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New chitinozoan species from the Devonian of the Paraná Basin, south Brazil, and their biostratigraphic significance

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Abstract. Devonian chitinozoans from two wells in the north-northwestern outcrop belt of the Paraná Basin, and three in the eastern outcrop belt of the same basin, have been investigated for this study. A new, hitherto undescribed chitinozoan assemblage of Early Devonian, pre-late Emsian age is recognized above the *Ramochitina magnifica* Lange interval range Zone, in addition to new species from younger Devonian beds. A new Early Devonian biozone, the *Ancyrochitina pachycerata* interval range Zone, is erected. Altogether, 16 new species are described of which 10 are left in open nomenclature due to insufficient number of well-preserved specimens. The biostratigraphy of the new chitinozoan species is compared with the chitinozoa and miospore zones previously recognized in the Paraná Basin, and to standard conodont zonation.

Resumen. NUEVAS ESPECIES DE QUITINOZOOS DEL DEVÓNICO DE LA CUENCA DE PARANÁ, SUR DE BRASIL, Y SU SIGNIFICADO BIOESTRATIGRÁFICO. Se han estudiado quitinozoos devónicos de dos sondeos en el cinturón de afloramientos del nor-noroeste de la cuenca de Paraná, y de tres sondeos en el cinturón de afloramientos oriental de la misma cuenca. Se ha identificado una nueva asociación de quitinozoos, no descrita anteriormente para el Devónico inferior, con edad anterior al Emsiano tardio, y situada por encima de la Zona de rango interval de *Ramochitina magnifica* Lange, además de otras nuevas especies en capas devónicas más jóvenes. Se describe y propone una nueva biozona para el Devónico inferior: la Zona de rango interval de *Ancyrochitina pachycerata*. En conjunto, se describen 16 nuevas especies, de las cuales 10 quedan en nomenclatura abierta debido al insuficiente número de especímenes bien preservados. Se compara la bioestratigrafía de las nuevas especies de quitinozoos con las zonas de quitinozoos y esporas previamente identificadas en la cuenca de Paraná, y con la zonación estándar de conodontos.

Key words. Devonian. Chitinozoa. Paraná Basin. Brazil.

Palabras clave. Devónico. Quitinozoa. Cuenca de Paraná. Brasil.

Introduction

For a general introduction to the Devonian geology of the Paraná Basin, good reviews have been published by Lange and Petri (1967), Melo (1988), Grahn (1992), Milani and Thomaz Filho (2000), and Grahn *et al*. (2000, 2002). The Paraná basin is the largest sedimentary basin in South America and covers 1.000.000 km² in south Brazil, 100.000 km² in east Paraguay, 100.000 km² in central Uruguay, and 400.000 km² in northeast Argentina. The two latter areas are also referred to as the Chaco-Paraná Basin (Grahn, 2003). The Paraná Basin in Brazil is subdivided into two sub-basins: the Alto Garças Sub-basin in the north, and the Apucarana Sub-basin in the south (figure 1). Devonian rocks are exposed in narrow belts on the north-northwestern and northeastern margins of the Alto Garças Sub-basin, and on the eastern margin of the Apucarana Sub-basin (figure 1). Two of the investigated wells in this study (RVR-1 and RSP-1) are situated within the outcrop belt in the north-northwestern part of the Alto Garças Sub-basin. Here, early Devonian rocks are commonly exposed, and a continuous sedimentation from latest Eifelian to late Frasnian have been described from well RSP-1 (Burjack *et al*., 1987; Loboziak *et al*., 1988; Burjack and Paris, 1989; Oliveira, 1991; Grahn *et al*., 2002). Three of the wells (9-PPG-2-PR, 9-PPG-6-PR and 9-PPG-7-PR) are situated within the eastern outcrop belt in the Apucarana Sub-basin (figure 1). The present paper presents partial results of a Master thesis by Gaugris (2004).

Material and methods

Altogether, 97 samples from wells RVR-1, RSP-1, 9-PPG-2-PR, 9-PPG-6-PR, and 9-PPG-7-PR (figures 2-

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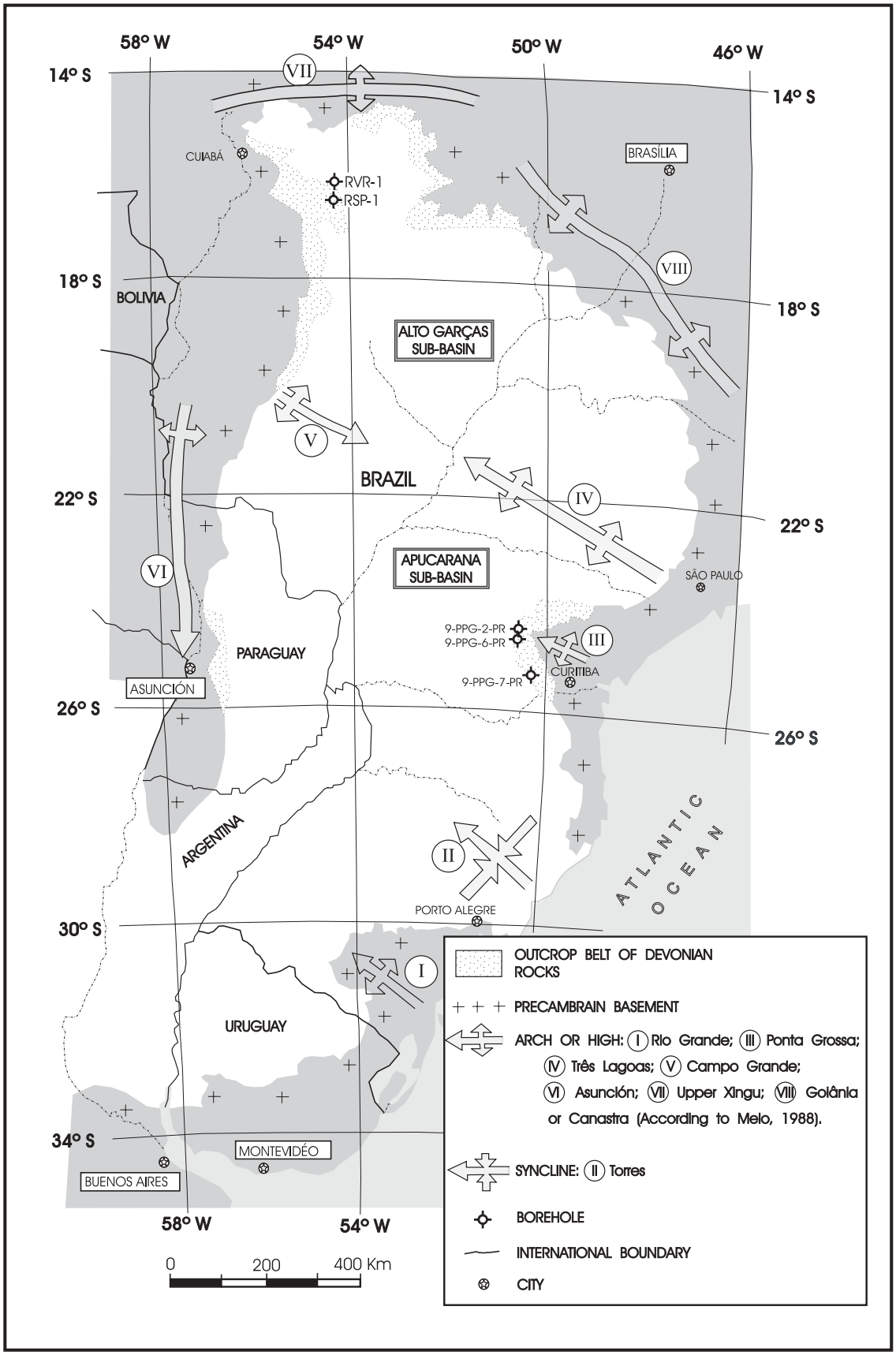

Figure 1. Map showing the geographic position of the investigated wells in the Paraná Basin. Dark grey colour symbolizes older pre-Cambrian terrain / *mapa mostrando la posición geográfica de los pozos investigados en la Cuenca de Paraná. El color gris oscuro representa terrenos precámbricos más antiguos.*

