

# Crustacean microcoprolites from the Upper Jurassic–Lower Cretaceous of the Neuquén Basin, Argentina: Systematics and biostratigraphic implications

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As a result of a microfacial study in the outer and middle ramp deposits of the Vaca Muerta Formation (lower Tithonian–upper Valanginian), four ichnotaxa of crustacean microcoprolites are described: *Palaxius azulensis* Kietzmann isp. nov., *Palaxius caracuraensis* Kietzmann isp. nov., *Helicerina?* isp. A. aff. *Helicerina siciliana* and *Helicerina* isp. B. They represent one of the first records of crustacean microcoprolites for the Neuquén Basin and Argentina. *Helicerina* is reported for the first time from the Upper Jurassic and Lower Cretaceous of South America. It is inferred that *Palaxius* ichnospecies were produced by callianassids, while *Helicerina* ichnospecies could be produced by decapods of Mecochiridae, Erymidae, and/or Nephropidae affinity. Two assemblages of crustacean microcoprolites are recognised, a middle Tithonian to lower Berriasian *Palaxius*-dominated assemblage and an early to late Valanginian *Helicerina*-dominated assemblage.

**Key words:** Crustacean microcoprolites, *Palaxius*, *Helicerina*, Jurassic–Cretaceous, Vaca Muerta Formation, Neuquén Basin, Argentina.

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## Introduction

Some crustaceans produce internally structured microcoprolites. The structures consist of longitudinal canals that, in cross-section, show particular characteristics which allow the discrimination of different ichnotaxa (Brönnimann 1972). The canals are formed by pyloric fingerlets inside the crustacean's gut (Powell 1974). Mass accumulation of these fecal pellets are very common in the Late Jurassic and Early Cretaceous carbonate platforms, and are mostly associated with shallow marine soft sediments (Flügel 2004). However, some studies report also the presence of microcoprolites from outer ramp environments (De Romero and Galea-Alvarez 1995; Schweigert et al. 1997) and, more recently, from deep-sea environments (Peckmann et al. 2007; Senowbari-Daryan et al. 2007; Buchs et al. 2009).

The marine deposits from the Jurassic–Cretaceous boundary interval of the Neuquén Basin contain a rich invertebrate fauna mainly represented by mollusks (Aguirre-Urreta 2003). Crustaceans and their products, however, are poorly known. The remains of decapods from the Mendoza Group (Fig. 1) include palinurids, anomurids and astacideans, which are com-

monly preserved as isolated chelipeds (Aguirre-Urreta 1989, 2003). On the other hand, *Thalassinoides* Ehrenberg, 1944 burrow systems with boxwork-like architecture, typically associated with callianassids (see Bromley 1990), are abundant in certain levels of the Vaca Muerta Formation (Kietzmann and Palma 2009). Crustacean microcoprolites in South America had been reported from Peru, Colombia, Venezuela, and Chile (Förster and Hillebrandt 1984; Senowbari-Daryan and Stanley 1986; Blau et al. 1994, 1995; De Romero and Galea-Alvarez 1995). Recently, the first record of crustacean microcoprolites in the Neuquén Basin was reported by Kietzmann and Palma (in press), who report the presence of *Palaxius decaochetarius* Palik, 1965.

In this paper we present two new microcoprolites ichnospecies of the ichnogenera *Palaxius* Brönnimann and Norton, 1960 (*Palaxius azulensis* Kietzmann isp. nov. and *P. caracuraensis* Kietzmann isp. nov.), together with two possible new ichnospecies of the ichnogenera *Helicerina* Brönnimann and Masse, 1968. Results could be used for comparison with other localities worldwide, and provide biostratigraphic implications to the Jurassic–Cretaceous boundary of the Neuquén Basin.

*Institutional abbreviation.*—CPBA, Colección de Paleontología, Departamento de Ciencias Geológicas, Universidad de Buenos Aires, Argentina.

### Geological setting

During the Late Jurassic and Early Cretaceous, the Neuquén Basin constituted the setting for the development of a wide low-gradient carbonate ramp whose distal facies are represented by lower Tithonian–lower Valanginian middle ramp to basin deposits, which have been named the Vaca Muerta Formation (e.g., Legarreta and Uliana 1991; Scasso et al. 2005; Kietzmann et al. 2008). The proximal facies are represented by lower Valanginian inner ramp deposits and are known as the Chachao Formation (e.g., Legarreta and Uliana 1991; Palma and Lanés 2001; Palma et al. 2008) (Fig. 1).

