella holodentata* Ethington & Clark; Zhen *et al*., p. 38–39, pl. 2, fig. O.

Material. Eight Pa elements. They occur in the San Juan Formation sample LChi 5: INGEO-MP 1027/ (1 specimen), LChi 9–10: INGEO-MP 1052 (1 specimen), LCH 4: INGEO-MP 110/ (2 specimens), LCH 5: INGEO-MP 145/ (3 specimens), and Las Aguaditas Formation sample Lag 8 CML-C 2006/1 (1 specimen).

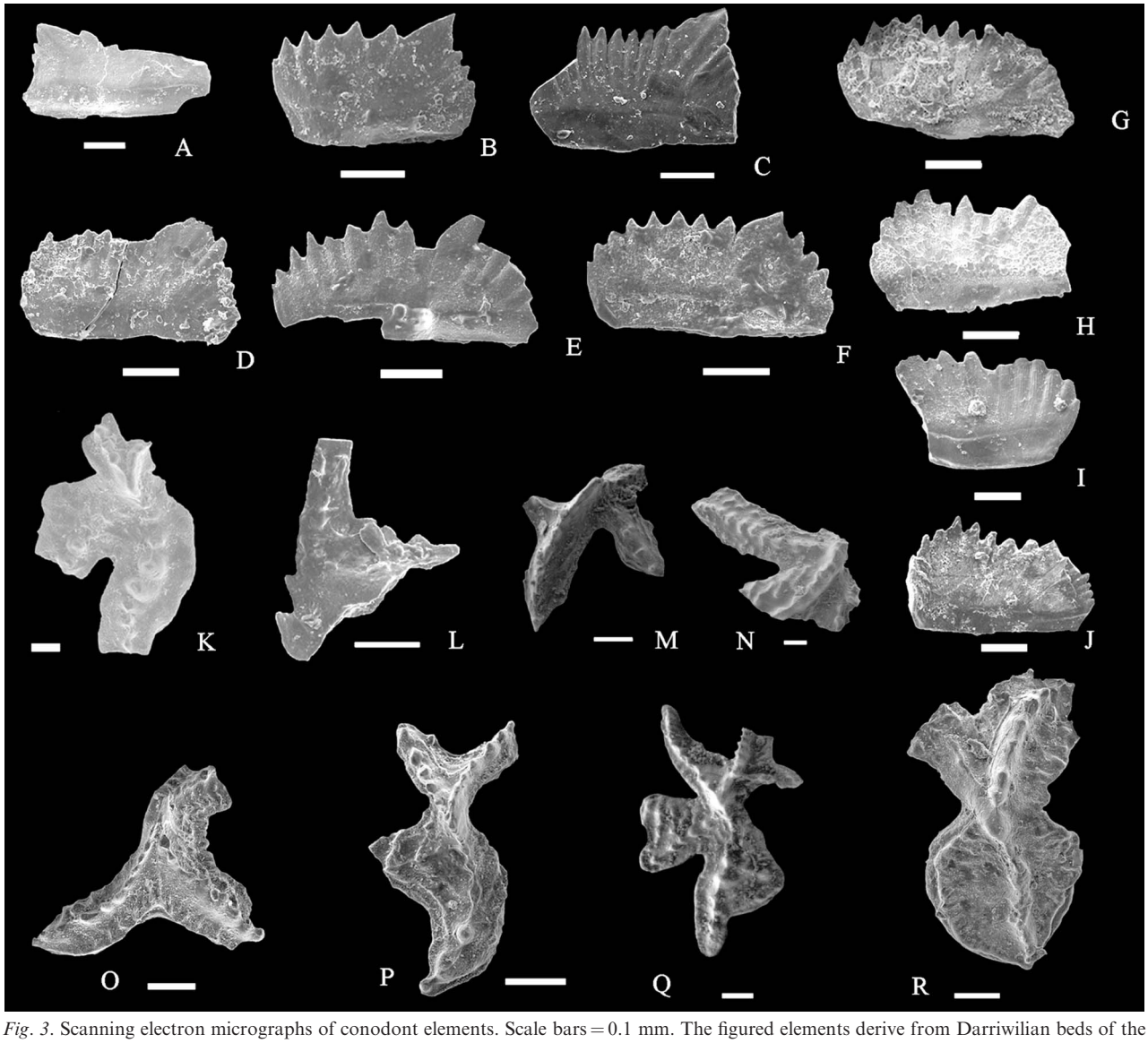

Fig. 3. Scanning electron micrographs of conodont elements. Scale bars = 0.1 mm. The figured elements derive from Darriwilian beds of the Precordillera. **A–D**, *Histiodella holodentata* Ethington & Clark. Lateral views of spathognadontiform P elements. **A**, San Juan Formation, Las Chacritas section LCH3, INGEO-MP 127/2. **B**, San Juan Formation, La Chilca section, LChi 5, INGEO-MP 1027/1. **C**, San Juan Formation, La Chilca section LChi 9–10, INGEO-MP 1052/1. **D**, Las Aguaditas Formation, Las Chacritas section Lag 8, CML-C 2006/1. **E–J**, *Histiodella kristinae* Stouge. Lateral views of spathonagdontiform P elements. **E**, San Juan Formation, La Chilca section LChi 6, INGEO-MP 1011/1. **F**, San Juan Formation, La Chilca section LChi 4, INGEO-MP 1053/ 1. **G**, San Juan Formation, Las Chacritas section LCH2, INGEO-MP 111/1. **H**, San Juan Formation, Las Chacritas section LCH3, INGEO-MP 127/1. **I**, San Juan Formation, Las Chacritas section LCH3, INGEO-MP 127/7. **J**, San Juan Formation, Las Chacritas section LCH2, INGEO-MP 111/2. **L**, *Microzarkodina* sp. cf. *M. ozarkodella* Lindström, Pa elements, San Juan Formation, La Chilca section LChi 4, INGEO-MP 1012/1. **M, N**, *Dzikodus tablepointensis* (Stouge), Pb and Pa elements, San Juan Formation, Las Chacritas section LCH1, INGEO-MP 102/9–10. **K, O, P**, *Eoplacognathus pseudoplanus* (Viira); **K,** dextral Pa, San Juan Formation, La Chilca section, LChi 4 INGEO-MP-1009(1); **O, P,** Pb sinistral and dextral Pa elements, Las Aguaditas Formation, Las Chacritas section, Lag 8, CML-C 2000/1, CML-C 2000/3. **Q, R.** *Eoplacognathus suecicus* Bergström, dextral Pa and dextral Pb elements, Las Aguaditas Formation, Las Chacritas section Lag 7, INGEO-MP 100/1; Lag 1, CML-C 3403/2.

