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LATE DEVONIAN AND MIDDLE-LATE DEVONIAN CONODONTS FROM EASTERN AND NORTHERN IRAN

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Abstract

Late Devonian conodonts (excluding the genera *Icriodus*, *Polygnathus* and *Palmatolepis*) from the Tabas region (E Iran) and Middle-Late Devonian conodonts from the Alborz Mountains (N Iran) are studied. Thirty-one taxa of *Bipennatus, Ancyrodella, Ancyrognathus, Pelekysgnathus, Palmatolepis* (only from the Khoshyeilagh Formation) are illustrated and three new species, *Bispathodus tabasensis, Protognathodus ruttneri* and *Pr. eftekhari* are described.

Key words: Conodont, Devonian, Shotori Range, Tabas area, Iran.

Resumen

Se estudian las faunas de conodontos (excluyendo *Icriodus, Polygnathus* y *Palmatolepis*) del Devónico Superior en la región de Tabas (E de Irán) y del Devónico Medio-Superior en las montañas de Alborz (N de Irán). Se ilustran 31 taxones de *Bipennatus, Ancyrodella, Ancyrognathus* y *Pelekysgnathus,* así como de *Palmatolepis* (sólo de la Formación Khoshyeilagh). Asimismo, se proponen tres nuevas especies, *Bispathodus tabasensis, Protognathodus ruttneri* y *Pr. eftekhari.*

Palabras clave: Conodonto, Devónico, Cadena Shotori, Tabas, Irán.

INTRODUCTION

In the Shotori Range and the Ozback-Kuh Mountains from east of Iran the Middle-Late Devonian successions include parts of the Shishtu Formation; in north of Iran they belong to the Khoshyeilagh Formation (Fig. 1). The Shishtu Formation has been studied in its type section, Ozback-Kuh Mountains (Ruttner *et al*., 1960's), in a reference section in the Howz-e-Dorah area (Stöcklin *et al.*, 1965) and in the Niaz area in the W flank of the Shotori Range (Fig. 2).

In the Ozback-Kuh Mountains and the Shotori Range Upper Devonian strata of the Shishtu Formation have been investigated. In the later area, the Shishtu Formation is characterized by a unit described as Cephalopod Bed (Stöcklin *et al.*, 1965). This interesting, fossiliferous unit is exposed on the western side of the Shotori Range to east of Tabas City (Figs. 3 and 4).

The Khoshyeilagh Formation has been studied in its type section in the Alborz Mountains (Bozorgnia, 1973; Brice *et al*., 1978; Ashouri, 1994). The formation is 1,345 m thick and is Middle-Late Devonian in age. About 1,300 m of the formation have been investigated.

Late Devonian conodont fauna from east of Iran have been studied by Weddige (1984), Ashouri (1990, 1997, 1998, 2001a), Yazdi (1996, 1999) and Wendt *et al.,* (1997). Middle-Late Devonian conodonts from the Khoshyeilagh Formation have been investigated by Ahmadzade (1975), Weddige (1984) and Ashouri (1990, 1994, 2001a, 2001b).

In the Cephalopod Bed the conodont fauna is much more abundant and diversified than in the corresponding beds of the Khoshyeilagh Formation.

Palmatolepis species from the Shotori range and Ozback-Kuh Mountains were studied by Ashouri (2002) and *Icriodus* and *Polygnathus* taxa from north of Iran by Ashouri (in press a). The other conodont taxa from these areas are illustrated herein.

FIGURE 1–Locality map of the investigated area.

SYSTEMATICS

The figured specimens are housed in the Department of Geology of Ferdowsi University of Mashhad (Iran) under the Prefix AFUM. Only the 3 new species are described.

Bispathodus tabasensis n. sp.
Pl. 2, Fig. 23

Derivation of name.–Tabas is the name of the city, located in east Iran where the best Palaeozoic sequences of the Middle East are exposed.

Holotype.–AFUM796, the specimen illustrated on Pl. 2, Fig. 23 from sample N.° 2 of the Niaz area.

Diagnosis.–A species of *Bispathodus* distinguished by very open cross ridges formed on the left side of the basal cavity and beginning at the anterior tip.

Remarks.–The species is readily distinguished from the other species of the genus on the basis of a well-developed left-side basal cavity, ornamented by cross ridges nearly from its anterior end.

Range and occurrence.–The species occur in the Niaz area. On the basis of the associated conodont fauna, it is referred to the Middle to Late *expansa* Zone.

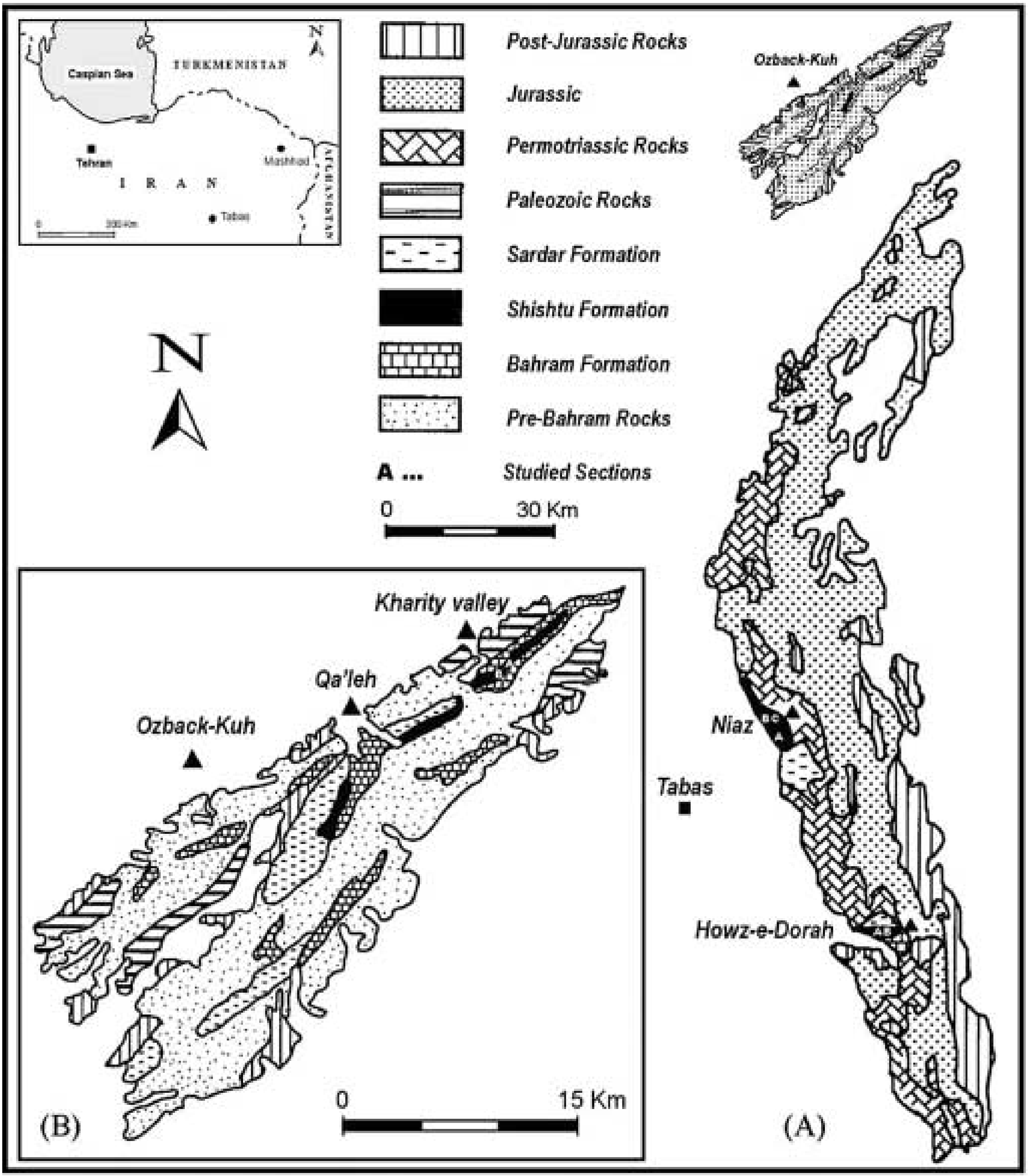
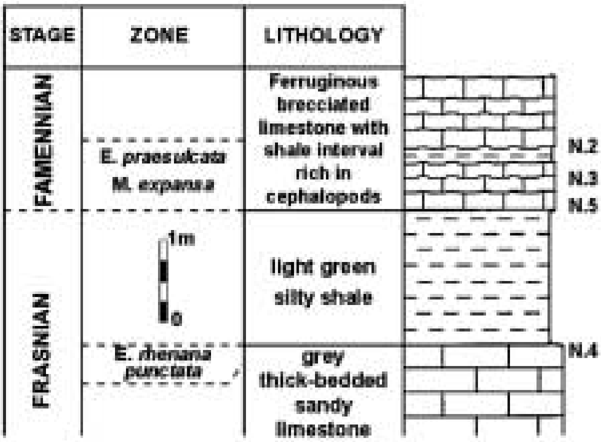
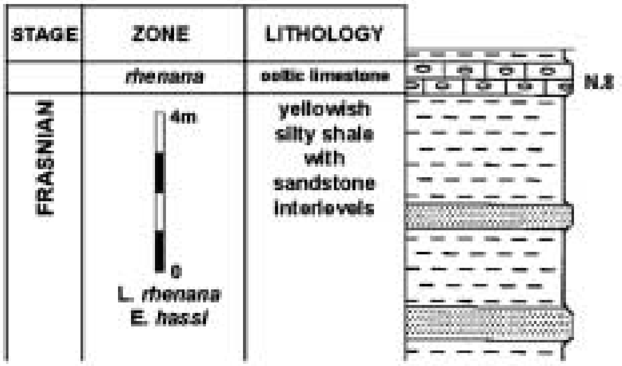


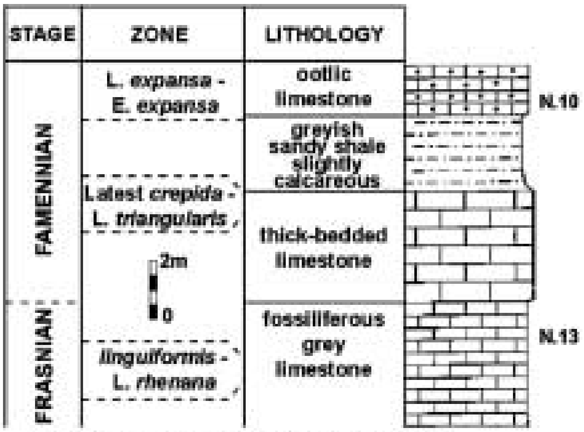
FIGURE 2–Simplified geological map of the Shotori Range and Ozbak-Kuh Mountains.



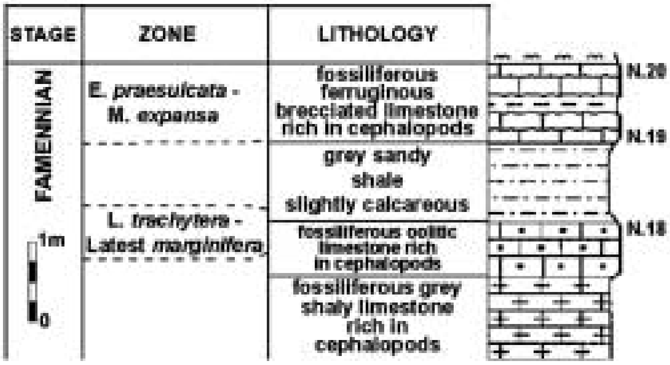
Niaz A section; Part of the Cephalopod Bed
(Modified from Ashouri, 1990).



Niaz B section; Part of the Cephalopod Bed
(Modified from Ashouri, 1990).



Niaz C section; Part of the Cephalopod Bed
(Modified from Ashouri, 1990).



Niaz D section; Part of the Cephalopod Bed
(Modified from Ashouri, 1990).

FIGURE 3–Studied stratigraphical columnar sections.

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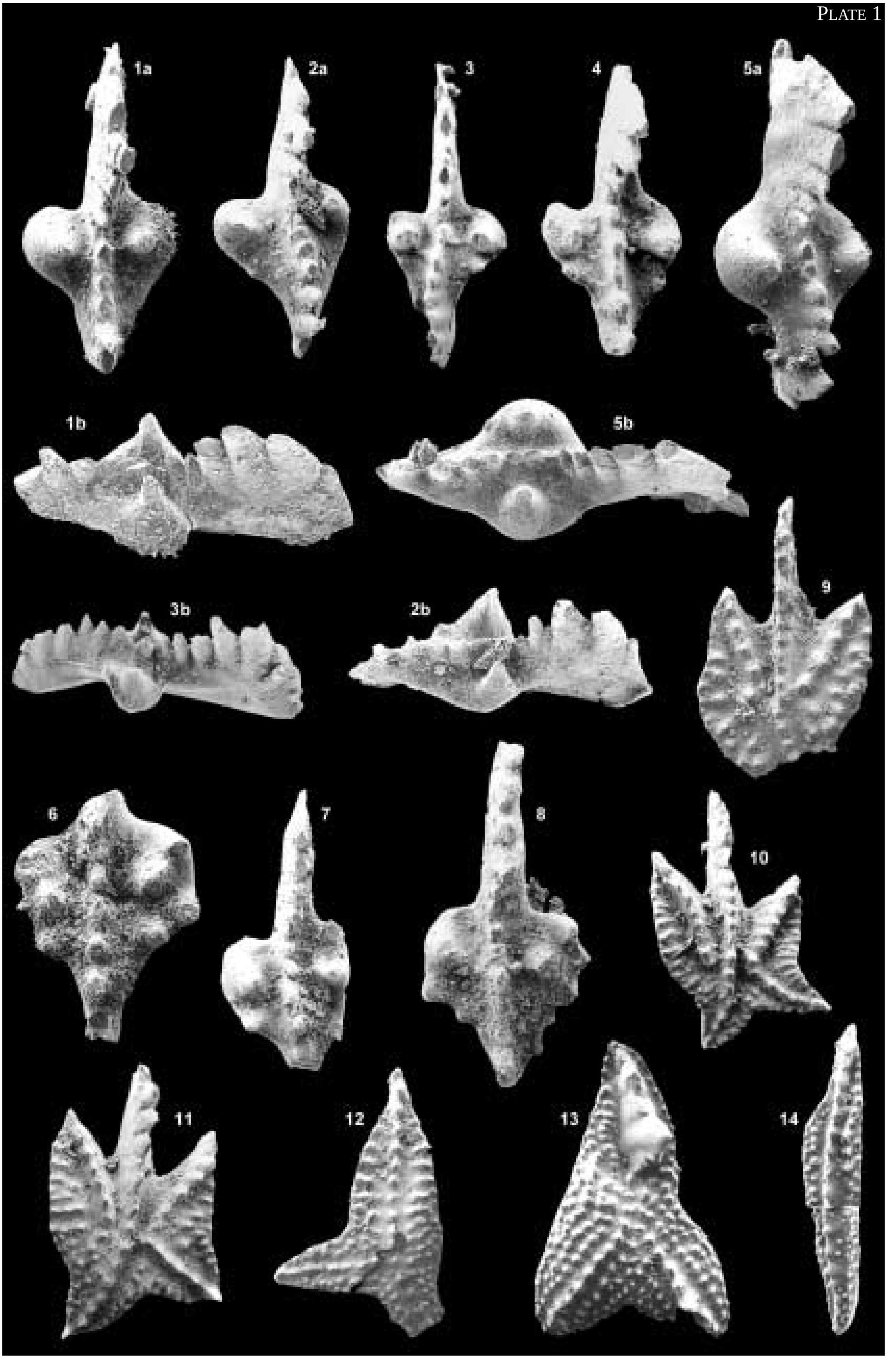
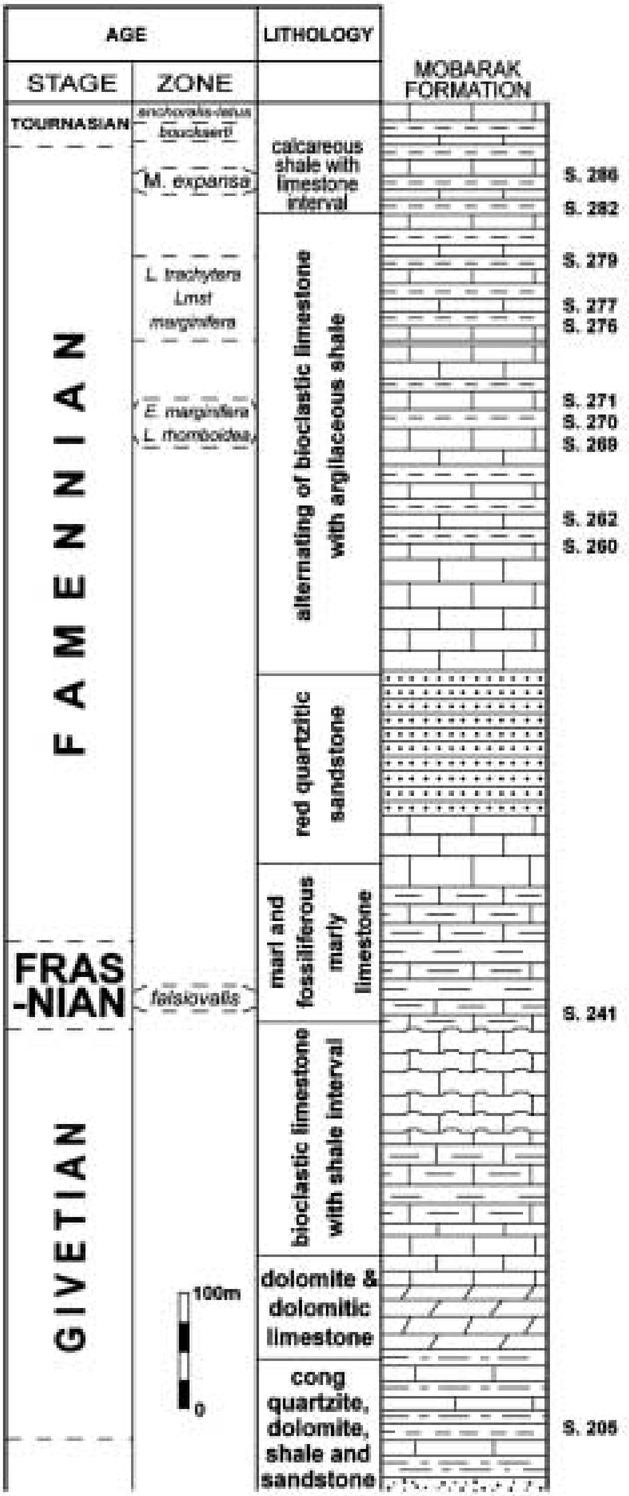
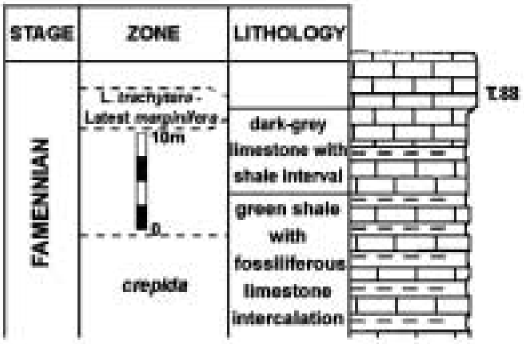
PLATE 1–*10, 13,* x40; *3, 11,* x50; *1, 2, 4, 5, 7, 8, 12, 14,* x60; *6,* x80. *Ancyrodella binodosa* Uyeno, 1967. *1,* Upper, lateral views of AFUM515. S. 241, Khoshyeilagh section. *2,* Upper, lateral views of AFUM517. S. 241, Khoshyeilagh area. *3,* Upper, lateral views of AFUM520. S. 241, Khoshyeilagh area. *4,* Upper view of AFUM521. S. 221, Khoshyeilagh area. *5,* Upper, lateral views of AFUM516. S. 241, Khoshyeilagh area. *Ancyrodella pristina* Khalimbadzha & Chernysheva, 1970. *6,* Upper view of AFUM537. S. 241, Khoshyeilagh area. *7,* Upper view of AFUM540. S. 241, Khoshyeilagh area. *8,* Upper view of AFUM538. S. 241, Khoshyeilagh area. *Ancyrodella lobata* Branson & Mehl, 1934. *9,* Upper view of AFUM530. N. 4, Niaz area. *Ancyrodella curvata* (Branson & Mehl, 1934). *10,* Upper view of AFUM526. N. 13, Niaz area. *11,* Upper view of AFUM528. N. 13, Niaz area. *Ancyrognathus triangularis* Youngquist, 1954. *12,* Upper view of AFUM533. N. 8, Niaz area. *Ancyrognathus calvini* (Miller & Youngquist, 1947). *13,* Upper view of AFUM531. T. 16, Howz-e-Dora area. *Ancyrognathus sinelaminus* (Branson & Mehl, 1934). *14,* Upper view of AFUM538. S. 260, Khoshyeilagh area.

PLATE 1

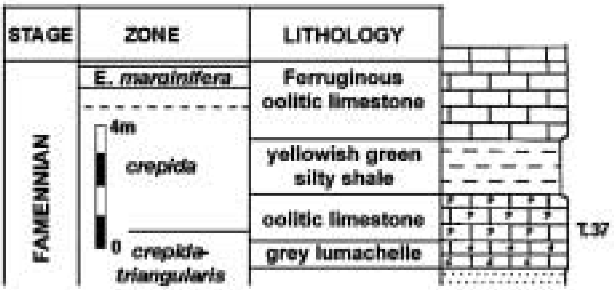




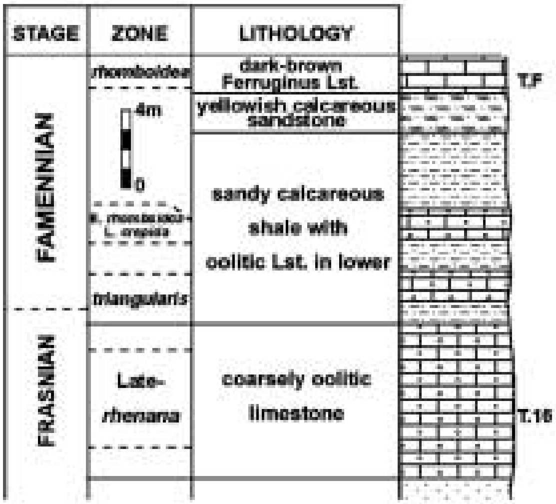
Khoshyeilagh Formation in its type locality (Modified from Ashouri 1990)



Ozbak-Kuh section; part of the Shishtu Formation (Modified from Ashouri, 1990).



Howz-e-Dorah A section; part of the Cephalopod-Bed (Modified from Ashouri, 1990).



Howz-e-Dorah B section; part of the Cephalopod-Bed (Modified from Ashouri, 1990).

FIGURE 4–Studied stratigraphical columnar sections.

Protognathodus ruttneri n. sp.
Pl. 3, Fig. 22

Derivation of name.–In honor of Prof. A. Ruttner for his work on the geology of Iran and who introduced the Shishtu Formation, host rock of the species.

Holotype.–AFUM796, the specimen illustrated on Pl. 3, Fig. 22 from sample N. 3 of the Niaz area.

Diagnosis.–A species of *Protognathodus* characterized by an asymmetrical and heart-shaped cup. The cup is submerged in the blade close to its posterior end. On each side of the cup there are distinct bulge-like nodes. The right node is larger. Posterior of these there is one small node on each side.

Remarks.–Although the posterior most end of the blade is broken, this new species is easily separated from the other species because of the different cup outline and the upper surface ornamentation. The species is distinguished from *Pr. collinsoni* which has a slightly asymmetrical cup and bears one node which may exist on either side of the cup. It is distinguished from *Pr. kuehni* which has a slightly asymmetrical cup and bears robust transverse ridge ornamentation which projects from the margin of the cup to the median row of the cup. It differs from *Pr. kockeli,* which has a spherical cup with one or two rows of nodes on each side of the cup, and from *Pr. meischneri*, which has a symmetrical and unornamented cup.

Range and occurrence.–The species occurs in the Cephalopod Bed in the Niaz area. Its range is Middle to Late *expansa* Zone.

Protognathodus eftekhari n. sp.
Pl. 3, Fig. 21

Derivation of name.–In honor of Dr. J. Eftekharnejad for introducing the host rock of the species.

Holotype.–AFUM796, the specimen illustrated on Pl. 3, Fig. 21 from sample N. 3 of the Niaz area.

Diagnosis.–A *Protognathodus* species with a narrow fusiform shaped and nearly symmetrical cup and having a large anterior node and a small posterior node on each side of the cup.

Remarks.–The cup is very narrow and fusiform. It shows a slight expansion beneath the blade where midway to the base it forms a rectangular edge. Two nodes are the only lateral ornament. These nodes lay half way between the carina and the margin. There is a sharp downturn of the margin and the nodes lie on this.

The species differs from the other described species by the cup outline. The cup shape in all the other forms show a range of heart-shaped to almost spherical. In this form the shape is narrow and fusiform.

Range and occurrence.–The species derived from the Niaz area. Its range based on the associated conodont fauna is Middle to Late *expansa* Zone.

ACKNOWLEDGMENTS

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PLATE 2–*3,* x30; *2, 4, 8, 10, 26,* x40; *16, 21,* x50; *1, 5, 7, 9, 11, 18, 19, 22, 23, 24, 27, 28, 29, 30, 31,* x60; *6, 12, 13, 14, 15, 17, 20,* x80; *25,* x100. *Bispathodus costatus* (E. R. Branson, 1934). *1,* Upper view of AFUM652. N. 3, Niaz area. *2,* Upper view of AFUM653. N. 10, Niaz area. *3,* Upper view of AFUM654. N. 10, Niaz area. *4,* Upper view of AFUM659. N. 10, Niaz area. *20,* Upper view of AFUM697. N. 3, Niaz area. *22,* Upper view of AFUM694. N. 20, Niaz area. *Bispathodus jugosus* (Branson & Mehl, 1934). *5,* Upper view of AFUM662. N. 19, Niaz area. *6,* Upper view of AFUM663. N. 20, Niaz area. *Bispathodus ultimus* (Bischoff, 1975). *7,* Upper view of AFUM675. N. 2, Niaz area. *8,* Upper view of AFUM646. N. 5, Niaz area. *9,* Upper view of AFUM647. N. 20, Niaz area. *Bispathodus aculeatus aculeatus* Branson & Mehl, 1934. *10,* Upper view of AFUM680. S. 286, Khoshyeilagh area. *11,* Upper view of AFUM681. N. 3, Niaz area. *12,* Upper view of AFUM683. N. 5, Niaz area. *13,* Upper view of AFUM684. N. 20, Niaz area. *14,* Upper view of AFUM686. N. 20, Niaz area. *15,* Upper view of AFUM687. T. F, Howz-e-Dorah area. *21,* Upper view of AFUM693. N. 19, Niaz area. *Bispathodus bispathodus* Ziegler, Sandberg & Austin, 1974. *16,* Upper view of AFUM688. S. 286, Khoshyeilagh area. *17,* Upper view of AFUM689. N. 19, Niaz area. *18,* Upper view of AFUM690. N. 10, Niaz area. *19,* Upper view of AFUM692. N. 2, Niaz area. *Bispathodus tabasensis* n. sp. *23,* Upper view of holotype, AFUM796. N. 2, Niaz area. *Bispathodus stabilis* Branson & Mehl, 1934. *24,* Upper view of AFUM636. N. 2, Niaz area. *25,* Upper view of AFUM637. N. 3, Niaz area. *26,* Upper view of AFUM638. N. 5, Niaz area. *27,* Upper view of AFUM643. N. 10, Niaz area. *28,* Upper view of AFUM644. N. 5, Niaz area. *29,* Upper view of AFUM645. N. 3, Niaz area. *Bipennathus bipennatus* (Bischoff & Ziegler, 1957). *30,* Upper view of AFUM504. S. 205, Khoshyeilagh area. *31,* Upper view of AFUM508. S. 205, Khoshyeilagh area.

PLATE 2

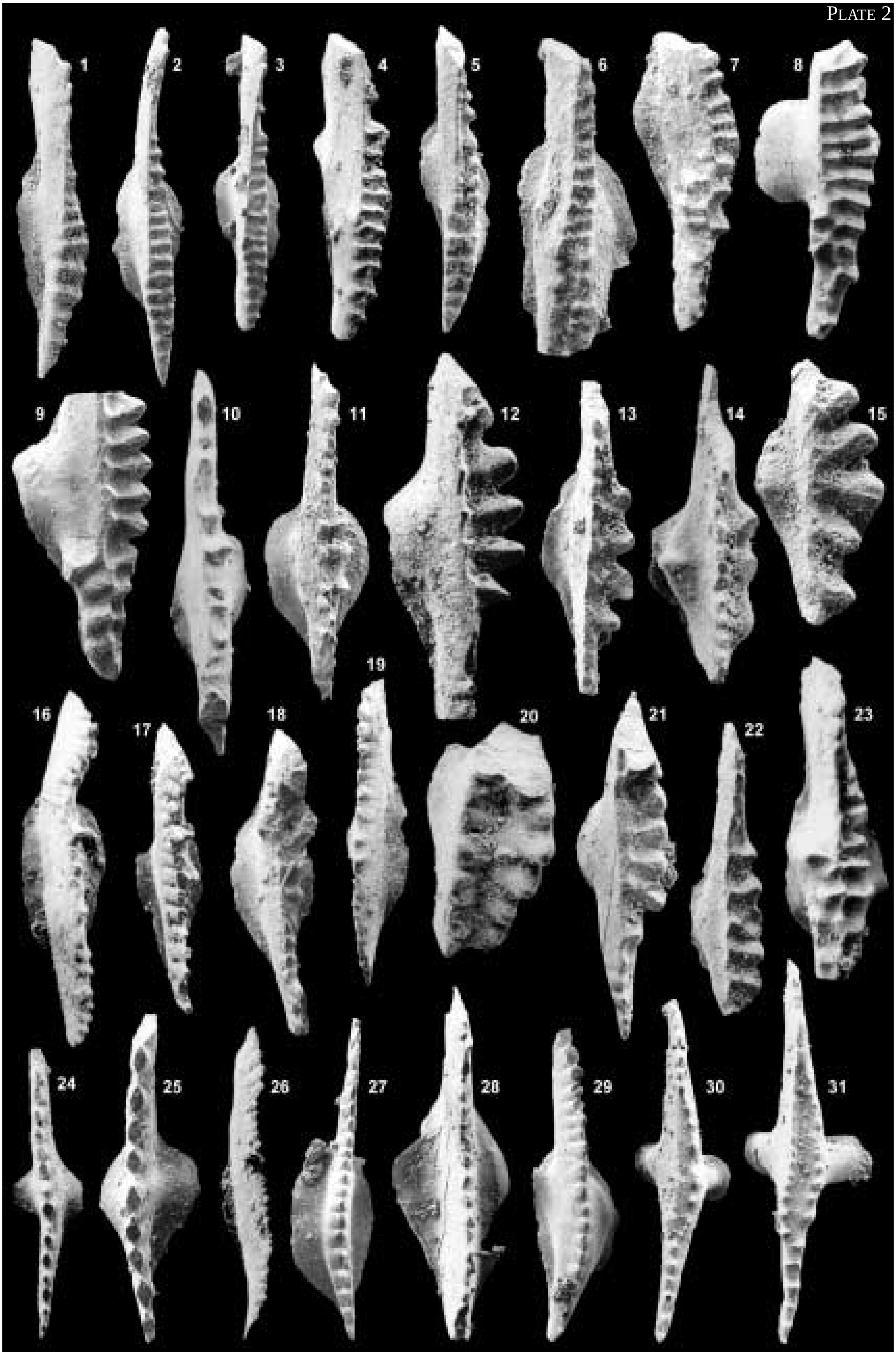
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Plate 3–*4,* x30; *1, 3, 6, 15, 19,* x40; *7,* x50; *5, 12, 13, 14, 21,* x60; *2, 8, 9, 10, 11, 16, 17, 18, 20, 22,* x80. *Palmatolepis wolskajae* Ovnatanova, 1959. *1,* Upper view of AFUM630. S. 271, Khoshyeilagh area. *Palmatolepis quadrantinodosa inflexa* Müller, 1956. *2,* Upper view of AFUM552. S. 270, Khoshyeilagh area. *Scaphignathus velifer* Helms, 1959. *3,* Upper view of AFUM736. T. 88, Ozback-Kuh Mountains. *4,* Upper view of AFUM735. T. 88, Ozback-Kuh Mountains. *5,* Upper view of AFUM737. T. 88,Ozback-Kuh Mountains. *6,* Upper view of AFUM740. S. 276, Khoshyeilagh area. *7,* Upper view of AFUM742. S. 279, Khoshyeilagh area. *Scaphignathus subserratus* Branson & Mehl, 1934. *8,* Upper view of AFUM800. N. 2, Niaz area. *9,* Upper view of AFUM801. N. 18, Niaz area. *10,* Upper view of AFUM802. N. 18, Niaz area. *11,* Upper view of AFUM803. N. 20, Niaz area. *Clydagnathus ormistoni* Beinert, Klapper, Sandberg & Ziegler, 1971. *12,* Upper view of AFUM725. T. 88, Ozback-Kuh Mountains. *13,* Upper view of AFUM728. S. 277, Khoshyeilagh area. *14,* Upper view of AFUM730. S. 279, Khoshyeilagh area. *Clydagnathus cavusformis* Rhodes, Austin & Druce, 1969. *15,* Upper view of AFUM723. S. 279, Khoshyeilagh area. *16,* Upper view of AFUM724. S. 281, Khoshyeilagh area. *Pelekysgnathus brevis* Sandberg & Dreesen, 1984. *17,* Upper view of AFUM514. S. 269, Khoshyeilagh area. *Pelekysgnathus inclinatus* Thomas, 1949. *18,* Upper view of AFUM513. T. 37, Howz-e-Dorah area. *Pelekysgnathus housei* Ashouri, in press. *19,* Upper view of AFUM797. S. 260, Khoshyeilagh area. *Pelegysgnathus talenti* Ashouri, in press. *20,* Upper view of AFUM798. S. 262, Khoshyeilagh area. *Protognathodus eftekhari* n. sp. *21,* Upper view of holotype, AFUM794. N. 3, Niaz area. *Protognathodus ruttneri* n .sp. *22,* Upper view of holotype, AFUM793. N. 3, Niaz area.