The samples containing microcoprolites come from different stratigraphic sections of the Vaca Muerta Formation outcropping in the Mendoza province. They have been ob-

tained in levels of middle Tithonian and early Berriasian age (*Aulacosphinctes proximus* to *Substeuroceras koeneni* zones), late Berriasian (*Spiticeras damesi* Zone) and early Valanginian age (*Lissonia riveroi* and *Olcostephanus atherstoni* zones) (Fig. 1). Microcoprolites are found in thin sections of laminated packstones and wackestones, rich in ammonites, bivalves, and radiolarians. These facies are associated with black shales, radiolarian and bioclastic mudstones/wackestones and storm induced calcareous sandstones turbidites (Kietzmann et al. 2008). Originally, many peloids were mentioned previously as peloidal micrites by Scasso et al. (2005) and Kietzmann et al. (2008), and interpreted in some cases as the result of possible microbial activity (Kietzmann and Palma 2009). However, the reexamination of these microfacies in new localities (Fig. 1) indicates that many of these peloidal micrites are actually mass accumulations of microcoprolites.

Two types of preservation are present. The best specimens of microcoprolites are recognised in microcoprolitic grainstones that partially fill the chambers of some ammo-

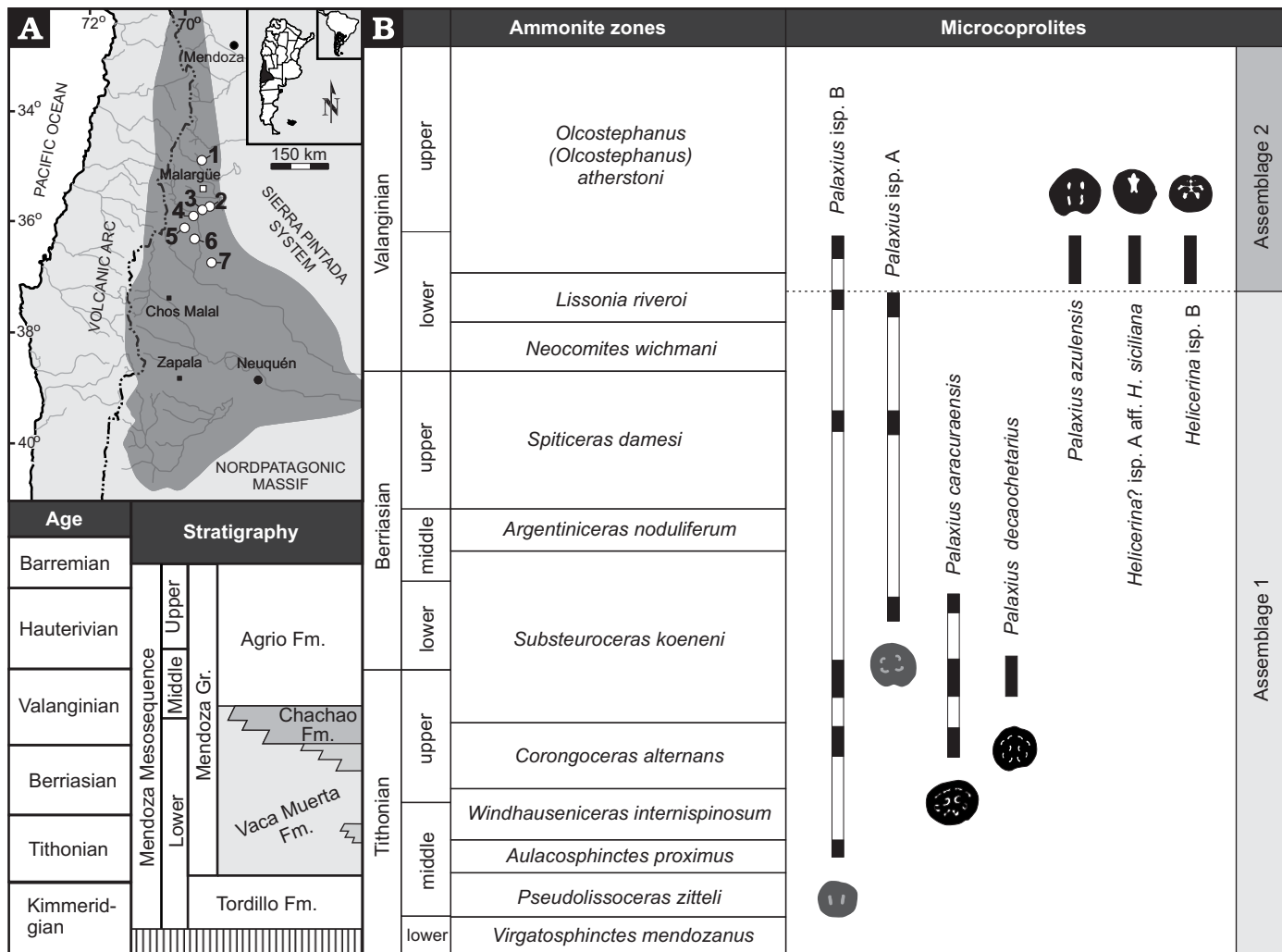


Fig. 1. **A.** Location map of the Neuquén Basin with study localities and a stratigraphic chart of the Mendoza Group. 1, Tres Esquinas; 2, Loncoche creek; 3–4, Bardas Blancas; 5, Rahue creek; 6, Yeso creek; 7, Cara Cura range. **B.** Microcoprolites distribution in the Vaca Muerta Formation. Ammonite Zonation according to Aguirre-Urreta et al. (2008) and Riccardi (2008).

nites. Within these chambers, microcoprolite preservation improves toward the center of the chamber due to an inward gradient in the intensity of calcitic cementation. On the other hand, microcoprolite preservation is generally quite poor in wackestone or packstone microfacies. In such cases, the canals are filled with mud and the edges are diffuse, probably as a consequence of the higher availability of mud, and the effects of compaction.

## Systematic palaeontology

(by D.A. Kietzmann)