Description. The spathognathodontiform element recovered from the Precordillera has an anterior and posterior denticulate blade. The cusp is high, twice as wide as the anterior denticles, and its position is posterior to the midpoint in the blade. It has a costa in the middle part, from the base to the top, that is identical to that of the illustrated paratype (Stouge 1984, pl. 18, fig. 12, 14). Posterior denticles are apically free and reclined parallel to the cusp. The Percordillera specimens have three to five posterior denticles, and the anterior blade bears nine denticles. The anterior denticles are broader than those posteriorly. Those adjacent to the cusp are reclined posteriorly, but those further away are oriented vertically.

The basal region of the blade is hyaline in contrast to the white matter of the blade.

Occurrence in the sections. *Histiodella holodentata* is restricted to the *Y. crassus* and *E. pseudoplanus* Zones (Fig. 2).

Histiodella kristinae Stouge, 1984 (Fig. 3C–G)

1984 *Histiodella kristinae*; Stouge, p. 87, pl. 18, figs 1–7, 9–11, fig. 17.
1998 *Histiodella kristinae* Stouge; Zhang, p. 72, pl. 9, figs 16, 17.
2001 *Histiodella holodentata* Ethington & Clark; Ramussen (cum. syn.). p. 84, pl. 7, figs 18, 19.
2001 *Histiodella kristinae* Stouge; Rasmussen (cum. syn.), p. 82, pl. 8, figs 1–3, 5.
2004 *Histiodella* sp.; Zhen & Percival, p. 97, pl. 5, figs G, H.
2004 *Histiodella holodentata* Ethington & Clark; Löfgren, pl. 7, fig. t.
2004 *Histiodella kristinae* Stouge; Löfgren, pl. 7, fig. u.
2005 *Histiodella kristinae* Stouge; Heredia *et al*., pl. 3, fig. O. [2005a].