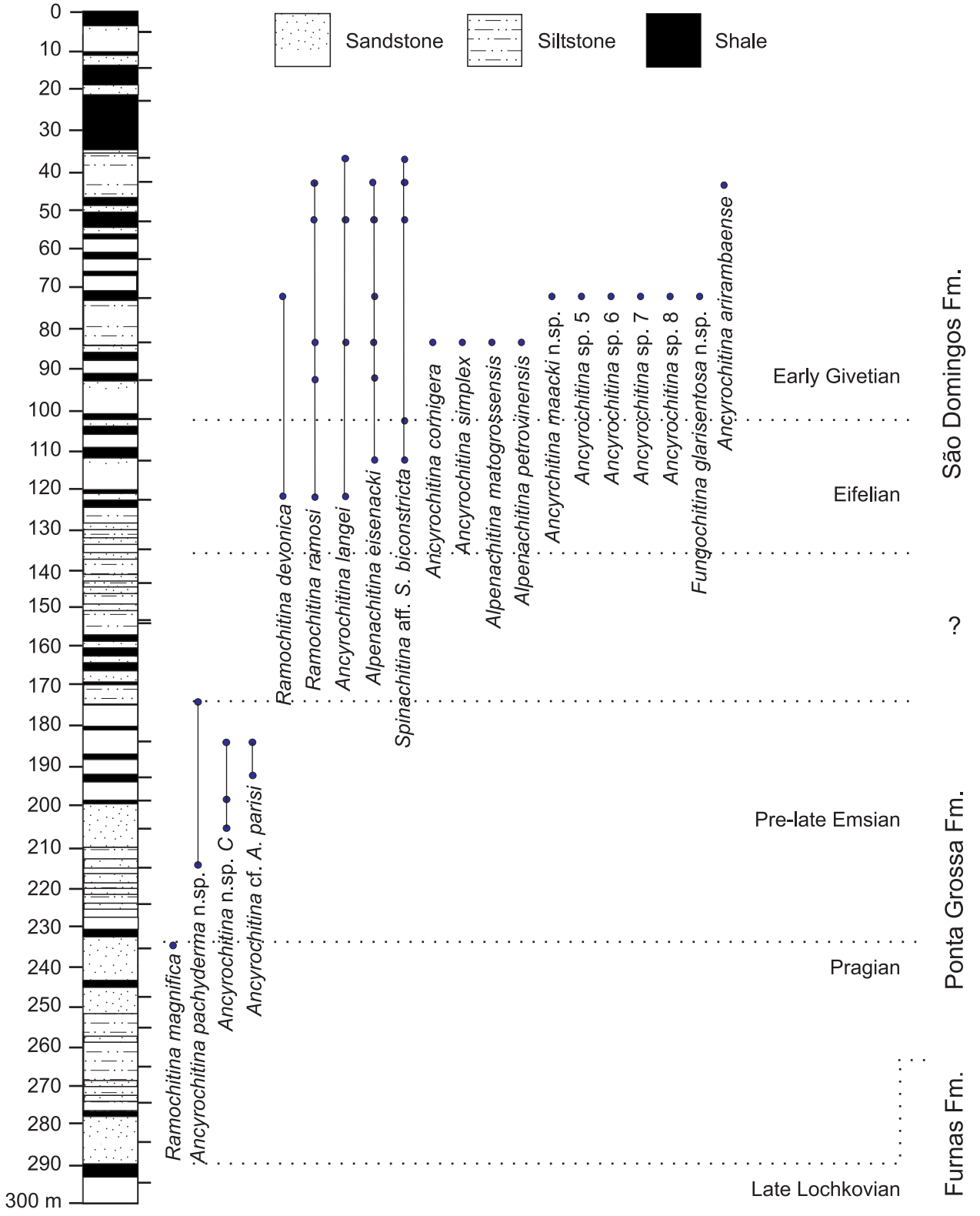

Figure 2. Lithologic column and chitinozoan range chart for the RVR-1 well / *columna litológica y cuadro de rangos de quitinozoos para el pozo RVR-1.*

4) have been investigated from the north-northwestern and eastern outcrop-belts of the Paraná Basin. Most of these samples yielded chitinozoans. Wells RVR-1 and RSP-1 were drilled by Companhia Rio Doce Geologia e Mineração S.A. (DOCEGO) in the 1970´s and 80´s, and the PPG wells in the 1990´s by

PETROBRAS. The residues were studied for chitinozoans using a binocular stereoscopic microscope, and representative chitinozoan specimens picked for scanning electron microscope (SEM) studies in co-operation with the Applied Biostratigraphy and Paleoecology Management (BPA) at PETROBRAS Research and Development Center (CENPES) in Rio de Janeiro, Brazil, and Géosciences, Université de Rennes, Rennes, France. Sample processing and SEM-preparations were done according to the techniques described by Laufeld (1974) and Paris (1981). All photographed chitinozoans are stored at the Department of Stratigraphy and Paleontology at Universidade do Estado do Rio de Janeiro (UERJ/DEPA).

Localities and chitinozoan biostratigraphy

The localities in this study (see below) covers the Ponta Grossa and São Domingos formations (*sensu* Grahn *et al*., 2000, 2002) of the Paraná Basin. Chitinozoans from these formations have earlier been described or discussed by Burjack and Paris (1989), Costa (1966, 1971), Grahn (1992, 1999), Grahn *et al*. (2000, 2002), Lange (1949, 1967), Milani and Daemon (1992), and Sommer (1963).

Well RVR-1 (São José do Povo) was drilled ca. 11 km north of the city of São José do Povo, State of Mato Grosso (figures 1-2). The total depth is 300m, and the Ponta Grossa and São Domingos formations are represented between 21.20 and 289 m (Oliveira, 1991). The lithologies consists of sandstones with interbedded shales and siltstones. No chitinozoan information is available from the Emsian -Eifelian and Eifelian-Givetian transitions. However, the first spores of a middle Devonian affinity (*Duvernaysphaera angelae* Deunff, *Emphanisporites annulatus* MCGregor, *Estiastra* cf. *rhytidoa* Wicander and Wood, *Hemirupta legaulti* Ottone) occur at 133.90 m (J.H. Melo, pers. comm.). Between 164.00 and 235.80 m occurs a spore assemblage lacking diagnostic late Emsian or younger Devonian species (J.H. Melo, pers. comm., 2004), and contains long-ranging acritarch and spore species known from the Early Devonian elsewhere (e.g. *Archaeozonotriletes chulus* (Cramer) Richardson and Lister, *Emphanisporites rotatus* MCGregor, *Palacanthus ledanosii* (Deunff) Playford, *Polyedrixium pharaone* Deunff, *Schizocystia saharica* Jardine *et al*., *Triangulina alargarda* Cramer, and others. The chitinozoans in this interval are tentatively correlated with a latest Pragian-pre-late Emsian age. The presence of *Ramochitina magnifica* Lange at 235.80 m indicates an older Pragian age for that level.

Well RSP-1 (Serra da Petrovina) was drilled in Serra da Petrovina (16° 42′ 6.3′′ S, 54° 12′ 37.8′′ W), State of Mato Grosso (figures 1, 3). The total depth is 365m, and the São Domingos formations is represented from 4.70 m downwards (Oliveira, 1991). The lithologies are interbedded siltstones and shales with intercalating sandstone beds. The well has been investigated for spores by Loboziak *et al*., (1988) and acritarchs (Oliveira, 1991). The chitinozoan (Grahn *et al*., 2002) information supports the spore stratigraphy. The new chitinozoan information in this investigation does not change the biostratigraphic results of Grahn *et al*. (2002).

All of the PPG wells represent the lower part of the Ponta Grossa Formation, and yield a badly preserved and sparse acritarch and spore flora in addition to the chitinozoans. Present are long-ranging palynomorph species as *Bimerga bensonii* Wood, *Dactylofusa fastidiona* (Cramer) Fensone *et al*., 1990 nov. comb., *Pterospermella onondagaensis* (Deunff) Fensome *et al*., 1990 nov. comb., *Exochoderma irregularis* Wicander, *Polyedrixium fragolosum* Playford, *Schizocystia saharica*, *Triangulina alargada*, *Cirratriradites diaphanous* Steemans, *Synorisporites tripapillatus* Richardson and Lister and others (J.H. Melo, pers. comm.). The presence of *Dactylofusa fastidiona* and *Dictyotriletes* spp., and the absence of younger Devonian index species tentatively date the assemblage as Pragian-earliest Emsian (J.H. Melo, pers. comm.). The chitinozoan fauna consists exclusively of *Ancyrochitina* species and is described for the first time.

Well 9-PPG-2-PR (Project Ponta Grossa nº 2) was drilled ca. 5 km SE of Tibaji, State of Paraná (figures 1, 4). The total depth is 117.50 m. The lithologies consist of silty shales with interbedded sandstones, and to a minor part silty sandstones.

Well 9-PPG-6-PR (Project Ponta Grossa nº 6) was drilled ca. 8 km S of Tibaji, State of Paraná (figures 1, 4). The total depth is 80.70 m. The lithologies are predominantly silty shales with interbedded silty sandstones in the lower part.

Well 9-PPG-7-PR (Project Ponta Grossa nº 7) was drilled ca. 12 km SE of Ponta Grossa, State of Paraná (figures 1, 4). The total depth is 138.28 m. The lithologies are predominantly silty shales with interbedded silty sandstones.

Systematic paleontology

Sixteen new chitinozoan species were identified in the present study. Those with less than 5 well-preserved specimens are left in open nomenclature. Most of the specimens recovered are compressed, and a correction factor of 0.8 (Paris, 1981; Jaglin, 1986) was used to calculate their uncompressed dimensions (values given within brackets). The taxonomy follows that proposed by Paris *et al*. (1999).