Coprolites are considered trace fossils and their nomenclature is governed by the International Code of Zoological Nomenclature (ICZN). However, coprolites are one of those groups of trace fossils whose dependence or independence from the Linnean system is still under discussion. As Bertling et al. (2006) have stated, an amendment of the ICZN will probably be necessary in order to properly apply its nomenclatorial rules to groups such as this one. In addition to the nomenclatorial problem for fossil microcoprolites, the systematic position of fossil crustaceans in the extant groups remains uncertain (Blau and Grün 2000). At present, the ichnotaxonomy most often followed by the experts is the one proposed by Vialov (1978), who introduced the term Favreinidae for canal-bearing coprolites in order to distinguish them from their producers (crustaceans).

The features used for ichnotaxonomic subdivision of canalised microcoprolites are the number, shape and arrangement of the internal canals. Using size of canals as a diagnostic feature may be confusing because in some microcoprolites the canal-system alters during ontogeny (e.g., Schweigert et al. 1997). Presently, there are eleven ichnogenera of microcoprolites attributed to crustaceans (Senowbari-Daryan and Kube 2003). Systematic characteristics and a list of the main ichnotaxa known can be found in Blau and Grün (2000).

### Ichnofamily Favreinidae Vialov, 1978

#### Ichnogenus *Palaxius* Brönnimann and Norton, 1960

*Type ichnospecies:* *Palaxius habanensis* Brönnimann and Norton, 1960, La Habana, Cuba, Miocene.

*Diagnosis.*—The ichnogenus *Palaxius* is characterised by the presence of longitudinal canals with crescent or hook-shaped outline, arranged bilaterally to a symmetry plane (Brönnimann 1972).

*Remarks.*—The ichnogenus *Palaxius* contains 27 known ichnospecies from the Late Carboniferous to the Miocene, including the 2 new ichnospecies described in this paper (cf. Senowbari-Daryan and Kube 2003; Senowbari-Daryan et al. 2007; Buchs et al. 2009). *Palaxius biserialis* (Kristan-Tollmann, 1989) has been reported for the Tithonian and *P. decaochetarius* Palik, 1965, and *P. tetraochetarius* Palik, 1965 from the Berriasian–Valanginian interval.

#### *Palaxius azulensis* Kietzmann isp. nov.

Fig. 2A.

*Etymology:* Named after the Sierra Azul range, where the new ichnospecies was found.

*Holotype:* The specimen presented in Fig. 2A, thin section CPBA-N° 20675.

*Type locality:* Rahue creek, Mendoza province, Argentina (36°01.762'S, 69°59.393'W).

*Type horizon:* Vaca Muerta Formation, *Olcostephanus* (*Olcostephanus*) *atherstoni* Zone, at approximately 340 m from the base.

*Diagnosis.*—Ichnospecies of the ichnogenus *Palaxius* with four internal canals clustered around a symmetry plane (2:2). It is differentiated from all other four-canaled *Palaxius* ichnospecies by the orientation of the canals (Fig. 2A).