PLATE 3

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FORAMINIFERAL AND ALGAL EVIDENCE FOR THE RECOGNITION OF THE ASBIAN/BRIGANTIAN BOUNDARY IN THE GUADIATO AREA (MISSISSIPPIAN, SOUTHWESTERN SPAIN)

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Abstract

Foraminiferal and algal assemblages from the composite Sierra del Castillo and El Collado sections in the Guadiato Area (southwestern Spain) record the interval spanning the Asbian/Brigantian boundary. Typical Brigantian foraminiferal markers in other European basins are rarely recorded. The first occurrences, last occurrences and acmes of the taxa recorded in the Guadiato Area are compared with those from other western Tethyan basins, especially with the Brigantian stratotype section at Janny Wood in England. In the Guadiato Area, the Brigantian can be recognised by the first occurrence (*Pojarkovella guadiatensis*, *Climacammina* sp., *Janischeswkina?* sp., *Eostaffella* aff. *ikensis*, *Calcifolium*? *punctatum*), last occurrence (*Vissariotaxis* spp.), marked decrease in numbers (*Kamaenella tenuis, Koninckopora* spp.) and acmes (*Pseudoendothyra sublimis, Endostaffella, Pojarkovella efremovi, Eovelebitella* sp.) observed in numerous algal and foraminiferal taxa.

Key words: Algae, foraminifera, taxonomy, biostratigraphy, Carboniferous, Mississippian, SW Spain.

Resumen

Se han estudiado las asociaciones de algas y foraminíferos de las secciones de la Sierra del Castillo y El Collado, en el Área del Guadiato (suroeste de España). Las secciones estudiadas comprenden el tránsito del Asbiense al Brigantiense. Se han encontrado típicos foraminíferos guía del Brigantiense, pero raramente. La primera y última aparición así como los acmes de los taxones en el Área del Guadiato, se comparan con sus registros en otras cuencas de Tethys occidental, en particular con Janny Wood en Inglaterra, estratotipo de límite de la base del Brigantiense. En el Área del Guadiato, el Brigantiense se reconoce por la aparición (*Pojarkovella guadiatensis, Climacammina* sp., *Janischeswkina?* sp., *Eostaffella* aff. *ikensis, Calcifolium*? *punctatum*), desaparición (*Vissariotaxis* spp.), marcado empobrecimiento (*Kamaenella tenuis, Koninckopora* spp.) y acmes (*Pseudoendothyra sublimis, Endostaffella, Pojarkovella efremovi, Eovelebitella* sp.) de numerosos foraminíferos y algas.

Palabras clave: Algas, foraminíferos, taxonomía, biostratigrafía, Carbonífero, Mississippiense, SO España.

INTRODUCTION

The Guadiato Area contains one of the best Mississippian carbonate platform sequences in southwestern Spain (Fig. 1). An extensive fieldwork program has been undertaken in the last few years which enabled us to recognise the stratigraphic succession throughout the late Viséan and Pendleian (Cózar, 1996, 1998, 2003; Cózar & Rodríguez, 1999a, 1999b, 1999c, 2001). The Pendleian rocks are always separated by major faults from the upper Viséan rocks, thus no continuous record of the transition of Viséan to Pendleian rocks is found.

The calcareous algae have been traditionally ignored as biostratigraphic markers, but progressive improvement in the knowledge of this fossil group is demonstrating its usefulness (e. g. Skompski *et al.*, 1989; Sebbar and Mamet, 1996, 1999; Mamet, 1991,

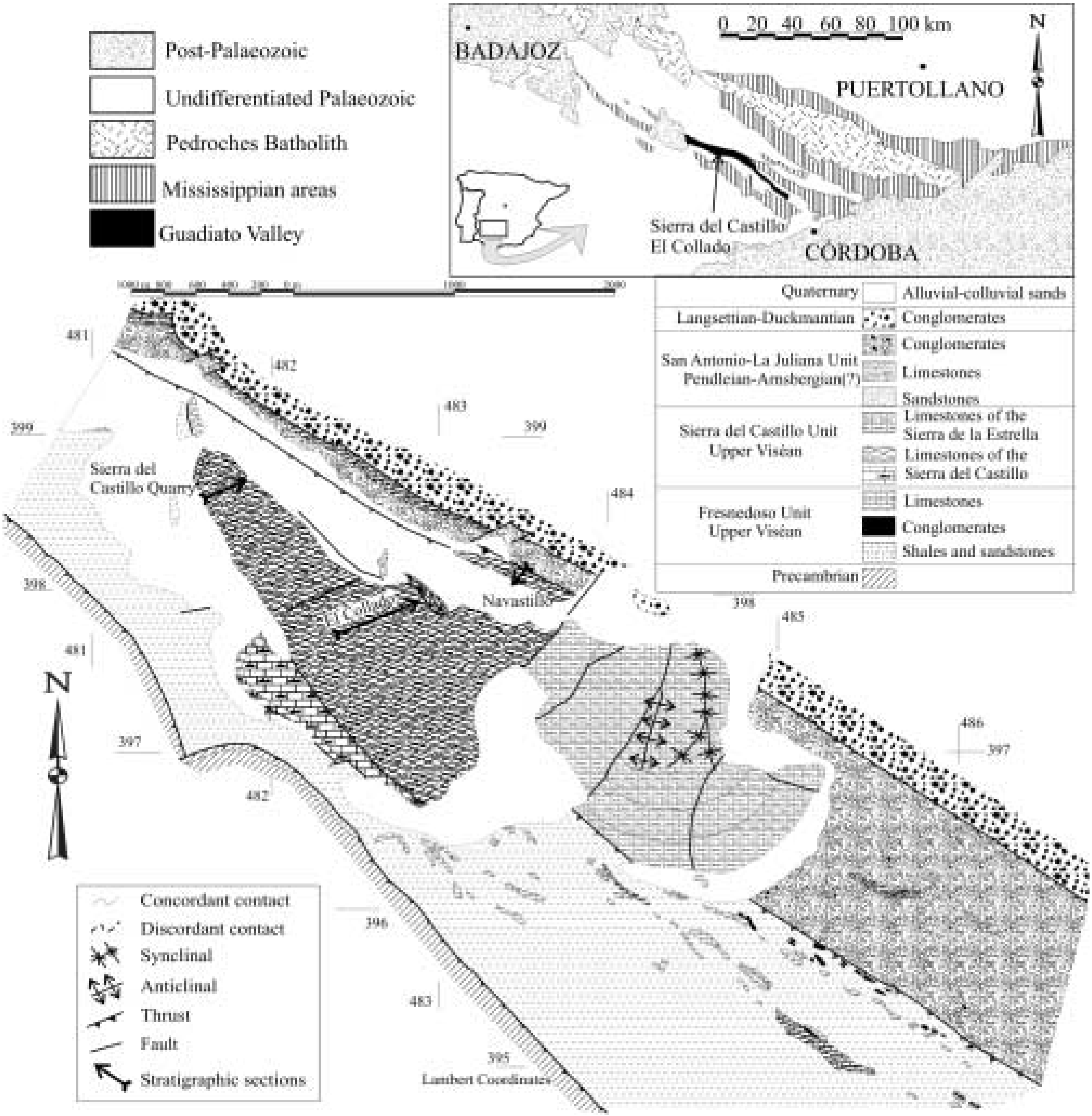


FIGURE 1–Location of the studied area in the southwestern Iberian Peninsula (modified from Cózar, 1998).

2002; Vachard *et al.*, 2001, Krainer & Vachard, 2002). Furthermore, calcareous algae commonly are more abundant than foraminifera and can be used successfully in solving biostratigraphic problems such as recognition of the Asbian/Brigantian boundary in northern England and Ireland (Cózar & Somerville, 2004, in press b).

The most favourable sequence for recognising the Asbian/Brigantian boundary in the Guadiato Area is within the inner ramp rocks, which contain rich foraminiferal/algal assemblages, and are dominated by carbonates, compared to the marls and shales in the mid to outer ramp. These inner ramp beds are found within the composite stratigraphic succession of the Sierra del Castillo/El Collado sections (Figs. 3 to 6). The base of Mamet foraminiferal Zone 16 (Fig. 2) was first placed at the base of unit 7 (Moreno-Eiris *et al.*, 1995; Cózar, 1996) and later, unit 13 (Cózar, 1998; Cózar & Rodríguez, 1999b) in El Collado section (Figs. 4, 6). The base of Zone 16 in this section was defined on the first occurrence of *Neoarchaediscus* (following Mamet, 1974), although the first occurrences of foraminiferal markers do not always coincide with the base of the stages (e. g. Little Asby Scar, Asbian stratotype, Strank, 1981). Moreover, if we consider the correlation of the base of Zone 16 with the base of the Cf6γ subzone (e. g. Herbig & Mamet, 1985; Vachard & Berkhli, 1992; Hecker, 2002; Fig. 2), this might suggest that Brigantian rocks are not recorded in the Sierra del Castillo/Collado succession. The typical conodont Brigantian *Lochriea mononodosa* Biozone (= *L. nodosa* auct.) is not recorded in the succession (Bermúdez, 2003; Fig. 2). However, Brigantian rugose corals occur in unit 7 and at the base of unit 9 in El Collado (*Palastraea regia*, Moreno-Eiris *et al.*, 1995; Rodríguez and Falces, 1996; Hernando-Hernando, 2000), and thus the presence of Brigantian rocks in this succession is confirmed, but its precise basal location remains to be elucidated.

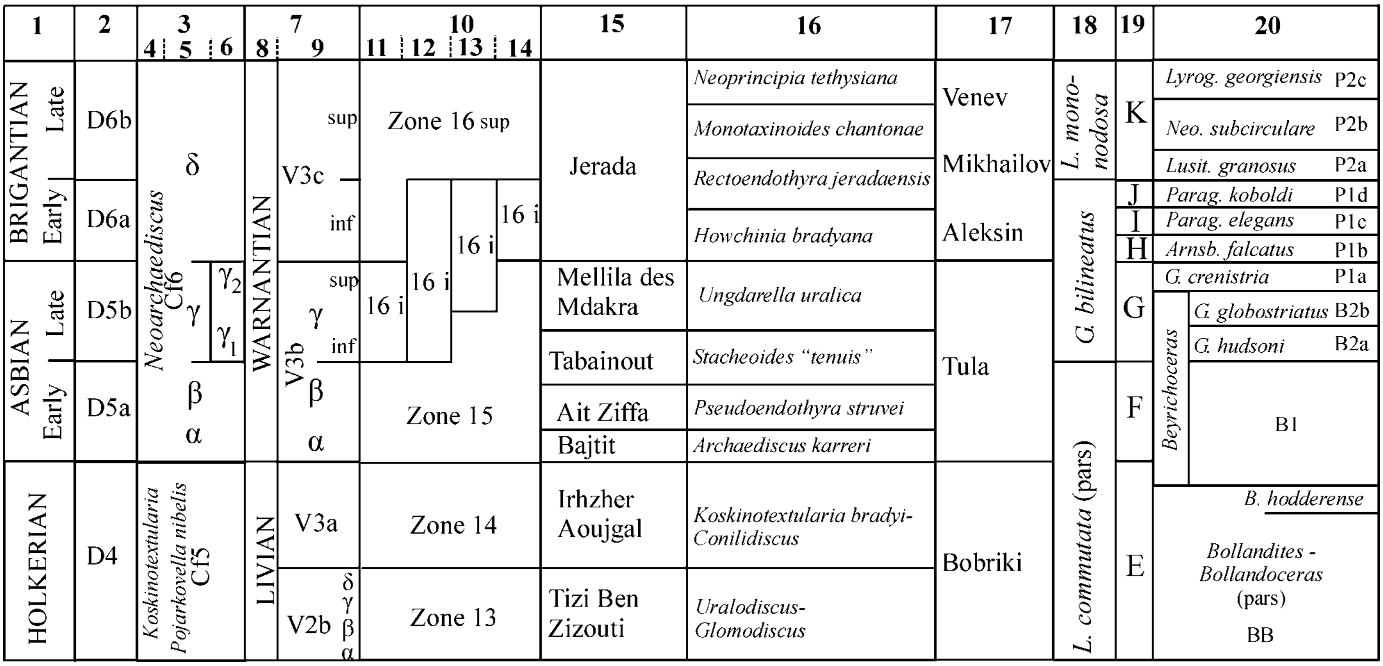


FIGURE 2–Correlation of the stratigraphic units in the upper part of the Viséan in different Tethyan areas and different faunal and floral biozonations. 1. Stages and sub-Stages in Britain; 2. Mesothems in northern England (based on Ramsbottom, 1973); 3. Foraminiferal zones defined in Britain (based on Conil *et al.*, 1980, 1991); 4. Nominal foraminiferal zones; 5. Sigles; 6. Subdivision of the Cf6γ foraminiferal zone in Ireland (based on Jones & Somerville, 1996); 7. Stages and foraminiferal zones in Belgium and France; 8. Stages; 9. Sigles (based on Conil *et al.*, 1977; Vachard, 1977); 10. Foraminiferal zones defined for the western Tethys (based on Mamet, 1974); 11. Correlation proposed by Vachard & Tahiri (1991) and Berkhli & Vachard (2001); 12. Correlation proposed by Herbig & Mamet (1985); 13. Correlation proposed by Cózar (2003); 14. Correlation proposed by Hecker (2002); 15. Moroccan type localities (modified from Berkhli & Vachard, 2001); 16. Moroccan index-fossils (modified from Berkhli & Vachard, 2001); 17. Moscow Basin Horizons (modified from Hecker 2002); 18. Conodont zones (based on Varker & Sevastopulo, 1985); 19. Rugose coral zones (based on Mitchell, 1989); 20. Goniatite zones (based on Riley, 1993).

In consequence, with the aim of reconciling palaeontological data, detailed bed-by-bed sampling and reexamination of the Sierra del Castillo/Collado succession was undertaken for this study (Fig. 1, detailed location in Cózar, 1996). As previously described in Cózar (1996, 1998), the basis for the correlation between the Sierra del Castillo and El Collado sections was the continuity of the tempestite horizons with common *Siphonodendron* corals in unit 12 in the Sierra del Castillo and units 2-3 in El Collado. This interval of rocks can be walked out in the field from the Sierra del Castillo to El Collado.

MATERIALS AND METHODS

165 m of outcrop were exposed in the quarry where the Sierra del Castillo section was first sampled (Cózar, 1996), but due to more recent excavations an upper 15 m interval has been uncovered, giving a total thickness of 180 m (September, 2002, Figs. 3). The section in Figs. 3 and 5 is a composite of the upper two benches of the quarry. The previous log of this quarry (Cózar, 1996) was limited to the lower bench. The new upper bench exposes well developed palaeokarsts (Figs. 3, 5), not recognised in the lower bench due to the absence of important clay-wayboards, but detailed reexamination of this lower bench reveals that they also occur. Most of the succession is composed of thin well-bedded limestones, with occasional massive beds in the lower part of the section and marly sediments in the middle part and top of the section. The sampling interval was selected at meter intervals in the lower and upper parts (units 1 to 9, 14 and 15, Fig. 3), and every 2 m in the middle part (units 10 to 13, Fig. 3). Thus, a total of 128 samples were studied (Pc2103 to Pc2230). One standard thin-section (2.4 x 4.8 cm) was prepared from each sample, with duplicates made from samples Pc2200-Pc2230.

The Collado section (165 m thick) is more marly and contains only about 80 m of limestone (Fig. 4). 119 limestone beds were sampled (Fig. 4), and two (Pc Pc680-Pc690, and Pc721-Pc799) or four (Pc691-Pc720) standard thin-sections were prepared from each sample, resulting in a sampling interval of 0.5-1 m for the limestones. Additionally, the 70 thin-sections studied in El Collado and Sierra del Castillo sections by Cózar (1996) have been reexamined.

About 530 thin-sections have been examined with the petrographic microscope. As the number of thin-sections differs between sections, the number of specimens documented are per thin-section, except when only one or two specimens were found (independently of the number of thin-sections).

ALGAL ASSEMBLAGES

Many of the taxa in the Guadiato Area exhibit long stratigraphic ranges, being present in most parts of the succession, but with different acmes or trends (Figs. 3-4). Only the most significant taxa are highlighted (Pl. 1). For example, the problematic alga *Koninckopora* (*K. minuta* Weyer, *K. pruvosti* Güvenç, *K. tenuiramosa* Wood, *K. inflata* (de Koninck) and *K. mortelmansi* Mamet) is well represented in most parts of the Sierra del Castillo/El Collado succession, but it is less abundant from unit 6 upward in El Collado. In the Sierra del Castillo section, *Koninckopora* thalli per thin-section are commonly 20-30, and in some horizons (unit 7 in Sierra del Castillo, Fig. 2), it is the main rock-forming bioclast. In the upper part of the succession (approx. from unit 6 in El Collado, Fig. 4), usually no more than 7-8 thalli are recorded per thin-section, and it is absent in many samples. However, up to 15 thalli are recorded in some horizons in the upper part of El Collado section (unit 11).

Eovelebitella sp. occurs rarely in units 8 and 11 in Sierra del Castillo, and even its identification is questionable because specimens are oblique sections. It is more abundant in El Collado; where rare specimens occur mostly in units 4 and 5, and become common in units 10 and 12. “*Windsoporella*” only occurs in unit 8 in Sierra del Castillo. Occurrences of *Cabrieropora pokornyi* Mamet & Roux are rare in units 11 and 15 in the Sierra del Castillo section, but very common at the base of El Collado section (unit 4 and base of unit 5). The first occurrence of *Coelosporella jonesi* Wood is in unit 1 in El Collado. It is rare in units 2 and 3 at that locality and also in unit 15 at the top of Sierra del Castillo, but very abundant in units 10 and 12 at the latter section. Specimens of *Coelosporella* in the upper part of El Collado are much smaller than those found at the base, and they can be assigned to *C. wetheredii* Wood. *Kulikia sphaerica* Golubsov occurs commoly in El Collado. *Palepimastoporella espielensis* Cózar & Vachard is common at the base of El Collado (type locality), and it extends more rarely up to unit 10 (Fig. 4). However, horizons equivalent to the base of El Collado in the Sierra del Castillo section do not contain this dasyclad, suggesting a strong facies control on its distribution. *Pseudokulikia khenifraensis*

Mamet occurs only in unit 9 to 13 in the Sierra del Castillo. The facies in which this codiacean is recorded are similar to those described by Mamet (1997), suggesting also a strong facies control.

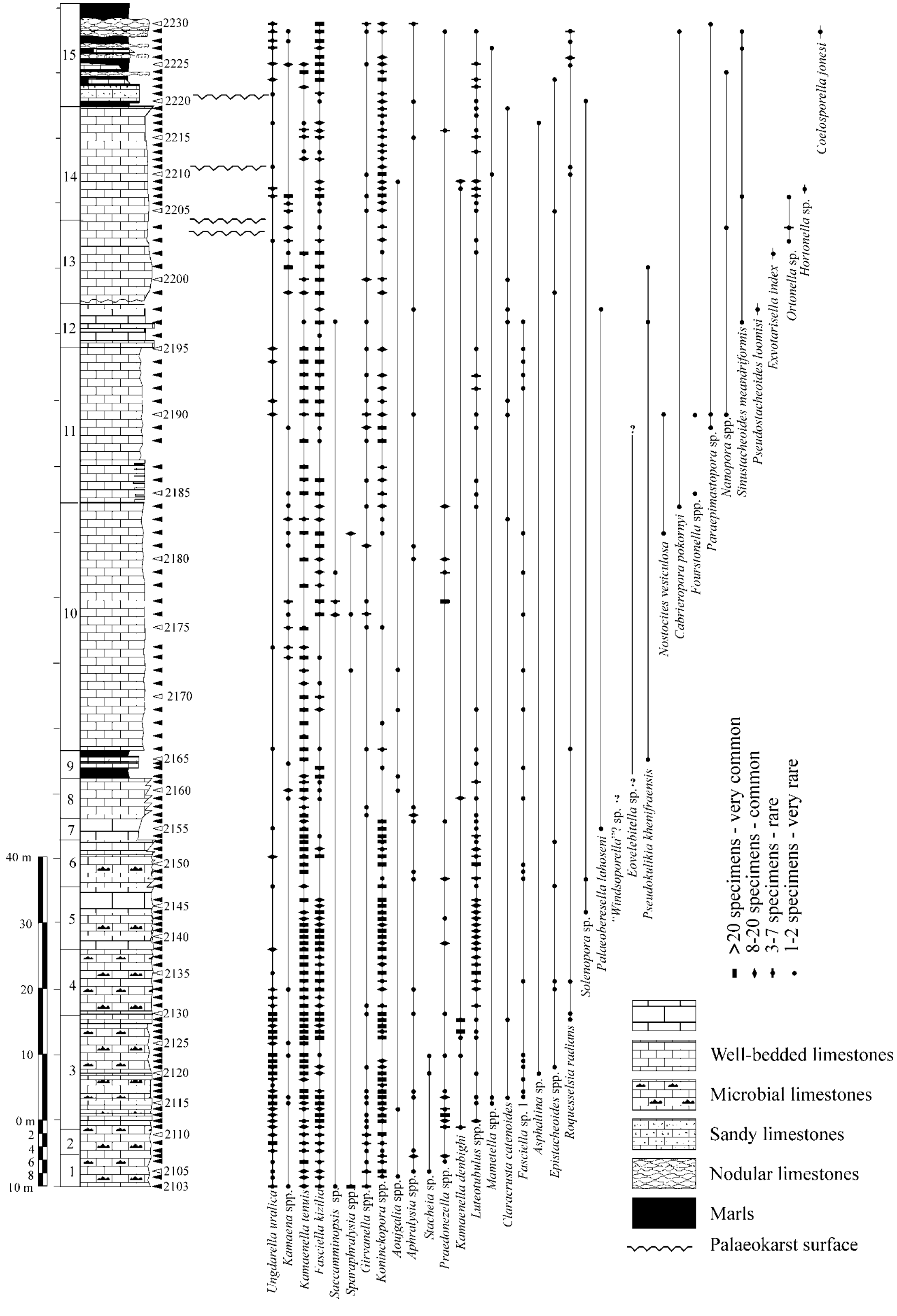


FIGURE 3–Algal distribution in the Sierra del Castillo section.

Saccamminopsis spp. exhibits rare occurrences from the base of the succession to the upper part of El Collado, but rich concentrations are recorded only in unit 10 in El Collado section (Fig. 4). Specimens in the

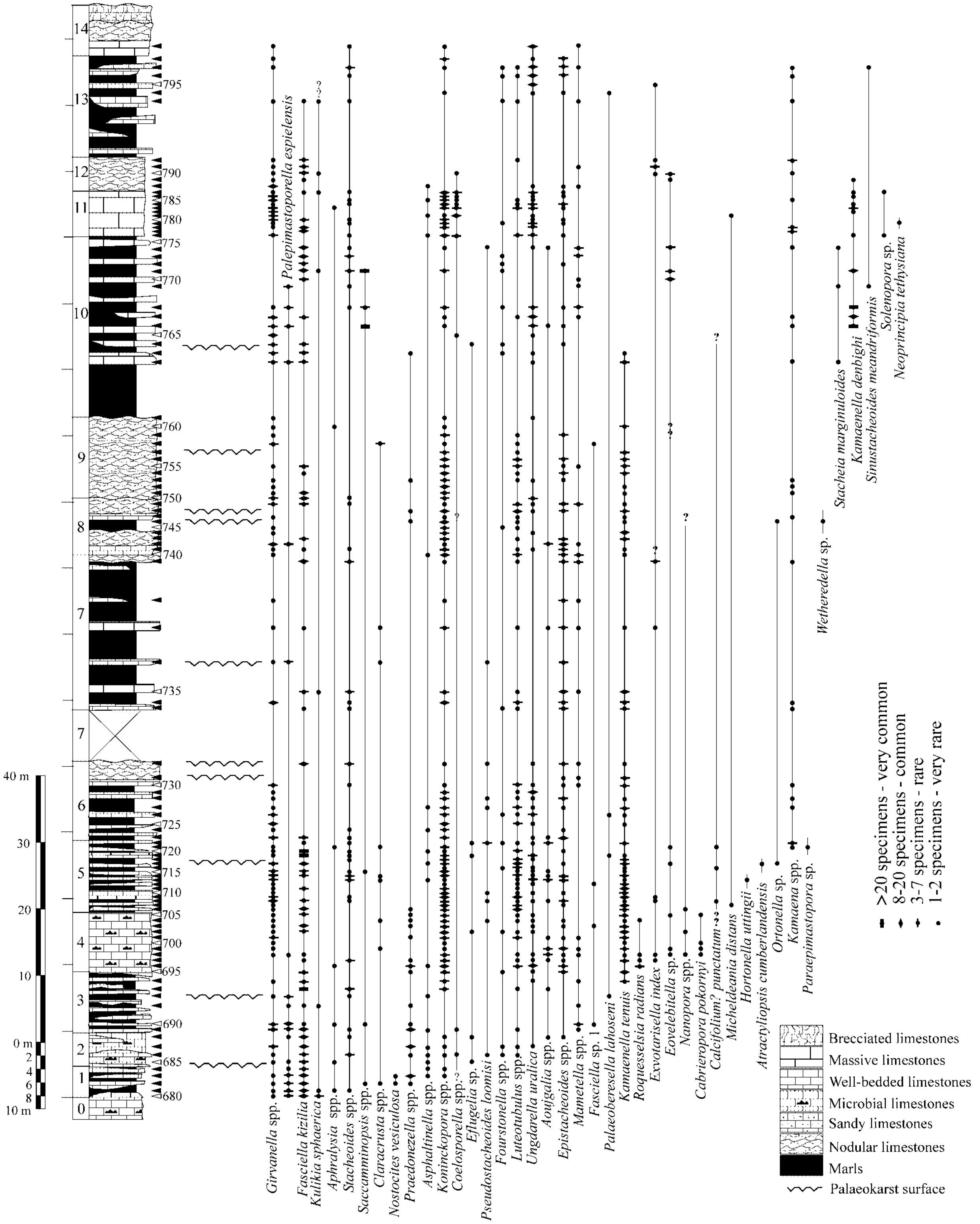


FIGURE 4–Algal distribution in El Collado section.

Sierra del Castillo and base of El Collado are less than 1 mm in diameter but larger specimens occur in unit 10 at El Collado. They all exhibit the typical shape of *S.* ex gr. *fusulinaeformis* (McCoy).

Kamaenella is very common in Sierra del Castillo, and in some horizons it is the dominant bioclast of the microfacies, ranging up to 50-60% in total rock volume. These assemblages are dominated by *Kamanella tenuis* (Möller), with rarer *K. denbighi* Mamet & Roux in Sierra del Castillo (Fig. 3). The latter does not occur in the lower part of El Collado, although scarce specimens may be admixed with numerous *K. tenuis,* which are usually broken and concentrated, and rarely preserved as bafflestones. In the upper part of El Collado, the smaller *K. tenuis* disappears and the larger *K. denbighi* occurs as the only species of the genus throughout units 10-12.

Ungdarella uralica Maslov is common at the base of Sierra del Castillo and throughout El Collado. However, the number of specimens is highest in the lower part of El Collado (units 4 and 5).

Aphralysia spp. (mostly *A. ferreoli* Mamet & Roux) is relatively common in Sierra del Castillo and in El Collado at the base (below unit 5), and in only two samples in units 9 and 11.

Claracrusta spp. (mostly *C. catenoides* (Homman) emend. Vachard) occurs rarely, throughout the succession.

In El Collado section, specimens of *Calcifolium? punctatum* Maslov occur rarely in unit 5, and questionably in units 4 and 10. The taxon is encrusting (Pl. 1, Figs. 5 and 9; compare with Cózar & Vachard, in press), but the preservation of the rock is not good enough for a precise identification. Thus, some specimens could be attributed to recrystallised *Fasciella*. However, some well preserved specimens were chemically extracted from the limestone beds of unit 5 (Pl. 1, Fig. 5; Bermúdez, 2003). *Calcifolium? punctatum* is very abundant in the Guadiato Area in indurated Pendleian limestone beds as well as in marls, from which, whole specimens were extracted (see Cózar & Vachard, in press).

The final significant alga is a rhodophyte, *Neoprincipia tethysiana* Cózar & Vachard occurring in unit 8 in El Collado.

FORAMINIFERAL ASSEMBLAGES

Many foraminifera are long-ranging taxa, and furthermore, their stratigraphic range are not significant for recognition of the Asbian/Brigantian boundary, because they can occur in older (lower and mid Viséan) and younger rocks (Serpukhovian). Moreover, in some cases, species are not especially significant, because most species of a given genus share the same stratigraphic range (at least within the studied interval Asbian to Brigantian). Thus, only the occurrence of the genus is highlighted in Figures 5-6, where most of the taxa are in open nomenclature. Some selected foraminifera are illustrated in Plates 1 and 2.

On the other hand, some of the groupings used in Figs. 5-6 need a brief systematic explanation, because they are informal taxa, rarely used in the literature. For instance, the Archaediscidae is the most useful family for biostratigraphic purposes in the Viséan-basal Namurian interval. However, its classification is not free of controversy, and many attempts for achieving a general consensus have been undertaken (e. g. Pirlet & Conil, 1977; Conil *et al.,* 1980; Altiner & Zaninnetti, 1980, Brenckle *et al.*, 1987; Vachard, 1988; Pinard & Mamet, 1998). Thus, criteria to distinguish the genera cannot be standardised and universally applied.

The archaediscids have been divided into three informal groups: *Paraarchaediscus*, “*Archaediscus*” and *Archaediscus*. These groups are related to the presence of the microgranular layer. *Paraarchaediscus* is used here for those archaediscid specimens with a well developed microgranular layer (following the criteria of Brenckle *et al.,* 1987). *Archaediscus* is used for those specimens in which the microgranular layer is poorly developed to virtually absent (also similar to the definition in the classification of Brenckle *et al.*, 1987). However, in contrast to the latter classification, there are many specimens in which the development of the microgranular layer would be defined as intermediate. Thus, it is possible to ascribe specimens either to *Paraarchaediscus s. s.* or to *Archaediscus s. s.* genus. All these specimens have been identified as *“Archaediscus”*. This unorthodox and informal classification is systematically controversial, because it does not permit identification of most specimens to species level, unless the systematics of the Archaediscidae is revised. Because it is not possible to identify species, these groups of *Archaediscus s. l.* have been divided into the evolutionary stages defined by Pirlet & Conil (1977) and Conil *et al.* (1980). Thus, *Archaediscus s. l.* at the *involutus, concavus* and *angulatus* stages have been recognised (Figs. 5-6). No *Archaediscus* at the *tenuis* stage have been recognised. These stages are particularly useful because the occurrence of the *concavus* stage is a marker of the

Holkerian, and the *angulatus* stage is a marker for the base of the Asbian in France, Belgium, England and Ireland (Conil *et al.*, 1977, 1980, 1991; Vachard, 1977; Somerville *et al.*, 1992).