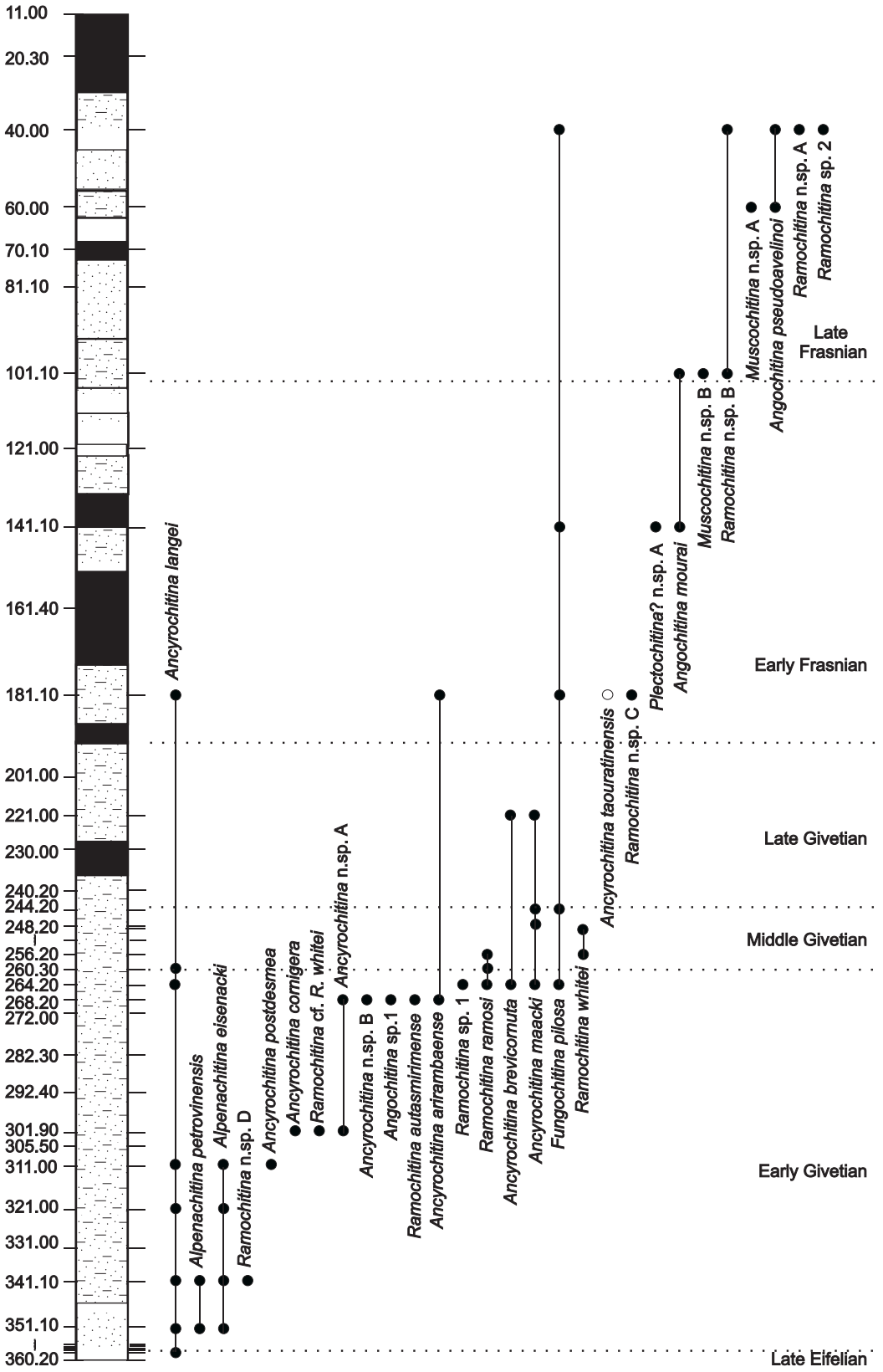

Figure 3. Lithologic column and chitinozoan range chart for the RSP-1 well. Open circle indicates probably reworked specimens. For complementary chitinozoan information, see Grahn *et al*. (2002) / *columna litológica y cuadro de rangos de quitinozoos para el pozo RSP-1. El círculo blanco indica especímenes probablemente retrabajados. Para más información sobre quitinozoos, véase Grahn* et al. *(2002).*

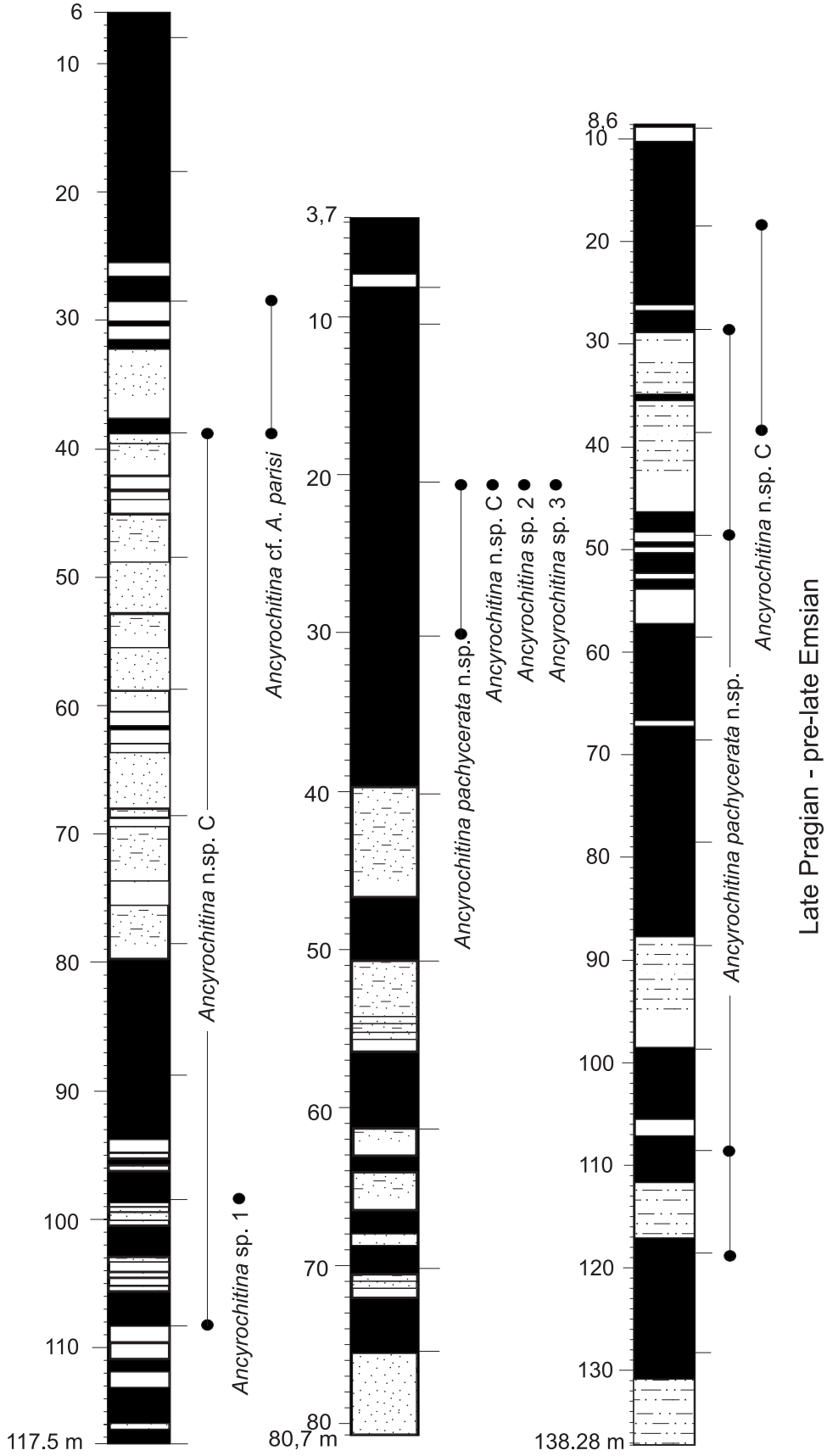

Figure 4. Lithologic columns and chitinozoan range chart for the 9-PPG-7-PR, 9-PPG-6-PR and 9-PPG-2-PR wells / *columnas litológicas y cuadro de rangos de quitinozoos para los pozos 9-PPG-7-PR, 9-PPG-6-PR y 9-PPG-2-PR.*

Order PROSOMATIFERA Eisenack, 1972
Family LAGENOCHITINIDAE Eisenack, 1931 *emend*. Paris, 1981
Subfamily ANGOCHITININAE Paris, 1981

Genus ***Fungochitina*** Taugourdeau, 1966

Type species. *Conochitina fungiformis* Eisenack, 1931.

Fungochitina glarisentosa n.sp.
Figure 5.D

Derivation of name. Greek, *glaris*, chisel and Latin, *sentosa*, spiny. Referring to the general shape and spinose ornamentation of this species.
Diagnosis. A *Fungochitina* species with an elongated subconical body and a short cylindrical neck. Flexure indistinct. The vesicle wall is covered by small simple spines.

Holotype. Figure 5. D. UERJ/DEPA SEM collection 300941.
Type locality. Well RVR-1, 72.70 m.

Description. See diagnosis. Dufka in Vavrdová *et al*. (1996) illustrated a similar species as *Belonechitina* sp. (Vavrdová *et al*., 1996, Pl. 6, figs. 3, 7) from the upper part of the Tequeje Formation (Pragian) in the Madre de Díos Basin, northern Bolivia. *F. glarisentosa* differs in having a more slender form and smaller spines. Dimensions (5 specimens measured). Total length 200-262 µm. Holotype 262 µm; maximum width 70(56)-100(80) µm. Holotype 100(80) µm; width of aperture 31(25)-41(33) µm. Holotype 40(32) µm; length of neck 2/5-1/4 of the total length. Holotype 2/5 of the total length; length of spines < 9 µm. Holotype 5 µm.
Occurrence. Paraná Basin. São Domingos Formation, early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8). Well RVR-1 (72.70 m).

Genus ***Angochitina*** Eisenack, 1931

Type species. *Angochitina echinata* Eisenack, 1931.

Angochitina pseudoavelinoi n.sp.
Figures 5.A-C

?2002. *Lagenochitina avelinoi* Lange. Grahn in Grahn *et al*., Pl. 2, fig. H.
?2002. *Lagenochitina avelinoi* Lange. Grahn and Melo, Pl. 1, fig. 2.

Derivation of name. Latin, *pseudoavelinoi*, resembles *Lagenochitina avelinoi* Lange 1952 although the new species has minute spines covering the vesicle.
Diagnosis. A long slender species with an ellipsoidal body and a long cylindrical neck. The vesicle is covered by minute simple spines.