*Material.*—Eight specimens: thin sections CPBA-N° 20675, CCPBA-N° 20676.

*Description.*—Rod-like microcoprolite with ventral groove and a cross section of 300 to 500 µm in diameter. Internally, it shows four canals. These are arranged bilaterally to the symmetry plane in two groups (2:2), each consisting of a dorsal canal (canal 1) and a ventral canal (canal 2). The canals have a crescent shaped outline, 100 µm long and 30 µm wide, with their concave side facing the symmetry plane, and with extremities characterised by rounded protuberances. Canal 1/1' is displayed at a 60° angle from the bilateral symmetry plane, while canal 2/2' is at a 90° angle (Fig. 2).

*Comparisons.*—*Palaxius azulensis* Kietzmann isp. nov. differs from *P. caucaensis* Blau, Moreno, and Senff, 1995, *P. kumaensis* Senowbari-Daryan and Silantiev, 1991, *P. tetraochetarius* Palik, 1965, and *P. osaensis* Buchs, Guex, Stucki, and Baumgartner, 2009 because of its cross-section morphology and the arrangement of the canals (Fig. 3). The only ichnospecies with ventral groove and crescent-shaped canals with their concave side facing the symmetry plane is *P. salataensis* Brönnimann, Cros, and Zaninetti, 1972, that can be distinguished by the orientation of canals 2 and 2', which are orientated at 45° in *P. salataensis* and at 90° in *P. azulensis* in respect to the center of the microcoprolite.

*Stratigraphic and geographic range.*—The new ichnospecies was recognised at different levels corresponding to the *Lissonia riveroi* and *Olcostephanus* (*Olcostephanus*) *atherstoni* zones (Valanginian) in the Rahue creek and Yeso creek (Sierra Azul range) sections of the Vaca Muerta Formation (Fig. 1). Other poorly preserved microcoprolites (Favreinidae indet.) have been recognised in the *Aulacosphinctes proximus* (middle Tithonian) and *Spiticeras damesi* (late Berriasian) zones (Fig. 1), so the presence of this ichnotaxon in levels of Tithonian and Berriasian age is possible.

#### *Palaxius caracuraensis* Kietzmann isp. nov.

Fig. 2B.

*Etymology:* After the Cara Cura range, where the new ichnospecies was found.

*Holotype:* The specimen illustrated in Fig. 2B, thin section CPBA-N° 20689.