Material. Twenty-five Pa elements. They occur in the San Juan Formation samples LCH 2: INGEO-MP 111/1 to LCH 3: INGEO-MP 127/ (19 specimens), LChi 4: INGEO-MP 1011/ (1 specimen), LChi 6: INGEO-MP 1037/ (3 specimens) and Las Aguaditas Formation sample Lag 8: CML-C 2006/2 (2 specimens).

Description. The specimens from the Precordillera represent only spathognathodontiform P elements. The cusp is as high as the anterior denticles and is 1.5 times as wide as the width of the anterior denticles. The oral edge is straight to convex. The cusp is situated within the distal third of the whole unit and is reclined. Denticles anterior to the cusp are reclined, but those further away are oriented vertically, and the most anteriorly are proclined. The posterior denticles are fused and reclined parallel to the cusp. The specimens recovered from LCHI have a more robustly developed posterior process bearing

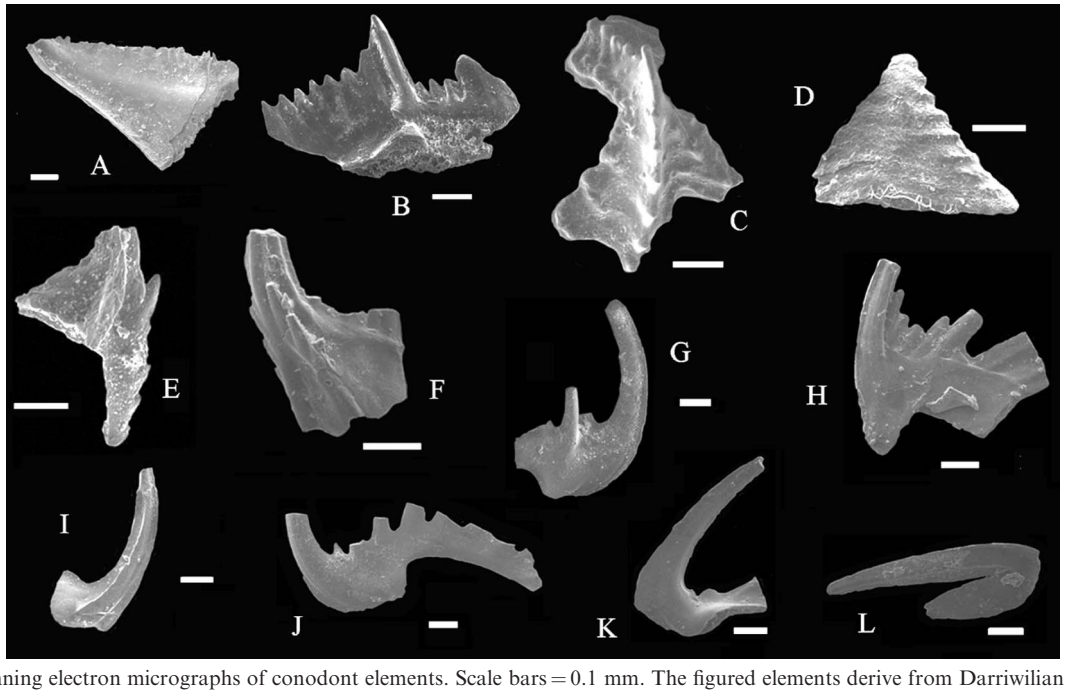

Fig. 4. Scanning electron micrographs of conodont elements. Scale bars = 0.1 mm. The figured elements derive from Darriwilian beds of the San Juan and Las Aguaditas formations, Las Chacritas section. **A**, *Ansella jemtlandica* (Löfgren), S element, San Juan Formation LCH3, INGEO-MP 112/1. **B**, *Bryantodina* sp. aff. *B. typicalis* (Stauffer), Pa