Holotype. Figure 5. A-B. UERJ/DEPA slide collection 1405/4051 (Q 47/2).
Type locality. Well RSP-1, 40.00 m.

Description. See diagnosis. The spines are often difficult to observe in light-microscope, and *A. pseudoavelinoi* can therefore be easily mixed with *Lagenochitina avelinoi* Lange, 1952, a glabrous and contemporary species.
Dimensions (12 specimens measured). Total length 373-630 µm. Holotype 630 µm. Maximum width 75(60)-90(72) µm. Holotype 90(72) µm. Width of aperture 41(33)-61(49) µm. Holotype 50(40) µm. Length of neck 1/2-2/3 of the total length. Holotype 63% of the total length. Length of spines ≤ 4 µm. Holotype ca. 2 µm.
Occurrence. Paraná Basin. São Domingos Formation, late Frasnian (BMu miospore Zone, tentatively correlated with the upper *rhenana*-lower-middle *linguiformis* conodont Zone; see figure 8). Well RSP-1, 40.00 m, 60.00 m.
Remarks. The specimens of *Lagenochitina avelinoi* Lange, 1952 reported from levels 15.00 m, 52.80 m, 60.10 m, and 70.10 m in well RSP-1 (Grahn in Grahn *et al*., 2002) might partly be conspecific with *Angochitina pseudoavelinoi* and need to be re-examined.

Genus ***Muscochitina*** Paris, 1981

Type species. *Muscochitina muscosa* Paris, 1981.

Muscochitina n.sp. A
Figures 5.E-G

?2002. *Angochitina* sp. C. Grahn in Grahn *et al*., Pl. 8, fig. I.

Discussion. This species is characterized by an elongated ovoid body and a short cylindrical neck that slightly widens at the aperture. The meshlike surface is supported by short pillars, less than 10 per 100 µm^2.
Dimensions (2 specimens measured). Total length 240-248 µm; maximum width 96(77)-108(86) µm; width of aperture 56(45)-60(48) µm; length of neck 1/3 of the total length; length of pillars ca. 3 µm.
Occurrence. Paraná Basin. São Domingos Formation, late Frasnian (BMu miospore Zone, tentatively correlated with the upper *rhenana*-lower-middle *linguiformis* conodont Zone; see figure 8). Well RSP-1, 60.00 m. Similar specimens were recovered from the same stratigraphic interval in well 1-CA-1-PR, *i.e*., from cores 16 (1667.5-1670.5 m) and 21 (1691.5-1694.5 m), as *Angochitina* sp. C (Grahn *et al*., 2002).

Muscochitina n.sp. B
Figures 5.H-J.

Figure 5. New Devonian Chitinozoa from the Paraná Basin. The scale bar represents 100 µm for figures A, B-E, G-!, K-N, P-S, and U-V. All others 10 µm / *nuevos quitinozoos devónicos de la Cuenca de Paraná. La barra de escala representa 100 µm para A, B-E, G-I, K-N, P-S y U-V. En el resto representa 10 µm.* **A-C, *Angochitina pseudoavelinoi*** n.sp. Well / *Pozo* RSP-1, 40.00 m. São Domingos Formation, late Frasnian/ *Frasniano tardío* (BMu miospore Zone / *Zona de miosporas BMu*, tentatively correlated with the *linguiformis* conodont Zone / *correlacionado de forma tentativa con la Zona de conodontos* linguiformis). **A,** Holotype / *Holotipo*. **B,** Detail of vesicle wall of A / *Detalle de pared vesicular de A*. **C,** Lateral view / *Vista lateral.* **D, *Fungochitina glarisentosa*** n.sp. Well / *Pozo* RVR-1, 72.70 m. São Domingos Formation, early Givetian/ *Givetiano temprano* (LLi miospore Zone/ *Zona de miosporas LLi*, tentatively correlated with the *hemiansatus* conodont Zone /

Discussion. A distinct flexure separates the spherical body from the cylindrical neck. The meshlike surface is supported by short pillars, between 15-20 per 100 μm². The general outline separates *Muscochitina* n.sp. B from other *Muscochitina* species of the Paraná Basin.
Dimensions (2 specimens measured). Total length 149-154 μm; maximum width 92(72) μm; width of aperture 44(35)-54(43) μm; length of neck 1/3-2/5 of the total length.
Occurrence. Paraná Basin. São Domingos Formation, late Frasnian (BMu miospore Zone, tentatively correlated with the upper *rhenana*-lower-middle *linguiformis* conodont Zone; see figure 8). Well RSP-1, 101.10 m.

Genus ***Ramochitina*** Sommer and van Boekel, 1964 *emend*. Paris *et al*., 1999

Type species. *Ramochitina ramosi* Sommer and van Boekel, 1964.

Ramochitina whitei n.sp.
Figures 5.K-M

1967. Tipo 122 a-b - Lange, Pl. 9, figs. 122 a-b.
2002. *Ramochitina* 122b-Grahn in Grahn *et al*., Pl. 2, fig. B.

Derivation of name. Latin, *whitei*, in honor of the late Dr. Israel C. White, American geologist and pioneer in Paleozoic studies of the Paraná Basin.
Diagnosis. A *Ramochitina* species with an elongated ovoid body and a cylindrical neck. The vesicle is provided with six crests of simple spines with wide bases.

Holotype. Figure 4. K. UERJ/DEPA slide collection 1415/4156 (O 50/3).
Type locality. Well RSP-1, 256.20 m.
Description. The species is easily distinguished from other *Ramochitina* species by its spines that are arranged in six widely spaced crests (4-5 spines in each crest). The base of the spines corresponds to about half of their length. The vesicle wall between the spines is feltlike. The cylindrical neck slightly widens towards the straight aperture. The body is ovoid to almost cylindrical.
Dimensions (9 specimens measured). Total length 177-259 μm. Holotype 196 μm; maximum width 71(57)-94(75) μm. Holotype 72(58) μm; width of aperture 35(28)-56(45) μm. Holotype 48(38) μm; length of neck 1/5-1/4 of the total length. Holotype 1/5 of the total length; length of spines 20-29 μm. Holotype 24 μm.
Occurrence. Paraná Basin. São Domingos Formation, Well RSP-1, middle Givetian (lower Trg miospore Zone, tentatively correlated with the *varcus* conodont Zone, except the topmost part; see figure 8), 249.00 m (reported as *Ramochitina* 122 b by Grahn *et al*., 2002), 256.20 m. Amazonas Basin (Lange, 1967). Well 1-AM-1-AM, Ererê Fm, early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8), core 21 (1372-1378 m).

Ramochitina n.sp. A
Figures 5.N-P

Discussion. This species is characterized by 12 crests of widely spaced simple spines, which are provided with a wide base (figure 5.O). The vesicle wall between the spines is glabrous. A distinct flexure separates the elongated ovoid body from the cylindrical neck. The aperture is straight.
Dimensions (4 specimens measured). Total length 216-280 μm; maximum width 80(64)-89(71) μm;

correlacionado de forma tentativa con Zona de conodontos hemiansatus). **E-G, *Muscochitina*** n.sp. A. Well / Pozo RSP-1, 60.00 m. São Domingos Formation, late Frasnian/ *Frasniano tardío* (BMu miospore Zone / *Zona de miosporas BMu*, tentatively correlated with the *linguiformis* conodont Zone / *correlacionado de forma tentativa con Zona de conodontos* linguiformis). **E,** Lateral view/ *vista lateral.* **F,** Detail of vesicle wall of E / *Detalle de pared vesicular de E.* **G,** Lateral view / *vista lateral*. **H-J, *Muscochitina*** n.sp. B. Well / *Pozo* RSP-1, 101.10 m. São Domingos Formation, late Frasnian, *Frasniano tardio* (BMu miospore Zone/ *Zona de miosporas BMu*, tentatively correlated with the *linguiformis* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* linguiformis). **H-I,** Lateral view / *vista lateral.* **J,** Detail of vesicle wall of I / *detalle de pared vesicular de I.* **K-M, *Ramochitina whitei*** n.sp. Well / *Pozo* RSP-1, 256.20 m. São Domingos Formation, middle Givetian, *Givetiano medio* (lower Trg miospore Zone / *Zona de miosporas Trg inferior,* tentatively correlated with the *varcus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* varcus). **K,** Holotype/ *Holotipo.* **L-M,** Lateral view / *vista lateral.* **N-P, *Ramochitina*** n.sp. A. Well / *Pozo* RSP-1, 40.00 m. São Domingos Formation, late Frasnian, *Frasniano tardío* (BMu miospore Zone / *Zona de miosporas BMu*, tentatively correlated with the *linguiformis* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* linguiformis). **N,** Lateral view / *vista lateral.* **O,** Detail of vesicle wall of N / *Detalle de pared vesicular de N.* **P,** Lateral view/ *vista lateral.* **Q-R, *Ramochitina*** n.sp. B. Well/ *Pozo* RSP-1, 40.00 m. São Domingos Formation, late Frasnian/ *Frasniano tardio* (BMu miospore Zone / *Zona de miosporas BMu*, tentatively correlated with the *linguiformis* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* linguiformis). **Q,** Lateral view / *vista lateral*. **R,** Detail of vesicle wall of Q / *detalle de pared vesicular de Q.* **S-T, *Ramochitina*** n.sp. C. Well / *Pozo* RSP-1, 181.00 m. São Domingos Formation, late Givetian or earliest Frasnian / *Givetiano tardio o Frasniano inicial* (upper Trg miospore Zone / *Zona de miosporas Trg superior*, tentatively correlated with the *falsiovali-transitans* conodont zones / *correlacionado de forma tentativa con zonas de conodontos* falsiovali-transitans). **S,** Lateral view / *vista lateral.* **T,** Detail of vesicle wall of S / *detalle de pared vesicular de S.* **U-V, *Ramochitina*** n.sp. D. Well / *Pozo* RSP-1, 341.00 m. São Domingos Formation, early Givetian / *Givetiano temprano* (LLi miospore Zone / *Zona de miosporas LLi*, tentatively correlated with the *hemiansatus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* hemiansatus). **U,** Lateral view / *vista lateral.* **V,** Lateral view / *vista lateral.* The neck is incomplete / *el cuello está incompleto*.

width of aperture 44(35)-52(42) µm; length of neck 1/3-2/5 of the total length; length of spines < 20 µm.
Occurrence. Paraná Basin. São Domingos Formation, late Frasnian (BMu miospore Zone, tentatively correlated with the upper *rhenana*-lower-middle *linguiformis* conodont Zone; see figure 8). Well RSP-1, 40.00 m.