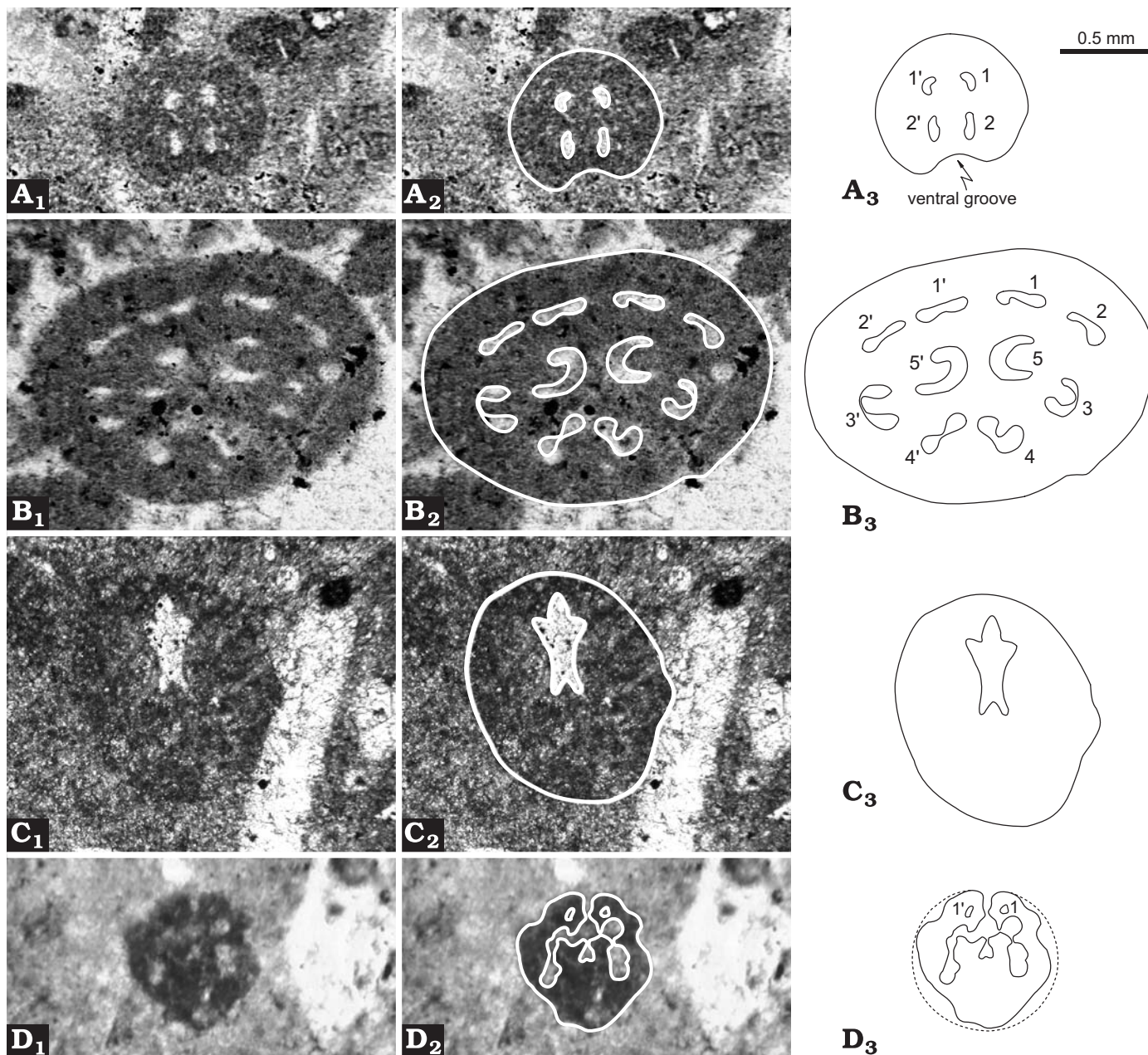


Fig. 2. Transversal section of crustacean microcoprolites from the Vaca Muerta Formation. **A.** *Palaxius azulensis* Kietzmann isp. nov. (CPBA-N° 20675, early Valanginian, Rahue creek). **B.** *Palaxius caracuraensis* Kietzmann isp. nov. (CPBA-N° 20689, late Tithonian, Cara Cura range). **C.** *Helicerina?* isp. A aff. *Helicerina siciliana* Senowbari-Daryan, Schäfer, and Catalano, 1979 (CPBA-N° 20675, early Valanginian, Rahue creek). **D.** *Helicerina* isp. B (CPBA-N° 20675, early Valanginian, Rahue creek).

*Type locality:* La Tosca creek, Cara Cura range, Mendoza province, Argentina (36°40'12.28''S, 69°40'13.21''W).

*Type horizon:* Vaca Muerta Formation, *Substeueroceeras koeneni* Zone, 170 m from the base.

*Diagnosis.*—Species of the genus *Palaxius* with ten canals clustered around a symmetry plane (2-3:3-2). It differs from comparable ichnospecies (*P. habanensis* Brönnimann and Norton, 1960 and *P. decaochetarius* Palik, 1965) in the orientation of canals 1 and 2 in respect to the center of the coprolite, and the different morphology of canals 4 and 5 (Fig. 2B).

*Material.*—Six specimens from thin section CPBA-N° 20689 and nine specimens from thin section CCPBA-N° 20690, 20691, 20692.

*Description.*—Microcoprolite with circular to oval cross section. The holotype has a diameter of 1,300  $\mu$ m in cross section parallel to the symmetry plane and 1,800  $\mu$ m perpendicularly to it. Internally, it shows ten canals arranged in two bilaterally symmetric groups of five canals (2-3:3-2). Each group consists of two “dorsal” canals (canals 1 and 2) and three “ventral” canals (3/3', 4/4' and 5/5'). Observed perpendicularly to the symmetry plane, canals 1/1' and 2/2' are

crescent shaped and their concave sides face the symmetry plane, canal 3/3' is sickle shaped with its concave side towards the symmetry plane, while canals 4/4' and 5/5' are sickle shaped and their convex sides face the symmetry plane. Canals are 250  $\mu\text{m}$  long and 60–80  $\mu\text{m}$  wide. Their extremities show rounded protuberances. Canal 1/1' is orientated at 20° from the bilateral symmetry plane; canals 2/2' and 4/4' are at 45°; canal 3/3' is at 120°, and canal 5/5' is at 90°. In none of our specimens was a ventral groove observed.