element, Las Aguaditas Formation Lag 8, INGEO-MP 184/1. **C**, *Polonodus clivosus* (Viira), Pa element, San Juan Formation LCH5, INGEO-MP 104/1. **D**, *Polonodus galerus* (Albanesi), P element, San Juan Formation LCH4, INGEO-MP 107/1. **E**, **F**, *Baltoniodus medius* (Dzik), Pb and Sa elements, San Juan Formation LCH3, INGEO-MP 201/5; INGEO-MP 201/2. **G**, **J**–**L**, *Paroistodus horridus* (Barnes & Poplavski), San Juan Formation LCH3, **G**, Sb element, INGEO-MP 108/10, **J**, P element, INGEO-MP 108/2, **K**, Sa element, INGEO-MP 108/12; **L**, M element, INGEO-MP 108/5. **H**, *Periodon aculeatus zgierzensis* (Dzik), Sb element, San Juan Formation LCH3, INGEO-MP 109/1. **I**, *Protopanderodus gradatus* Serpagli, c element, San Juan Formation LCH4, INGEO-MP 132/1.

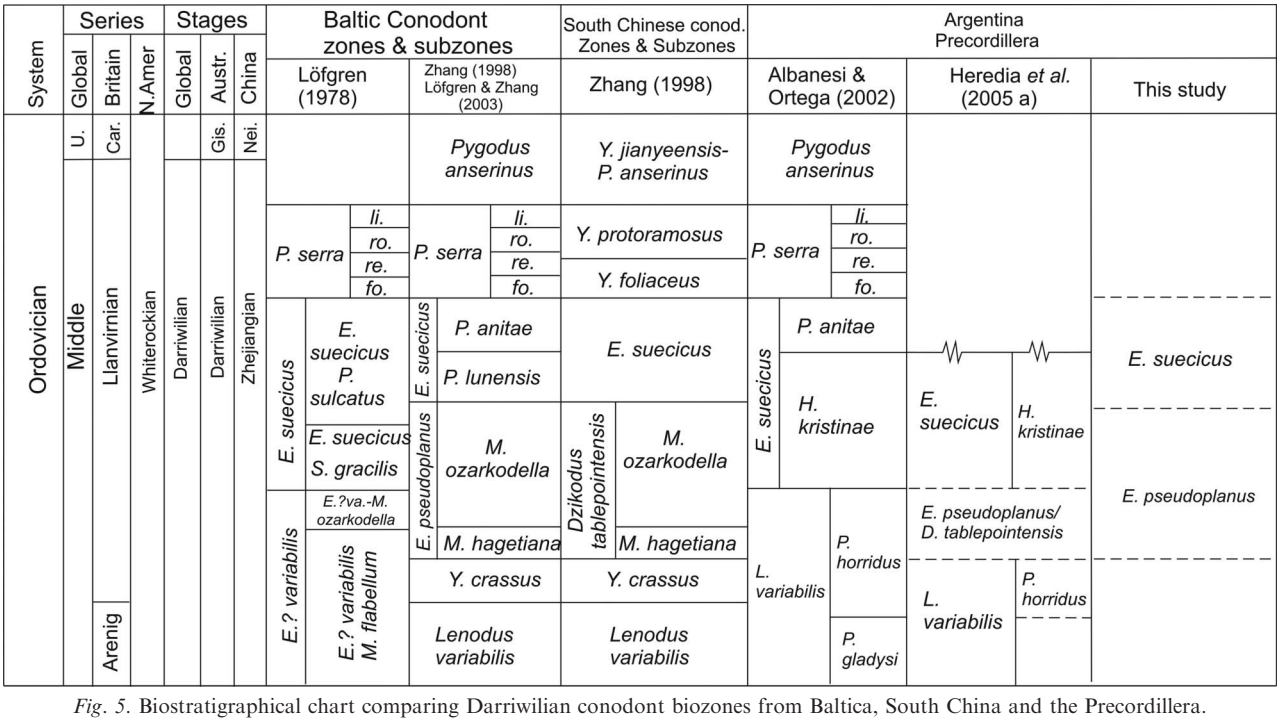

Fig. 5. Biostratigraphical chart comparing Darriwilian conodont biozones from Baltica, South China and the Precordillera.

denticles with a width similar to the anterior examples, and this is identical to the paratype illustrated by Stouge (1984, pl. 18, figs 6, 7). On the other hand, the specimens recovered from LCHA are similar to another paratype illustrated by Stouge (1984, pl. 18, figs 2, 3; Löfgren 2004, pl. 7, fig. u.; Zhang, pl. 9, figs 16, 17).