In the Sierra del Castillo section, there is a predominance of *Paraarchaediscus* at the *angulatus* stage. However, *Paraarchaediscus* at the *concavus* stage are also common, mostly at the lower part of the section, and from unit 10 upward, they are rarer. This trend is clearer in El Collado section in which *Paraarchaediscus* at the *concavus* stage disappear in unit 8, whereas *Paraarchaediscus* at the *angulatus* stage are common throughout the section but mostly in the lower part (units 1 to 9). There are rare *Paraarchaediscus* at the *involutus* stage in the Sierra del Castillo section from units 10-14. All the *"Archaediscus"* and *Archaediscus* exhibit a well defined *angulatus* stage. *"Archaediscus"* occur rarely in the Sierra del Castillo section, in unit 6, but they are common in El Collado at the top of unit 5, and from units 10 to 14. *Archaediscus* first occur in unit 11 in El Collado, and are common in units 12 and 14.

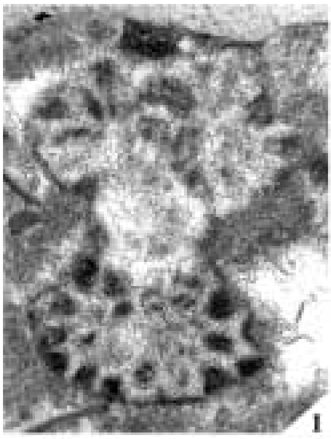
Another informal category used in Figs. 5 and 6 are the large *Archaediscus* group, including *Archaediscus* ex gr. *karreri* (Brady) characterised by sigmoidal coiling and a globose test (e. g. *Archaediscus karreri grandis* Conil & Lys, and *Archaediscus karreri vertens* Conil & Lys). In this group are also included *A.* ex gr. *chernoussovensis* Mamet with oscillating coiling and lenticular test (e. g. *A. chernoussovensis* Mamet). All these *Archaediscus* are more than 450 µm in diameter and have a well defined *angulatus* stage, and poorly developed microgranular layer. The large *Archaediscus* first occur within unit 2 in El Collado section, and they occur infrequently throughout the succession.

The Asteroarchaediscinae exhibit similar problems to those of the Archaediscinae, and classifications and criteria to recognise the genera are diverse. Here, four genera have been distinguished: *"Nodosarchaediscus"*, *"Nodasperodiscus"*, *Neoarchaediscus* and *Neoarchaediscus? "Nodosarchaediscus"* is considered here to include those specimens with partial occlusion of the lumen, in which the occlusion is marked simply by nodes (rounded shape), with a well developed microgranular layer and sutures at the *concavus* stage (cf. Vachard, 1988). In fact, the validity of this genus is not free of controversy, and some authors consider it as invalid (e. g. Brenckle *et al.*, 1987; Pinard & Mamet, 1998). *"Nodasperodiscus"* is considered here to include those specimens with partial occlusion of the lumen by nodes, a variable development of the microgranular layer, and sutures at the *angulatus* stage; the complete occlusion of the central whorls is debatable. *Neoarchaediscus* is considered here to include those specimens with fully occluded initial whorls, in which the occlusion exhibits a typical "W" shape, a variable development of the microgranular layer (but generally poor), and sutures at the *angulatus* stage (cf. Brenckle *et al.*, 1987 = Vachard, 1988 = Pinard & Mamet, 1998 = *Asperodiscus* cf. Conil *et al.*, 1980). Finally, *Neoarchaediscus?* includes those specimens whose internal volutions are not preserved well enough to distinguish between *Neoarchaediscus* or *"Nodasperodiscus"*.

→

PLATE 1–Selected calcareous algae and foraminifera from the Guadiato Area. The species name is followed by the specimen number, stratigraphic section, unit and magnification in parentheses. *1, Eovelebitella* sp., Pc771b-2282/28, El Collado, unit 10 (x60). *2, Coelosporella wetheredii* Wood, Pc781-2282/32, El Collado, unit 11 (x22). *3, Kamaenella denbighi* Mamet & Roux bafflestone, Pc2127-2276/11, Cantera del Castillo, unit 13 (x26.5). *4, Pseudokulikia khenifraensis* Mamet, CCS/13a-2285/5, Cantera del Castillo, unit 13 (x26). *5, Calcifolium? punctatum* Maslov, El Collado, unit 5 (x30). *6, Saccamminopsis* ex gr. *fusulinaeformis* (McCoy), Pc771a-2282/27, El Collado, unit 10 (x11). *7, Neoprincipia tethysiana* Cózar & Vachard, Pc779-2147/12, El Collado, unit 11 (x53). *8, Palepimastoporella espielensis* Cózar & Vachard, holotype, Pc685-2148/29, El Collado, unit 2 (x13.3). *9, Calcifolium? punctatum* Maslov, Pc717b-2277/26, El Collado, unit 5 (x53). *10, Paraarchaediscus* at angulatus stage, Pc788-2283/26, El Collado, unit 12 (x53). *11, Archaediscus* at angulatus stage, Pc2196-2276/26, Cantera del Castillo, unit 12 (x133). *12, Archaediscus* ex gr. *karreri* Brady, Pc688-2277/11, El Collado, unit 2 (x53). *13, "Archaediscus"* at angulatus stage, Pc2206-2276/30, Cantera del Castillo, unit 14 (x133). *14, Neoarchaediscus?* sp., Pc2216-2277/2, Cantera del Castillo, unit 14 (x133). *15, Neoarchaediscus incertus* (Grozdilova & Lebedeva), Pc788-2283/35, El Collado, unit 11 (x133). *16, Vissariotaxis longa* Brazhnikova, Pc2166-2276/21, Cantera del Castillo, unit 10 (x133). *17, Howchinia bradyana* (Howchin) emend. Davis, Pc775-2283/23, El Collado, unit 10 (x53). *18, "Nodasperodiscus"* sp., Pc2156-2276/17, Cantera del Castillo, unit 7 (x133). *19, Planohowchinia espielensis* Cózar & Mamet, Pc2123-2276/9, Cantera del Castillo, unit 3 (x100). *20, Vissariotaxis* transitional to *Howchinia,* Pc2164-2276/20, Cantera del Castillo, unit 9 (x133). *21, Neoarchaediscus stellatus* (Bozorgnia), Pc799-2283/32, El Collado, unit 14 (x133).

PLATE 1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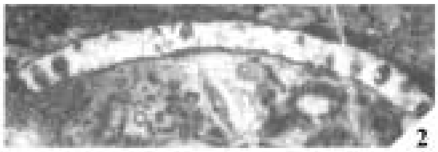
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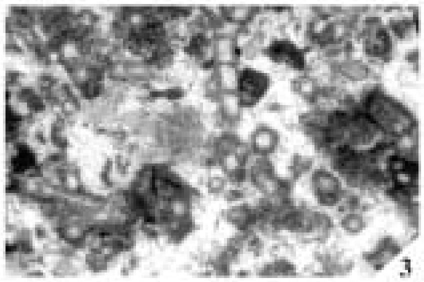
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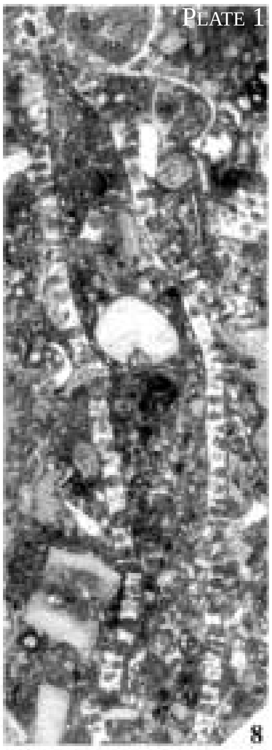
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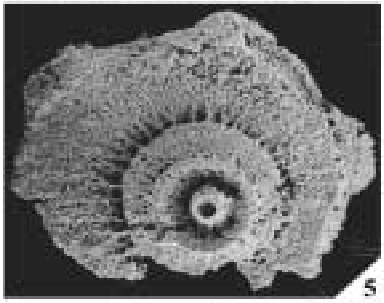
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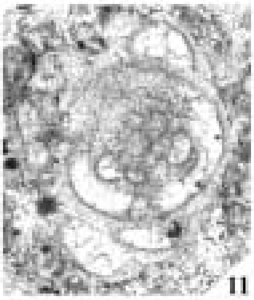
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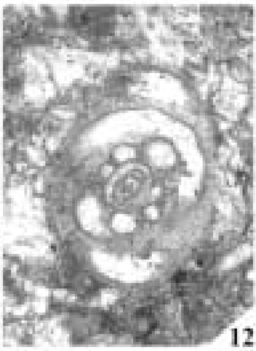
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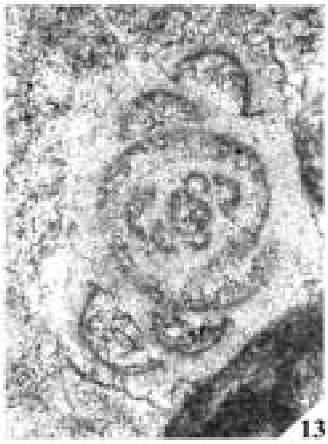
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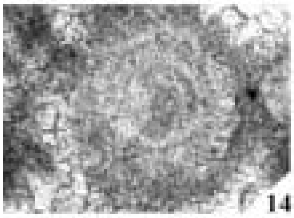
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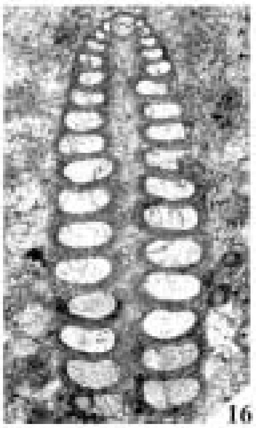
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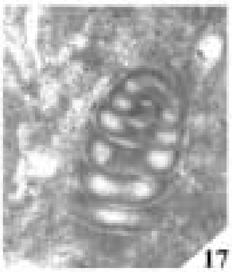
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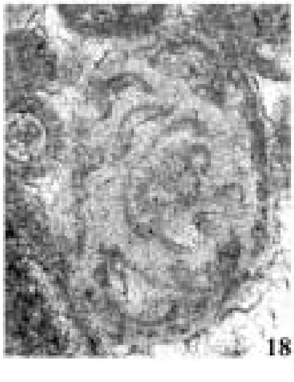
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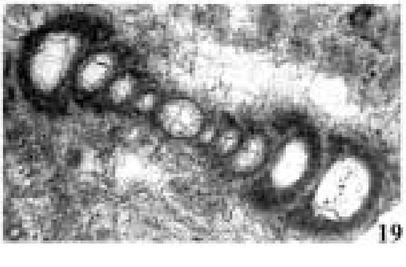
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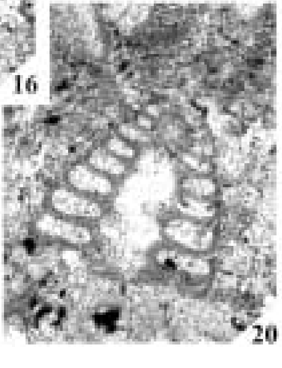
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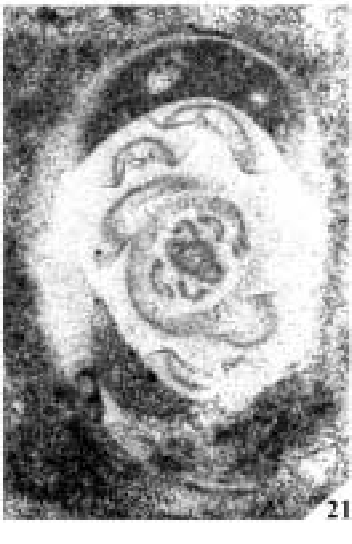
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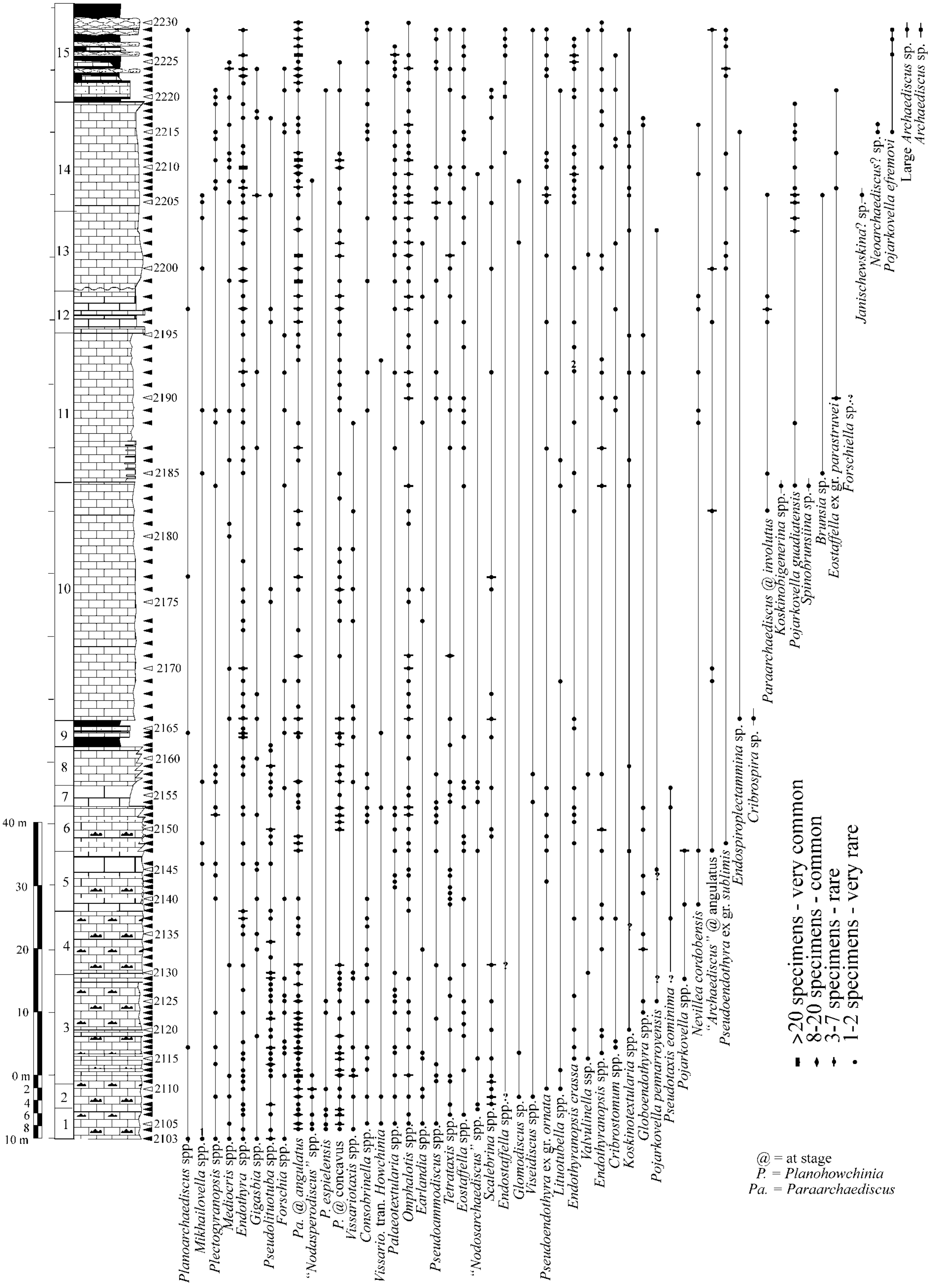

FIGURE 5–Foraminiferal distribution in the Sierra del Castillo section.

“Nodosarchaediscus”, although more or less rare, extend up to unit 11 in El Collado section, and thus are virtually present throughout the entire succession. *“Nodasperodiscus”* first occur from unit 1 in the Sierra del Castillo section, but they are rare in this section, and in the lower part of El Collado. They are common from unit 8 in El Collado section up to the top. *Neoarchaediscus?* first occur at the same stratigraphic level in Sierra del Castillo (top of unit 14, Pl. 1, Fig. 14), as at El Collado (top of unit 4), and they are rare up to the top of the succession. *Neoarchaediscus incertus* (Grozdilova & Lebedeva) only occurs within unit 12 in El Collado (very rare). *Neoarchaediscus stellatus* (Bozorgnia) also occurs in unit 12 (together with *N. incertus*) in El Collado and is very common in unit 14.

Vissariotaxis spp., i. e. *V. exilis* (Vissarionova), *V. “compressa”* (Brazhnikova) and *V. “compressa longa”* (Brazhnikova), are common throughout the Sierra del Castillo section, and in the lower part of El Collado section, but these species disappear suddenly at the base of unit 4 in El Collado. However, there is a species, considered here (Figs. 5-6) to be transitional from *Vissariotaxis* to *Howchinia*, which reanges from units 1-11 in the Sierra del Castillo section, and from units 2-11 in El Collado. This species shows a limited development of the fibrous layer, which is absent in some whorls. This species could be ascribed to ‘primitive’ *Howchinia*, which is occasionally documented in the literature (e. g. Conil *et al.*, 1991). True *Howchinia* such as *H. bradyana* (Howchin) emend. Davis first occurs in unit 10 of El Collado section. *Planohowchinia espielensis* Cózar & Mamet is common at the base of the Sierra del Castillo section, but it also occurs at the top of this section and near the base of El Collado.

Several species of *Tetrataxis* have been recorded, but they lack biostratigraphic significance. Conil *et al.* (1980) documented that large *Tetrataxis* are typically Brigantian, and in fact some large *Tetrataxis* have been recorded at that level in El Collado section, but they have been also recorded from the Asbian at the base of the Sierra del Castillo. Thus, this morphology can be useful in reinforcing the recognition of Brigantian rocks, but it cannot be regarded as a typical guide for this stage. *Valvulinella youngi* (Brady) is a rare taxon in the Sierra del Castillo, but it is common in El Collado. Two specimens with primitive and rudimentary septation were recorded from these sections by Cózar (1996, 2000a), but no more specimens have been recorded. At the top of the succession (horizon Pc796), a specimen of *Valvulinella* exhibits incipient development of a fibrous layer. This is an unusual feature, that needs to be studied further.

The Palaeotextulariidae are well represented through the succession, with common *Consobrinella* spp., *Koskinotextularia* spp., *Palaeotextularia* spp. and *Cribrostomum* spp. The dominant species are, respectively, *C. consobrina* (Lipina), *K. cribriformis* Eickhoff, *P. longiseptata* Lipina and *C. lecomptei* Conil & Lys. Most of these species first occur between units 1 and 3 in the Sierra del Castillo section, and they range up to the upper part of El Collado section. *Koskinobigenerina* spp. is less frequent, and it occurs rarely in unit 10 in Sierra del Castillo, and from unit 4-8 in El Collado. The most significant taxon of this family is *Climacammina* sp., which questionably occurs in unit 5 at El Collado section (Pl. 2, Fig. 8), but definitely units 8 and 10 (Pl. 2, Fig. 10).

Most specimens of *Lituotubella* belong to *L. magna* Rauzer-Chernousova (typical Asbian-Brigantian species), but rare specimens of *L. glomospiroides* Rauzer-Chernousova also occur (typically represented in rocks older than Brigantian).

Omphalotis omphalota (Rauzer-Chernousova & Reitlinger) first occurs near the base of Sierra del Castillo (unit 2), but it is progressively more frequent higher in the section. However, *Omphalotis minima* (Rauzer-Chernousova & Reitlinger) is much more abundant throughout the succession, and in some horizons in El Collado section exhibits significant acmes or “floods” up to more than 20 specimens per thin-section.

Several species of *Endothyranopsis* have been identified, but the most useful species is *Endothyranopsis crassa* (Brady). This species occurs from the base of the Sierra del Castillo section, but it is progressively more frequent throughout the succession. It is recorded in most horizons from unit 14 in the Sierra del Castillo or from unit 5 in El Collado. Specimens transitional from *E. crassa* to *E. sphaerica* (Rauzer-Chernoussova & Reitlinger) only occur in three horizons, Pc2192 (unit 11, Sierra del Castillo, Fig. 5), and Pc713 and Pc795 (units 5 and 13 respectively, El Collado setion, Fig. 6).

Several species of *Plectogyranopsis* are recognised. The most common are *P. convexa* (Rauzer-Chernousova), *P. ampla* (Conil & Lys), *P. hirosei* (Okimura), *P. settlensis* Conil & Longerstaey, and no major trends are observed. However, *Plectogyranopsis* sp. 1 first occurs in unit 4 in El Collado, and it reappears commonly within units 11-13.

The dominant species of *Mikhailovella* in Sierra del Castillo and the lower part of El Collado are

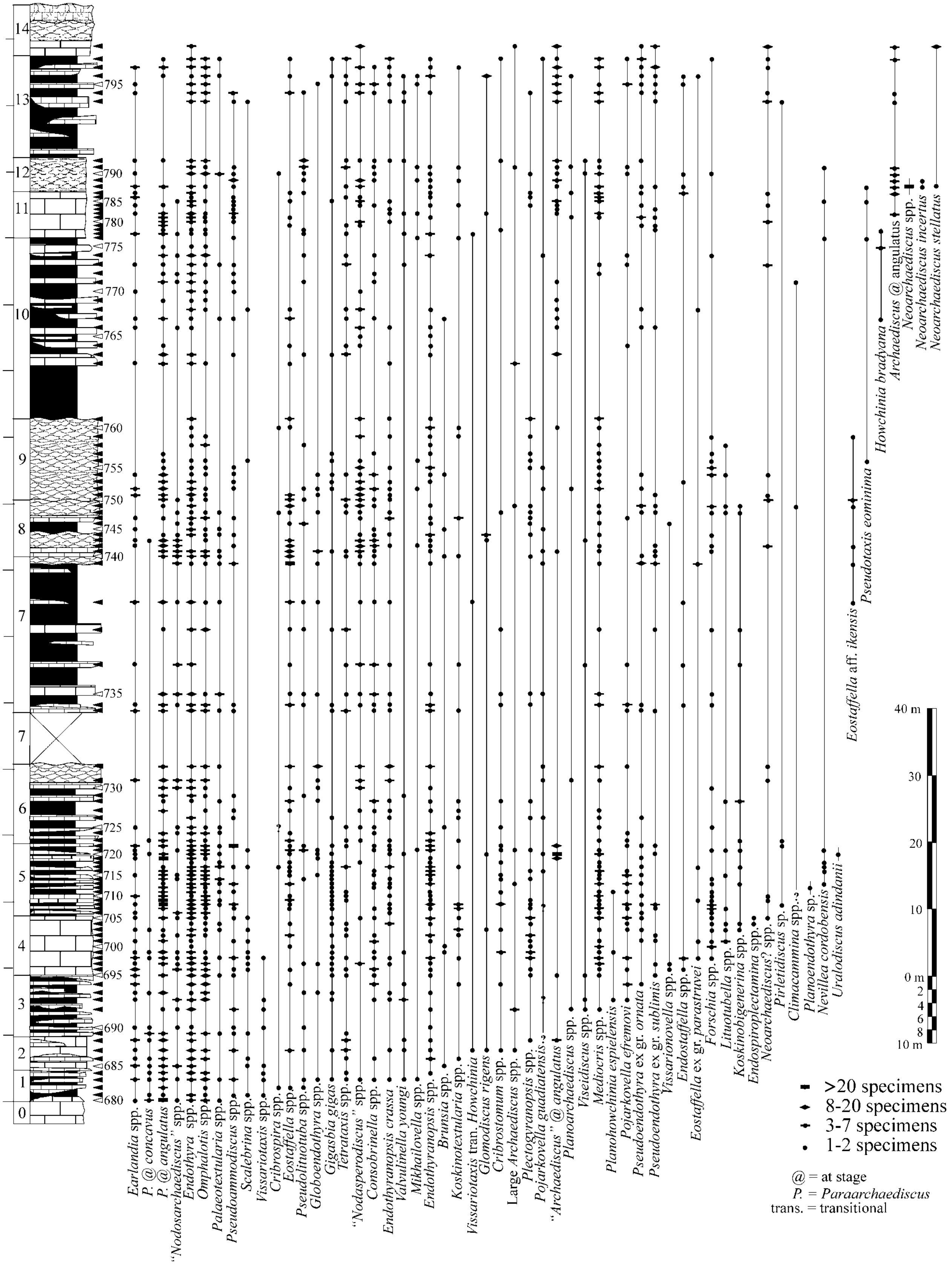

FIGURE 6–Foraminiferal distribution in El Collado section.

Mikhailovella fresnedosensis Cózar and *Mikhailovella* spp. (oblique or juvenile specimens of cf. *M. mica* Ganelina and *Mikhailovella popleformis* Durkina). However, at the base of the Sierra del Castillo section (horizon Pc2103, Fig. 5), there is a specimen of *Mikhailovella gracilis* Rauzer-Chernousova. This species reappears in unit 9 in El Collado, and all *Mikhailovella* recorded in units 9, 11 and 13 belong to this species. Thus a relay exists between the small and more primitive species to larger and more evolved species such as *M. gracilis*.

Cribrospira first occurs from the base of unit 10 in the Sierra del Castillo section, with *C. mira* Rauzer-Chernoussova and *Cribrospira* sp., species that occur rarely in El Collado. *Cribrospira panderi* Möller occurs in El Collado (units 5, 8 and 12). Only one broken specimen of *Janischewskina?* sp. has been identified in the Guadiato Area, it superficially looks like a *Cribrospira panderi*, but it is possible to recognise a fragmented cribate septum with alveolar-like wall (compare Pl. 2, Fig. 13 with Pl. 19, Fig. 11 and Pl. 26, Fig. 13 in Conil *et al.*, 1980). The secondary sutural apertures are not clear, and no other well oriented specimen has been recorded.

Mediocris is a long-ranging genus, and it is represented throughout the succession. However, it is remarkably abundant from units 4-13 in El Collado section.

Several species of *Pojarkovella* have been recorded. *Pojarkovella pennarroyensis* Cózar is recorded from units 3-5, and the top of unit 13 in Sierra del Castillo. *Pojarkovella* sp. [cf. *P. nibelis* (Durkina)] is recorded rarely at the base of Sierra del Castillo. However, the most significant species of *Pojarkovella* are *P. guadiatensis* Cózar and *P. efremovi* (Vdovenko & Rostovtseva). The former species was described from Brigantian rocks in the Navacastillo section (Fig. 1), laterally equivalent to the upper part of El Collado section (Cózar, 2002). In Sierra del Castillo, it is recorded rarely in unit 11, but it is common from the top of unit 13 into 14. At El Collado, this species is recorded from units 5-14, and questionably from unit 3. *P. efremovi* (= *Euxinita*, see Cózar, 2002), first occurs at the top of unit 14 in Sierra del Castillo and unit 3 in El Collado, and it is common in units 4 and 5 although its range extends up to the top of the Collado section.

Two groups of *Eostaffella* have been distinguished. First, the *Eostaffella* spp., that contains those specimens in which the wall is not differentiated. The second group, *Eostaffella* ex gr. *parastruvei* Rauzer-Chernousova, contains those specimens in which is possible to recognised an outer darker and more dense microgranular layer within the primary wall. Some of the species included in *Eostaffella* ex gr. *parastruvei*, such as *Eostaffella mosquensis* Vissarionova, occur typically in Brigantian rocks (e. g. Strank, 1985; Somerville *et al.*, 1992; Vachard & Berkhli, 1992; Gallagher & Somerville, 1997; Sebbar *et al.*, 2000). It is notable that rare specimens of *Eostaffella* ex gr. *parastruvei* Rauzer-Chernousova first occur in unit 11 of the Sierra del Castillo section, but the group is also recorded infrequently throughout El Collado section. One species, *Eostaffella* aff. *ikensis* Vissarionova, exhibits a short range from units 7-9 in El Collado. It is characterised by a large size and well defined rhombic shape, similar to the typical rhombic-shaped species from the Russian Platform, such as *E. ikensis* Vissarionova or *E. tenebrosa* Vissarionova.

Two groups of *Pseudoendothyra* have been distinguished: the *Pseudoendothyra* ex gr. *ornata* (Brady) and *P*. ex gr. *sublimis* (Schlykova). The latter group contains the large species of the genus, such as *P. kremenskensis* Rozovskaya, *P. bona* Rozovskaya and *P. sublimis* (Schlykova). Most authors regard these large species as typically Brigantian (e. g. Mamet, 1974; Vachard, 1977; Somerville *et al.*, 1992), but they can occur in Asbian rocks (Conil *et al.*, 1980; Strank, 1981). However, in the Guadiato Area, some representatives of this group are found in even older rocks, latest Holkerian-early Asbian (e. g. Cózar, 1999, 2003). In the Sierra del Castillo section, the first occurrence of *P*. ex gr. *sublimis* is in unit 6, and is common from the top of unit 13 to unit 15. In El Collado section, it occurs at a similar level to its common occurrence in Sierra del Castillo at the top of unit 3, and it is abundant throughout the succession (Fig. 6).

VARIATION IN RANGE OF ALGAE ACROSS THE BOUNDARY

Koninckopora is very abundant in late Asbian rocks, and in some basins in western Europe and North Africa it disappears dramatically at the top of the Asbian or is very rarely recorded in the early Brigantian (Conil & Lys, 1964; Hallett, 1971; Chisholm *et al.*, 1983; Somerville & Strank, 1984; Somerville *et al.*, 1992; Gallagher, 1996; Johnson & Nudds, 1996, Berkhli & Vachard, 2001; Cózar & Somerville, 2004, in press a, in press b). However in Algeria and Morocco, this decrease in number occurs at the top of the Brigantian (e. g. Vachard & Berkhli, 1992; Sebbar & Mamet, 1996, 1999; Sebbar, 1998; Berkhli & Vachard, 2001; Sebbar *et al.*, 2000).

The dasyclad *Eovelebitella occitanica* Vachard is considered as a Brigantian marker in France (Vachard, 1974, 1977), and as a Zone 16 inf. marker in France and southeastern Spain (Herbig & Mamet, 1985; Mamet & Herbig, 1990; Mamet, 1991). Thus, if Zone 16 inf. is partly correlated to the upper part of the Cf6γ subzone (Fig. 2), this implies that *E. occitanica* first occurs in the late Asbian. However, specimens recorded in the Guadiato Area contain fewer phloiopores and a greater fan arrangement of the pores. In fact, this species is similar to the specimens recorded in Ireland and northern England as *Eovelebitella* sp. (Cózar & Somerville, 2004, in press b). *Eovelebitella* sp. is very common in the early Asbian of southwestern Ireland, mostly in the Buttevant district (Gallagher & Somerville, 1997, as *Kulikia*), but in southeastern and northeastern Ireland it is occasionally recorded in the late Asbian and is common in the Brigantian (Cózar & Somerville, in press b). Furthermore, Herbig & Mamet (1985) documented *Eovelebitella* sp. in the microflora assemblage of Mamet Zone 15 that could represent an older level in the early Asbian (Fig. 2). However, this *Eovelebitella* sp. was not illustrated or described, and thus, it is not possible to ascertain if this species from southeastern Spain is exactly the same species as in the Guadiato Area, England and Ireland. A similar record of *Eovelebitella* sp. is documented by Sebbar (1998) in the late Viséan of Algeria. This taxon was also referred to in Sebbar & Mamet (1999), but in the latter work, *Eovelebitella* was considered as "abundant" in the late Viséan, and rare in the Serpukhovian. The taxon was not illustrated.

Coelosporella exhibits a similar range all over Ireland and northern England. It is recorded occasionally in the late Asbian and in the uppermost Asbian and base of the Brigantian, it exhibits a significant acme (Hallett, 1971; Somerville, 1999; Cózar & Somerville, 2004, in press a, in press b). In Morocco, this alga is common in the Brigantian (Vachard & Berkhli, 1992), but in Algeria, *Coelosporella* sp. occurs in the late Viséan, but no acmes were documented (e. g. Sebbar & Mamet, 1999). *C. jonesii* is recorded in most of the succession in southwestern Spain, but *C. wetheredii* only occurs in the upper part of El Collado section. However, according to Perret & Vachard (1977), the species are synonymous with *C. wetheredii* having priority. Nevertheless, specimens in the lower part of the succession (*C. jonesii*) are clearly larger in size than those in units 10 and 12 in El Collado (*C. wetheredii*). Thus this synonym is questionable.