**Comparisons.**—Other five ichnospecies with ten canals are known (Fig. 3). The new ichnospecies presents similarities with *P. habanensis* and *P. decaochetarius*. It is differentiated from *P. habanensis* by the direction of canals 1/1' and 2/2', as well as by the morphology of canals 4/4' and 5/5', which are crescent shaped in *P. habanensis* and sickle shaped in *P. caracuraensis* Kietzmann isp. nov. It differs from *P. decaochetarius* in the morphology of canals 4/4' and 5/5' which are crescent shaped in *P. decaochetarius*, and also in size and width of the canals.

**Stratigraphic and geographic range.**—The new ichnospecies was recognised in levels corresponding to the *Corongoceras alternans* (lower late Tithonian) and *Substeueroeceras koeneni* (upper late Tithonian–early Berriasian) zones, in the Cara Cura range section, Vaca Muerta Formation (Fig. 1). Similar but poorly preserved microcoprolites were documented in the same levels but in the Loncoche creek, Chihuido slope, and Yeso creek sections.

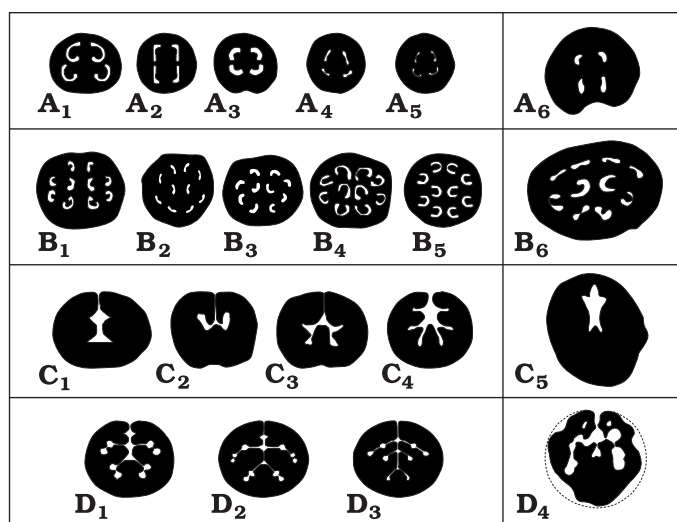


Fig. 3. Schematic diagrams of the different ichnospecies of *Palaxius* and *Helicerina* mentioned in this work (Modified from Blau and Grün (2000), not to scale). **A.** *Palaxius* ichnospecies with 4 canals: *Palaxius caucaensis* (A<sub>1</sub>), *P. kumaensis* (A<sub>2</sub>), *P. salataensis* (A<sub>3</sub>), *P. tetraochetarius* (A<sub>4</sub>), *P. osaensis* (A<sub>5</sub>), and *P. azulensis* Kietzmann isp. nov. (A<sub>6</sub>). **B.** *Palaxius* ichnospecies with 10 canals: *Palaxius colombiensis* (B<sub>1</sub>), *P. decaochetarius* (B<sub>2</sub>), *P. habanensis* (B<sub>3</sub>), *P. decemlunulatus* (B<sub>4</sub>), *P. decemporatus* (B<sub>5</sub>), and *P. caracuraensis* Kietzmann isp. nov. (B<sub>6</sub>). **C.** *Helicerina* ichnospecies with simple canals: *Helicerina siciliana* (C<sub>1</sub>), *H. alata* (C<sub>2</sub>), *H. spinosa* (C<sub>3</sub>), *H. keuperiana* (C<sub>4</sub>), and *Helicerina* isp. A aff. *H. siciliana* (C<sub>5</sub>). **D.** *Helicerina* isp. with multiple canals: *Helicerina ruttei* (D<sub>1</sub>), *H. kaina-chensis* (D<sub>2</sub>), *H. kalakya* (D<sub>3</sub>), and *Helicerina* isp. B (D<sub>4</sub>).

### Ichnogenus *Helicerina* Brönnimann and Masse, 1968

**Type ichnospecies:** *Helicerina spinosa* Brönnimann and Masse, 1968, southern France, late Barremian lower Aptian.

**Diagnosis.**—The ichnogenus *Helicerina* is characterised by triangular or diamond-shaped canals within the symmetry plane of cross sections. Laterally, rounded shaped canals can develop from spine-like extensions of the central canals (Brönnimann and Masse 1968 emended by Schweigert et al. 1997).

**Remarks.**—This ichnogenus contains 7 ichnospecies (Fig. 3) known from the Middle Triassic to the Miocene (Schweigert et al. 1997; Blau and Grün 2000), but only *H. siciliana* Senowari-Daryan, Schäfer, and Catalano 1979 is known from the Jurassic (Upper Triassic and Middle Jurassic; see Schweigert et al. 1997). Two possibly new ichnospecies are described herein.