Ramochitina n.sp. B
Figures 5.Q-R

Discussion. A *Ramochitina* species with an ovoid body and a cylindrical neck. The species is characterized by thick multirooted spines arranged in 20-25 crests. The individual spines are joined over short distances along the crests.
Dimensions (3 specimens measured). Total length 159-216 µm; maximum width 76(61)-100(80) µm; width of aperture 40(32)-51(41) µm; length of neck 1/3-1/2 of the total length; length of spines ca. 4 µm.
Occurrence. Paraná Basin. São Domingos Formation, Frasnian (BPi-BMu miospore Zones, tentatively correlated with the uppermost *transitans*-lower *rhenana* conodont zones; see figure 8). Well RSP-1, 40.00 m,101.10 m.

Ramochitina n.sp. C
Figures 5.S-T

Discussion. A slender *Ramochitina* species with an elongated ovoid body and a cylindrical neck. The vesicle wall displays 14-16 crests with short conical spines.
Dimensions (1 specimen measured). Total length 235 µm; maximum width 77(62) µm; width of aperture 46(37) µm; length of neck 1/3 of the total length; length of spines 2 µm.
Occurrence. Paraná Basin. São Domingos Formation, late Givetian or earliest Frasnian (upper Trg miospore Zone, tentatively correlated with the lower? *falsiovali* conodont Zone; see figure 8). Well RSP-1, 181.00 m.

Ramochitina n.sp. D
Figures 5.U-V

Discussion. This *Ramochitina* species has an ovoid body and cylindrical neck. The body displays 8 crests with short, simple or branching spines. Each branch can be further subdivided 2-4 times into smaller branches. Similarly shaped spines occur in six crests on the neck. The vesicle wall is smooth around the distinct flexure. *Ramochitina* n.sp. D differs from *R. milanensis* (Collinson and Scott, 1958) in having more complex and densely distributed spines, and from *R. stiphrospinata* Grahn and Melo (2005) by its ovoid body, longer neck, and more complex spines.
Dimensions (2 specimens measured). Total length 162-204 µm; maximum width 80(64)-85(68) µm; width of aperture 39(31)-44(35) µm; length of neck 2/5 of the total length; length of spines <15 µm.
Occurrence. Paraná Basin. São Domingos Formation, early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8). Well RSP-1, 341.10 m.

Subfamily ANCYROCHITININAE Paris, 1981

Genus ***Ancyrochitina*** Eisenack, 1955

Type species. *Conochitina ancyrea* Eisenack, 1931.

Ancyrochitina pachycerata n.sp.
Figures 6.A-F

2000. *Ancyrochitina* sp. A-Grahn in Grahn *et al*., Plate 4, fig. 5.

Derivation of name. Greek, *pachys*, thick, and *keratos*, horn, referring to the robust nature of the appendices and apertural spines.
Diagnosis. A slender *Ancyrochitina* species with an ovoid body and a cylindrical neck. The basal margin displays four thick simple and hooked appendices. At least two similarly shaped spines occur at the aperture.

Holotype. Figure 6. A. UERJ/DEPA SEM collection 300962.
Type locality. Well 9-PPG-7-PR, 118.60 m.

Description. This species is easily distinguished from other *Ancyrochitina* species by its few and very thick appendices and spines, both with wide bases. The vesicle wall between basal margin and aperture is glabrous.
Dimensions (21 specimens measured). Total length 219-364 µm. Holotype 289 µm; maximum width 83(66)-114(91) µm. Holotype 105(84) µm; width of aperture 36(29)-73(58) µm. Holotype 53(42) µm; length of neck 2/5-1/2 of the total length. Holotype 1/3 of the total length; length of appendices ≤ 89 µm. Holotype 89 µm; length of spines ≤ 90 µm. Holotype 74 µm.
Occurrence. Paraná Basin. Ponta Grossa Formation, Early Devonian, within the latest Pragian-early Emsian span (upper part of the Ems miospore Zone, tentatively correlated with the *pirenae*-lower *nothoperbonus* conodont zones; see figure 8), and to the base of the *parisi* Zone (occurrence together with *A. parisi*). Wells RVR-1 (174.90 m, 215.00 m), 9-PPG-6-PR (20.50 m, 30.40 m) and 9-PPG-7-PR (28.60 m, 48.70 m, 108.70 m, and 118.60 m).
Remarks. In the Paraná Basin, the total range of *Ancyrochitina pachycerata* defines a regional biozone of Early Devonian age (equivalent to the upper part

of the Ems miospore Zone, tentatively correlated with the *pireneae*-lower *nothoperbonus* conodont zones; see figure 8). Grahn *et al*. (2000) reported *A. pachycerata* (as *A.* sp. A) from probable Pragian beds (Ems miospore Zone, tentatively correlated with the *pireneae* conodont Zone; see figure 8) in the Jaguariaíva type section, and late Emsian beds (GS miospore Zone, tentatively correlated with the upper *serotinus-patulus* conodont zones; see figure 8) of the Tibaji-Telêmaco (Tibaji Member) and Baliza sections.

Ancyrochitina brevicornuta n.sp.
Figures 7.A-C

Derivation of name. Latin, *brevis*, short, and *cornuta*, horn-bearing, referring to the shape of the appendices.
Diagnosis. A long slender *Ancyrochitina* species with four simple, short and conical appendices.

Holotype. Figure 7. A-B. UERJ/DEPA slide collection 1412/4027 (O 46/1).
Type locality. Well RSP-1, 221.10 m.

Description. This species is characterized by its slender appearance. The body is elongated and conical, and the neck long and cylindrical. Flexure indistinct. The rounded basal margin is provided with four short and conical appendices. From the basal margin towards the straight aperture the vesicle wall is smooth. "*Cladochitina*" *biconstricta* Lange (1967) is similar, but has a slightly convex base and a constriction oralwards the basal margin. The appendices are more slender than those of *A. brevicornuta*, and simple spines occur randomly distributed on the body; with a tendency to be more concentrated on the neck. "*C*". *biconstricta* also have a shorter neck and a conical body. *Sommerochitina langei* Cruz and Quadros (1985) differs in having longer and slender appendices below the basal margin, a vesicle covered by tubercles, and a neck expanding to a lip at the aperture.
Dimensions (7 specimens measured). Total length 332-480 µm. Holotype 430 µm; maximum width 71(57)-90(72) µm. Holotype 82(66) µm; width of aperture 36(29)-50(40) µm. Holotype 36(29) µm; length of neck 1/2-2/3 of the total length. Holotype 3/5; length of appendices ≤ 24 µm. Holotype ≤ 22 µm.
Occurrence. Paraná Basin. São Domingos Formation, Givetian (Lli-upper Trg miospore Zone, tentatively correlated with the *hemiansatus-disparilis* conodont zones; see figure 8). Well RSP-1, 221.10 m, 264.20 m.