Neoprincipia occurs rarely in the early Viséan of Australia, and Meramecian of Alaska, and there are three rare records in late Asbian rocks from Poland, Morocco and Ireland (Mamet & Roux, 1983; Brenckle *et al.*, 1982; Skompski, 1996; Vachard & Fadli, 1991; Cózar & Vachard, 2003). The genus is mostly restricted to Brigantian and Serpukhovian rocks. In Janny Wood (Asbian/Brigantian Boundary Stratotype), *Neoprincipia* is common in the base of the Brigantian, but also from the uppermost Asbian (Cózar & Somerville, 2004, in press a). No other common occurrence of *Neoprincipia* is known elsewhere in Tethyan basins in the late Asbian (see revision in Cózar & Vachard, 2003).

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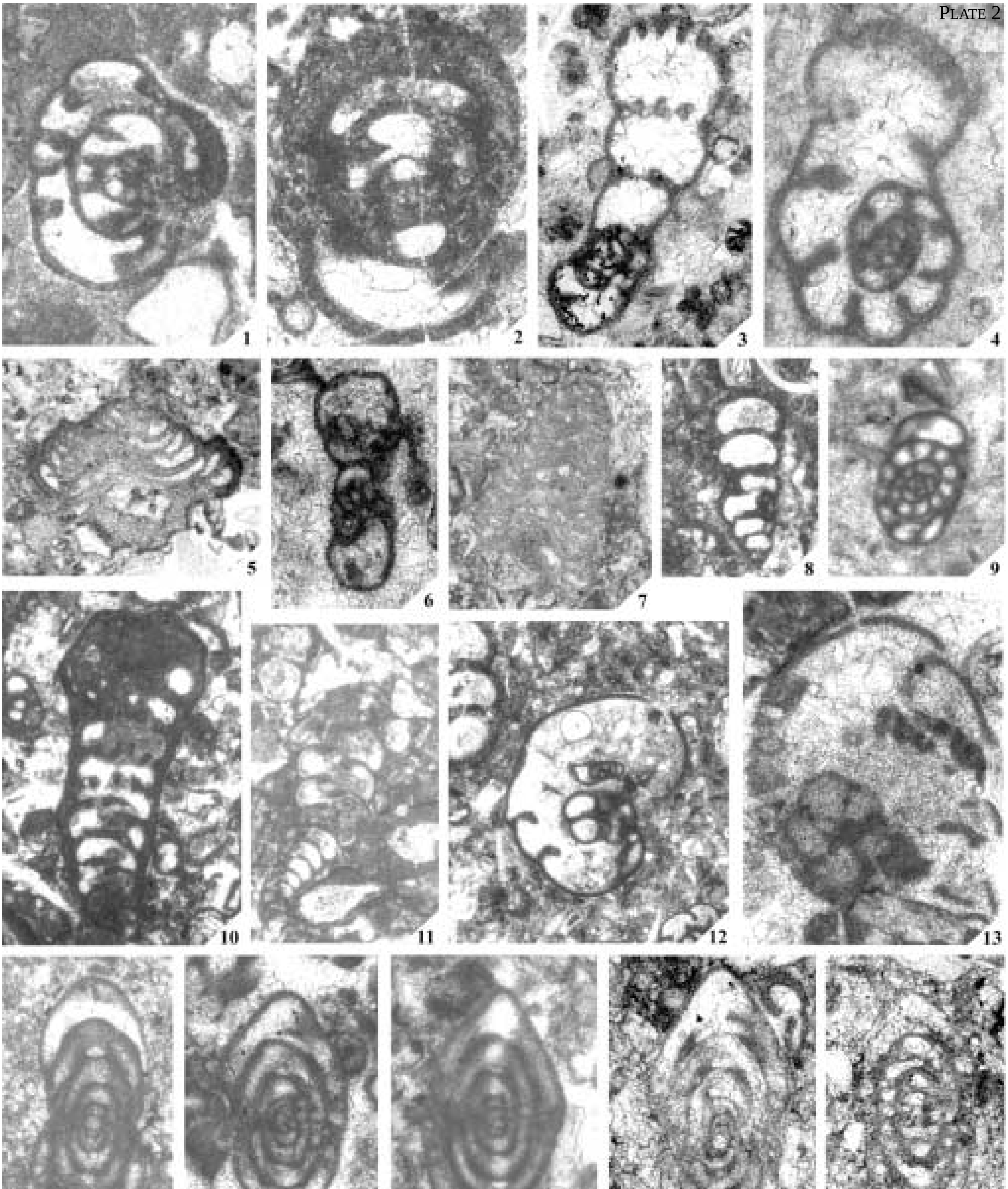
PLATE 2–Selected foraminifera from the Guadiato Area. *1, Endothyranopsis crassa* (Brady) transitional to *E. sphaerica* (Rauzer-Chernousova & Reitlinger), Pc713-2283/16, El Collado, unit 5 (x40). *2, Endothyranopsis crassa* (Brady), Pc2151-2276/16, Cantera del Castillo, unit 6 (x53). *3, Mikhailovella popleformis* Durkina, Pc782a-2283/13, El Collado, unit 11 (x53). *4, Mikhailovella gracilis* (Rauzer-Chernousova), Pc2103-2276/1, Cantera del Castillo, unit 1 (x53). *5, Tetrataxis* sp., Pc2141-2276/15, Cantera del Castillo, unit 5 (x26.5). *6, Pojarkovella guadiatensis* Cózar, Pc2206-2276/31, Cantera del Castillo, unit 14 (x53). *7, Valvulinella* sp., Pc796b-2283/22, El Collado, unit 13 (x53). *8, Climacammina?* sp., Pc710-2283/19, El Collado, unit 5 (x26.5). *9, Pojarkovella efremovi* (Vdovenko & Rostovseva), Pc704-2277/14, El Collado, unit 4 (x53). *10,Climacammina antiqua* Brady, Pc749a-2283/20, El Collado, unit 8 (x26.5). *11, Cribrostomum lecomptei* Conil & Lys, Pc748b-2283/24, El Collado, unit 8 (x26.5). *12, Cribrospira panderi* (Möller), Pc790a-2283/14, El Collado, unit 12 (x40). *13, Janischewskina?* sp., Pc2206-2276/32, Cantera del Castillo, unit 14 (x53). *14, Eostaffella parastruvei* Rauzer-Chernousova, Pc2122-2276/36, Cantera del Castillo, unit 3 (x53). *15, Eostaffella mosquensis* Vissarionova, Pc2190-2276/24, Cantera del Castillo, unit 11 (x53). *16, Eostaffella* aff. *ikensis* Vissarionova, Pc750-2283/9, El Collado, unit 8 (x53). *17, Pseudoendothyra sublimis* (Schlykova), Pc795-2283/18, El Collado, unit 13 (x53). *18, Pseudoendothyra kremenskensis* Rozovskaya, Pc2200-2276/28, Cantera del Castillo, unit 13 (x53).

PLATE 2



Calcifolium? punctatum has been commonly documented in Brigantian and Serpukhovian rocks, although its stratigraphic range varies from one region to another. In northern England, it is recorded in the early Brigantian from the Gayle Limestone in the Askrigg Block or the Smiddy Limestone in the Alston Block and Stainmore Trough (Cózar & Somerville, 2004, in press b). These first occurrences are in older rocks than those documented by Hallett (1971) from the Askrigg Block, but the base of the Brigantian Stage in these areas is at the base of the Hawes and Peghorn limestones, respectively (see George *et al.*, 1976; Ramsbottom, 1981). Strank (in Ramsbottom, 1981) identified *Calcifolium* sp. in the Peghorn Limestone in the stratotype of Janny Wood, but reexamination of this material (Cózar & Somerville, 2004) could not confirm this occurrence in thin-section KR3114, 7.4 m below the top of the top of the lower Peghorn Limestone (as documented by Strank in Ramsbottom, 1981). However, there is certainly *C.? punctatum* in thin-section ARE1324, from the Smiddy Limestone in Janny Wood (Cózar & Somerville, 2004). In Ireland, *Calcifolium? punctatum* also first occurs close to the base of the Brigantian Stage in Cookstown Quarry (Cózar & Somerville, in press b). In other regions, the first ocurrence of this species is in younger strata, and their precise location is also close to the base of the Brigantian: Scotland, Poland and Algeria (e. g. Maslov, 1956; Burgess, 1965; Skompski, 1981, 1996; Mamet, 1972; Massa & Vachard, 1979). There are numerous occurrences of this taxon in Serpukhovian rocks. In the Moscow Basin, it is documented from the Aleksinsky to the Venevsky Horizons (Maslov, 1956; Ivanova, 1973; Fig. 2), formerly considered as Asbian in age, but recently updated as possible Brigantian by Hecker (2002). In the Donetz Basin, the species seems to be present also from the base of the possible Brigantian (C_1^vf2 in Vdovenko, 2001). In Algeria, *Calcifolium? punctatum* was identified as "perforation of microendolithic bacteria" (e. g. Sebbar & Mamet, 1996, 1999; Sebbar, 1998; see Cózar & Vachard, in press). Sebbar (1998) documented common *Calcifolium* from the late Viséan, but the single specimen illustrated as *C. okense* is questionably that species (= ? indet. alga), and all the "perforation of microendolithic bacteria" illustrated in Sebbar (1998) and Sebbar & Mamet (1996, 1999), are from Brigantian and Serpukhovian rocks. Sebbar & Mamet (1999) updated the occurrence of *C. okense* to the upper part of the late Viséan (Brigantian?). Hence the occurrence of *Calcifolium* in upper Asbian rocks needs independent confirmation, justification with other fossil groups, and illustrations.

VARIATION IN RANGE OF FORAMINIFERA ACROSS THE BOUNDARY

A significant reduction of the microgranular layer in the Archaediscidae is observed throughout the succession, from species with a well-developed (= *Paraarchaediscus* cf. Brenckle *et al.,* 1987) to poorly developed microgranular layer (= *Archaediscus* cf. Brenckle *et al.,* 1987). However, similar *Archaediscus s.s.* are well-known from Asbian rocks in western Tethyan basins (e. g. Conil *et al.*, 1980).

The first occurrence of *Neoarchaediscus* is a debatable datum, not only because data in the literature do not agree, but also because there is clearly a certain "delay" in the first occurrence of the representatives of the family Archaediscidae in the Guadiato Area, as has been documented in this paper for the *Archaediscus s.l.* According to Conil *et al.* (1977, 1980, 1991), Vachard (1977), Laloux (1988) and Skompski *et al.* (1989), *Neoarchaediscus* first occurs in the Cf6α or from the base of the early Asbian in England, Belgium, France and Poland, as well as in Morocco (e. g. Vachard *et al.*, 1991; Vachard & Berkhli, 1992), and they are common in the Cf6β and higher. According to Mamet (1974), *Neoarchaediscus* first occurs in Zone 16, which, depending on the zonal scheme used, would not be older than Cf6γ or the base of the late Asbian (Fig. 2). In northern England, *Neoarchaediscus* was considered as a Brigantian marker (George *et al.*, 1976), but it has been documented in the latest Asbian (Strank, 1981, as *Asperodiscus*), as well as in North Wales, where it is recorded only a few metres below the Asbian/Brigantian boundary (Somerville & Strank, 1984). In southwestern Ireland, it has been documented in the Asbian (Gallagher, 1996; Gallagher & Somerville, 1997), and in southeastern Ireland in the latest Asbian (Cózar & Somerville, in press a). Regarding the data published in the literature, the first occurrence of *Neoarchaediscus* varies from the Cf6α to upper Cf6γ, as well as its identification also as *Rugosoarchaediscus*, *Asperodiscus*, *Nodasperodiscus* and even, *Asteroarchaediscus*. Thus, *Neoarchaediscus* does not seem to be a reliable datum for recognising the Asbian/Brigantian boundary. In El Collado section, *Neoarchaediscus incertus* and *N. stellatus* first occur in unit 12, much higher than any of the proposed bases for the Brigantian, and much later than in any other western Tethyan basin. However, *Neoarchaediscus?* spp. are recognised from unit 4 in El Collado, and unit 14 in Sierra del Castillo.

Large *Archaediscus* with a well defined *angulatus* sutures and poor developed microgranular wall, such as *A. karreri* or *A. chernoussovensis*, occur rarely in the late Asbian (Conil *et al.*, 1980; Strank, 1981), but its stratigraphic range is mostly Brigantian (Conil *et al.*, 1980; Fewtrell *et al.*, 1981). In North Wales, in the Cefn Mawr Limestone, *A. karreri* (= *A. karreri grandis* cf. Conil *et al.*, 1980) occurs 1 metre above the Asbian/Brigantian boundary (Somerville & Strank, 1984). In consequence, it has been considered useful to distinguish this special group of *Archaediscus* from other species in the same genus, because their first occurrence is a few metres below the Asbian/Brigantian boundary or in Brigantian rocks. Nevertheless, they can be abundant in the Brigantian (Cózar & Somerville, 2004, in press a), yet in the Guadiato Area, specimens are always rare. Furthermore, no giant *Archaediscus* (e. g. *Archaediscus karreri karreri* Brady, *Archaediscus* sp. 1 cf. Conil *et al.*, 1980; see Cózar & Somerville, 2004) have been recorded in the Guadiato Area.

Pojarkovella efremovi was considered as a late Asbian marker by Laloux (1988) and Conil *et al.* (1991) for France, Belgium and Great Britain. However, all the specimens illustrated in the literature from these regions are always from Brigantian rocks, and Conil *et al.* (1980) considered this species as a Brigantian marker, a fact that suggests the scarcity of this taxon in upper Asbian rocks. In most sections in northern England and Ireland (Cózar & Somerville, 2004, in press a), *Pojarkovella efremovi* is only recorded in the Brigantian. A similar stratigraphic range is observed in other regions, such as the Donetz Basin (C_1^{v}f2 in Vdovenko, 2001). However, in Janny Wood, it occurs from the base of the Robinson Limestone (previously considered as late Asbian, e. g. George *et al.*, 1976, but updated to probable base of the Brigantian by Cózar & Somerville, 2004), and in the upper part of this bed and in the succeeding Birkdale Limestone, where it is common (thin-sections ARE1294 to ARE1298; Cózar & Somerville, 2004). Nevertheless, none of these specimens has been illustrated or documented (they are included in Strank, 1981 and Strank in Ramsbottom, 1981 as *Plectostaffella*). It is also common in the Peghorn Limestone, but less frequent than in underlying limestone beds.

Eostaffella ex gr. *parastruvei* is considered here as a species of *Eostaffella* with a differentiated external darker microgranular layer in the wall. For example, *E. mosquensis* is included in this group. Although there are some authors who considered the first occurrence of this group to be at the base of the Asbian (e. g. George *et al.*, 1976), this is most unlikely. Its first occurrence can be more reliably regarded as late Asbian, although this group is typically represented in the Brigantian (e. g. Vachard, 1977; Strank, 1985; Vachard & Berkhli, 1992; Somerville *et al.*, 1992; Sebbar *et al.*, 2000).

Representatives of the large *Pseudoendothyra* ex gr. *sublimis* (e. g. *P. sublimis*, *P. kremenkensis*) first occur in Asbian rock, but they are also mostly Brigantian in age (e. g. Mamet, 1974; Somerville *et al.*, 1992; Gallagher & Somerville, 1997).

Howchinia is considered by some authors as a basal Asbian marker (e. g. Mamet, 1974), or late Asbian (Vachard, 1977; Conil *et al.*, 1980, 1991), and even uppermost late Asbian (Jones & Somerville, 1996; Gallagher, 1996). In the Guadiato Area, *Howchinia* was also regarded as a marker of the base of Mamet Zone 15 or Asbian (Cózar, 2000b, 2003). However, specimens that occur in older rocks exhibit a poor development of the fibrous layer. Thus, in the present work, they have been identified as *Vissariotaxis* transitional to *Howchinia*. True *Howchinia bradyana* occur higher in the succession (e. g. unit 8 at El Collado section). In consequence, this species seems to be restricted to the Brigantian, and its occurrence in the late Asbian could not be confirmed. On the other hand, *Howchinia bradyana* is not recorded in the late Asbian in northern England or southeastern Ireland, but usually a few metres above the Asbian/Brigantian boundary (Cózar & Somerville, 2004, in press a). Furthermore, *Vissariotaxis* is not recorded in Brigantian rocks in other basins (Vachard, 1977; Vachard & Berkhli, 1992; Vdovenko 2001). *Vissariotaxis* transitional to *Howchinia* is recorded in the Asbian, but the occurrence of *Howchinia bradyana* can be considered as virtually restricted to the Brigantian.

The occurrence of *Janischewskina* is widely recognised as a Brigantian guide (Conil *et al.*, 1980, 1991; Strank, 1981; Fewtrell *et al.*, 1981; Jones & Somerville, 1996). However, specimens of *Janischewskina* occurring from the base of the Brigantian in Janny Wood, should be transferred to *Janischewskina?* sp. (those specimens also exhibit cribrate septa with alveolar-like wall structure), and true *Janischewskina* is recorded higher in the section (late Brigantian; Cózar & Somerville, 2004). In Belgium, it occurs in the late Brigantian (Laloux, 1988; Conil *et al.*, 1991). Unfortunately, the specimen of *Janischewskina?* sp. recorded in El Collado is not well preserved, but the particular structure of the septa seems distinctive, and thus, the attribution of the limestone bed containing this taxon to the Brigantian is probably justifiable. Nevertheless, specimens with better preserved secondary sutural apertures would be desirable.

Endostaffella is also a taxon that exhibits its acme in Brigantian rocks (Vachard, 1977, Conil *et al.*, 1980), although it can occur from older rocks.

Climacammina is regarded as an Asbian or late Asbian marker for many authors (e. g. Mamet, 1974; Conil *et al.*, 1980; Sebbar, 1998). However, in northern England, Ireland and Belgium, its most likely record is late Brigantian (Hallett, 1971; Laloux, 1988; Conil *et al.*, 1991; Cózar & Somerville 2004, in press a), or only recorded in Serpukhovian rocks (Fewtrell *et al.*, 1981). No well oriented specimens of *Climacammina*, which can be used as confirmation, occur in Janny Wood, and most of the horizons supposedly containing this genus (as documented in Strank, 1981), only contain *Cribrostomum* or *Koskinobigenerina* (Cózar & Somerville, 2004).

POSITIONING OF THE ASBIAN/ BRIGANTIAN BOUNDARY

Most of the Sierra del Castillo section and the base of the El Collado section are assigned to the late Asbian. The foraminiferal guides for the late Asbian are *Cribrostomum lecomptei, Palaeotextularia, Endothyranopsis crassa, Cribrospira*, common *Vissariotaxis compressa*, common *Archaediscus s.l.* at angulatus stage (Conil *et al.*, 1980, 1991), and *Vissariotaxis* transitional to *Howchinia* (possibly equivalent to the ‘primitive’ *Howchinia* in Conil *et al.*, 1991).

Important events which could suggest a Brigantian age are: (1) disappearance of *Vissariotaxis* in unit 3 in El Collado section; (2) marked decrease in numbers of *Kamaenella tenuis* and *Koninckopora* spp. in units 5 and 6, respectively, in El Collado; (3) marked increase in numbers of *Pseudoendothyra sublimis* and *Endostaffella* from unit 3 upward in El Collado; (4) common *Eovelebitella* from unit 4 and its acme in unit 10 in El Collado; (5) first occurrence of *Coelosporella* in unit 2 in El Collado; (6) first occurrence of *Pojarkovella guadiatensis* in unit 11 in Sierra del Castillo and becoming common from unit 14 in Sierra del Castillo and unit 5 in El Collado; (7) common *Pojarkovella efremovi* from unit 4 in El Collado, with only few specimens earlier; (8) first occurrence of *Calcifolium? punctatum* in unit 4 in El Collado; (9) a single occurrence of *Janischeswkina?* sp. in unit 14 in Sierra del Castillo; (10) first occurrence of *Climacammina* in unit 8 in El Collado and questionably in unit 4; (11) first occurrence of *Eostaffella* aff. *ikensis* in unit 7 in El Collado; (12) first occurrence of the rugose coral *Palastraea regia* in unit 7 in El Collado.

These features suggest that the succession below unit 3 in El Collado (= unit 13 in Sierra del Castillo) can be assigned to the late Asbian, and unit 7 in El Collado, can be assigned to the Brigantian. However, data between unit 4 and 6 in El Collado (= part of units 14 and 15 in Sierra del Castillo) are ambiguous. Most of the relative acmes recorded in these units suggest a Brigantian age from unit 4 in El Collado (= unit 14 in Sierra del Castillo). Furthermore, *Calcifolium? punctatum* usually first occurs in Brigantian rocks, although questionable and occasionally documented in upper Asbian rocks, usually first occurs in Brigantian rocks. The occurrence of *Janischewskina?* Could be definitive for correlation of unit 14 in Sierra del Castillo (= unit 4 in El Collado) to the Brigantian, as well as the presence of true *Climacammina*. Scarcity of specimens and their poor preservation and orientation, however, limits their usefulness, and better material is needed.

CONCLUSIONS

Detailed analysis of two stratigraphic sections in the Guadiato Area permit documentation of variability in the foraminifera and algae across the Asbian/ Brigantian boundary, which is mot likely located above the top of unit 13 in Cantera del Castillo section (= top of unit 3 in El Collado section), and the top of unit 6 in El Collado section. The top of unit 13 in Sierra del Castillo or unit 3 in El Collado is most likely.

Taxa first occurring in the Brigrantian include: *Calcifolium? punctatum*, *Janischewskina?*, *Climacammina*, *Howchinia*, *Neoprincipia tethysiana*, *Eostaffella* aff. *ikensis* and *Neoarchaediscus*. Some virtual first appearances (only occasionally recorded in the latest Asbian) include: *Eovelebitella*, *Coelosporella*, *Kulikia*, *Pojarkovella efremovi* and *Pojarkovella guadiatensis*. *Vissariotaxis* and *Pseudokulikia* last occur at that level.

Furthermore, the abundance of *Kamaenella* decreases at the boundary whereas others become abundant (acmes) in the Brigantian. The latter include *Ungdarella*, *Endothyranopsis crassa*, *‘Nodasperodiscus’*, *Eostaffella* ex gr. *parastruvei*, *Pseudoendothyra* ex gr. *sublimis*, *Endostaffella*, *Eovelebitella*, *Coelosporella*, *Kulikia* and *“Windsoporella”*.

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PERMIAN FUSULINIDS (FORAMINIFERA) OF THE SUBSURFACE OF ISRAEL: TAXONOMY AND BIOSTRATIGRAPHY

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Abstract

Permian foraminifera from two boreholes, Gevim-1 and Pleshet-1, of the southern Coastal Plain in Israel are analyzed. For the first time, 10 species of fusulinids are described, including three new species: *Reichellina leveni*, *Ogbinella*? *plata* and *Pseudodunbarula minuta.* Three foraminiferal local biozones are defined: a) First local zone –Upper Capitanian/Midian, ranging from the Sa'ad Formation into the lower part of the 'Arqov Formation and named *Pseudodunbarula arpaensis*; b) Second local zone –Lowermost Wuchiapingian/Dzhulfian, middle part of 'Arqov Formation, correlates with the *Codonofusiella kwangsiana* Zone; c) Third local zone –Wuchiapingian/Dzhulfian, upper part of the 'Arqov Formation, correlated with the *Reichelina media* Zone. The foraminifera that occur at the very top of the sequence are probably uppermost Wuchiapingian/Dzhulfian and/or lowermost Changhsingian/Dorashamian.The Levant fusulinids represent only eurybiontic smaller fusulinids of the Shubertellida, Ozawainellida and Staffellida orders. The Middle and Late Permian foraminifera from the subsurface of Israel are similar to some assemblages of the Transcaucasia, of the Abadeh Area, Iran and of the East Taurus, Turkey. The Levant assemblages differ from some assemblages of the others Tethyan regions by the absence of the fusulinids such as *Yabeina, Lepidolona, Neoshwagerina, Paleofusulina* and *Paradunbarula*. The absence of fauna younger than lowermost Changhsingian/Dorashamian suggests a hiatus of the uppermost Permian strata.

Key words: Fusulinids, Foraminifera, subsurface, Permian, Israel.

Resumen

Se han estudiado los foraminíferos pérmicos procedentes de dos sondeos (Gevim-1 y Pleshet-1) de la Llanura Costera del sur de Israel. Se describen por primera vez diez especies de fusulínidos y, de ellas, tres son nuevas: *Reichellina leveni, Ogbinella*? *plata* y *Pseudodunbarula minuta*. Las tres biozonas locales de foraminiferos se definen como: a) Primera Zona local: edad Capitaniense superior/medio de la Formación Saád en la parte inferior de la Formación 'Arqov y se denomina Zona *Pseudodunbarula arpaensis;* b) Segunda Zona local: edad Wuchiapingiense inferior/Dzhulfiense, parte media de la Formación 'Arqov que se puede correlacionar con la Zona *Codonofusiella kwangsiana;* c) Tercera Zona local: edad Wuchiapingiense/Dzhulfiense, parte superior de la Formación 'Arqov y se puede correlacionar con la Zona *Reichelina media.* Los foraminíferos que se presentan en la parte superior de la secuencia son de edad probablemente Wuchiapingiense superior/Dzhulfiense y/o Changhsingiense inferior/Dorashamian. Los fusulínidos levantinos están representados sólo por pequeños fusulínidos euribiontes, de los órdenes Shubertinella, Ozawainellida y Staffellida. Los foraminíferos del Pérmico medio y superior de Israel son similares a los descritos en las asociaciones del área Transcaucásica, del área de Abadeh en Irán y del área de Taurus oriental, en Turquía. Las asociaciones levantinas difieren de las asociaciones de otras regiones del Tethys por la ausencia de fusulínidos, tales como *Yabeina, Lepidolona, Neoshwagerina, Paleofusulina* y *Paradunbarula.* La ausencia de fauna más joven que la edad Changhsingiense/Dorashamiense sugiere un hiato en los sedimentos de edad pérmica.

Palabras clave: Fusulínidos, Foraminifera, subsuelo, Pérmico, Israel.

INTRODUCTION

Stratigraphy, paleoenvironment and paleogeography of the Permian period as well as the Permian-Triassic boundary have been extensively debated (Leven, 2001a,b; Jin, 1996; Jin *et al.*, 1997; Taraz, 1999; Mei *et al.*, 1999). The extreme variety of types of environments during the Permian have resulted in the establishment of multiple time-scales, according to the type of sediments, faunas and floras that define the facies of the deposits in each area.

Permian rocks are not exposed in Israel, and all available information comes from boreholes penetrated in the northern Negev and the southern Coastal Plain of South Israel. Information about Permian foraminifers from boreholes in Israel was first reported by Weissbrod (1969) and Hirsch (1975, 1976). Subsequently, the Permian foraminifers have been defined and listed by B. Derin (Derin & Gerry, 1981; Garfunkel & Derin, 1984) and L. Grossowich (Buchbinder *et al.,* 1998).

In this paper the description of the superorder Fusulinoida Fursenko, 1958 from the Permian of Israel is presented for the first time. The systematics of the foraminifera is given in accordance with Rauzer-Chernousova *et al*. (1996).

Material was analyzed from two boreholes: Gevim-1 (4,079-4,580 m section) and Pleshet-1 (4,788-5,343 m section) (Fig. 1). The total number of thin sections studied from fragments of rocks and cores were 300.

All specimens identified in this work are deposited in the palaeontological collection of the Geological Survey of Israel, Jerusalem (GSI).

GEOLOGIC AND STRATIGRAPHICAL SETTING

Permian rocks are not exposed in Israel, and information comes from boreholes in the South of Israel: Southern Coastal Plain and Northwestern Negev. A relative continuous sequence of alternating sandstones, shales and carbonates of shallow marine and continental environments reaches a highest thickness of approximately 550 m in the Coastal Plain.

At the present time, the Permian deposits were assigned to the Sa’ad and ‘Arqov formations, although originally its age were determinate by Weissbrod (1969) for the Sa’ad Formation as Upper Carboniferous and for the ‘Arqov Formation as Upper Carboniferous/Permian. The Permian Sa’ad Formation unconformably overlies the Precambrian

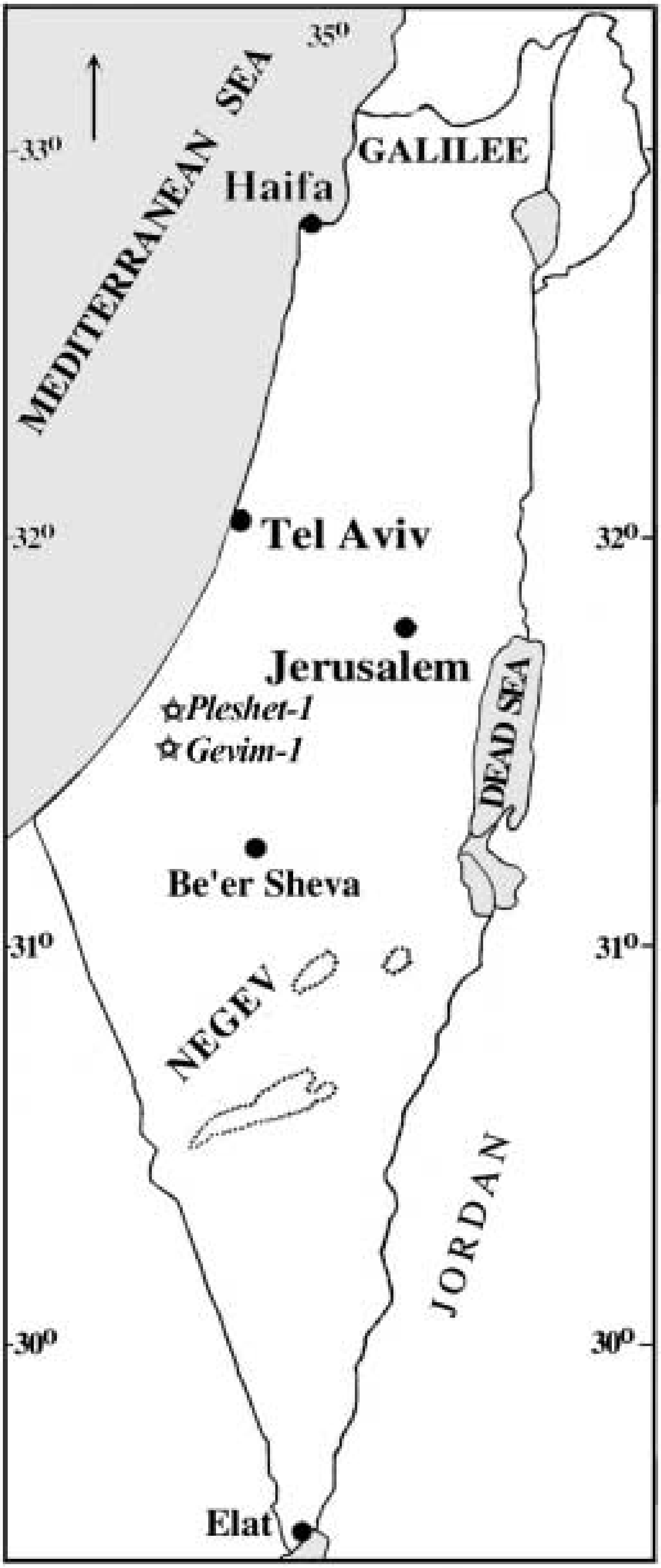

FIGURE 1–Location map.

Zenifim Formation and consists mostly from sandstone with some carbonaceous shales and limestone interlayer with plant remains in the Negev. Thickness of the formation is from 75 to 100 m. The carbonate sequence of the ‘Arqov Fm represents a wedge-like body of strata with highest thickness of approximately 450 m in the Coastal Plain (circa 250 m thick in the northern Negev).

The boundary between the Permian and Triassic was found to be represented by a hiatus of latest Permian and Induan strata, well marked by red-beds (Eshet, 1990)

The Sa’ad and ‘Arqov formations were dated by palynomorphs as Lower and Upper Permian (Eshet, 1990). Eshet (1990) established two palynological zones: 1) the *Potoniesporites novicus* Zone (Autunian, Early Permian), defining the Sa’ad Formation and, lower part of the ‘Arqov Formation, and 2) the *Lueckisporites virkkiae* Zone (Thuringian, Late Permian), defining the ‘Arqov Formation. Foraminifera (Fusulinids) as *Codonofusiella* were reported (Hirsch, 1975, 1976; Derin & Gerry, 1981; Garfunkel & Derin, 1984) and ostracodes of the *Italogeisina-Hungarogeisina* Assemblage zone (Gerry *et al.*, 1987) indicate a Middle Permian age (Abadehian) (Table 1).