#### *Helicerina?* isp. A aff. *Helicerina siciliana* Senowari-Daryan, Schäfer, and Catalano 1979

Fig. 2C.

**Material.**—Four poorly preserved specimens of thin section CPBA-N° 20675, 20676, Rahue creek (Fig. 1, 36°01.762'S, 69°59.393'W).

**Description.**—Microcoprolite with circular outline and a cross section of 900  $\mu\text{m}$  in diameter. The specimen is characterised by one canal which lies in the symmetry plane. This canal can be compared with the canal developed in *Helicerina siciliana* Senowari-Daryan, Schäfer, and Catalano, 1979. In contrast to *Helicerina siciliana* the canal in *Helicerina?* isp. A is not clearly separated in distinct canals (in *Helicerina siciliana*: a dorsal diamond shaped and a ventral triangular shaped canal) but seems to form one “unit”.

Contrary to all other known *Helicerina* ichnospecies the canal shows no connection to the “outside of the coprolite” (terminology according to Senowari-Daryan and Bernecker 2005). However, this connection is very thin and can be closed. If additional findings will confirm the lack of connection, our specimen belongs to a new ichnogenus and -species.

**Stratigraphic and geographic range.**—*Helicerina* isp. A aff. *Helicerina siciliana* was recognised in levels corresponding to the *Lissonia riveroi* and *Olcostephanus* (*Olcostephanus*) *atherstoni* zones (early Valanginian) of the Vaca Muerta Formation.

#### *Helicerina* isp. B

Fig. 2D.

**Material.**—Four specimens in thin section CPBA-N° 20675, 20676, Rahue creek (Fig. 1, 36°01.762'S, 69°59.393'W).

**Description.**—Microcoprolite with circular outline and a cross section of 500 to 800  $\mu\text{m}$  in diameter. Due to the poor state of preservation it is not possible to accurately determine the exact shape and number of canals. However, it is possible to notice three canals in the symmetry plane interconnected by



a pronounced dorsal groove; and some canals interconnected by thinner grooves, two of them joined to the first angular canal at each side of the symmetry plane (Fig. 2D).

*Comparisons.*—*Helicerina* isp. B shares similarities with *H. kainachensis* Fenninger and Hubmann, 1994 from the Santonian–Campanian and with *H. ruttei* Schweigert, 1997 (see Fig. 3) from the Miocene. Even when the preservation of the samples does not allow their proper classification, the ichnospecies from the Vaca Muerta Formation presents a circular canal joined to the first angular canal at each side of the symmetry plane, which permits to assure that it is a possible new ichnospecies.

*Stratigraphic and geographic range.*—*Helicerina* isp. B was recognised in levels corresponding to the *Lissonia riveroi* and *Olcostephanus (Olcostephanus) atherstoni* zones (early Valanginian) of the Vaca Muerta Formation (Fig. 1).

## Discussion

A generic/specific level identification of the microcoprolite producers becomes impossible when body fossils are not present. However, some crustacean microcoprolites allow identification of the producers at the family level (Schweigert et al. 1997). At the present time, the ichnogenus *Palaxius* is produced by the genera *Callianassa* and *Protocallianassa* (Moore 1939; Blau and Grün 2000), and this association is also known from the fossil record (Peckmann et al. 2007). According to Blau et al. (1993) the ichnogenera *Payandea* and *Thoronetia* can be associated with the family Galatheididae, while the ichnogenera *Favreina*, *Parafavreina*, and *Palaxius* with the family Thalassinidae. On the other hand, *Helicerina* has been found in association with decapods of the genus *Proballaya* (family Potamididae, Schweigert et al. 1997).

The distribution of crustacean fossils in the Mendoza Group has been described by Aguirre-Urreta (1989, 2003) and Aguirre-Urreta et al. (2008). Astacideans have been reported for the Berriasian and the Valanginian, while palinurids are represented in the late Valanginian. However, anomurids are the most abundant decapods in the Mendoza Group rocks (Fig. 1) and have been recognised in middle Tithonian of the Vaca Muerta Formation (Leanza and Zeiss 1990), as well as in the late Berriasian and early Valanginian deposits (Aguirre-Urreta 1989). These last records have been assigned by Aguirre-Urreta (2003) to *Callianassa* aff. *peruviana*.