Ancyrochitina maacki n.sp.
Figures 7.D-G, J

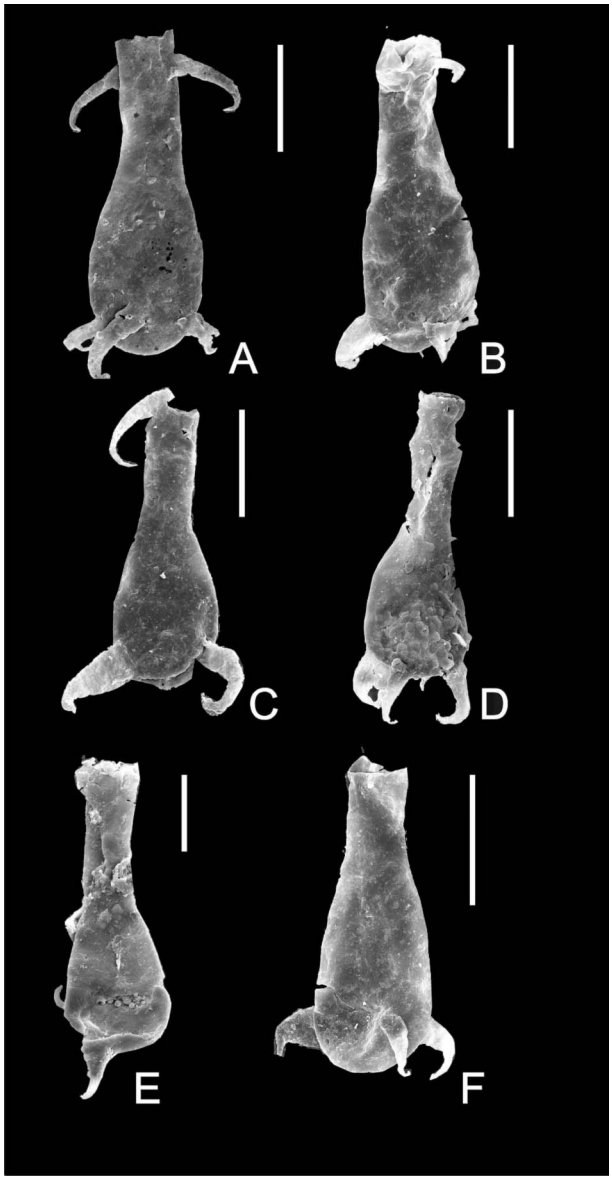

Figure 6. New Devonian Chitinozoa from the Paraná Basin. Ponta Grossa Formation, tentatively dated as latest Pragian-prelate Emsian (upper Ems-lower GS miospore zones, tentatively correlated with the *pireneae-serotinus* conodont zones). The scale bar represents 100 µm / *nuevos quitinozoos devónicos de la Cuenca de Paraná. Formation Ponta Grossa, datado de forma tentativa como Pragiano más tardío-pre-Emsiano tardío (zonas de miosporas Sem superior - GS inferior, correlacionado de forma tentativa con zonas de conodontos* pireneae-serotinus*). La barra de escala representa 100 µm.* **A-F, *Ancyrochitina pachycerata*** n.sp. **A-C,** Well / *Pozo* 9-PPG-7-PR. **A,** Holotype / *Holotipo* 118.60 m. **B,** 108.70 m. **C,** 118.60 m. **D-E,** Well / *Pozo* RVR-1. **D,** 215.00 m. **E,** 174.90 m. **F,** Well / *Pozo* 9-PPG-7-PR ,118.60 m.

Derivation of name. Latin, *maacki*, in honor of the late Dr. Reinhard Maack, German geologist and pioneer in Paleozoic studies of the Paraná Basin.
Diagnosis. An *Ancyrochitina* species with a short, conical body and cylindrical neck. Basal margin provided with 4-6 short conical appendices. Spines of

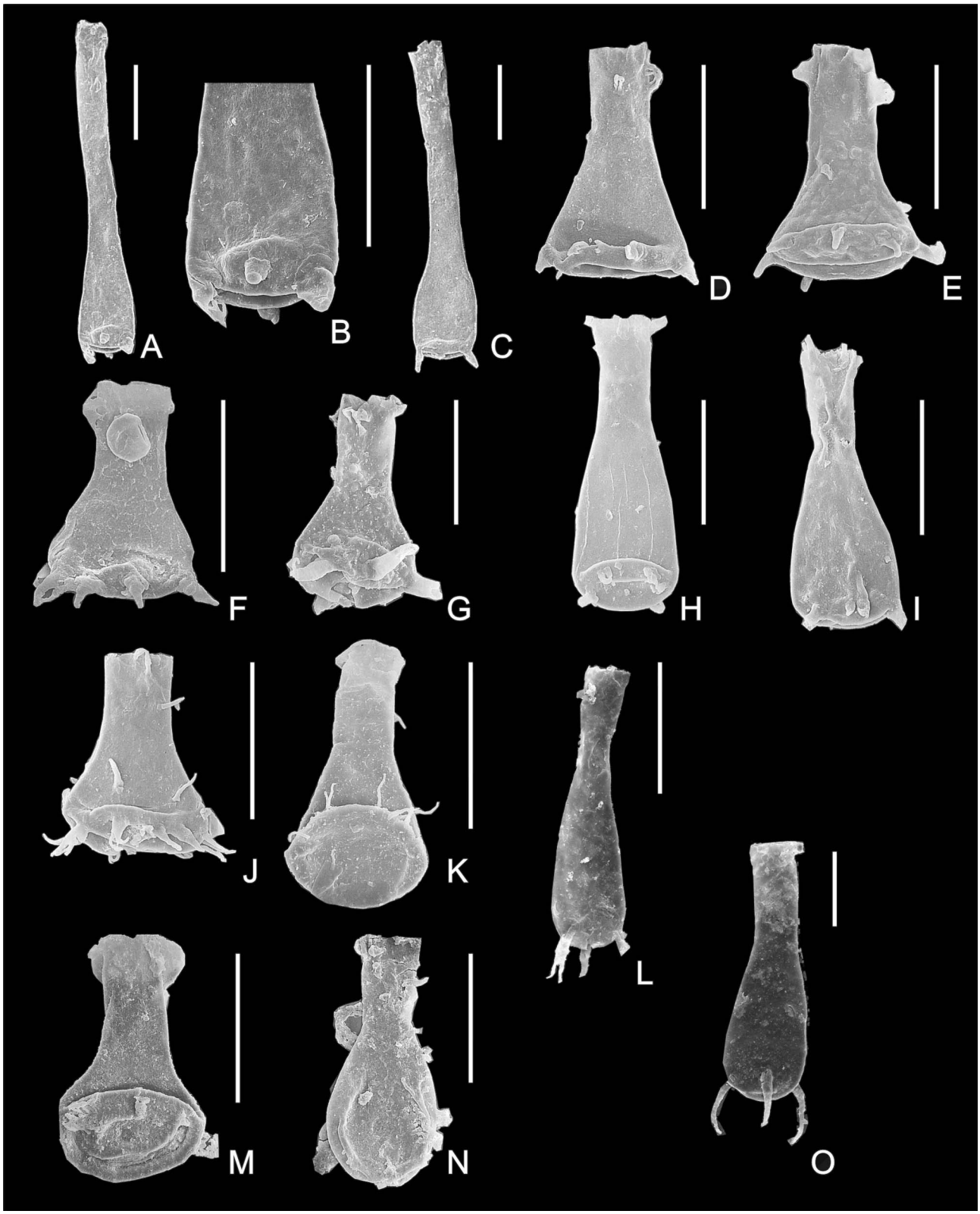

Figure 7. New Devonian Chitinozoa from the Paraná Basin. The scale bar represents 100 µm / *nuevos quitinozoos devónicos de la Cuenca de Paraná. La barra de escala representa 100 µm.* **A-C.** ***Ancyrochitina brevicornuta*** n.sp. Well / *Pozo* RSP-1, 221.10 m. São Domingos Formation, late Givetian / *Givetiano tarde* (upper Trg miospore Zone / *Zona de miosporas Trg superior*, tentatively correlated with the *hermanni-cristatus-dispurilis* conodont zones / *correlacionado de forma tentativa con zonas de conodontos* hermanni-cristatus-dispurilis. **A,** Holotype/ *Holotipo*. **B,** Detail of basal part of A / *detalle de la parte basal de A*. **C,** Lateral view / vista lateral. **D-G,** ***Ancyrochitina maacki*** n.sp. **D,** Holotype / *Holotipo*. Well / *Pozo* RSP-1, 264.20 m. São Domingos Formation, early Givetian/ *Givetiano temprano* (LLi miospore Zone / *Zona de miosporas LLi*, tentatively correlated with the *hemiansatus* conodont Zone / *correlacionado de forma tentativa con Zona de*

similar shape may occur near the aperture and oralwards the basal margin.

Holotype. Figure 7. D. UERJ/DEPA slide collection 1414/4144 (O 46/-).
Type locality. Well RSP-1, 264.20 m.

Description. Characteristic for *A. maacki* are 6-8 short conical appendices, and the presence of at least 2 conical spines near the aperture. Spines similar to the appendices might occur about 1/3 of the body length towards the flexure (see figures 7.E, J). The flexure is distinct and the aperture straight. Minute simple spines cover the vesicle. *Ancyrochitina simplex* Grahn, 2002 (in Grahn *et al*., 2002), differs in having long simple appendices, and no other ornamentation. *Ancyrochitina arirambaense* Grahn and Melo (in press) have a longer neck and long simple appendices, and no ornamentation between basal margin and aperture. *Ancyrochitina frankeli* Wright, 1976, has a longer neck and branching appendices, and long simple spines near the aperture.
Dimensions (8 specimens measured). Total length 140 -188 µm. Holotype 164 µm; maximum width 95(76)-108(86) µm. Holotype 108(86) µm; width of aperture 40(32)-60(48) µm. Holotype 40(32) µm; length of neck 1/3-1/2 of the total length. Holotype 1/3 of the total length; length of appendices 12-40 µm. Holotype 12 µm; length of spines 8-24 µm. Holotype 16 µm.
Occurrence. Paraná Basin. São Domingos Formation, Givetian (LLi-upper Trg miospore zones, tentatively correlated with the *hemiansatus-disparilis* conodont zones; see figure 8). Wells RSP-1, 221.00 m, 244.20 m, 248.20 m, 264.20 m and RVR-1, 72.70 m.

Ancyrochitina n.sp. A
Figures 7.H-I

Discussion. An *Ancyrochitina* species with a conical body and a short cylindrical neck. The species is distinguished from other *Ancyrochitina* species of the Paraná Basin by its four short appendices and at least two spines at the aperture. Longitudinal structures observed on the vesicle of one of the specimens (figure 7.H) might be artifacts. The flanks are convex. The flexure is distinct, the basal margin rounded, and the base convex.
Dimensions (3 specimens measured). Total length 212-240 µm; maximum width 80(64)-84(67) µm; width of aperture 44(35)-48(38) µm; length of neck 1/3-1/2 of the total length; length of appendices ≤ 16 µm; length of spines 12-16 µm.
Occurrence. Paraná Basin. São Domingos Formation, early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8). Well RSP-1, 282.30 m, 301.90 m.