Most of the Permian and Early Triassic interval in southern Israel comprises essentially carbonates, shales and some sand bodies, deposited in near-shore marine palaeoenvironments (Weissbrod, 1969, 1981). The lithological composition of the sequence appeared to be a continuous sedimentation in shallow marine and continental environments.

COMPOSITION AND AGE OF THE FORAMINIFERAL LOCAL BIOZONES

Permian foraminifera were analyzed in the same order of succession of the two boreholes, Gevim-1 and Pleshet-1, through the subsurface of the southern Coastal Plain in Israel. As a result, three foraminiferal local biozones have been defined (Table 1 and Figure 2).

The **First local biozone** occurs in the Sa’ad Formation and at the lowermost part of the ‘Arqov Formation at Pleshet-1 (5,343-5,001 m depth), and at Gevim–1 (4,500-4,284 m depth). The assemblage of foraminifera includes 70 species, among them: *Globivalvulina vonderschmitti* Reichel, *Baisalina pulchra* Reitlinger, *Hemigordius irregulariformis* Zaninetti, Altiner & Çatal, *Multidiscus padangensis* (Lange), *Frondina permica* Sellier et Dessauvagie, *Geinitzina caucasica* K. M.-Maclay, *Codonofusiella erki* Rauser, *Pseudodunbarula minuta* O. Orlova, sp. nov., *P. arpaensis* Chediya, *Ogbinella ogbinensis* (Chediya). The species *Yangchienia* cf. *hainanica* Sheng is identified from the borehole Gevim-1. The local biozones recognized in this interval corresponds to the Late Capitanian/Midian of the Middle Permian (i. e. late in the Leven’s Scale). Although the association does not include the genera *Yabeina* and *Lepidolina* and other fusulinids that are characteristic of this age, diagnostic foraminifera in these strata allow to correlate the interval with the upper part of the Arpa Formation and Khachic Formation of Transcaucasus, Azeirbazhan (Kotlyar *et al.*, 1983; Leven, 1998). The presence of *Yangchienia* cf. *hainanica* Sheng (sample 4,293-99 m in the borehole Gevim-1) strongly supports a Capitanian/Midian age assumption. The First local biozone is named *“Pseudodunbarula arpaensis”*.

The **Second local biozone** is defined from the boreholes Pleshet-1 (5,001-4,926 m depth) and Gevim-1 (4,284-4,203 m depth) in strata related to the ‘Arqov Formation. The assemblage of foraminifera includes 77 species, among them *Paraglobivalvulina mira* Reitlinger, *Dagmarita* sp., *Geinitzina postcarbonica* Spandel, *Pachyphloia cukurkoyi* Sellier et Dessauvagie, *Nodosaria piricamerata* Efimova, *Protonodosaria globifrondina* Sellier et Dessauvagie, *Schubertella rara* Sheng, *Codonofusiella kwangsiana* Sheng, *C. nana* Erk, *Pseudodunbarula arpaensis* Chediya, *Ogbinella ardaglensis* (Chediya), *Abadehella* sp. This association correlates with the *Codonofusiella kwangsiana* Zone, described at Unit 5 of the Abadeh Formation, Iran (Taraz *et al.*, 1981) and at the *Codonofusiella* beds (the uppermost of Khachik Fm –Chanahchy beds) of the Transcaucasia, Azerbaidzhan (Leven, 1998). Fauna of our local biozone shows a strong similarity to the fauna of the lower half of the Wuchiaping Formation of South China [(*Codonofusiella* zone, from Hoshan Formation, Wuchiaping Limestone, from Lopingian of Guizhou Province (Sheng, 1963)]. This assemblage can be dated as Dzhulfian age (the Tethyan Scale). Thus, we propose to assign this biozone to the earliest of the Dzhulfian Stage in the Tethyan Scale, or the lower part of the Wuchiapingian of the Global Permian Scale (Jin, 1996). The Second Local biozone named *“Codonofusiella kwangsiana”*.

The **Third local biozone** has been found in Pleshet-1 (4,926-4,791 m depth) and at Gevim-1

FORMATION	**POLLEN**				**OSTRACODA FORAMINIFERA**					**CONO-DONTA**			**FORAMINIFERA**				
	Eshet, 1990				Derin et Gerry, 1981; Gerry & al., 1987					Hirch et Gerry, 1974			This paper				
													System	Series	Stage	Foraminiferal local biozone	
YAMIN	TRIASSIC	LOWER	SCYTHIAN	*Endosporites papillatus (III)*	TRIASSIC	LOWER	SCYTHIAN	*Glomospira* spp. (lower zone)	*"Monoceratina" sp.*	TRIASSIC	OLENEKIAN	*Pachycladina spp.* *Hadrodontina spp.*	TRIASSIC	LOWER			
'ARQOV	PERMIAN	UPPER	THURINGIAN	*Lueckisporites virkkiae (II)*	Not defined								?				
					PERMIAN	UPPER	ABADEHIAN	*Codonofusiella* sp.	*Italogeisina - Hungarogeisina (Sargentina sp.)*				PERMIAN	UPPER	CHANGHSINGIAN / DORASHAMIAN?	*THIRD*	*Reichelina media*
															WUCHIAPINGIAN / DZHULFIAN		
																SECOND	*Codonofusiella qwangsiana*
		LOWER	AUTUNIAN	*Potonicsropites novicus (I)*										MIDDLE	CAPITANIAN / MIDIAN	*FIRST*	*Pseudodunbarula arpaensis*
SA'AD					Not defined												

TABLE 1–Comparison of the major biozones in the Permian sequence of Israel.

(4,203-4,090 m depth) and relates to the 'Arqov Formation. The assemblage of foraminifers includes 67 species, among them: *Paraglobivalvulina mira* Reitlinger, *Dagmarita* sp., *Robuloides lens* Reichel, *R. acutus* Reichel, *Pseudotristix* (?) ex gr. *solida* Reitlinger, *Geinitzina gloria* G. Pronina, *G. ichnousa* Sellier et Dessauvagie, *Nodosaria armeniensis* Efimova, *N. dorashamensis* G. Pronina, *Protonodosaria globifrondina* Sellier et Dessauvagie, *Lingulonodosaria kamaensis* K. M.-

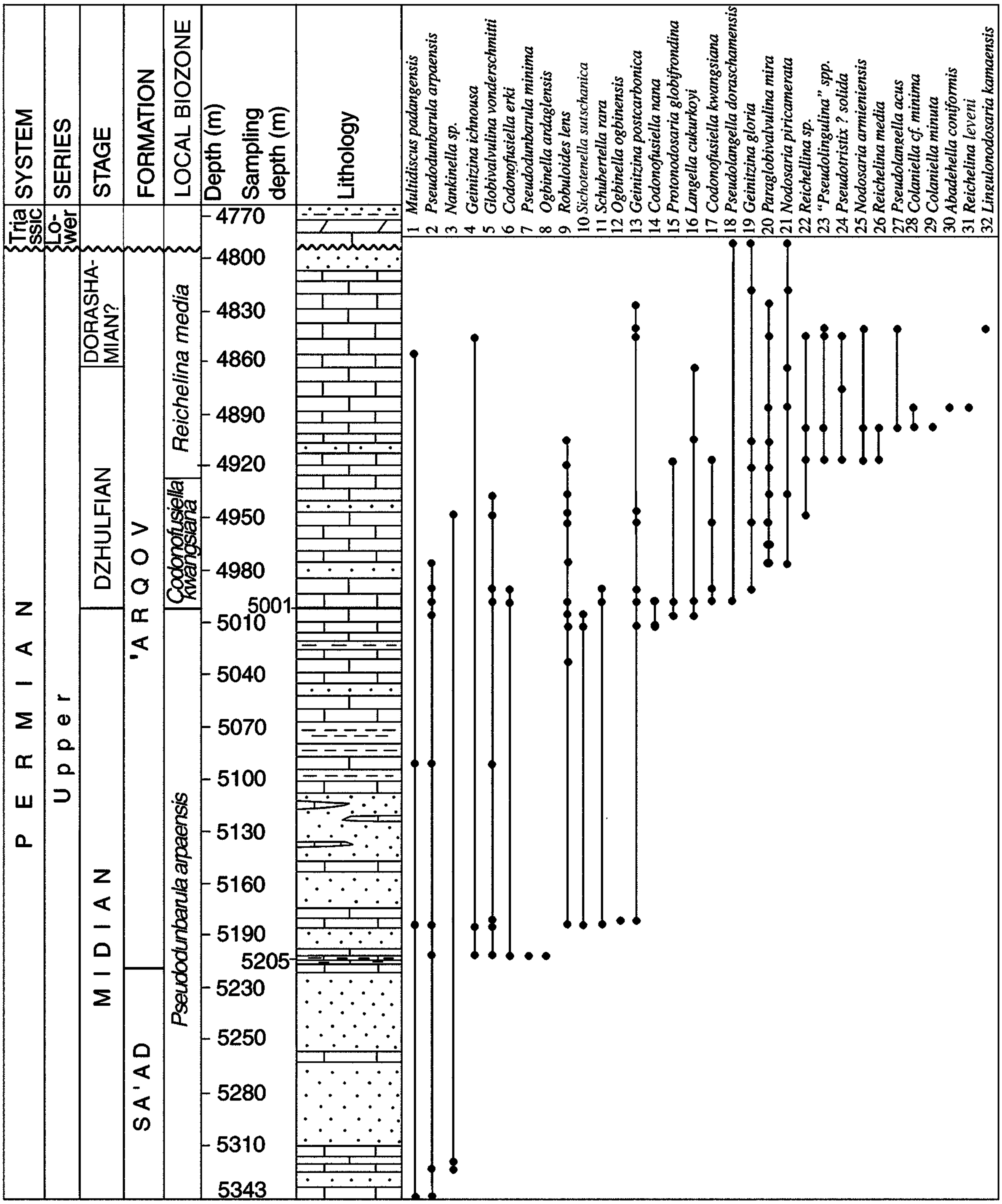

FIGURE 2–Distribution of the main foraminifera of the Pleshet-1 borehole.

Maclay, *Pseudolangella doraschamensis* G. Pronina, *P. acus* G. Pronina, *Reichelina media* K. M.-Maclay and *Codonofusiella* sp. The lower strata (Pleshet-1, level 4,926-4,863 m) correlate with the *Reichelina media* Zone that corresponds to Unit 6 (lower 2/3) of the Hambast Formation (Central Iran) (Taraz *et al.*, 1981) and may correspond to the *Vedioceras* Zone of the Dzhulfian Stage (late Permian). At the top of this interval in Pleshet-1 (level 4,863-4,791 m), the following species occur: *Colaniella* cf. *minima* Wang, *C. minuta* Okimura, *Abadehella coniformis* Okimura et Ishii. Originally, the species were found in lowermost Changhsingian/Dorashamian (Sheng, 1963). Therefore, this interval correlates with the uppermost Wuchiapingian/Dzhulfian and/or lowermost Changhsingian/Dorashamian. The Third local biozone can be named "*Reichelina media*" zone.

The absence of fauna younger than lowermost Dorashamian suggests a hiatus of the uppermost Permian strata.

SYSTEMATIC DESCRIPTIONS

All the specimens identified in this work are deposited in the collection of the Geological Survey of Israel. In this first part are described species of the superorder Fusulinoida Fursenko, 1958. The systematics of the Foraminifera is in accordance with Rauzer-Chernousova *et al.* (1996).

The descriptions of species include tables, with the following abbreviations: n = number of volutions; Do = proloculus diameter; D = diameter or width of test; L = axial length of test; L : D = form ratio or length/diameter ratio; W = wall thickness. Measurements are given in mm.

Superorder FUSULINOIDA Fursenko, 1958
Order OZAWAINELLIDA Solovieva, 1980
Family OZAWAINELLIDAE
Thompson & Foster, 1937
Subfamily REICHELININAE A.
Miklukho-Maclay, 1959
Genus *Reichelina* Erk, 1942

Type species.–*Reichelina cribroseptata* Erk (1942, pp. 250-251, Pl. 14, Figs. 17-21).

Remarks.–Small *Reichelina* consisting of two parts: first part has 3 or 4 volutions of subrhomboidal, rarely elongate-nautiloid tests; second part: the final whorl is uncoiled.

Reichelina media K. Miklukho-Maclay, 1954
(Pl. 1, Figs. 6, 7)

1954 *Reichelina media* K. Miklukho-Maclay, p. 76, 78, Pl. 4, Figs. 12-15; Pl. 15, Fig. 2
1963 *Reichelina media* K. Miklukho-Maclay. Sheng, p. 150, Pl. 1, Fig. 1-9.
1984 *Reichelina media* K. Miklukho-Maclay. Kotlyar *et al.*, Pl. 6, Figs. 19-21.
1993 *Reichelina media* K. Miklukho-Maclay. Vachard *et al.*, Pl. 8, Figs. 9-12.

Material.–7 axial and oblique sections.

Description.–Test small, subrhomboidal with narrowly pointed periphery, convex lateral sides and closed umbilicus. In inner volutions test is nautiloid with narrowly rounded periphery and flat or slightly convex lateral sides. First and second inner volutions coiled at angles to outer whorls (~ 70 degrees). The final whorl is uncoiled. Specimens have of five involute volutions, 0.43 to 0.49 mm in diameter and 0.26 to 0.30 mm in axial or length, giving a form ratio of 0.57 to 0.58.

	n	**D**					**L**		**L : D**
		1	**2**	**3**	**4**	**5**	**4**	**5**	
P4917-26(2)-2	5	0.04	0.08	0.17	0.30	0.45	0.18	0.26	0.577
G4203-09 (10)	5	0.05	0.10	0.23	0.35	0.46	0.20	0.27	0.587

Proloculus is small and spherical. Spirotheca are thin (0.010-0.015 mm), and weakly differentiated, composed of a tectum and lower, homogeneous light layer. Coil is even, expands gradually through growth. Septa are also thin and straight. Chomata are distinct, narrowly-subtriangle or keel forms, thickened in basal deposits similar the weakly, ribbon-like.

Remarks.–*Reichelina media* K. Miklukho-Maclay, 1954, which has been described from the Nikitina Formation in the northern Caucasus, is the closest to our specimens but differs in the same equatorial diameter dimension by slightly more volutions (our specimens usually have 5 whorls, the specimens from the northern Caucasus –usually have 4). Our specimens differ from *Reichelina cribroseptata* Erk, by smaller size of the test, also uncoiled volution and weaker secondary deposits.

Distribution and age.–Type sections of *Reichelina media,* described from Northern Caucasus, Malaya Laba River basin Nikitin and Urushten Formations of late Permian (K. Miklukho-Maclay, 1954). It occurred in Bolshaya Laba River and Belaya River basins of the Northern Caucasus, Nikitin and Urushten Formations of late Permian. Also, this species found in the Transcaucasus (Dorasham II-1, Dzhulfian Stage, zone *Vedioceras ventrosulcatum),* Changsing Limestone, as well as Wuchiaping Limestone in South China (Sheng, 1963) and Dorashamian of Greece (Attica, Beletsi Range) (Vachard *et al.,* 1993).

Occurrence.–Boreholes Gevim-1 and Pleshet-1; ‘Arqov Formation (upper part). Third local biozone (Wuchiapingian/Dzhulfian stage, late Permian).

Reichelina leveni sp. nov.

(Pl. 1, Fig. 15)

Derivation of name.–Named in honor of Prof. Ernst Ya. Leven.

Holotype.–Pleshet-1 borehole, 4,881-4,890 m depth, No P4881–90 (2)- 5.

Material.–2 axial section and 2 slightly oblique sections.

Description.–Test small, lenticular or narrowly-subrhomboidal with narrowly pointed periphery, slightly convex lateral sides and distinct umbilicus depressions. In inner volutions test is nautiloid with narrowly rounded periphery and slightly convex lateral sides. One-half inner volution coiled at angles to outer whorls (~ 90 degrees). The final whorl is uncoiled. Specimens have of 5 involutes volutions, 0.43 to 0.49 mm in diameter and 0.18 to 0.20 mm in length, giving a form ratio of 0.42.

	n	**D**					**L**			**L : D**
		1	**2**	**3**	**4**	**5**	**3**	**4**	**5**	
P4881-90(2)-5	5	0.04	0.10	0.19	0.31	0.45	0.09	0.14	0.19	0.42

Spirotheca are thin (0.010-0.015 mm), and weakly differentiated, composed of a tectum and thin light layer –diaphanotheca. Coil is relatively free, expands gradually through growth. Chomata are distinct, keel forms which thicken in basal deposits, some attaining 1/3 the volution height were observed in third and fourth whorls. Tunnel is narrow, expands gradually through growth. Last uncoiling volution still has six chambers. Height of camera: 1- 0.11 mm, 2-0.09 mm, 3-0.09 mm, 4-0.08 mm, 5-0.09 mm, 6-0.12 mm.

Remarks.–Our specimens show affinities to *Reichelina minuta* Erk (1942, p. 251, Pl. 13, Fig. 15, 16, Pl. 14, Fig. 22-24), although their size is smaller and their umbilical depression stronger umbilicus. The similar looking *Reichelina minuta* Erk has been described from the Middle-Upper Permian (*Parafusulina-Polydiexodina* zones) in the Bursa region of Turkey.

The represented specimens are also close to *Reichelina chichibuensis,* originally described by Morikawa (1956, p. 251, Pl. 32, Figs. 1-11, 13, 17), from Onagata district, Kamiyoshida Group, *Yabeina* zone and later, *R. chichibuensis* Morikawa, has been described by Ishibashi (1986, p. 98, Pl. 13, Figs. 1-9) from the Ryukyu Islands, locality Ihyg, Iheya-jima. However, our specimens differ by lenticular or narrowly-subrhomboidal form of test with narrowly pointed periphery, slightly convex lateral sides and distinct umbilicus depressions, and more developed chomata. (Chomata are distinct keel forms, which are thickened in base). The main difference of the new species from the known species of *Reichelina* is slightly convex lateral sides and distinct umbilicus depressions of test.

Distribution, occurrence and age.–Boreholes Gevim-1 and Pleshet-1; ‘Arqov Formation (upper part), Third local biozone (Wuchiapingian/Dzhulfian stage, late Permian).

Order SCHUBERTELLIDA Skinner, 1931
Family SCHUBERTELLIDAE Skinner, 1931
Genus *Schubertella* Staff & Wedekind, 1910

Type species.–*Schubertella transitoria* Staff and Wedekind (1910, p. 121, Pl. 4, Figs. 7-8).

Remarks.–Small fusulinid having an ellipsoidal to fusiform test with 1-2 inner volutions turned (coiled) at angles to outer whorls, and two-layers of the wall, septa unfluted. Chomata are generally large, highly and asymmetrical.

Schubertella rara Sheng, 1963
(Pl. 1, Figs. 9–11)

1963 *Schubertella rara* Sheng, p. 160, Pl. 4, Fig. 12
1998 *Schubertella rara* Sheng - Leven, Pl. 2, Figs. 13, 15-18.

Material.–5 axial sections and 6 slightly oblique sections.

Description.–The fusiform test is short with rounded median part; polar ends are slightly depressed and bluntly pointed. Shell expands gradually. Spirotheca thin composed of a tectum and a less dense layer. Measurements of specimen No P4992-5001 (1/19): L = 0.48 mm, D = 0.30 mm, L : D = 1.6 and number volutions: 4. First inner volution is with endothyroid coiling. Angles of the coil between the inner volution and outer whorls are about 70 degrees. Septa unfluted, plane. Chomata of the second volution are broad and asymmetrical.

Remarks.–Our specimens are most closely to *Schubertella rara* Sheng, 1963. *Schubertella obscura penchiensis* Sheng (1958) differ from our specimens by larger number of volutions, the polar ends of the test are more bluntly pointed, and its form ratio is smaller.

Distribution and age.–*Schubertella rara* Sheng, 1963 has been described from Yangsinian, lower part of the Chihsia limestone of Guizhou Province (*Misellina* subzone of the lower *Parafusulina* zone). Later, it was found in the Transcaucasia, at lower and middle parts of Asni Formation corresponding to the entire Kubergandian stage and the lower half of the Murgabian stage (Leven, 1998).

Occurrence.–Boreholes Gevim-1 and Pleshet-1; ‘Arqov Formation, Second and Third local biozones (Wuchiapingian/Dzhulfian stage, late Permian).

Schubertella paramelonica minor Suleimanov, 1949
(Pl. 1, Figs. 12-14)

1949 *Schubertella paramelonica* var. *minor* Suleimanov, pp. 32-33, Pl.1, Figs. 6-8.

Material.–5 axial sections and 3 oblique sections.

Description.–Test is ellipsoidal with rounded median part and axial ends. Shell expands gradually. Measurements: L = 0.39-0.55 mm, D = 0.26-0.32 mm, L : D = 1.48-1.7:1 and number of volutions: 3.5-4. Spirotheca is thin. Septa are straight throughout the length of the volutions, except the ends of the axis, where they are weakly twisted. Chomata are weak, broad, subquadrate and asymmetrical.

Remarks.–The characteristic features of the specimens are short ellipsoidal test with rounded axial ends, small dimensions, 3.5-4 volutions, weakly twisted septa of the axial ends. These features identify its with *Schubertella paramelonica minor* Suleimanov, 1949 and differ from close species *S. melonica* Dunbar et Skinner, 1937 and *S. paramelonica* Suleimanov, 1949.

Distribution and age.–*Schubertella paramelonica* Suleimanov *minor* Suleimanov, 1949 has been described from Artinskian Stage (an upper part of the

→

PLATE 1–All specimens: x 50. *1, 2, Nankinella* sp. *1,* paraaxial section, Gevim-1 borehole, 4,271-78 m depth; No G4271-78-(1)-1; *2,* oblique section, Gevim-1 borehole, 4,271-78 m; No G4271-78(2)-1. *3, Sichotenella*? *sutchanica* Tumanskaya. *3,* axial section, Pleshet-1 borehole, 5,001-10 m depth, No P5001-10(2)-6. *4, 5, Sichotenella*? *maichensis* Sosnina. *4,* axial section, Pleshet-1 borehole, 4,845-4,854 m depth, No P4845-4854 (2)-04; *5,* oblique section, Pleshet-1 borehole, 5,181-5,187 m depth, No P5181-87 (4)-29. *6, 7, Reichelina media* K. Miklukho-Maclay. *6,* oblique section, Pleshet-1 borehole, 4,917-26 m depth, No P4917-26(2)-2; *7,* slightly oblique section, Gevim-1 borehole, 4,203-4,209 m depth, No G4203-09N. *8, Reichelina changhsingensis* Sheng et Chang. *8,* tangential section, Gevim-1 borehole, 4,209-4,215 m depth, No G 4209-15. *9, 10, 11, Schubertella rara* Sheng. *9, 10,* axial sections, Gevim-1 borehole, 4,221-4,227 m depth; No G4221-27-5, No G4221-27-7; *11,* slightly oblique section, Gevim-1 borehole, 4,131-4,137 m depth, No G4131-37. *12-14, Schubertella paramelonica minor* Suleimanov. *12,* axial section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78 (1)- 3; *13,* axial section, Pleshet-1 borehole, 5,181-5,187 m depth, No P5181-87 (3)-5; *14,* slightly oblique section, Pleshet-1 borehole, 5,001-5,010 m depth, No P5001-10 (1)/37. *15, Reichelina leveni* sp. nov. *15,* holotype, axial section, Pleshet-1 borehole, 4,881-4,890 m depth, No P4881-90 (2)-5.

Plate 1


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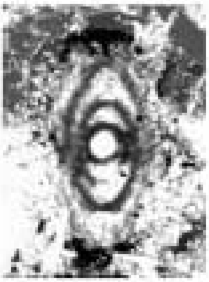
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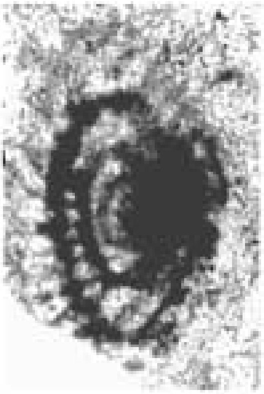
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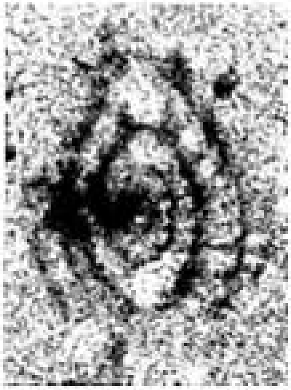
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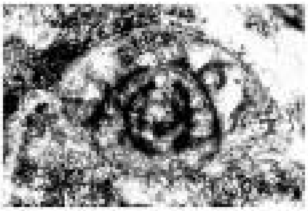
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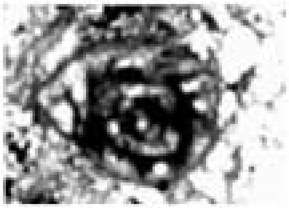
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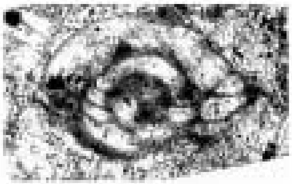
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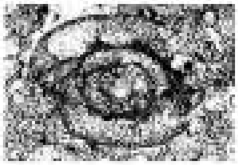
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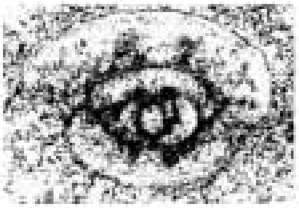
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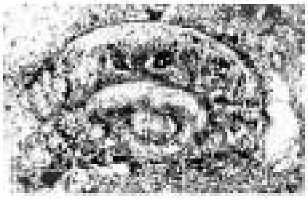
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Schwagerina zone) of the Kusyaplklovski Massiv, Ural.

Occurrence.–Boreholes Gevim-1 and Pleshet-1; Sa'ad and 'Arqov formations, First and Second local biozones (Capitanian/Midian and Wuchiapingian/ Dzhulfian stages, late Permian).

Family PALEOFUSULINIDAE A. Miklukho-Maclay, 1963, emend. Leven, 1987

Genus *Codonofusiella* Dunbar & Skinner, 1937

Type species.–*Codonofusiella paradoxica* Dunbar & Skinner, 1937, pp. 607-609, 710, Pl. 45, Figs. 1-9.

Remarks.–Small Paleofusulinid having a fusiform to ellipsoidal coiled part and one well-developed uncoiled flaring lip. Spirotheca thin. Septa are weakly to strongly fluted, chomata are present.

Codonofusiella kwangsiana Sheng, 1963
(Pl. 2, Figs. 4-6, 8-10)

1963 *Codonofusiella kwangsiana* Sheng, pp. 169-170, Pl. 6, Figs. 1-9.
1984 *Codonofusiella kwangsiana* Sheng. Chediya in Kotlyar *et al.*, Pl. 4, Figs. 1-5, 9.
1998 *Codonofusiella kwangsiana* Sheng. Leven, Pl. 3, Figs. 14-15, 17-20.

Material.–2 axial sections and 9 paraxial, tangential and oblique sections.

Description.–Shell small, consisting of 2 parts. The first part has 3 or 4 volutions and a short fusiform test with bluntly pointed polar ends. First and second volutions coiled (skewed) to outer ones. The second part is a one-half last uncoiled volution, abruptly expanded.

Measurements.–Specimens of 4 1/2 to 5 volutions, 0.43 to 0.50 mm in diameter and 0.80 to 1.12 mm in axial or length in inner volutions, giving a form ratio of 2.0-2.24. In second part (one-half volution, forming the uncoiled lip) test reaches to 1.37 mm.

Proloculus is minute and spherical. Spirotheca, thin and composed of a tectum and diaphanotheca. Septa thin, strongly and regularly fluted throughout length of shell. Chomata are indistinct and developed only in middle volutions.

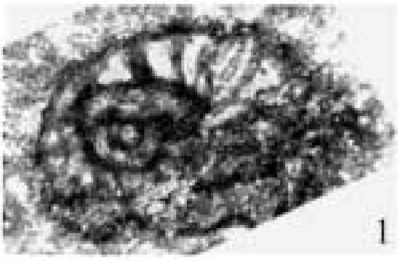
Remarks.–Our specimens are similar to *Codonofusiella asiatica* K. Miklukho-Maclay (1954) from late Permian deposits of the Northern Caucasus, but differs by its smaller size, smaller form ratio and weaker septal fluting. They are also similar to *Codonofusiella schubertelloides* Sheng (1956) from the Wuchiaping Limestone of Liangshan in southern Shensi, but our specimens differ by more numbers of volutions, larger size of the shell, chomata is present in middle volutions, septal fluting are slightly stronger. The closest to our specimens is *Codonofusiella kwangsiana*, originally described by Sheng (1963) from Lopingian, Hoshan Formation, Wuchiaping Limestone, *Codonofusiella* zone of Guizhou Province.

Distribution and age.–*Codonofusiella kwangsiana*, Sheng (1963) described from Lopingian, Hoshan Formation, Wuchiaping Limestone, *Codonofusiella* zone of Guizhou Province. They also occur at Khachic Formation in beds with *Codonofusiella- Araxilevis* (Kotlyar *et al.*, 1983). According to Leven (1998), they occur in Khachic Formation of Chanachi beds, from the Transcaucasia. This species also founded in Abadeh region (Central Iran), at Unit 5 of the Abadeh Formation (Taraz *et al.*, 1981) where *Codonofusiella kwangsiana* Zone was established.

→

PLATE 2–All specimens: x 50. *1, Codonofusiella erki* Rauser. *1,* slightly oblique section, Gevim-1 borehole, 4,197-4,203 m depth; No G4197-203. 2. *Codonofusiella* sp. *2,* oblique section, Pleshet-1 borehole, 4,992-5,001 m depth, No P4992-5001(3)-4. 3. *Codonofusiella nana* Erk. *3,* slightly oblique section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983-92 (1)-1. *4-6, 8-10, Codonofusiella kwangsiana* Sheng. *4,* oblique section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983-92 (2); *5,* axial section, Gevim-1 borehole, 4,278-4,284 m depth, No G4278-84; *6,* oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78. *8,* oblique section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983-92 (1), *9,* oblique section, Pleshet-1 borehole, 4,992-5,001 m depth, No P4992-5001- *6, 10,* oblique section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983-92(2)-17. *7, Codonofusiella?* sp. *7,* oblique section, Gevim-1 borehole, 4,278-4,284 m depth, G4278-84 (3).