Occurrence in the sections. The FAD of *Histiodella kristinae* is restricted to the upper part of the *E. pseudoplanus* Zone (Fig. 2).

Discussion

Lehnert (1995), Albanesi & Ortega (2002) and Heredia *et al.* (2005a) mentioned the occurrence of *Histiodella sinuosa*, *H. holodentata* and *H. kristinae* in different sections of the Precordillera. The Darriwilian species discussed here are *H. holodentata* (=*tableheadensis*) and *H. kristinae*.

The *Histiodella tableheadensis* (=*H. holodentata*) and *Histiodella kristinae* zones were defined by Stouge (1984; p. 23, table 3) for Newfoundland. The first is correlative with most of the Baltoscandian *E. variabilis–M. ozarkodella* zones and the second with the *E. suecicus–S. gracilis* Zone (Löfgren 1978), which in terms of current terminology is equivalent to the *E. pseudoplanus* Zone–*M. ozarkodella* Subzone (Zhang 1998, Löfgren 2004).

Lehnert (1995) proposed that the first appearance of *H. kristinae* was coincident with the base of the *E. suecicus* Zone, a criterion followed by Albanesi & Ortega (2002), Heredia *et al.* (2005a) and Ortega *et al.* (2007). The middle Darriwilian of the Argentine Precordillera is subdivided into two conodont zones and four subzones: the *L. variabilis* Zone composed of the lower *Periodon gladysi* and the upper *Paroistodus horridus* subzones, and the *E. suecicus* Zone comprising the lower *Histiodella kristinae* and the upper *Pygodus anitae* subzones (Albanesi *et al.* 1998, Albanesi & Ortega 2002, Heredia *et al.* 2005a, Ortega *et al.* 2007; Fig. 5).

The middle Darriwilian conodont fauna of the LCHA and LCHI sections is very similar at species level to correlative faunas of the Baltic and South China regions (Sarmiento 1985, Albanesi *et al.* 1998, Heredia *et al.* 2005a, Mestre 2010). Nevertheless, the Darriwilian conodont zonation of the Precordillera does not match those established in Baltica and South China (Bagnoli & Stouge 1996, Albanesi & Ortega 2002) because of the poorly resolved distribution of certain index species in the Precordillera.

Stouge (1984) proposed new species of *Histiodella* from the Table Head Formation of Newfoundland, defining *H. tableheadensis* (=*H. holodentata*) and *H. kristinae*. These species occur together in samples TP61 to TP66 that represent 20 m of the Table Point section (Stouge 1984 figs 16, 18) at the base of the *H.*

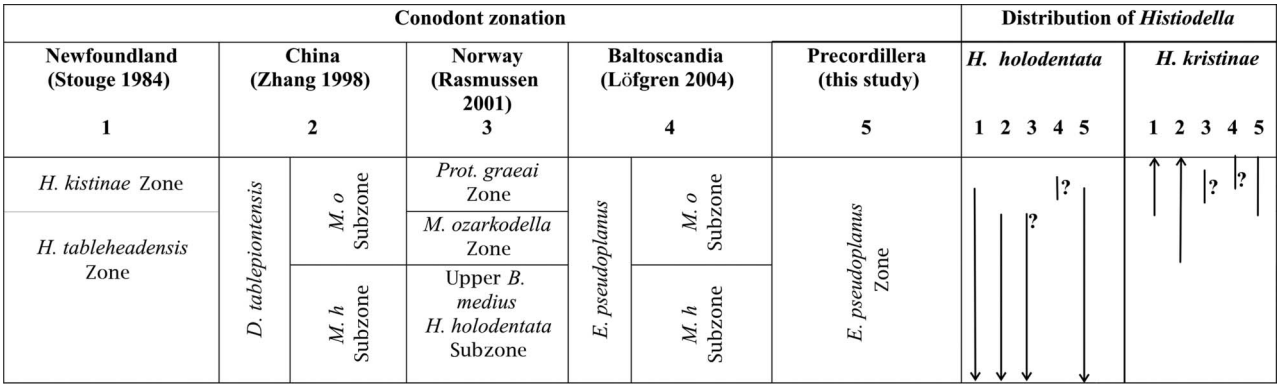

Fig. 6. Comparison chart showing the Darriwilian stratigraphical distribution of *Histiodella holodentata* and *H. kristinae* in Newfoundland, China, Baltoscandia and the Precordillera.

kristinae Phylozone. A similar distribution of these species is apparent at the top of the San Juan Formation in the Precordillera (Fig. 6).