Ancyrochitina n.sp. B
Figure 7.K

Discussion. This *Ancyrochitina* species has a conical body and a cylindrical neck. A collar is present at the aperture. The basal margin is provided with 8-10 long simple appendices. Simple spines occur on the middle part of the neck. The vesicle wall is covered by minute simple spines.
Dimensions (1 specimen measured). Total length 159 µm; maximum width 82(66) µm; width of aperture 41(33) µm; length of neck 2/5 of the total length; length of appendices ≤ 20 µm; length of spines ≤ 8 µm.
Occurrence. Paraná Basin. São Domingos Formation, early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8). Well RSP-1, 282.30 m.

conodontes hemiansatus). **E-G,** Well / *Pozo* Rsp-1, 248.20 m. São Domingos Formation, middle Givetian / *Givetiano medio* (lower Trg miospore Zone / *Zona de miosporas Trg inferior*, tentatively correlated with the *varcus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* varcus). **H-I, *Ancyrochitina*** n.sp. **A,** Well / *Pozo* RSP-1, 301.90 m. São Domingos Formation, early Givetian / *Givetiano temprano* (LLi miospore Zone / *Zona de miosporas LLi*, tentatively correlated with the *hemiansatus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontos* hemiansatus). **J, *Ancyrochitina maacki*** n.sp. Well / *Pozo* RSP-1, 248.20 m. São Domingos Formation, middle Givetian / *Givetiano medio* (lower Trg miospore Zone / *Zona de miosporas Trg inferior*, tentatively correlated with the *varcus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontes* varcus). **K, *Ancyrochitina*** n.sp. **B,** Well / *Pozo* RSP-1, 282.30 m. São Domingos Formation, early Givetian, *Givetiano temprano* (LLi miospore Zone / *Zona de miosporas LLi*, tentatively correlated with the *hemiansatus* conodont Zone / *correlacionado de forma tentativa con Zona de conodontos* hemiansatus). **L, *Ancyrochitina*** n.sp. **C,** Well / *Pozo* RVR-1, 198.00 m. Ponta Grossa Formation, tentatively dated as latest Pragian-early Emsian / *datado de forma tentativa como Pragiano terminal-Emsiano temprano* (upper Ems miospore Zone / *Zona de miosporas Ems superior*, tentatively correlated with the *pireneae-kitabicus* conodont zones / *correlacionado de forma tentativa con zonas de conodontos* pireneae-kitabicus). **M-N, *Plectochitina*?** n.sp. **A,** Well / *Pozo* RSP-1, 141.10 m. São Domingos Formation, early Frasnian / *Frasniano temprano* (BPi miospore Zone / *Zona de miosporas BPi*, tentatively correlated with the *punctata-hassi* conodont zones / *correlacionado de forma tentativa con zonas de conodontos* punctata-hassi). **O, *Ancyrochitina*** n.sp. **C,** Well / *Pozo* 9-PPG-7-PR, 38.60 m. Ponta Grossa Formation, tentatively dated as latest Pragian-early Emsian / *datado de forma tentativa como Pragiano terminal-Emsiano temprano* (upper Ems miospore Zone / *Zona de miosporas Ems superior*, tentatively correlated with the *pireneae-kitabicus* conodont zones / *correlacionado de forma tentativa con zonas de conodontos* pireneae - kitabicus).

Ancyrochitina n.sp. C
Figures 7.L, O

Discussion. A long and slender *Ancyrochitina* species with an elongated ovoid body and a cylindrical neck. The basal margin is provided with four long and simple appendices. At least 2 minute spines occur at the straight aperture, or just below it. The vesicle wall is feltlike. *Ancyrochitina* n.sp. D differs from *A. pachycerata* n.sp. in having much shorter spines at the aperture and much thinner appendices.
Dimensions (4 specimens measured). Total length 258-353 μm; maximum width 79(63)-113(90) μm; width of aperture 47(38)-66(53) μm; length of neck 1/3-2/5 of the total length; length of appendices < 87 μm; length of spines < 11 μm.
Occurrence. Paraná Basin. Ponta Grossa Formation, Early Devonian, within the latest Pragian-early Emsian age span (upper Ems miospore Zone, tentatively correlated with the *pirenae*-lower *nothoperbonus* conodont zones; see Fig. 8). Wells RVR-1 (184.70 m, 205.00 m), 9-PPG-2-PR (38.80 m, 108.40 m), 9-PPG-6-PR (20.50 m), and 9-PPG-7-PR (18.60 m, 38.60 m).

Genus ***Plectochitina*** Cramer 1964

Type species. *Plectochitina carminae* Cramer, 1964.

Plectochitina? n.sp. A
Figures 7.M-N

Discussion. This species, questionably referred to *Plectochitina*, has a conical body and a cylindrical neck provided with a lip. Six appendices of unknown length are present on the basal margin, and long spines of unknown length and number occur on the neck close to the flexure. The vesicle wall is feltlike. Possibly similar and more complete specimens - displaying thick, spongy and long, unbranched appendices and coalescent spines of similar texture near the aperture - are known from about the same stratigraphic interval (latest Givetian - earliest Frasnian of southern Subandean Bolivia. Basal Iquiri Formation: YG and José Henrique G. Melo, PETROBRAS/CENPES, own observations).
Dimensions (2 specimens measured). Total length 162-192 μm; maximum width 88(70)-95(76) μm; width of aperture 56(45)-64(51) μm; length of neck 2/5-1/3 of the total length.
Occurrence. Paraná Basin. São Domingos Formation, early Frasnian (upper Trg miospore Zone, tentatively correlated with the upper *falsiovalis* conodont Zone; see figure 8). Well RSP-1, 141.10 m. Possibly present also in latest Givetian to early Frasnian strata of Bolivia.

Chitinozoan biostratigraphy

The new chitinozoan species described in the present paper have good biostratigraphic potential in the Paraná Basin (figures 2-4) and other intracratonic basins of Brazil and adjacent areas. They have increased the stratigraphical precision of the Devonian in the Paraná Basin considerably, especially for the pre-late Emsian and middle Givetian sequences (figure 8). One new chitinozoan biozone of Early Devonian age is defined. On the other hand, the miospore and chitinozoan biostratigraphy of the Givetian/Frasnian transition interval of the reference well RSP-1 is currently undergoing revision, so it is still premature to define any new chitinozoan biozones for this interval until more samples from various sections of same age are investigated. A correlation between Devonian miospore (Melo and Loboziak, 2003), conodont (Clausen *et al*., 1993; Yolkin *et al*., 1997), and chitinozoan (Grahn, 2003; Grahn *et al*., 2000, 2002) zones in the Paraná Basin is shown in figure 8. The characteristic chitinozoan assemblages for the Devonian sequences investigated are discussed below. For complementary biostratigraphic information references are made to (Grahn *et al*., 2000, 2002).

Interval tentatively dated as latest Pragian - prelate Emsian (upper Ems-AB miospore zones, tentatively correlated with the *pirenae*-lower *nothoporbonus* conodont zones; see figure 8). This interval is dominated by *Ancyrochitina* species, most of them still unrecorded in previous studies. Of stratigraphic importance are *Ancyrochitina pachycerata* n.sp. and *Ancyrochitina* n.sp. C. The latter is seemingly restricted to pre-late Emsian. The palynoflora in this interval is characterized by small miospores with simple morphology (J.H.G. Melo, pers. comm.). The Late Emsian chitinozoan assemblage is distinguished from earlier Devonian ones by the first occurrence of *Ramochitina ramosi* Sommer and van Boekel, 1964, and the index species *Ancyrochitina parisi* Volkheimer *et al*., 1986 (Grahn *et al*., 2000).

Interval range zone of Ancyrochitina pachycerata

Definition. This interval range zone is defined from the first occurrence of *Ancyrochitina pachycerata* to the first occurrence of *Ancyrochitina parisi* Volkheimer *et al*. (1986).
Type interval and locality. Well 9-PPG-7-PR, 28.60-118.60 m.
Characteristic chitinozoans. Besides *A. pachycerata* also *Ancyrochitina* n.sp. C occurs in this zone (figure 3). A few scattered specimens of the former species