PLATE 2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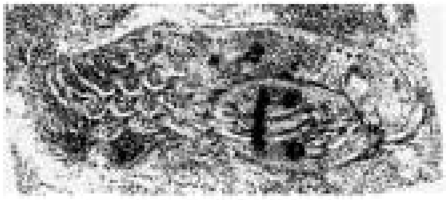
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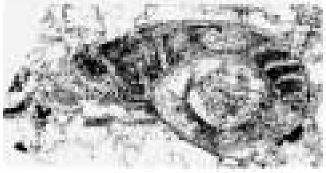
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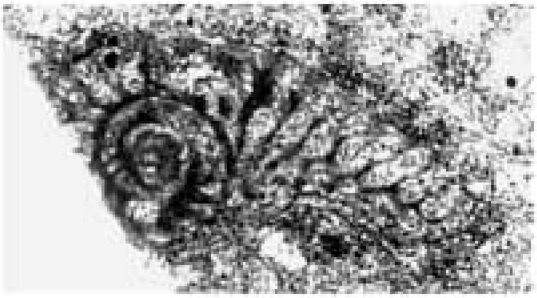
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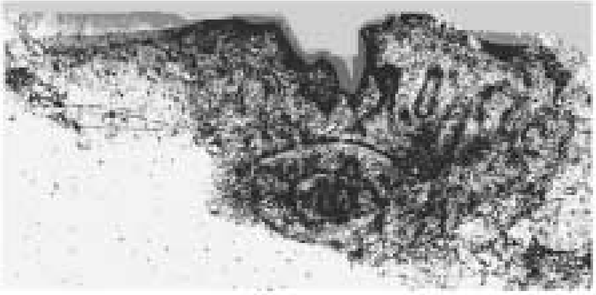
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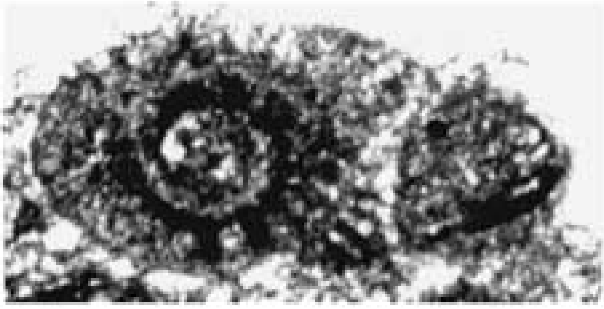
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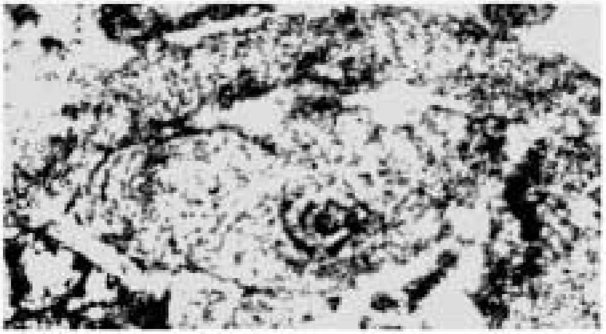
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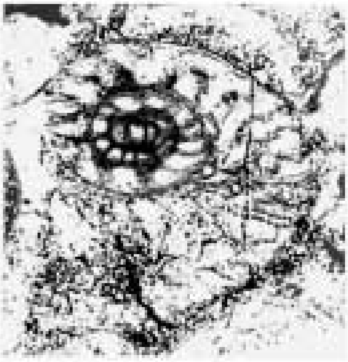
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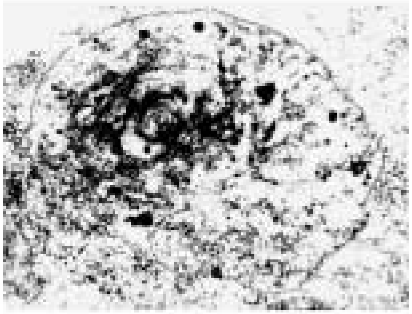
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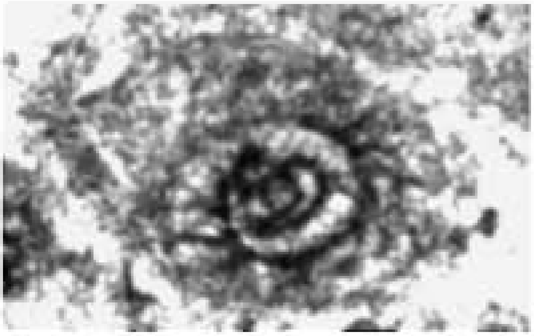
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Occurrence.–Boreholes Gevim-1 and Pleshet-1; ‘Arqov Formation, Second and Third Local biozones (Wuchiapingian/Dzhulfian stage, late Permian).

Codonofusiella nana Erk, 1942
(Pl. 2, Fig. 3)

1942 *Codonofusiella nana* Erk, p. 248-249, Pl. 13, Figs. 7-13.
1969 *Codonofusiella nana* Erk-Pantich, Pl. 6, Figs. 1 - 2.
1978 *Codonofusiella nana* Erk-Lys in Lys *et al.*, Pl. 8, Figs. 22, 27.

Material.–3 axial sections and 7 oblique sections.

Description.–Shell small, consisting of 2 parts. The first part has 2 1/2 or 3 volutions, an ellipsoidal test with bluntly pointed-rounded polar ends. The second part-one-half volution abruptly expanded, forming a flaring lip. Specimens of 3 to 3 1/2 whorls, 0.69-0.71 mm in length and 0.29 to 0.30 mm in width, give a form ratio of 2.3.

Proloculus is minute and spherical. Spirotheca are thin and composed of a tectum and diaphanotheca. Septa are thin and fluted. Chomata are not seen.

Remarks.–Our specimen is closely related to *Codonofusiella nana* Erk, 1942, originally described from the *Parafusulina-Polydiexodina* zones in the Bursa region of Turkey. It also resembles *Codonofusiella schubertelloides* Sheng, 1956 from Upper Permian, Wuchiaping limestone, *Codonofusiella* Zone in general, but differs in having more elongate tests with pointed-rounded polar ends in inner part.

Distribution and age.–*Codonofusiela nana* Erk, 1942, originally described from the Middle-Upper Permian (zones *Parafusulina-Polydiexodin*a) in the Bursa region of Turkey. Also, this species is known from the Dzhulfian stage of the Alboez of the North-East Iran (Lys *et al.*, 1978) and the late Permian of the locality Peovac of Western Serbia (Pantich, 1969).

Occurrence.–Boreholes Gevim 1 and Pleshet 1; Sa’ad (upper part) and ‘Arqov Formations, First and Second local biozones (Capitanian/Midian and Wuchiapingian/Dzhulfian stages, late Permian).

Genus *Ogbinella* Chediya, 1989

1989 *Ogbinella* Chediya –*in* Kotlyar *et al.*, pp. 101-102.
1996 *Ogbinella* Chediya –Rauzer-Chernousova *et al.*, p. 90, Pl. 21, Fig. 10.

Type species.–*Boultonia avushensis* Chediya (*in* Kotlyar *et al.*, 1984, pp. 130-131, Pl. 2, Figs. 4-6).

Remarks.–Small primitive *Paleofusulinid* having an elongated-fusiform test in outer volutions weakly and regularly fluted. Genus *Ogbinella* differs from *Pseudodunbarula* and *Paradunbarula* by the elongate form of the test.

Ogbinella ogbinensis (Chediya), 1984
(Pl. 3, Figs. 2, 5)

1984 *Boultonia ogbinensis* Chediya –Chediya *in* Kotlyar *et al.*, p. 129-130, Pl. 2, Figs. 1-3, 15.
1998 *Ogbinella ogbinensis* Chediya –Leven, Pl. 2, Figs. 33, 35.

Material.–3 axial sections and 3 oblique sections.

Description.–Test small, an elongated-fusiform with blunt polar ends. Inner two or three volutions have ellipsoidal to fusiform test. Specimens have 3 1/2 –5 volutions, 0.86 mm –length and 0.33 mm –width, and a form ratio –2.6. One or one-half inner volutions coiled at angles to outer ones.

	D					L				L : D	
P5181-	**0**	**1**	**2**	**3**	**3$^1/_2$**	**1**	**2**	**3**	**3$^1/_2$**	**3**	**3$^1/_2$**
5187-(4)-6	0.04	0.07	0.12	0.23	0.33	0.09	0.18	0.86	0.42	1.65	2.65

Proloculus is small and spherical, 0.040 mm in outside diameter. Spirotheca thin (0.010-0.015 mm) and composed of a tectum and lower, homogeneous light layer –diaphanoteca. Coil is moderate in inner whorls, expanded and free in outer one-half or one volutions. Thickness of spirotheca, 0.010-0.015 mm. Septa are weakly and regularly fluted, developed from third volution, reaching 1/3 the volution height. Chomata are indistinct, tunnel is broad and border fluted septa.

Remarks.–Our specimens resemble also *Ogbinella avushensis* (Chedia, 1984), but differ by elongated-fusiform shape with a blunt polar ends. Our specimens is the closest to species *Ogbinella ogbinensis* (Chediya, 1984) from beds *Codonofusiella –Araxilevis* of Transcaucasia, but differ by the large size of the test.

Distribution and age.–Ogbinella ogbinensis originally described by Chediya (in Kotlyar *et al.*, 1984), from beds *Codonofusiella –Araxilevis* (Transcaucasia). Later on, this species was also identified by Leven (1998) from Khachic Formation, Chanachi beds (Transcaucasia).

Occurrence.–Boreholes Gevim 1 and Pleshet 1; Sa'ad Formation, First local biozone (Capitanian/ Midian stage, late Permian).

Ogbinella? *plata* sp. nov.
(Pl. 3, Figs. 7-9)

Derivation of name.–Originated from Latin word *"planus"*–flat.

Holotype.–Pleshet-1 borehole, 4,992-5,001 m depth, No P4992-5001 (2) –12 (Pl. 3, Fig. 7).

Material.–3 axial sections and 5 oblique sections.

Description.–Test small, an ellipsoidal form with flattened median part and bluntly rounded polar ends. Inner first whorl is endothyroid. Second volution has an elongated-fusiform test. Specimens of volutions 3 to 4, 0.40 to 0.48 mm in length and from 0.20 to 0.30 mm in diameter, giving a form ratio of 1.67-1.77.

	D				**L**			**L : D**
	0	**1**	**2**	**3**	**1**	**2**	**3**	**3**
P4992-5001(2)-12(holotype)	0.035	0.07	0.13	0.26	0.11	0.24	0.46	1.77

Proloculus is small and spherical, 0.035 mm in outside diameter. Spirotheca thin (0.010-0.015 mm) and composed of a tectum and diaphanoteca. The coiling of the shell expands gradually, and its growth is moderate. Thickness of spirotheca, 0.010-0.015 mm. Septa are weakly and regularly fluted in median and polar parts of outer whorl, reaching 1/2 height of volution. Septa are folds with parallel-sided in median region and imitated chomata, flats form arches in polar ends into second volution.

Remarks.–Our specimens is similar to *Ogbinella ardaglensis* Chediya (in Kotlyar *et al.*, 1983) from beds *Codonofusiella-Araxilevis* of Transcaucasia, but differ by the flattened median part of the shells, by smaller diameters and lengths, and less number of volutions (*O. ardaglensis* Chediya has diameter 0,49-51 mm, length –1,00-1,12 mm, number of volutions –4 $^{1}/_{2}$). Our specimens differ from others species of the genus *Ogbinella* by the smaller size, and also by weakly elongated-ellipsoidal test, flatted median part of outer volution and bluntly rounded polar ends. Therefore, this species related to the genus *Ogbinella* conventionally.

Distribution, occurrence and age.–Boreholes Gevim-1, David 1 and Pleshet-1; 'Arqov Formation, Second local biozone (Wuchiapingian/Dzhulfian stage, late Permian).

Genus *Pseudodunbarula* Chediya, 1984

Type species.–Pseudodunbarula arpaensis: Chediya, 1984, pp. 132-133, Pl. 5, Figs. 1, 2, 4, 5, 8.

Remarks.–Small Paleofusulinid having an inflated fusiform, subspherical to ellipsoidal tests. Septa are weak and fluted regularly or randomly throughout length of shell. Chomata are weak and asymmetrical or completely absent. It differs from *Paradunbarula*, according to Chediya (1984, in Kotlyar *et al.*, 1984), by smaller size (less by half).

Pseudodunbarula dzhagahzurensis Chediya, 1984
(Pl. 3, Fig. 13)

1984 *Pseudodunbarula dzhagahzurensis* Chediya –Chediya in Kotlyar *et al.*, p. 133, Pl. 5, Figs. 7, 10, 14-16, 18.

1998 *Pseudodunbarula dzhagahzurensis* Chediya –Leven, Pl. 3, Figs.1-3.

Material.–4 axial sections and 6 oblique sections.

Description.–Test small, inflated-fusiform with pointed polar ends. Inner two volutions have a short subrhomboidal to subspherical test. Specimen has of 3 $^{1}/_{2}$ volutions, 0.62 mm in length and 0.36 mm in width, giving a form ratio of 1.7. Inner 1 or 1 $^{1}/_{2}$ volutions coiled at angles to next whorls.

	D					L				L : D	
P5195-	**0**	**1**	**2**	**3**	**3 1/2**	**1**	**2**	**3**	**3 1/2**	**3**	**3 1/2**
5203-(2)-1	0.04	0.08	0.11	0.21	0.36	0.16	0.21	0.36	0.62	1.71	1.72

Proloculus is small and spherical, 0.040 mm in outside diameter. Spirotheca is thin and composed of a tectum and lower layer –diaphanoteca. Thickness of spirotheca is 0.010 to 0.015 mm. Coiling into all whorls is moderate, shell expands gradually through growth. Septa are weakly and unevenly fluted and chaotic or randomly arranged. Chomata are absent, tunnel is indistinct.

Remarks.–*Pseudodunbarula dzhagahzurensis* Chediya (1984) from beds of *Codonofusiella-Araxilevis* (Transcaucasia), differs from our specimens only by its larger size of the test. *Pseudodunbarula arpaensis* Chediya (1984) from beds of *Codonofusiella-Araxilevis* (Transcaucasia), differs from our specimens by subspherical form and its larger size of the test (the length and width), by the number of volutions and another form ratio (*Pseudodunbarula arpaensis* has a form ratio from 1.3 to 1.4).

Distribution and age.–*Pseudodunbarula dzhagahzurensis* described by Chediya (in Kotlyar *et al.*, 1984) from beds of *Codonofusiella-Araxilevis* of the Transcaucasia. Later on recorded by Leven (1998) from Khachic Formation, Chanachi beds of Transcaucasia.

Occurrence.–Boreholes Gevim 1 and Pleshet 1; Sa'ad Formation, First local biozone (Capitanian/ Midian stage, late Permian).

Pseudodunbarula minuta sp. nov.
(Pl. 3, Fig. 11, 12)

Derivation of name.–Originated from Latin word *"minuta"* –minute.

Holotype.–Gevim-1 borehole, 4,293-4,299 m depth, No G4293-99-10 (Pl. 3, Fig. 11).

Material.–3 axial sections and 3 oblique sections.

Description.–Test small, inflated fusiform to subspherical with bluntly rounded polar ends. Inner two volutions have a subspherical test. Specimens of 3 to 3 1/2 volutions, 0.43 to 0.45 mm in length and from 0.30 to 0.36 mm in width, giving a form ratio of 1.30-1.47. First, inner one-half volution coiled at angles to next whorls.

→

PLATE 3–All specimens: x 50. *1, Codonofusiella* sp. *1,* oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78. *2, 5, Ogbinella ogbinensis* (Chediya). *2,* oblique section, Pleshet-1 borehole, 5,181-5,187 m depth, No P5181- 87-(4)-6; *5,* slightly oblique section, Pleshet-1 borehole, 5,218-5,227 m depth, No P5218-27-13. *3, Ogbinella ardaglensis* (Chediya). *3,* slightly oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78-02. *4, Ogbinella* cf. *avushensis* (Chediya). *4,* oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78-01. *6, Codonofusiella sp*. (*Codonofusiella* cf. *nana* Erk). *6,* oblique section, Pleshet-1 borehole, 5,193-5,203 m depth, No P5193-203 (2)-2. *7-9, Ogbinella? plata* sp. nov. *7,* holotype, axial section, Pleshet-1 borehole, 4,992-5,001 m depth, No P4992-5001 (2)-12; *8,* axial section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983 –92 (2)-1; *9,* slightly oblique section, Pleshet-1 borehole, 4,992-5,001 m depth, No P4992 –5001-11. *10, 15, Pseudodunbarula arpaensis* Chediya. *10,* axial section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78 (1)-11, *15,* oblique section, Gevim-1 borehole, 4,278-4,284 m depth, No G4278-84 (1)-9. *11, 12, Pseudodunbarula minuta* sp. nov. *11,* holotype, axial section, Gevim-1 borehole, 4,293-4,299 m depth, No G4293-99-10; *12,* axial section, Pleshet-1 borehole, 5,338-5,343 m depth, No P5338 –43 (1). *13, Pseudodunbarula dzhagahzurensis* Chediya. *13,* oblique section, Pleshet-1 borehole, 5,193-5,203 m depth, No P5193-203 (2)-1. *14, Pseudodunbarula* sp. *(Pseudodunbarula* cf. *arpaensis* Chediya). *14,* oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78 (1). *16, Pseudodunbarula minima* (Sheng and Chang). *16,* slightly oblique section, Pleshet-1 borehole, 4,983-4,992 m depth, No P4983-92 (1)-12. *17, Codonofusiella schubertellinoides* Sheng, 1956. *17,* oblique section, Gevim-1 borehole, 4,271-4,278 m depth, No G4271-78(1)-13a. *18, Yangchienia* cf. *hainanica* Sheng. *18,* oblique section, Gevim-1 borehole, 4,293-4,299 m depth, No G4293-4299 (1).

PLATE 3


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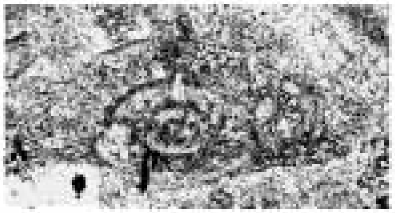
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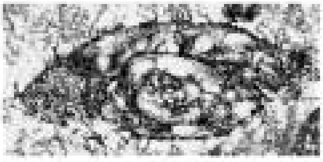
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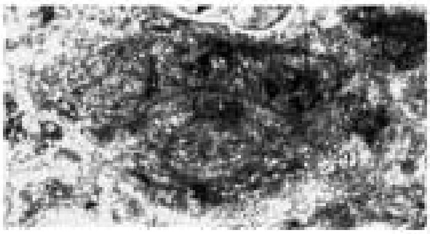
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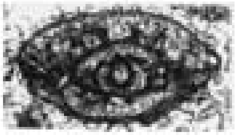
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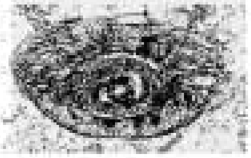
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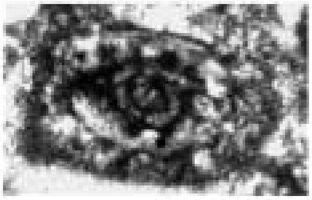
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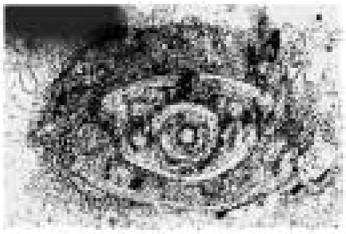
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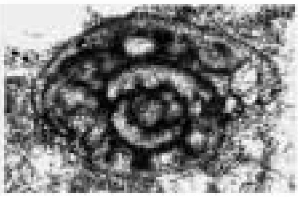
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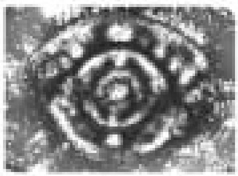
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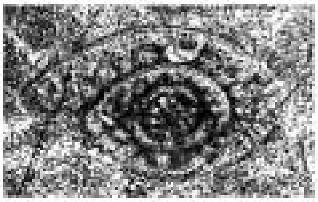
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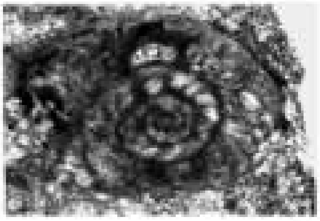
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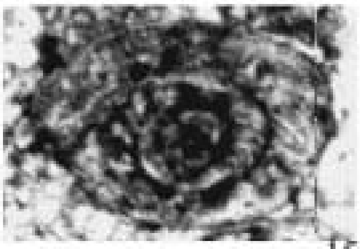
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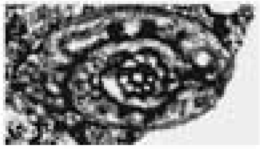
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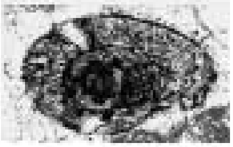
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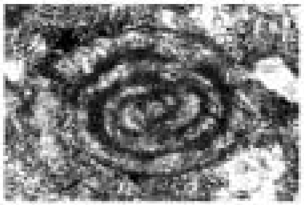
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	D				**L**				**L : D**	
	1	**2**	**3**	**$3^{1}/_{2}$**	**1**	**2**	**3**	**$3^{1}/_{2}$**	**2 or 3**	**3 or $^{1}/_{2}$**
G4293 4299-(1)	0.07	0.11	0.20	0.30	0.09	0.15	0.23	0.43	1.15	1.43
P5338 5343-1	0.09	0.21	0.35		0.15	0.25	0.45		1.19	1.36

Proloculus is small and spherical, 0.040 to 0.06 mm in outside diameter. Spirotheca is thin and composed of a tectum and lower layer –slightly fine porous diaphanoteca. Thickness of spirotheca is 0.010-0.015 mm. Coil is free and even into all volutions. Shell expands gradually through growth. Septa are parallel-sided, even fluted folds, 2/3 the height of the outer volution. Chomata expressed, asymmetrical, the tunnel is high and board.

Remarks.–*Pseudodunbarula arpaensis* originally described by Chediya (1984) from beds of *Codonofusiella –Araxilevis* of Transcaucasia, differ from our specimens by its larger size of the test (the length and width and the number of volutions), also by absence of the chomata. *Pseudodunbarula minima* Sheng and Chang (1958), described from the upper part of the Changhsing limestone (*Paleofusulina* zone) in the northestern Chekian Province differ from our specimens by the form of the test in the inner volutions (subspherical), larger size of the test and stronger fluttering of the septa. *Pseudodunbarula simplex* by Sheng and Chang, (1958) described from the upper part of the Changhsing limestone (*Paleofusulina* zone) in the northeastern Chekian Province differ from our specimens by presence of free coil of the test in inner volutions, more evenly fluted folds, large size and number of whorls of the test.

Distribution, occurrence and age.–Boreholes Gevim-1 and Pleshet-1; Sa'ad Formation, First local biozone (Capitanian/Midian stage, late Permian).

CONCLUSIONS

1. Three foraminiferal local biozones are defined within the Sa'ad and 'Arqov Formations from several boreholes of the northern Negev and southern Coastal Plain of Israel. None of the boundaries of the lithostratigraphic subdivisions of the Sa'ad and 'Arqov formations are coinciding with the foraminiferal local biozones and palynological zones. The First local biozone-*"Pseudodunbarula arpaensis"*–characterizes the Sa'ad Formation– medium part of the 'Arqov Formation, to which it assigns a Capitanian/Midian age.

The Second and Third local biozones subdivide the upper part of the 'Arqov Formation. The Second local biozone –*"Codonofusiella kwangsiana"*– correlates with the *Codonofusiella kwangsiana* Zone and corresponds to the earliest Wuchiapingian/Dzhulfian. The Third local biozone –*"Reichelina media"*– probably correlates with the *Reichelina media* Zone of the Wuchiapingian/Dzhulfian. The uppermost layers of this local biozone are probably uppermost Wuchiapingian/Dzhulfian or Changhsingian/Dorashamian.

2. The Permian fossil assemblage in the subsurface of Israel includes palynomorphs, fragmented crinoids, bryozoans, and calcareous algae (Dasycladaceae –Pseudovermiporella, Gymnocodium, Mizzia and red algae– Permocalculus). Ostracods and smaller calcareous benthonic foraminifera dominate into the microfauna. The smaller foraminifers are represented by Miliolina, Lagenina and Globivalvulinacea. Among the families, the following genera are dominant: *Pachyophloia, Globivalvulina, Hemigordius, Frondina, Robuloides, Baisalina, Nodosaria, Agatammina*. Common taxa include *Geinitziana, Multidiscus, Langella, Ichthyolaria, Paraglobivalvulina* and rare taxa include *Neodiscus, Abadahella, Colaniella, Frondinonodosaria*.

Permian Fusulinids of the subsurface of Israel are represented only eurybiontic smaller fusulinids of the Shubertellida, Ozawainellida and Staffellida orders. The Middle and Late Permian foraminifera from the subsurface of Israel are similar to some assemblages of the Transcaucasia (Kotlyar *at el.,* 1984; Pronina, 1988; Leven, 1998), of the Abadeh Area, Iran (Taraz *et al.*, 1981) and of the East Taurus, Turkey (Zaninetti *et al.*, 1981). The assemblage of the First local biozone shows to few affinities with Midian assemblages of the Batain Plain, Easter Oman (Vachard *et al.*, 2002). However, the Levant assemblages differ from other assemblages of Tethyan regions by the absence of the fusulinids, such as *Yabeina, Lepidolona, Neoshwagerina, Paleofusulina* and *Paradunbarula*.

The absence of fossils younger than uppermost Changhsingian/Dorashamian suggests a hiatus of the uppermost Permian strata.

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PALYNOLOGY OF THE ESTRATOS DE MASCASÍN, UPPER CARBONIFEROUS, PAGANZO BASIN, ARGENTINA: SYSTEMATIC DESCRIPTIONS AND STRATIGRAPHIC CONSIDERATIONS

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Abstract

The Estratos de Mascasín, a sequence known only from subsurface at the YPF-LR-SM es-1 well, constitutes part of the widespread Upper Paleozoic rocks deposited in the Paganzo Basin, northwestern Argentina. Palynomorphs are abundant in the intervals 3,423-3,429 m and 3,336-3,342 m. Although mentioned in previous studies, they are described here in detail for the first time. A new genus, *Grossusporites,* and four newly named species, *Apiculatisporis densus, Dibolisporites variatus, Granulatisporites plicatus* and *Vallatisporites pauper,* are formally proposed. Originally, the lowest association was considered the only record of the Argentinian *Potonieisporites* Palynozone. However, the 70 species recognized in this study are found in other Late Carboniferous Argentinian assemblages belonging to *Raistrickia densa-Convolutispora muriornata* Biozone.

Key words: Carboniferous, Argentina, palynology, systematics.

Resumen

Los Estratos de Mascasín, secuencia únicamente conocida en la perforación YPF-LR-SM es-1, forma parte de los extensos depósitos del Paleozoico Superior de Cuenca Paganzo, en el noroeste argentino. Los palinomorfos son abundantes en los intervalos 3.423-3.429 m y 3.336-3.342 m y, aunque fueron mencionados en estudios previos, ellos son por primera vez descritos en detalle. Son formalmente propuestos un nuevo género, *Grossusporites* y cuatro nuevas especies de esporas: *Apiculatisporis densus*, *Dibolisporites variatus, Granulatisporites plicatus* y *Vallatisporites pauper*. Originalmente, la asociación inferior fue usada como el único registro de la palinozona argentina *Potonieisporites*. Sin embargo, las setenta especies reconocidas en este estudio son también encontradas en otras asociaciones de edad carbonífera tardía de Argentina, asignadas a la Biozona *Raistrickia densa-Convolutispora muriornata*.

Palabras clave: Carbonífero, Argentina, palinología, sistemática.

INTRODUCTION

The palynological assemblages described here come from the Estratos de Mascasín, a stratigraphic unit that is only recognized in the Paganzo Basin subsurface. The Paganzo Basin, a large foreland basin (c. 140,000 km^2) that began to subside in Middle Carboniferous times and continued into the Middle Permian, is situated in northwestern Argentina (Fig. 1). The palynological samples are from the YPF LR SM.es-1, Salinas de Mascasín well, in the intervals 3,423-3,342 m and 3,336-3,342 m. Despite discussion of the stratigraphic position of the Mascasín palynofloras (Azcuy, 1986; Césari, 1986; Césari and Gutiérrez, 2001), no systematic palynological studies have been published. Azcuy and Jelin (1980) provided a limited general survey of palynomorphs from the interval 3,423-3,429 m of the Estratos de Mascasín; later Rocha Campos and Archangelsky (1985) and Archangelsky *et al*. (1987) listed and illustrated several species of spores and pollen grains, without descriptions.

Azcuy and Jelin (1980) recognized three palynozones for the Carboniferous-Permian of the Paganzo Basin: 1- *Ancistrospora* Palynozone dominated by spores (95%) and referred to the "Middle Carboniferous" (Namurian and/or Westphalian); 2- *Potoniesporites* Palynozone (Stephanian) was characterized by diverse monosaccate pollen grains, including a taeniate species; and 3- III Palynozone (Early Permian) containing a higher proportion of monosaccate (30%) and bisaccate (15%) pollen grains and some taeniate pollen grains. Azcuy (1986) emphasized the Late Carboniferous age of the *Potonieisporites* Palynozone according to the supposed stratigraphic position of the fossiliferous levels into the Estratos de Mascasín, apparently 5 m below red beds interpreted by Azcuy as Permian. Concurrently, Césari (1986) described few taeniate pollen grains in the Tupe Formation, originally referred to the *Ancistrospora* Palynozone, and proposed a revision of the biostratigraphic scheme. She defined the *Potoniesporites*/*Lundblandispora* (PL) Biozone (considering that the *Ancistrospora* and *Potoniesporites* were equivalents) and the younger *Cristatisporites* Biozone. The PL Biozone, characterized by the incoming of scarce taeniate pollen grains, was subdivided into two sub biozones: *Raistrickia-Plicatipollenites* and "Interval". Césari and Gutiérrez (2001) presented a revised palynostratigraphic scheme for northwestern Argentina, defining four biozones ranging from Early Permian to Early Carboniferous: I- *Lueckisporites-Weylandites* Assemblage Biozone, Permian; II- *Fusacolpites fusus-Vitattina subsaccata* Interval Biozone, Early Permian; II- *Raistrickia densa-Convolutispora muriornata* Assemblage Biozone, Late Carboniferous, subdivided into three subbiozones and the *Cordylosporites-Verrucosisporites* Assemblage Biozone (Late Tournaisian-Visean). These authors referred the palynofloras from the Estratos de Mascasín sequence to the *Raistrickia densa-Convolutispora muriornata* Biozone, more precisely to the Interval subbiozone B.

Our principal goal in this paper is to provide an illustrated, systematically descriptive and stratigraphically documented account of the palynomorphs of the Mascasín well. We have studied not only the samples from the interval 3,423-3,429 m (named here lower level) but also from the interval 3,336-3,342 m (upper level).

MATERIAL AND METHODS

The samples consist of cores from the Salinas de Mascasín well (YPF LR SM.es-1) located in the Paganzo Basin (Fig. 1). The analyzed samples were processed by conventional physico-chemical techniques. The photographs were taken with a Nikon Coolpix 995 adapted to an Olympus BX 51 microscope. Permanent repository of the specimens is the Palynological Collection at the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" BA PB Pal. 5612-1/24 (lower level) and 5613-1/13 (upper level). The terminology used for bilaterally symmetrical pollen grains is that applied by Playford and Dino (2002). The distribution mentioned for each species is exclusively Argentinian. The appendix provides curatorial information pertaining to each figured specimen (Plates 1-4, Fig. 2).

List of taxa

Anteturma PROXIMEGERMINATES Potonié, 1970
Turma TRILETES Reinsch emend. Dettmann, 1963
Suprasubturma ACAVATITRILETES Dettmann, 1963
Subturma AZONOTRILETES Luber emend.
Dettmann, 1963
Infraturma LAEVIGATI Bennie and Kidston emend.
Potonié, 1956

Calamospora hartungiana Schopf, Wilson and Bentall, 1944.

Leiotriletes tenuis Azcuy, 1975*a*.

Leiotriletes sp. 1.

Punctatisporites glaber (Naumova) Playford, 1962.

Punctatisporites gretensis Balme and Hennelly, 1956.

Punctatisporites sp. cf. *Punctatisporites* sp. A Azcuy, 1975*a*.

Infraturma RETUSOTRILETI Streel, 1974

Retusotriletes anfractus Menéndez and Azcuy, 1969.

Infraturma APICULATI Bennie and Kidston emend.
Potonié, 1956
Subinfraturma GRANULATI Dybová
and Jachowicz, 1957

Cyclogranisporites plicatus sp.nov.

Granulatisporites varigranifer Menéndez and Azcuy, 1969.

Granulatisporites cf. *G. varigranifer* Menéndez and Azcuy, 1969.

Granulatisporites sp.