In Baltica, the middle Darriwilian conodont zonation includes four successive zones (Löfgren 2000, 2004, Löfgren & Zhang 2003): *Lenodus variabilis*, *Yangtzeplacognathus crassus*, *Eoplacognathus pseudoplanus* (*M. hagetiana* and *M. ozarkodella* subzones) and *Eoplacognathus suecicus* (*P. lunnensis* and *P. anitae* subzones; Fig. 5). *Histiodella kristinae* and *H. holodentata* have been retrieved from beds of the upper part of the *E. pseudoplanus* Zone; *H. holodentata* is present in the lower–middle part of the upper *M. ozarkodella* subzone, where it co-ranges with *H. kristinae*, the latter persisting into the uppermost level of the *M. ozarkodella* subzone (Löfgren 2004; Fig. 6). Rasmussen (2001) reported the first appearance of *H. kristinae* in the Scandinavian Caledonides at the base of the *Protopanderodus graeai* Zone (Fig. 6). These data should be treated with caution because some of the material illustrated by Löfgren (2004, pl. 7, fig. t) and Rasmussen (2001, pl. 7, figs 18, 19) was originally assigned to *H. kristinae*.

Zhang (1998) erected the *Dzikodus tablepointensis* Zone in South China, divided into the *M. hagetiana* and *M. ozarkodella* subzones (Fig. 5). This zone and its constituent subzones are entirely coeval with the *E. pseudoplanus* Zone. In South China, *H. holodentata* occurs from the *Y. crassus* Zone to the *M. ozarkodella* Subzone, and *H. kristinae* ranges from the base of the *M. ozarkodella* Subzone (Zhang 1998; Fig. 6). A similar distribution for these species was proposed by Du *et al.* (2005) for the Tarim Basin.

In the Argentine Precordillera, *H. kristinae* and *H. holodentata* have their co-occurrence in the LCHA and LCHI sections in the upper part of the San Juan Formation; this co-occurrence had been previously reported by Lehnert (1995) whereby *H. kristinae* and *H. holodentata* occur in the same samples from the top of the San Juan Formation in the Puesto Los Potrerillos section (sample RA780) and Las Chacritas section (sample CH13). On the other hand, the occurrence of *H. kristinae* and *H. holodentata*, associated with *E. pseudoplanus* (late forms), *D. tablepointensis*, *P. graeai* and *M.* sp. cf. *M. ozarkodella*, suggests that all these species co-occurred within a short interval in the upper part of the *E. pseudoplanus* Zone. This represents a similar distribution to that reported in Newfoundland, Baltoscandia and South China regions (Stouge 1984, Zhang 1998, Rasmussen 2001, Löfgren 2004; Figs 2, 6).

Conclusions

Species of *Histiodella* have significant biostratigraphic value in the North American Midcontinental Province. They allow broad biozones to be defined in the Dapingian and Darriwilian stages. However, in the Darriwilian of the Argentine Precordillera, these species constitute a small part of the conodont fauna in the *Y. crassus* and *E. pseudoplanus* zones. For correlation, the Baltic zonal conodonts are currently the best tools in the Argentine Precordillera. Thus, species of *Yangtzeplacognathus*, *Eoplacognathus*, *Dzikodus* and *Microzarkodina* (when present) can give a clear correlation and age control in different areas of the Precordillera.

This biostratigraphical study reveals that the overlapping ranges of *H. holodentata* and *H. kristinae* seem to be restricted to a fairly short interval in the upper part of the *E. pseudoplanus* Zone. The FAD of *H. kristinae* Stouge is accurately positioned in the upper part of the *E. pseudoplanus* Zone, and so the FAD of this species should not be used to define the base of the *E. suecicus* Zone in the Ordovician of the Argentine Precordillera.

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