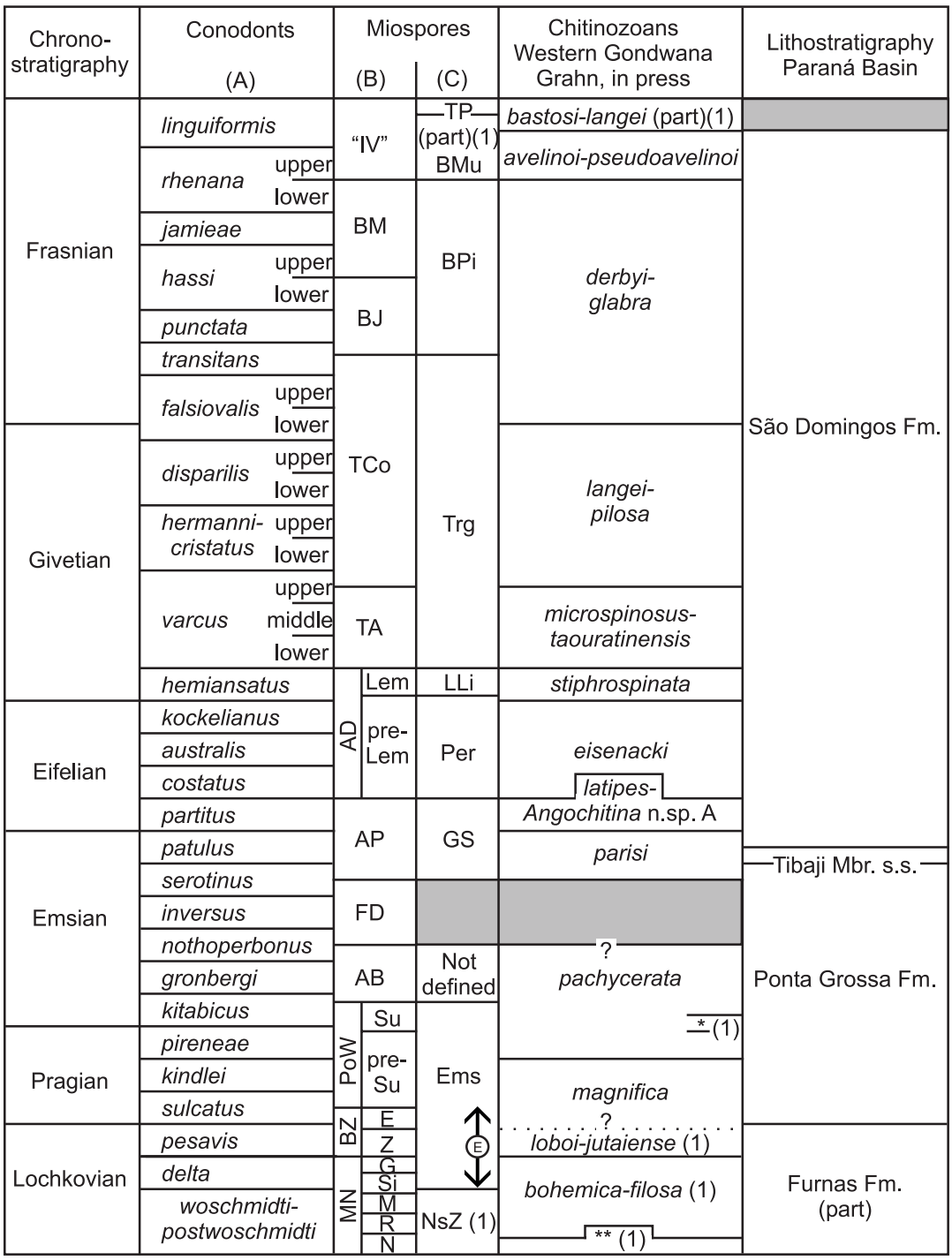

Figure 8. Correlation of international Devonian conodont and miospore zones with the coeval regional chitinozoan zones of the Paraná Basin and other Brazilian regions. The double-headed arrow next to encircled letter E (within the Ems miospore Zone) indicates the maximum stratigraphic span proposed by Rubinstein *et al.* (2005) for their *D. emsiensis* morphon Assemblage Zone, described from the Solimões and Paraná basins (Jutaí and uppermost Furnas formations, respectively). Other conventions: (A) = international conodont zonation after Clausen *et al.* (1993) and Yolkin *et al.* (1997). (B) = Western European miospore zonation after Streel *et al.* (1987) and Steemans (1989). (C) = Western Gondwanan (North Brazil) miospore zonation after Melo and Loboziak (2001, 2003). (1) = biozones unrecorded in the Paraná Basin. * = ***Ramochitina*** sp. A & B Zone. ** = ***Angochitina*** cf. ***Sphaerochitina densibaculata*** Zone / *correlación de zonas internacionales de conodontos y miosporas del Devónico con las zonas regionales coetáneas de quitinozoos de la cuenca Paraná y otras regiones de Brasil. Las dos flechas, abajo y arriba de la letra E circunscrita, y dentro de la Zona de miosporas Ems, indican la máxima amplitud estratigráfica propuesta por Rubinstein* et al. *(2005) para lo que ellos denominan Zona de Asociación del "morfo" D. emsiensis, que fue descrita en las cuencas Solimões y Paraná (Formación Jutaí y parte más alta de la Formación Furnas, respectivamente). Otras convenciones: (A) = zonación internacional de conodontos según Clausen* et al. *(1993) y Yolkin* et al. *(1997). (B) = zonación de miosporas de Europa Occidental según Streel et al. (1987) y Steemans (1989). (C) = zonación de miosporas de Gondwana Occidental (Norte de Brasil) según Melo y Loboziak (2001, 2003). (1) = biozonas no registradas en la Cuenca Paraná. * = Zona* **Ramochitina** *sp. A & B.* ** *= Zona* **Angochitina** *cf.* **Sphaerochitina densibaculata**.

occur already in underlying Pragian strata (in the uppermost range interval of *Ramochitina magnifica*; see Grahn *et al*., 2000, pl. 4, fig. 5). Other species are designated as *Ancyrochitina* sp. 1-8 (figures 2-4).

Remarks. The *Ancyrochitina pachycerata* Zone, tentatively dated as latest Pragian-pre-late Emsian age (upper Ems-miospore zones, tentatively correlated with the *pirenae*-lower *nothoporbonus* conodont zones; see figure 8) may correspond to the *Bursachitina bursa* global interval range zone by Paris *et al*. (2000).

Early Givetian (LLi miospore Zone, tentatively correlated with the *hemiansatus* conodont Zone; see figure 8, *stiphrospinata* chitinozoa Zone). This sequence is well documented by chitinozoans (Grahn *et al*., 2002) and miospores (Loboziak *et al*., 1988). The new chitinozoan species encountered in this study do not add any new information to the early Givetian stratigraphy. However, it should be noted that a very characteristic interval occurs some tens of meters above the Eifelian-Givetian boundary, identified by the joint occurrence of *Alpenachitina eisenacki* Dunn and Miller, 1964, *A. matogrossensis* Burjack and Paris, 1989 and *A. petrovinensis* Burjack and Paris, 1989.

Middle Givetian (lower Trg miospore Zone, tentatively correlated with the *varcus* conodont Zone (except the topmost part); see figure 8, *microspinosus-taouratinensis* chitinozoa Zone). This study suggests that some new chitinozoan species can contribute to the refinement of the middle Givetian biostratigraphy of the Paraná Basin. Grahn *et al.* (2002) used *Ancyrochitina taouratinensis* Boumendjel, 1985 as an index species for the middle Givetian (lower Trg miospore Zone). This species first occurs in the highest part of the LLi miospore Zone, but this study suggests that *A. taouratinensis* could range up to the top of Givetian. The joint occurrence of *Ancyrochitina maacki* and *Ramochitina whitei* is of potential significance and might serve as a good indicator for middle Givetian beds in the Paraná basin.

Late Givetian (upper Trg miospore Zone, tentatively correlated with the *hermanni-cristatus*-lowermost *falsiovalis* conodont zones; see figure 8, *langei-pilosa* chitinozoan Zone). Grahn *et al*. (2002) considered the co-occurrence of *Fungochitina pilosa* (Collinson and Scott, 1958) and *Ancyrochitina langei* Sommer and van Boekel, 1964 as a characteristic late Givetian assemblage in the Paraná Basin, although a few scattered *F. pilosa* specimens occur at the top of the underlying middle Givetian interval. *Ramochitina* n.sp. C also seems to be a good regional indicator of late Givetian age.

Early Frasnian (upper Trg-BPi miospore zones, tentatively correlated with the *falsiovali* (except the lowermost part) -lower *rhenana* conodont zones); see figure 8, *derbyi-glabra* chitinozoa Zone). The first occurrence of *Angochitina mourai* Lange, 1952 indicates the base of Frasnian in all intracratonic basins of Brazil. In addition, *Hoegisphaera glabra* Staplin, 1961 and possibly *Plectochitina*? n.sp. A are other potentially good indicators of earliest Frasnian age in the Paraná Basin.

Late Frasnian (BMu miospore Zone, tentatively correlated with the upper *rhenana*-lower-middle *linguiformis* conodont zones; see figure 8, *avelinoi-pseudoavelinoi* chitinozoa Zone). *Angochitina pseudoavelinoi*, *Ramochitina* n.sp. A and the two new *Muscochitina* species are restricted to the late Frasnian in the Paraná Basin. Other species from this interval were discussed by Grahn *et al*. (2002).

Concluding remarks

A new chitinozoan assemblage tentatively dated as latest Pragian to late Emsian age, yielding mainly new *Ancyrochitina* species, is described for the first time. It occurs above the *Ramochitina magnifica* Zone and below the *Ancyrochitina parisi* Zone (Grahn *et al*., 2000). No new late Emsian or Eifelian chitinozoans have been found in this study. A distinct biostratigraphic level occurs some tens of meters above the Eifelian-Givetian boundary, which is characterized by the joint occurrence of *Alpenachitina eisenacki*, *A. matogrossensis*, and *A. petrovinensis*. The middle Givetian interval succeeds the last occurrences of many characteristic early Givetian species, e.g. *Alpenachitina eisenacki* Dunn and Miller, 1964; *Ancyrochitina simplex* Grahn, 2002 (in Grahn *et al*., 2002); *Ancyrochitina postdesmea* Grahn, 2002; *Spinachitina biconstricta*=*Cladochitina biconstricta sensu* Quadros, 1982 and others, and is delimited upwards by the joint occurrence of *Ancyrochitina langei* and *Fungochitina pilosa*. The first occurrence of *Angochitina mourai* characterizes the earliest Frasnian, where *Plectochitina*? n.sp. A also occurs. The chitinozoan diversity is low in the earliest Frasnian, but increases considerably in the late Frasnian, and several new species appear, e.g.: *Angochitina pseudoavelinoi*, *Muscochitina* n.sp. A and n.sp. B (the first *Muscochitina* species described from Brazil), and *Ramochitina* n.sp. A. One new chitinozoan biozone is defined for an interval tentatively dated as latest Pragian-pre-late Emsian (*Ancyrochitina pachycerata* interval range Zone).

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