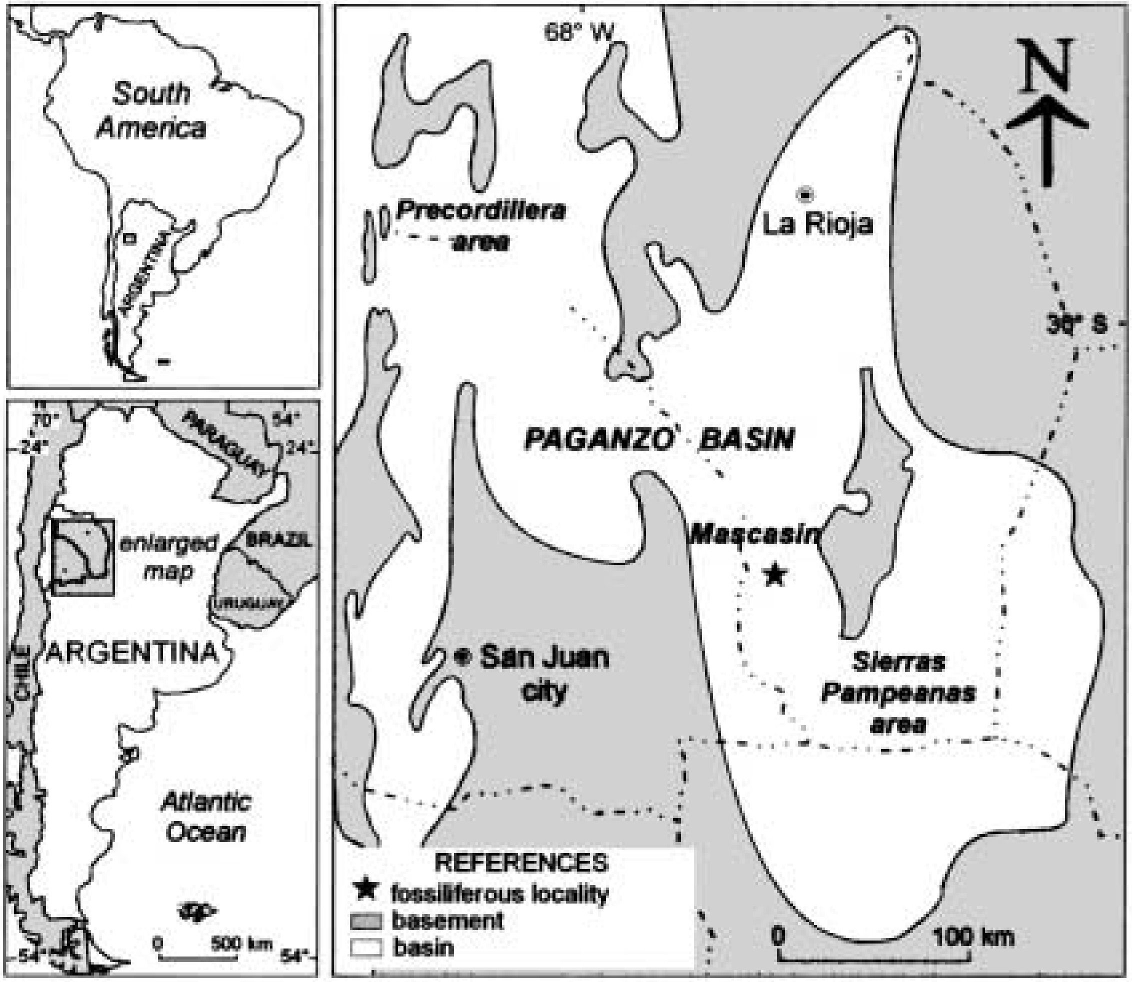


FIGURE 1–Locality map, Paganzo Basin, showing drillhole site whence core samples derive.

Subinfraturma VERRUCATI Dybová and Jachowicz, 1957

Verrucosisporites cordubensis Vergel, 1998.

Converrucosisporites sp.

Subinfraturma NODATI Dybová and Jachowicz, 1957

Apiculatasporites caperatus Menéndez and Azcuy, 1969.

Apiculatisporis densus sp. nov.

Apiculiretusispora sparsa Menéndez and Azcuy, 1971.

Apiculiretusispora ralla (Menéndez and Azcuy) Menéndez and Azcuy, 1971.

Lophotriletes sp. cf. *L. discordis* Gutiérrez and Césari, 1988.

Lophotriletes sp. cf. *L. rectus* Bharadwaj and Salujha, 1964.

Lophotriletes sp. cf. *L. rarus* Bharadwaj and Salujha, 1964.

Lophotriletes sp. cf. *L. intermedius* Azcuy, 1975*a.*

Dibolisporites variatus sp. nov.

Subinfraturma BACULATI Dybová and Jachowicz, 1957

Raistrickia cephalata Bharadwaj, Kar and Navale, 1976.

Raistrickia sp.

Horriditriletes uruguaiensis (Marques-Toigo) Archangelsky and Gamerro, 1979.

Infraturma MURORNATI Potonié and Kremp, 1954

Convolutispora muriornata Menéndez, 1965.

Convolutispora cf. *C. candiotensis* Ybert, 1975.

Convolutispora sp. 1.

Convolutispora sp. 2.

Foveosporites pellucidus Playford and Helby, 1968.

Microreticulatisporis puntatus Knox, 1950.

Dictyotriletes cortaderensis Césari and Limarino, 1987.

Dictyotriletes sp.

Suprasubturma LAMINATITRILETES Smith and Butterworth, 1967
Subturma ZONOLAMINATITRILETES Smith and Butterworth, 1967
Infraturma CINGULICAVATI Smith and Butterworth, 1967

Vallatisporites ciliaris (Luber) Sullivan, 1964.

Vallatisporites pauper sp. nov.

Cristatisporites sp. cf. *C. pseudozonatus* Lele and Makada, 1972.

Kraeuselisporites volkheimeri Azcuy, 1975*b.*

Grossusporites microgranulatus (Menéndez and Azcuy) nov. comb.

Suprasubturma PSEUDOSACCITITRILETES Richardson, 1965
Infraturma MONOPSEUDOSACCITI Smith and Butterworth, 1967

Spalaeotriletes ybertii (Marques-Toigo) Playford and Powis, 1979.

Anteturma VARIEGERMINANTES Potonié and Kremp, 1954
Turma SACCITES Erdtman, 1947
Subturma MONOSACCITES (Chitaley) Potonié and Kremp, 1954
Infraturma DIPOLSACCITES (Chitaley) Dibner, 1971
Subinfraturma APERTACORPINI Dibner, 1971

Cannanoropolis densus (Lele) Bose and Maheshwari, 1968.

Cannanoropolis janakii Potonié and Sah, 1960.

Plicatipollenites malabarensis (Potonié and Sah) Foster, 1975.

Plicatipollenites trigonalis Lele, 1964.

Potonieisporites barrelis Tiwari, 1965.

Potonieisporites brasiliensis (Nahuys *et al*.) Archangelsky and Gamerro, 1979.

Potonieisporites jayantiensis Lele and Karim, 1971.

Potonieisporites lelei Maheswari, 1967.

Potonieisporites magnus Lele and Karim, 1971.

Potonieisporites methoris (Hart) Foster, 1975.

Potonieisporites neglectus Potonié and Lele, 1961.

Potonieisporites novicus Bharadwaj, 1954.

Potonieisporites cf. *P. densus* Maheshwari, 1967.

Potoniesporites cf. *P. triangulatus* Tiwari, 1965.

Caheniasaccites densus Lele and Karim emend. Gutiérrez, 1993.

Forma A.

Forma B.

Infraturma DISACCITES Leschik, 1955

Limitisporites hexagonalis Bose and Maheshwari, 1968.

Limitisporites rectus Leschik, 1956.

Limitisporites sp. cf. *L. monosaccoides* Bose and Maheshwari, 1968.

Limitisporites sp.

Infraturma STRIATITI Pant, 1954

Protohaploxypinus amplus (Balme and Hennelly) Hart, 1964.

Protohaploxypinus limpidus (Balme and Hennelly) Balme and Playford, 1967.

Protohaploxypinus sp.

Striatobieites sp.

Vittatina sp.

INCERTAE SEDIS

Portalites gondwanensis Nahuys, Alpern and Ybert, 1968.

Spongocystia sp.

Tetraporina punctata (Tiwari and Navale) Kar and Bose, 1976.

Maculatasporites sp. 1.

Maculatasporites sp. 2.

SYSTEMATIC PALEONTOLOGY

Genus *Calamospora* Schopf, Wilson and Bentall, 1944

Type species.–Calamospora hartungiana Schopf, Wilson and Bentall, 1944.

Calamospora hartungiana Schopf in Schopf, Wilson and Bentall, 1944
Plate 1, Fig. 1

Description.–Spores radial, trilete. Amb subcircular. Laesurae more or less distinct, straight. Exine thin, usually folded, 1 µm thick or less, scabrate.

Dimensions.–Equatorial diameter 48-52 µm (2 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001). Mascasín, upper level.

Genus *Leiotriletes* (Naumova) Potonié and Kremp, 1954

Type species.–*Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954.

Leiotriletes tenuis Azcuy, 1975a
Plate 1, Fig. 2

Description.–Spores radial, trilete. Amb triangular, with slightly concave sides and rounded apices. Laesurae distinct, straight, with fine lips, reaching almost to the equatorial margin. Exine thin, 0.5 µm thick, laevigate.

Dimensions.–Equatorial diameter: 35-37 µm; polar axis: 26 µm (2 specimens).

Comparisons.–This species is distinguishable from *Leiotriletes virkkii* Tiwari, 1965 and *Leiotriletes corius* Kar and Bose, 1967 by its thinner exine. *Leiotriletes directus* Balme and Hennelly, 1956 differs by its smaller size and sinuous laesurae.

Distribution.–Malanzán (Azcuy 1975b; Gutiérrez and Limarino, 2001) and Lagares (Césari and Gutiérrez, 1984) Formations. Mascasín lower level.

Leiotriletes sp. 1
Plate 1, Fig. 3

Description.–Spore radial, trilete. Amb triangular, straight to concave sides and rounded apices. Laesurae straight, simple, with incipient bifurcation at the end of the rays, length three-quarters of spore radius. Exine laevigate, 1.5-1.8 µm thick.

Dimensions.–Equatorial diameter 39 µm (1 specimen).

Comparisons.–*Leiotriletes* cf. *L. inermis*, as described by Azcuy, 1975*a*, has also the ends of the rays slightly bifurcated but differs by its exine being apparently scabrate (Azcuy 1975a, Plate 2, Fig. 11). *Leiotriletes sp.* Ottone, 1989 differs in its slightly thinner (1.2 µm) and scabrate exine. *Leiotriletes* sp. Ottone, 1991, resembles our specimens but it is more subcircular, with smaller diameter (30 µm) and thinner exine.

Distribution.–Mascasín, lower level.

Genus *Punctatisporites* (Ibrahim) Potonié and Kremp, 1954

Type species.–*Punctatisporites minutus* Ibrahim, 1933.

Punctatisporites gretensis Balme and Hennelly, 1956
Plate 1, Fig. 5

Description.–Spores radial, trilete, amb rounded subtriangular to subcircular. Laesurae straight, length three-quarters of spore radius; accompanied by lips up to 0.8 µm wide and 1 µm high. Exine laevigate, 1-1.5 µm thick.

Dimensions.–Equatorial diameter: 44-45 µm (2 specimens).

Comparisons.–Although the size range of the studied specimens falls below that originally described for the species (Balme and Hennelly, 1956), we agree with Césari *et al.* (1995) in the irrelevant systematic value of *P. gretensis* forma *minor*.

Distribution.–This species has a widespread distribution in Upper Palaeozoic palynofloras from Argentina (Césari and Gutiérrez, 2001); Mascasín, upper level.

Punctatisporites glaber (Naumova) Playford, 1962
Plate 1, Fig. 6

Description.–Spores radial, trilete. Amb subcircular. Laesurae simple, straight, length one-half to two-thirds of spore radius. Exine laevigate, 1.5 µm thick.

Dimensions.–Equatorial diameter: 40-61 µm (3 specimens).

Distribution.–Malanzán (Azcuy, 1975a), Lagares (Menéndez and Azcuy, 1969) and Santa Máxima (Ottone 1989) Formations. Mascasín, upper level.

Punctatisporites sp. cf. *Punctatisporites* sp. A Azcuy, 1975a
Plate 1, Fig. 4

Description.–Spores radial, trilete. Amb subcircular. Laesurae straight, length *c.* one-half to one-third of the spore radius, accompanied by elevated lips, 1.5-3 µm, that diminish in height toward the equator. Exine laevigate, 1.5-2um thick.

Dimensions.–Equatorial diameter: 38-43 µm (2 specimens).

Comparisons.–*Punctatisporites* sp. A Azcuy, 1975a, and *Punctatisporites* sp. Azcuy *et al.*, 1982, are similar to our specimens but differ in their wider lips (up to 6.5 µm).

Distribution.–Mascasín, lower level.

Genus *Retusotriletes* (Naumova) Streel, 1964

Type species.–*Retusotriletes simplex* Naumova, 1953.

Retusotriletes anfractus Menéndez and Azcuy, 1969
Plate 1, Fig. 7

Description.–Spore radial, trilete. Amb rounded subtriangular with smooth margin. Laesurae sinuous with lips *c*. 3 µm high and 1 µm wide, length two-thirds of spore radius with imperfect curvaturae. Exine laevigate, 1.8 µm thick.

Dimensions.–Equatorial diameter: 30 µm. (1 specimen).

Comparisons.–Our specimen is clearly consonant with the specimens originally described by Menéndez and Azcuy (1969).

Distribution.–Tupe (Ottone and Azcuy, 1990), Lagares (Menéndez and Azcuy, 1969), Agua Colorada (Menéndez and Gonzalez-Amicón, 1979), Jejenes (Gonzalez-Amicón, 1973) and Santa Máxima (Ottone, 1989) Formations. Mascasín, lower level.

Genus *Cyclogranisporites* Potonié and Kremp, 1954

Type species.–*Cyclogranisporites leopoldi* (Kremp) Potonié and Kremp, 1954.

Cyclogranisporites plicatus sp. nov.
Plate 1, Figs. 9, 10

Derivation of name.–*plicatus* (Lat.), folded.

Holotype.–BA PB Pal. 5613/1: Y 28/1.

Type locality.–YPF-LR-SM.es-1 well, Estratos de Mascasín, upper level.

Diagnosis.–Spores radial, trilete. Amb subcircular. Laesurae straight, normally indistinct, simple or with very thin lips. Exine 1.2-2 µm thick, bearing comprehensively distributed elements irregular in form, less than 0.5 µm in height and 0.5-2 µm wide at the base, sometimes basally coalescent. Exine often folded through compression.

Dimensions.–Equatorial diameter: 38 (53) 63 µm (15 specimens).

Comparisons.–*Cyclogranisporites* sp. Ottone, 1989, is very similar to *C. plicatus* sp. nov. and they are probably conspecific. *Cyclogranisporites firmus* Jones and Truswell, 1992, resembles our specimens but differs in its thicker exine (3-4 µm). *Cyclogranisporites pisticus* Playford, 1978, differs in its denser sculpture of slightly lower grade and the usually less folded exine.

Distribution.–Mascasín, lower and upper level.

Genus *Granulatisporites* (Ibrahim) Potonié and Kremp, 1954

Type species.–*Granulatisporites granulatus* (Ibrahim) Potonié and Kremp, 1954.

Granulatisporites varigranifer Menéndez and Azcuy, 1969
Plate 1, Fig. 8

Description.–Spores radial, trilete. Amb subtriangular, with slightly concave sides and rounded apices. Laesurae straight, simple, length two-thirds to three-quarters of spore radius. Exine c.1 µm thick, sculptured densely and comprehensively with grana, 0.8-2 µm high and 1-2 µm wide.

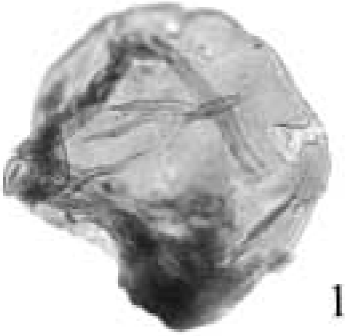
Dimensions.–Equatorial diameter: 36(43)49 µm (6 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001); Mascasín, lower level.

→

PLATE 1–*1, Calamospora hartungiana* Schopf, Wilson and Bentall, 1944. *2, Leiotriletes tenuis* Azcuy, 1975. x1200. *3, Leiotriletes* sp. *4, Punctatisporites glaber* (Naumova) Playford. *5, Punctatisporites gretensis* Balme and Hennelly, 1956. *6, Punctatisporites* sp. cf. *Punctatisporites* sp. A Azcuy, 1975. *7, Retusotriletes anfractus* Menéndez and Azcuy, 1969. *8, Granulatisporites varigranifer* Menéndez and Azcuy, 1969. *9, 10, Cyclogranisporites plicatus* sp. nov., 10x 300. *11, Granulatisporites* cf. *varigranifer* Menéndez and Azcuy, 1969. *12, Granulatisporites* sp. *13, Lophotriletes* cf. *Lophotriletes discordis* Gutiérrez and Césari, 1988. *14, Converrucosisporites* sp. *15, Apiculatasporites caperatus* Menéndez and Azcuy, 1969. *16, Apiculiretusispora sparsa* Menéndez and Azcuy, 1971. *17, 18, Apiculatisporis densus* sp. nov. *19, Verrucosisporites cordubensis* Vergel, 1998. All specimens from the Estratos de Mascasín, x 850 unless stated otherwise.

PLATE 1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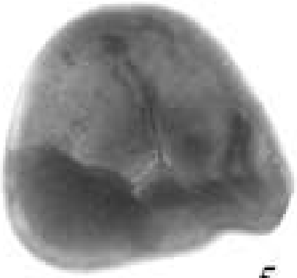
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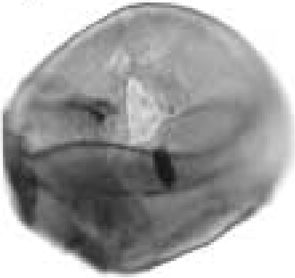
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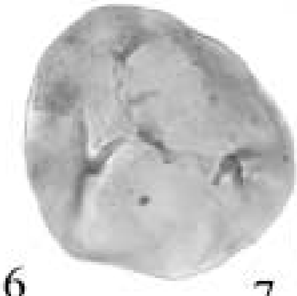
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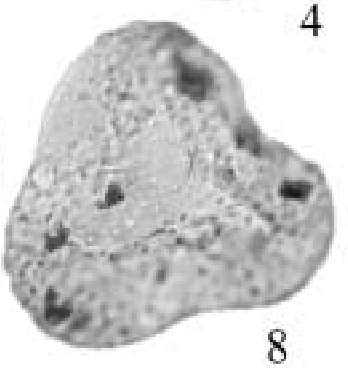
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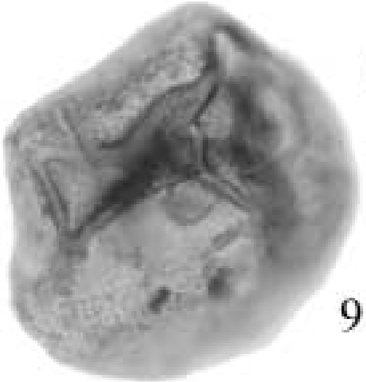
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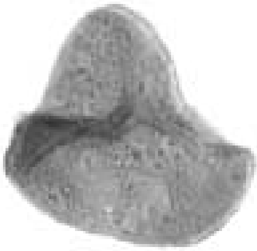
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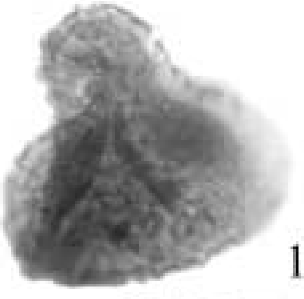
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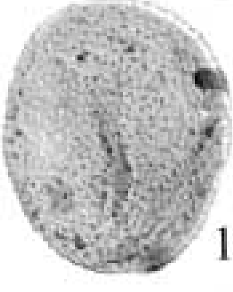
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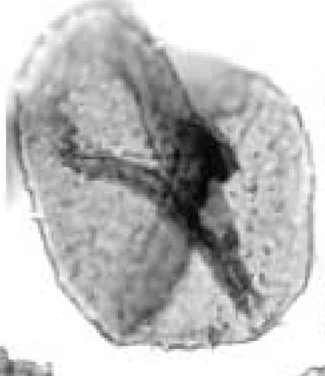
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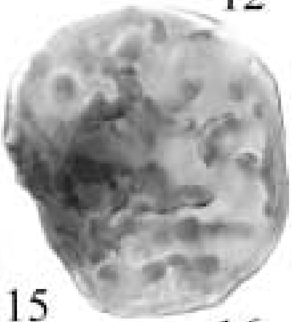
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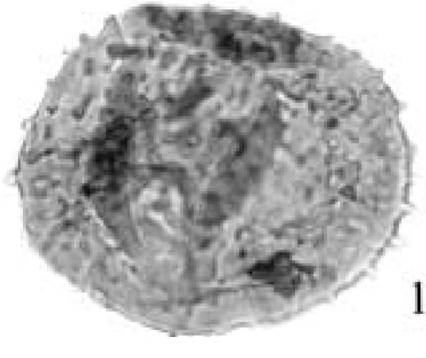
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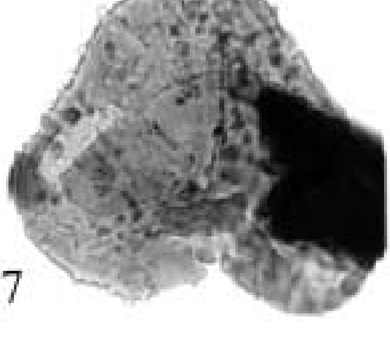
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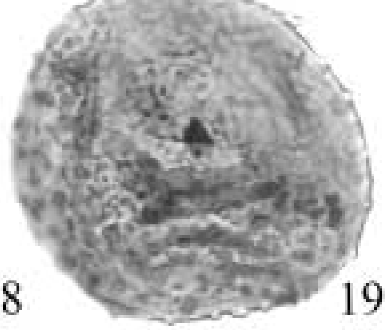

19

Granulatisporites sp. cf. *G. varigranifer* Menéndez and Azcuy, 1969
Plate 1, Fig. 11

Description.–Spore radial, trilete. Amb triangular with slightly concave sides and rounded apices. Laesurae straight, extending almost to equator, accompanied by thin lips. Exine c. 0.8-1 µm thick, sculptured with densely distributed grana, 0.5-1.5 µm high and 0.8-1 µm wide.

Dimensions.–Equatorial diameter: 39 µm (1 specimen).

Discussion.–The single specimen identified in the upper level of Mascasín well is very similar to those from the lower level that are referred to *G. varigranifer* Menéndez and Azcuy, 1969. Nevertheless, this specimen differs by the fine lips of the laesurae; this feature could be interpreted as an intraspecific variation, but we prefer to compare this unique specimen with *G. varigranifer*.

Distribution.–Mascasín, upper level.

Granulatisporites sp.
Plate 1, Fig. 12

Description.–Spores radial, trilete. Amb subtriangular, sides slightly convex to concave, apices rounded. Exine 0.8-1 µm thick, sculptured with grana and some coni up to 1 µm in basal diameter and height. Laesurae straight, simple, length one-half to two-thirds of spore radius.

Dimensions.–Equatorial diameter: 32(40)48 µm (5 specimens).

Comparisons.–*Granulatisporites trisinus* Balme and Hennelly, 1956, differs by having sinuous laesurae with lips that almost reach the equator, exine 1-2 µm thick, and larger equatorial diameter (see Foster, 1975). *Granulatisporites* sp. Menéndez and Azcuy, 1971, has a more varied sculpture including blunt coni. *Granulatisporites parvus* differs in its slightly thicked exine (1.5 µm) and smaller close-spaced grana. *Granulatisporites austroamericanus* Archangelsky and Gamerro, 1979, has sculpture principally restricted to the proximal face.

Distribution.–Mascasín, lower level.

Genus *Verrucosisporites* Ibrahim emend. Smith and Butterworth, 1967

Type species.–*Verrucosisporites verrucosus* Ibrahim, 1933.

Verrucosisporites cordubensis Vergel, 1998
Plate 1, Fig. 19

Description.–Spores radial, trilete. Amb subcircular. Laesurae simple, extending approximately three-quarters of distance to equator. Exine 1.5-2 µm thick, sculptured mainly with verrucae (1-3 µm wide at base and 0.5-1.5 µm high) and subordinate coni (1-1.5 µm wide and high). Some specimens have finer sculpture proximally.

Dimensions.–Equatorial diameter: 55-58 µm (2 specimens).

Comparisons.– Although the original description of *V. cordubensis* Vergel, 1998, includes a thinner exine and occasional coalescence of the verrucae, this is the more similar species. Nevertheless, the illustrations of the type specimens (Vergel, 1998, Plate 2, Figs. 4 and 5) show an exine thicker than 1 µm. *Verrucosisporites andersonii* (Anderson) Backhouse, 1988 differs in the presence of rugulae and occasional grana in the laesurae area. *Verrucosisporites chiquiritensis* Ottone, 1989, resembles our specimens but differs in the fusion of the sculpture near the laesurae.

Distribution.–Sachayoj Formation (Vergel, 1998). Mascasín upper level.

Genus *Converrucosisporites* Potonié and Kremp, 1954

Type species.–*Converrucosisporites triquetrus* (Ibrahim) Potonié and Kremp, 1954.

Converrucosisporites sp.
Plate 1, Fig. 13

Description.–Spore radial, trilete. Amb triangular with rounded apices and concave sides. Laesurae straight, simple, indistinct. Exine 2 µm thick, sculptured mainly with verrucae, 1-4 µm wide at base and 1-2 µm high, and subordinate grana (1-1.5 µm wide and high).

Dimensions.–Equatorial diameter 46 µm (1 specimen).

Distribution.–Mascasín, lower level.

Genus *Apiculatasporites* (Ibrahim) Smith and Butterworth, 1967

Type species.–*Apiculatasporites spinulistratus* (Loose) Ibrahim, 1933.

Apiculatasporites caperatus Menéndez and Azcuy, 1969
Plate 1, Fig. 14

Description.–Spores radial, trilete. Amb circular, margin slightly serrate due to projection of sculptural elements. Laesurae indistinct, simple, straight, length c. three-quarters of spore radius. Exine thinner than 1 µm, sculptured uniformly and densely with coni and grana, 0.5-1 µm high and wide at base. Secondary exinal folds usually evident.

Dimensions.–Equatorial diameter: 35(44)60 µm (15 specimens).

Comparisons.–The specimens are consonant with those originally described by Menéndez and Azcuy (1969).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001). Mascasín, lower and upper levels.

Genus *Apiculatisporis* (Ibrahim) Potonié and Kremp, 1956

Type species.–*Apiculatisporis aculeatus* (Ibrahim) Potonié and Kremp, 1956.

Remarks.–According to Ibrahim (1933), the genus includes trilete mega and microspores with circular amb and sculpture of more or less conical spines that frequently have a wide base and a height slightly exceeding the basal diameter. Later, Potonié and Kremp (1956) emended the genus and restricted it only to microspores. Following many authors, we include in the genus specimens with a more varied sculpture.

Apiculatisporis densus sp. nov.
Plate 1, Figs. 15, 17

Derivation of name.–*Densus* (Lat.), compact, dense.

Holotype.–BA PB Pal. 5612-6: P 50/4.

Type locality.–YPF-LR-SM.es-1 well, Estratos de Mascasín, lower level.

Diagnosis.–Spores radial, trilete. Amb circular to oval. Laesurae indistinct. Exine c.1-1.2 µm thick. Sculpture consisting predominantly of coni and grana (1-2 µm wide and high) with scarce verrucae (2 µm wide, 1-1.5 µm high), bacula (1 µm wide, 1.5-2 µm high) or mammillate elements (1.5 µm high, 2 µm wide).

Dimensions.–Equatorial diameter: 33(38)66 µm (14 specimens).

Comparison.–*Brevitriletes irregularis* (Ybert *et al*.) Césari, Archangelsky and Seoane, 1995, has coaser sculpture reduced proximally. *Acanthotriletes? plicatus* Azcuy, 1975*a*, differs in having thinner exine sculptured exclusively with coni and blunt spines.

Distribution.–Mascasín, lower and upper levels.

Genus *Apiculiretusispora* Streel, 1964

Type species.–*Apiculiretusispora brandtii* Streel, 1964.

Remarks.–According to Streel (1964), this genus is characterized by the proximal face being laevigate or with reduced sculpture and the distal face bearing coni, grana and/or spines. Later, Streel (1967) emended the taxon, restricting the length of the sculptural elements to a maximum of 1 µm. Because the acceptance of this emendation would force the erection of a new genus for more coarsely sculptured specimens, we agree with other authors (Richardson and Lister, 1969; Menéndez and Azcuy, 1971) in not accepting this emendation.

Apiculiretusispora sparsa Menéndez and Azcuy, 1971
Plate 1, Fig. 16

Description.–Spores radial, trilete. Amb circular to subcircular. Laesurae simple, straight, almost reaching equator with imperfect curvaturae. Exine *c.* 1 µm thick, proximally laevigate, distally sculptured with mammillae, 1.2-2 µm high and 2-4 µm wide and grana 1-2 µm high and 0.8-2 µm wide, irregularly distributed, not projecting equatorially.

Dimensions.–Equatorial diameter 25(36)45 µm (31 specimens).

Comparisons.–*Apiculiretusispora variornata* (Menéndez and Azcuy) Menéndez and Azcuy, 1971, differs in the presence of verrucae.

Distribution.–Lagares (Menéndez and Azcuy, 1971; Azcuy, 1975*a*), Jejenes (González-Amicon, 1973) and, Sachayoj (Vergel, 1998) Formations. Mascasín, lower and upper levels.

Apiculiretusispora ralla (Menéndez and Azcuy) Menéndez and Azcuy, 1971
Plate 2, Figs. 1, 2

Description.–Spores radial, trilete. Amb circular to subcircular. Laesurae simple, straight, almost reaching equator with imperfect to perfect curvaturae. Exine *c.* 2-2.5 µm thick. Distal sculpture of small coni with rounded apices and bacula, 0.7-1 µm basal wide and

1-1.5 µm high, not projecting equatorially. Elements sparsely and irregularly distributed. Proximal face with reduced sculpture or laevigate.

Dimensions.–Equatorial diameter: 32(36)40 µm, (17 specimens).

Comparisons.–Gutiérrez and Limarino (2001) referred to *A. ralla* a specimen with slightly coarser sculpture than the type material as observed by the present authors. *Apiculiretusispora alonsoi* Ottone, 1989, and *Apiculiretusispora manantialensis* Ottone, 1989, have finer sculpture.

Distribution.–Agua Colorada (Menéndez and González-Amicón, 1979), Lagares (Menéndez and Azcuy, 1969*)* and Malanzán (Gutiérrez and Limarino, 2001) Formations. Mascasín, lower and upper levels.

Genus *Lophotriletes* (Naumova)
Potonié and Kremp, 1956

Type species.–*Lophotriletes gibbosus* (Ibrahim) Potonié and Kremp, 1956

Remarks.–The original diagnosis includes specimens with triangular amb and exclusively conate sculpture. Nevertheless, some species referred to the genus display a more varied sculpture with subordinate spines, bacula, grana or verrucae.

Lophotriletes sp. cf. *L. discordis* Gutiérrez and Césari, 1988
Plate 1, Fig. 18

Description.–Spore radial, trilete. Amb triangular, sides slightly concave with rounded apices. Laesurae simple, straight, length two-thirds of spore radius. Exine 1.5-2 µm thick, sculptural elements 1-2 µm wide at base, 1-2.5 µm high, composed mainly of coni and grana with scarce bacula and verrucae.

Dimensions.–Equatorial diameter: 63 µm (1 specimen).

Comparisons.–*L. discordis* Gutiérrez and Césari, 1988, is the most similar species but is smaller and displays occasional spines instead of verrucae. *Lophotriletes intermedius* Azcuy, 1975*a,* is sculptured only with coni.

Distribution.–Mascasín, lower level.

Lophotriletes sp. cf. *L. rectus* Bharadwaj and Salujha, 1964
Plate 2, Fig. 3

Description.–Spores radial, trilete. Amb triangular; sides straight to slightly concave and apices rounded. Laesurae simple, straight, length c. three-quarters of spore radius. Exine thin (c. 0.5 µm thick), sculptured with coni, grana, and occasional verrucae, 1-2 µm in basal diameter and 1-1.5 µm high.

Dimensions.–Equatorial diameter: 22-36 µm (4 specimens).

Comparisons.–*L. rectus* Bharadwaj and Salujha, 1964 is similar but differs lacking verrucae.

Distribution.–Mascasín, lower level.

Lophotriletes sp. *L. rarus* Bharadwaj and Salujha, 1964
Plate 2, Fig. 14

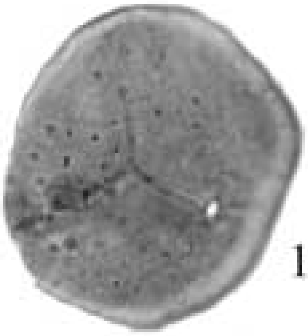
Description.–Spore radial, trilete. Amb triangular; sides straight to slightly convex, apices rounded. Laesurae simple, straight, length c. two-thirds of spore radius. Exine thin (c. 0.5 µm thick), sculptured with sharp coni and subordinate grana, 1 µm wide basally and high.

Dimensions.–Equatorial diameter: 59 µm (1 specimen).