Together with the four new ichnospecies described in this paper and the ichnospecies *P. decaochetarius* Palik, 1965 described in Kietzmann and Palma (in press), other poorly preserved *Palaxius* microcoprolites were observed in the Vaca Muerta Formation. They appear to have 2 or 4 canals and probably correspond to *P. groesseri* Blau, Grün, and Senff, 1993 (*Palaxius* isp. B in Fig. 1) and *P. salataensis* Brönnimann, Cros, and Zaninetti, 1972 (*Palaxius* isp. A in Fig. 1). According to the distribution of crustacean fossils in the

Tithonian–Valanginian deposits (Aguirre Urreta 1989, 2003; Leanza and Zeiss 1990), it can be inferred that *Palaxius* ichnospecies were produced by callianassids, while *Helicerina* ichnospecies could be produced by *Meyerella rapax* (Mecochiridae), *Eryma* sp. (Erymidae) and/or *Hoparia* sp. (Nephropidae).

Although the biostratigraphic utility of crustacean microcoprolites is currently in discussion (Schweigert et al. 1997; Senowbari-Daryan and Kube 2003), this study seeks to assess a possible contribution to the biostratigraphy of the Neuquén Basin. Blau et al. (1993) proposed that crustacean coprolites could be considered as stratigraphic correlation fossils, since the larvae of the crustaceans can easily migrate through the oceans. In effect, these authors correlated deposits from the Late Triassic and Early Jurassic of the western margin of Gondwana (Colombia) with successions from the western Tethys (Austria and Italy) using *Parafavreina thoronetensis*, *Favreina martellensis*, and *Thorontia quinaria*. Arguments of Schweigert et al. (1997) are based on the fact that the most simple ichnospecies have a much broader temporal range than the more complex ones. In effect, these idiosyncracies of ichnospecies morphology and distribution have been recognised by Senowbari-Daryan and Kube (2003) in their revision of the ichnogenus *Palaxius*, and have been attributed to different ontogenetic stages (Senowbari-Daryan and Kuss 1992; Schweigert et al. 1997), and to the differential evolutionary rate between the decapod morphology and their digestive system (Schweigert et al. 1997).

Taking into account these constraining characteristics of the crustaceans, the stratigraphic value of the microcoprolites may be of significance. The distribution of the microcoprolites in the Mendoza Group does not allow us to place the Jurassic–Cretaceous boundary in Mendoza Group sequence. However, there is a clear difference between the assemblage of crustacean microcoprolites from the middle Tithonian to early Berriasian (*Aulacosphinctes proximus* to *Substeueroceras koeneni* zones) and the assemblage from the Valanginian (*Lissonia riveroi* to *Olcostephanus (Olcostephanus) atherstoni* zones) (Fig. 1). Assemblage 1 is composed of *Palaxius caracuraensis* Kietzmann isp. nov., *Palaxius decaochetarius* Palik, 1965, *Palaxius* isp. (A and B), and other Favreinidae microcoprolites. Assemblage 2 is composed of *P. azulensis* Kietzmann isp. nov., *Helicerina* isp., *Palaxius* isp. B, and other Favreinidae microcoprolites. Despite poor temporal resolution, microcoprolite assemblages could be useful in subsurface studies, where other biostratigraphical information (such as ammonite biozones) is not easily established. Hopefully, future studies in other sectors of the basin will improve and/or corroborate the biostratigraphic utility of microcoprolites in these rocks.

## Conclusions

In this paper four new ichnotaxa (two formal, two informal) of crustacean microcoprolites from the Neuquén Basin are de-

scribed (*Palaxius azulensis*, *P. caracuraensis*, *Helicerina*? isp. A aff. *H. siciliana*, and *Helicerina* isp. B). They constitute the first record of the ichnogenera *Palaxius* and *Helicerina* for the Upper Jurassic and Lower Cretaceous of South America. Considering the distribution of the crustacean microcoprolites in the Vaca Muerta Formation, there is a noticeable change in the composition of the assemblages from the Tithonian–lower Berriasian, dominated by *Palaxius*, and from the Valanginian, dominated by *Helicerina*. It is inferred that the ichnogenus *Palaxius* was produced by callianassids, while *Helicerina* may be associated with Mecochiridae, Erymididae and/or Nephropidae. The use of crustacean microcoprolites as a correlation tool is questionable and only applicable to large stratigraphic intervals. However, this work establishes the possibility of discriminating two microcoprolites assemblages, one of the Tithonian to early Valanginian and another one from the early to the late Valanginian, that could be useful in local subsurface studies.

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