→

PLATE 2–*1, 2, Apiculiretusispora ralla* (Menéndez and Azcuy) Menéndez and Azcuy, 1971. *3, Lophotriletes* cf. *Lophotriletes rectus* Bharadwaj and Salujha, 1964. *4, Horriditriletes uruguaiensis* (Marques Toigo) Archangelsky and Gamerro, 1979. *5, Vallatisporites ciliaris* (Luber) Sullivan, 1964. *6-8, Dibolisporites variatus* sp. nov., *7,* Detail of sculpture of *6,* x1,500. *9, 13, Raistrickia cephalata* Bharadwaj, Kar and Navale, 1976, *13,* Detail of sculpture, x3,400. *10, Lophotriletes* cf. *Lophotriletes intermedius* Azcuy, 1975. *11, Raistrickia* sp. *12, Convolutispora* sp. 1. *14, Lophotriletes* cf. *Lophotriletes rarus* Bharadwaj and Salujha, 1964. *15, 17, Convolutispora* cf. *C. candiotensis* Ybert, 1975. *16, Convolutispora muriornata* Menéndez, 1965. *18, Convolutispora* sp. 2. x500. *19, Foveosporites pellucidus* Playford and Helby, 1968. All specimens from the Estratos de Mascasín, x750 unless stated otherwise.

PLATE 2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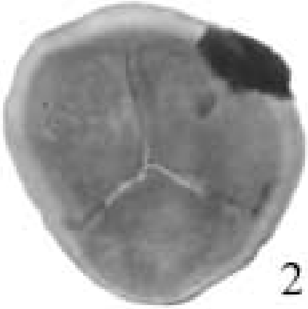
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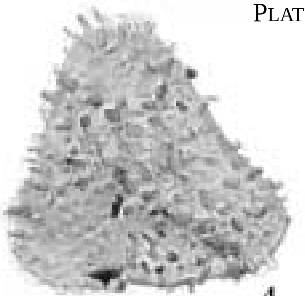
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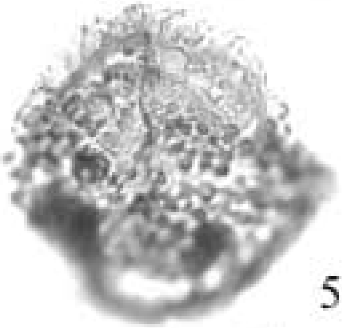
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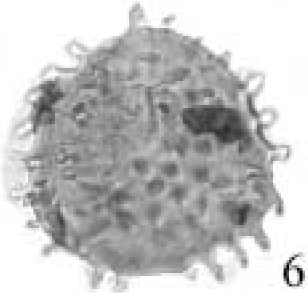
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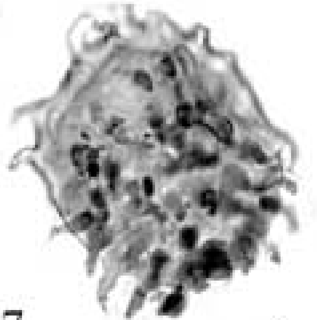
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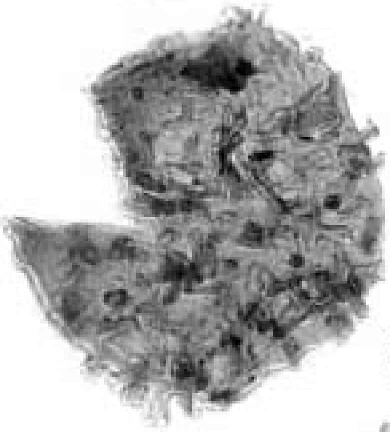
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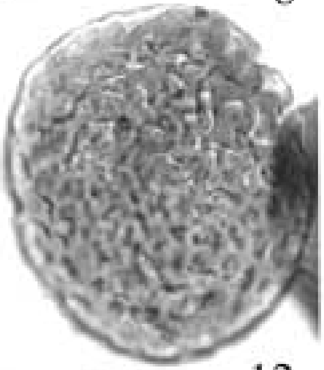
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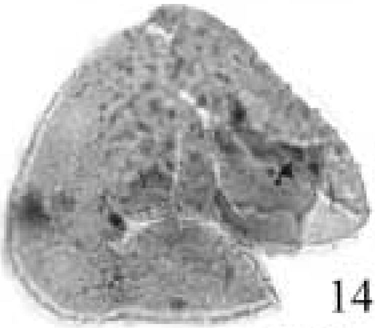
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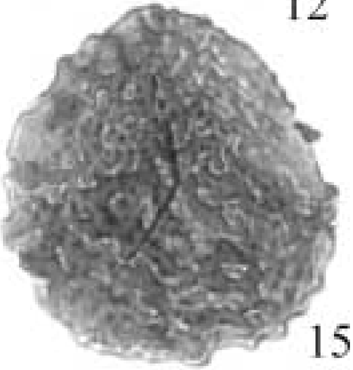
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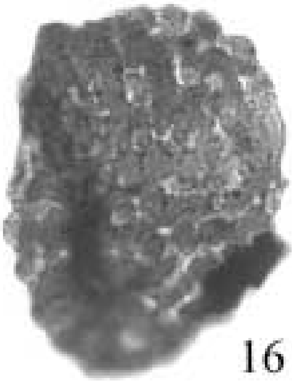
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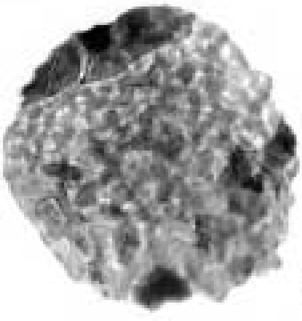
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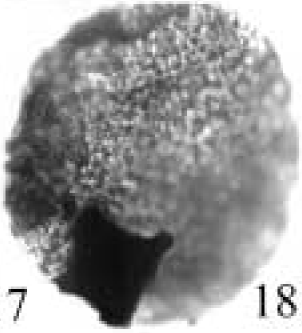
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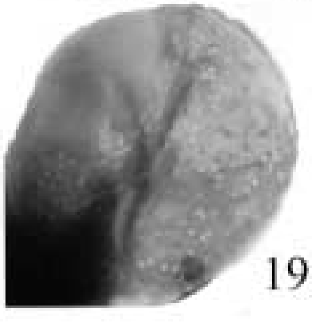
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Comparisons.–*Leiotriletes rarus* Bharadwaj and Salujha, 1964 is similar but is densely sculptured without grana. *Leiotriletes lentiginosus* Playford and Dino, 2000 differs in its concave sided amb.

Distribution.–Mascasín, lower level.

Lophotriletes sp. cf. *L. intermedius* Azcuy, 1975a
Plate 2, Fig. 10

Description.–Spore radial, trilete. Amb triangular. Laesurae simple, straight, length c. three-quarters of spore radius. Exine *c.* 1 µm thick, sculptured irregularly with coni having rounded and blunt apices, 1-2 µm wide basally and high.

Dimensions.–Equatorial diameter: 54 µm (1 specimen).

Comparisons.–*L. intermedius* Azcuy, 1975a resembles our specimen in density and type of sculpture but has a thicker exine.

Distribution.–Mascasín, lower level.

Genus *Dibolisporites* (Richardson) Playford, 1976

Type species.–*Dibolisporites echinaceus* (Eisenack) Richardson, 1965.

Dibolisporites variatus sp. nov.
Plate 2, Figs. 6, 8

Derivation of name.–*Variatus* (Lat.), varied.

Holotype.–BA PB Pal. 5612-10:H 53/1.

Type locality.–YPF-LR-Sm.es-1 well, Estratos de Mascasín, lower level.

Diagnosis.–Spores radial, trilete. Amb circular to subcircular. Laesurae straight, with fine lips reaching three-quarters of distance to equator. Exine thin (c. 0.5 µm thick), proximally laevigate to scabrate. Distal sparsely sculptured with bacula and coni, 1-2 µm wide and 2-5 µm high with subordinate grana and scarce verrucae, 1-2 µm basal diameter and 1-2 µm high. Bacula and coni usually display fine, irregular, lateral and apical modifications, showing slight irregular torulation (nodosity).

Dimensions.–Equatorial diameter: 35(38)47 µm (7 specimens).

Comparisons.–*Dibolisporites variatus* sp. nov. is characterized by the irregular form of the compound sculptural projections, differing from the other known species of the genus. The only comparable species is *Dibolisporites setigerus* Playford and Satterthwait, 1986 but this has denser and less diverse sculptural projections.

Distribution.–Mascasín, lower level.

Genus *Raistrickia* (Schopf *et al.*)
Potonié and Kremp, 1954

Type species.–*Raistrickia grovensis* Schopf, Wilson and Bentall, 1944.

Raistrickia cephalata Bharadwaj,
Kar and Navale, 1976
Plate 2, Figs. 9, 13

1980 *Raistrickia* sp., Azcuy and Jelin, Pl. 2, Fig. 10.
1995 *Raistrickia* sp. A, García, Pl. 3, Fig. 1.
2001 *Dibolisporites lictor* Foster and Helby, 1988; Césari and Gutiérrez, Pl. 1, Fig. 7.

Description.–Spores radial, trilete. Amb circular to subcircular. Laesurae usually indistinct. Exine 2.5-3 µm thick, bearing elements similar to pila, 5-8 µm high, wider (3-7 µm) at apices with irregularly lacerate or digitate apices, and few verrucae (1-3 µm in basal width and 1.5-2 µm high) and coni (2 µm and 3 µm in basal width and height).

Dimensions.–Equatorial diameter: 60, 99 µm (2 specimens).

Comparisons.–Playford and Dino (2000) described specimens of *Raistrickia cephalata* Bharadwaj, Kar and Navale, 1976, with tipically varied sculpture: mostly bacula (apically irregularly digitate/lacerate), together with coni and spinae having rounded, acute or obtuse apices. These Brazilian specimens are clearly consonant with ours. The presence of biform sculptural elements suggests comparison with *Dibolisporites lictor* Foster and Helby, 1988, but this species differs from the South American specimens in featuring more varied sculptural projections.

Raistrickia sp. A described by García (1995, Plate 3, Figure 1) is identical to our specimens and with the specimen from Mascasín well figured by Azcuy and Jelin (1980, Plate 2, Fig. 10). The Mascasín specimen illustrated by Rocha Campos and Archangelsky (1985, Plate 12, Fig. 10) was compared by Foster and Helby (1988) with *Dibolisporites lictor;* however, we suggest its inclusion in *R. cephalata.*

Distribution.–El Imperial (García, 1995) and Malanzán (Gutiérrez and Limarino, 2001) Formations. Mascasín, lower level.

Raistrickia sp.
Plate 2, Fig. 11

Description.–Spore radial, trilete; amb subcircular. Exine 1 µm thick, densely sculptured with bacula 5-6 µm high and 1-2 µm wide, with slightly wider, sometimes rounded apices; accompanied by spines (0.8-1 µm in basal width, 1-4 µm high) with acute apices, and scarce coni (1-1.5 µm in basal width, 1.5-2.5 µm high) and grana (1-1.5 µm wide basally, 1-2 µm high).

Dimensions.–Equatorial diameter: 61 µm (1 specimen).

Comparisons.–*Raistrickia* cf. *aculeata* Menéndez and Azcuy, 1971, possesses longer sculptural elements than our specimen. *Raistrickia* sp. B. Ottone, 1989, also resembles the present specimen but is more uniformly sculptured.

Distribution.–Mascasín, lower level.

Genus *Horriditriletes* Bharadwaj and Salhuja, 1964

Type species.–*Horriditriletes curvibaculosus* Bharadwaj and Salhuja, 1964.

Horriditriletes uruguaiensis (Marques Toigo) Archangelsky and Gamerro, 1979

Plate 2, Fig. 4

1980 *Neoraistrickia* cf. *N. baculicapillosa* Pons; Azcuy and Jelin, Pl. 2, Fig. 6.

Description.–Spores radial, trilete. Amb subtriangular, sides straight to slightly concave, apices rounded. Laesurae straight, simple, length four-fifths of spore radius. Exine up to 1 µm thick. Sculpture consisting of bacula, with rounded or blunt apices (0.8-2.5 µm wide, 2-4 µm high) and sometimes spines (0.8-1 µm wide basally, 3-3.5 µm high) and subordinate coni (1-2 wide at base, 1.2- 3 µm high) and grana (1-1.5 µm in diameter, 1-2 µm high).

Dimensions.–Equatorial diameter: 32(40)45 µm (25 specimens)

Discussion.–The specimen from Mascasín well illustrated by Azcuy and Jelin (1980, Pl. 2, Fig. 13) and Archangelsky *et al*. (1987, Pl. 12, Fig. 7) is included in *Horriditriletes uruguaiensis*.

Distribution.–This species has a widespread distribution in Late Carboniferous palynofloras from the Paganzo and Chacoparanense Basins (Césari and Gutiérrez, 2001). Mascasín, lower level.

Genus *Convolutispora* Hoffmeister, Staplin and Malloy, 1955

Type species.–*Convolutispora florida* Hoffmeister, Staplin and Malloy, 1955.

Convolutispora muriornata Menéndez, 1965

Plate 2, Fig. 16

Description.–Spores radial, trilete. Amb circular to subcircular, margin slightly undulating. Laesurae simple, perceptible. Exine comprehensively sculptured with rugulae 1.5-2 µm high and 2-4 µm wide, surmounted by small grana lower than 1 µm. Rugulae anastomose enclosing narrow and irregular lumina.

Dimensions.–Equatorial diameter: 47-60 µm (3 specimens).

Comparisons. Convolutispora muriornata is distinguished from other species of the genus by the presence of small grana on the muri.

Distribution.–This species is widely distributed in Late Carboniferous palynofloras of the Paganzo Basin (Césari and Gutiérrez, 2001). Mascasín, upper level.

Convolutispora cf. *C. candiotensis* Ybert, 1975

Plate 2, Figs. 15, 17

Description.–Spores radial, trilete. Amb subtriangular to subcircular, margin undulating. Laesurae simple, straight, length *c.* three-quarters of spore radius. Exine sculptured with smooth rugulae 1-3 µm high and 1-3 µm wide. Rugulae usually terminate freely, occasionally enclosing irregular lumina.

Dimensions.–Equatorial diameter: 48(52)56 µm (8 specimens).

Comparisons.–*C. candiotensis* Ybert, 1975 resembles our specimens in size and sculpture, but differs in its invariably triangular amb. *Convolutispora maximensis* Ottone, 1991, is similar but displays wider and higher muri. *Convolutispora sculptilis* Felix and Burbridge, 1967 differs in its coarser muri and *Convolutispora pintoi* Dellazana, 1976 is sculptured proximally with verrucae.

Distribution.–Mascasín, lower level.

Convolutispora sp. 1

Plate 2, Fig. 12

Description.–Spore radial, trilete. Amb circular to subcircular. Laesurae simple, straight, reaching three-quarters of distance to equator. Exine 2 µm thick, sculptured with close-spaced, sinuous rugulae 1-4 µm high and 1.5-4.5 µm wide.

Dimensions.–Equatorial diameter: 56 µm (1 specimen).

Comparisons.–*Convolutispora maximensis* Ottone, 1991, *C. ordonezii* Archangelsky and Gamerro, 1979, and *C. sculptilis* Felix and Burbridge, 1967, differ in their coarser sculpture. *C. pintoi* Dellazana, 1976, is verrucate proximally. *C. candiotensis* Ybert, 1975, has a subtriangular amb and narrower muri.

Distribution.–Mascasín, lower level.

Convolutispora sp. 2
Plate 2, Fig. 18

Description.–Spores radial, trilete. Amb subcircular to oval, margin undulating. Laesurae indistinct. Exine comprehensively sculptured with rugulae 1-2.5 µm high and 1.5-3 µm wide, and few discrete verrucae, 1-2 wide basally and 2 µm high.

Dimensions.–Equatorial diameter: 90-91µm (2 specimens).

Comparisons.–Convolutispora archangelskyi Playford and Dino, 2002, resembles our specimens but is of lesser equatorial diameter and bears numerous verrucae and less frequent grana.

Distribution.–Mascasín, upper level.

Genus *Foveosporites* Balme, 1957

Type species.–*Foveosporites canalis* Balme, 1957.

Foveosporites pellucidus Playford and Helby, 1968
Plate 2, Fig. 19

Description.–Spore radial trilete. Amb subcircular. Laesurae simple, straight, length four-fifths of spore radius. Exine 2 µm thick; sculptured with circular, triangular or elongate foveae 1-2 µm deep and 0.8-2.5 µm in diameter. Sculpture reduced on proximal surface, particularly in contact areas where the exine is micropunctate along the rays of the laesurae.

Dimensions.–Equatorial diameter: 46 µm (1 specimen).

Comparisons.–*Foveosporites hortonensis* (Playford) Azcuy, 1975*b*, does not feature proximally reduced sculpture.

Distribution.–Mascasín, lower level.

Genus *Microreticulatisporites* (Knox) Potonié and Kremp, 1954

Type species.–*Microreticulatisporites lacunosus* (Ibrah) Knox, 1950.

Microreticulatisporites punctatus Knox, 1950
Plate 3, Figs. 2, 3

Description.–Spores radial, trilete, originally spherical. Amb circular to subcircular. Laesurae simple, straight, reaching three-quarters of distance to equator. Exine microreticulate, muri (1-2.5 µm wide, 1-2 µm high) enclosing polygonal, subcircular, irregular and elongate lumina, usually 1 µm in diameter and up to 3 µm in length.

Dimensions.–Equatorial diameter: 46(48)63 µm (5 specimens).

Comparisons.–Our material is consonant with the specimens described by Menéndez and Azcuy (1973) from the Lagares Formation.

Distribution.–Lagares Formation (Menéndez and Azcuy, 1973). Mascasín, lower level.

Genus *Dictyotriletes* (Naumova) Potonié and Kremp, 1954

Type species.–*Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp, 1954.

Remarks.–According to Playford (1978) and Playford and Sattertwhait (1985) this genus differs from *Reticulatisporites* in the lower muri not projecting at the equator.

Dictyotriletes cortaderensis Césari and Limarino, 1987
Plate 3, Fig. 5

Description.–Spore radial, trilete, cavate. Amb subcircular. Laesurae reaching one-half of distance to equator. Exine 0.5 µm thick, microgranulate, sculptured with sinuous muri 1.5-2 µm high and 1-1.5 µm wide, not usually enclosing well-defined lumina. Each murus appears double in optical section, with two parallel bands separated by a narrow gap which represents the centre of the upfolded exine. Exine cavate, intexine constitutes distinct smaller inner body, 36 µm in diameter. On the proximal face the muri form a contorted zone in the centre of the contact area, in which muri form a series of sinuous rugulae.

Dimensions.–Equatorial diameter: 70 µm (1 specimen).

Comparisons.–Gutiérrez and Limarino (2001) proposed to combine *D. cortaderensis* with *Rugospora* Neves and Owens, 1966. This latter genus includes cavate miospores with microverrucose ornament and a persistent series of folds or plications which give the spores an irregular, corrugated appearance. We differ on that combination because *cortaderensis* has clearly defined muri that encircle lumina.

We prefer to maintain provisionally this species in *Dictyotriletes*, although this genus does not include cavate forms. A future revision of all the specimens described as *cortaderensis* will allow a most precise taxonomic assignment.

R. pseudopalliatus Staplin, 1960 has a similar appearance but is distinguished by higher muri (3-10 µm) that enclose polygonal lumina. *R. passaspectus* Ottone, 1991, is acavate and lacks muri with two parallel bands separated by a narrow gap.

Distribution.–Tupe (Césari, 1985) and Malanzán (Gutiérrez and Limarino, 2001) Formations. Mascasín, lower level.

Dictyotriletes sp.
Plate 3, Fig. 7

Description.–Spores radial, trilete. Amb circular and margin irregular. Laesurae trilete indistinct. Exine sculptured with muri enclosing subcircular to irregular lumina, 2-7 µm in diameter. Muri smooth, 1.5-2.2 µm high and 1.5-2.5 µm wide.

Dimensions. Equatorial diameter: 54-81 µm (3 specimens).

Comparisons.–Dictyotriletes anisopolaris (Naumova) Smith and Butterworth, 1967, differs by the smaller lumina in the proximal hemisphere. *Dictyotriletes diversiluminis* González-Amicon, 1973, displays bigger muri and *Dictyotriletes* sp. Ottone, 1989, has muri only on the distal hemisphere.

Distribution.–Mascasín, lower and upper levels.

Genus *Vallatisporites* Hacquebard, 1957

Type species.–*Vallatisporites vallatus* Hacquebard, 1957.

Vallatisporites ciliaris (Luber) Sullivan, 1964
Plate 2, Fig. 5

Description.–Spores radial trilete, cavate, zonate. Amb subtriangular with convex sides. Laesurae distinct, with fine lips reaching inner margin of zona. Exine two layered. Zona translucent, one-fourth to one-sixth of the spore radius in width. Zona with a thickening near outer margin, forming a ring, bearing coni, 1-2 µm wide and 2-4 µm high. Inner margin of zona marked by small radial vacuoles. Exoexine distally and equatorially bearing coni, papillae and verrucae, 2-3.5 µm high and 2-4 µm wide at base. Remainder of exoexine smooth or with reduced sculpture.

Dimensions.–Equatorial diameter: 48(60)67 µm (8 specimens).

Distribution.–This species has widespread distribution in Upper Palaeozoic palynofloras from Argentina. Mascasín, lower and upper levels.

Vallatisporites pauper sp. nov.
Plate 3, Figs. 4, 8

Holotype.–BA PB Pl 5612/19 S56/4.

Derivation of name.–*Pauper (Lat.),* poor.

Diagnosis.–Spores radial, trilete, cavate, zonate. Amb subtriangular, with convex sides and rounded apices. Laesurae distinct, slightly sinuous, extending to margin of spore cavity, with thin, elevated lips, 2-3 µm high. Exine bilayered, intexine thin. Central body subtriangular, 44-58 µm in diameter; exine finely punctate. Distal exoexine with irregularly distributed sculpture, variable between specimens, consisting of small coni, grana, verrucae or spines. Basal diameter of sculptural elements 0.8-2 µm, height 1-2.5 µm. Zona translucent; width one-third to one-fourth of spore radius, separated from central body by a narrow channel formed by small vacuoles. Sculpture of zona usually reduced proximally; distally including coni, occasionally fused basally, and projecting at the equator.

Dimensions.–Equatorial diameter: 55(60)80 µm (8 specimens).

Comparisons.–*Vallatisporites pauper* sp. nov. is distinguished from the other known species of the genus by its scarce but very varied sculpture irregularly distributed.

Distribution.–Mascasín, lower and upper levels.

Genus *Cristatisporites* (Potonié and Kremp)
Butterworth *et al.*, 1964

Type species.–*Cristatisporites indignabundus* (Loose) Potonié and Kremp, 1954.

Cristatisporites sp. cf. *C. pseudozonatus* Lele and
Makada, 1972
Plate 3, Fig. 1

Description.–Spores radial, trilete, cingulizonate. Amb convexly subtriangular, margin conspicuously dentate. Exine bilayered, cavate. Intexine distinct, enclosing a triangular central body, 30 µm in diameter, delimited by small vacuoles. Zona translucent, width one-quarter to one-sixth of spore diameter. Proximal surface with reduced sculpture. Laesurae straight, with fine lips, extending to the body margin. Distal surface sculptured with coni and grana, 2-3.5 µm in basal width and 1-2 µm high, and scarce verrucae locally coalescent basally. Zona sculptured with bacula (1.5-3 µm wide, 3-6 µm high), with a small apical spine; elements discrete or basally coalescent to form cristae.

Dimensions.–Equatorial diameter: 53-55 µm (4 specimens).

Comparisons.–*Cristatisporites pseudozonatus* differs from our specimens in having coarser coni and spines (2-9 µm high), on the distal surface.

Distribution.–Mascasín, upper level.

Genus *Kraeuselisporites* (Leschik) Jansonius, 1962

Type species.–*Kraeuselisporites dentatus* Leschik, 1955.

Discussion.–Jansonius (1962) emended this genus including cavate specimens, with laevigate proximal face and sculptured distal face. The sculpture is not fused to form cristae as in *Cristatisporites*.

Kraeuselisporites volkheimeri Azcuy, 1975b

Plate 3, Fig. 6

Description.–Spores radial, trilete, cavate, zonate. Amb subtriangular with convex sides, margin slightly serrated by projecting sculpture. Laesurae distinct, lipped, extending almost to inner margin of zona. Exine bilayered. Exoexine extended equatorially as narrow, translucent zona (width one-third to one-sixth of spore diameter). Intexinal body distinct, 35-50 µm in diameter. Proximal exoexine spongy. Distal exoexine bearing mainly galeae, with subordinate coni and grana. Height of sculptural elements 1.5-4 µm, basal breadth 2-5 µm. Inner portion of zona with spines and bacula, 1.5-3 µm wide at base and 3-7 µm high, sometimes distally bifurcate, occasionally fused to form cristae. Remainder of zona sculptured with sharp coni, sometimes projecting at equator.

Dimensions.–Equatorial diameter: 40(56)65 µm (7 specimens).

Comparisons.–*K. volkheimeri* Azcuy, 1975*b*, is consonant with our specimens but the latter are slightly larger. Although, the original description did not mention the presence of bacula and spines on the inner margin of the zona, these elements are clearly evident in the original illustration (Azcuy, 1975*b*, Fig. 156).

Distribution.–Malanzán (Azcuy, 1975*b*) Formation. Mascasín, lower level.

Grossusporites gen. nov.

Derivation of name.–*Grossus* (Lat.), thick, stout.

Type species.–*Grossusporites microgranulatus* (Menéndez and Azcuy) nov. comb.

Diagnosis.–Spores radial trilete, amb subcircular to convexly subtriangular. Proximal hemisphere often depressed; distal hemisphere strongly convex. Laesurae straight, simple, length two-thirds to three-quarters of spore radius with imperfect curvaturae (usually indistinct). Exine thick, microgranulate to micropunctate. Exine bilayered with the intexine normally closely associated with the exoexine. Exoexine slightly thickened equatorially.

Grossusporites microgranulatus (Menéndez and Azcuy) nov. comb.

Plate 3, Figs. 10, 12

1971 *Geminospora*? *microgranulata* Menéndez and Azcuy, Pl 2, Fig. 6, 7.

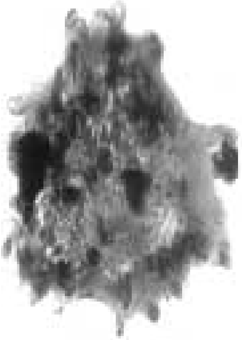
1979 *Cyclogranisporites microgranulatus* (Menéndez and Azcuy) Archangelsky and Gamerro, Pl. 1, Fig. 7.

2001 *Cyclogranisporites microgranulatus* (M. and A.) Archangelsky and Gamerro, Césari and Gutiérrez, Pl. 3, Fig. 10.

→

PLATE 3–*1, Cristatisporites* cf. *Cristatisporites pseudozonatus* Lele and Makada, 1972, x600. *2, 3, Microreticulatisporites punctatus* Knox, 1950. *4, 8, Vallatisporites pauper* sp. nov. *5, Dyctiotriletes cortaderensis* Césari and Limarino, 1987, x600. *6, Kraeuselisporites volkheimerii* Azcuy, 1975, x600. *7, Dictyotriletes* sp. *9, Spelaeotriletes ybertii* (Marques Toigo) Playford and Powis, 1979, x600. *10, 12, Grossusporites microgranulatus* (Menéndez and Azcuy) nov. comb. *10,* Detail of proximal surface SEM x5,000, 11 x450 and 12 x600. *13, Cannanoropollis janakii* Potonié and Sah, 1960, x500. *14, Cannanoropollis densus* (Lele) Bose and Maheshwari x500. *15, Potonieisporites brasiliensis* (Nahuys *et al.*) Archangelsky and Gamerro, 1979, x300. *16, Plicatipollenites malabarensis* (Potonié and Sah) Foster, 1975, x400. *17, Plicatipollenites trigonalis* Lele, 1964, x350. *18, Potonieisporites* cf. *Potonieisporites densus* Maheshwari, 1967, x350. *19, Potonieisporites barrelis* Tiwari, 1965. x350. All specimens from the Estratos de Mascasín, x850 unless stated otherwise.

Plate 3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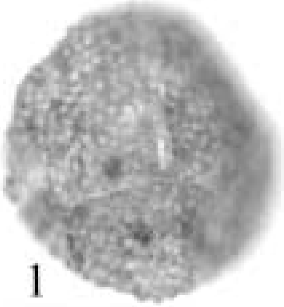
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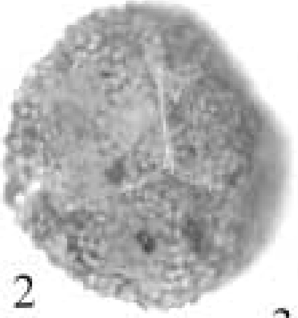
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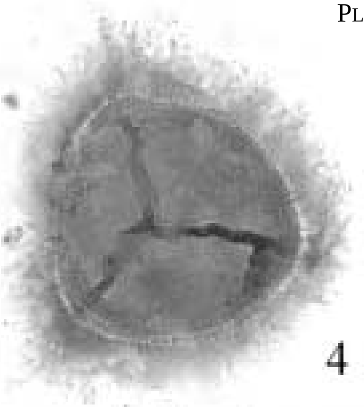
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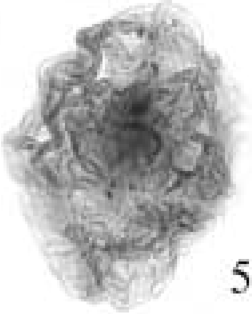
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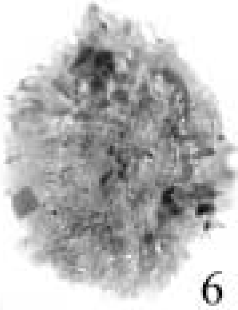
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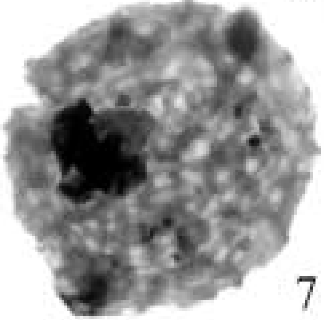
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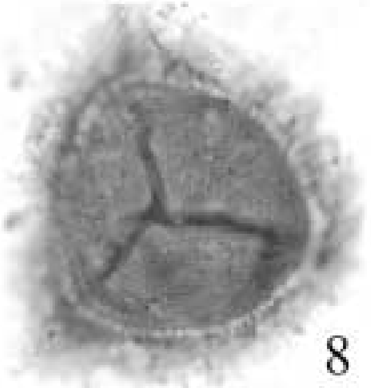
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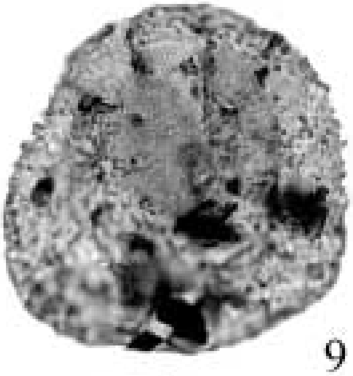
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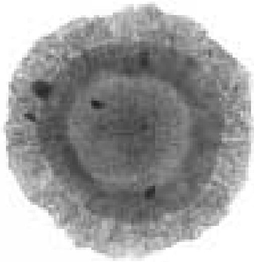
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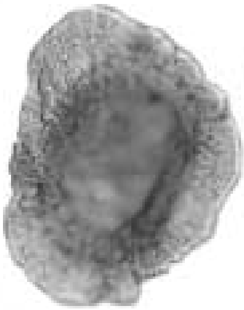
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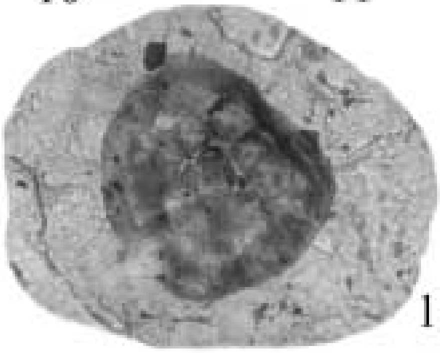
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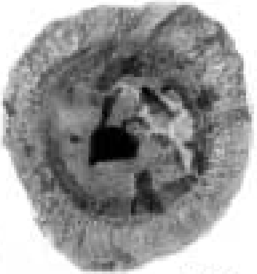
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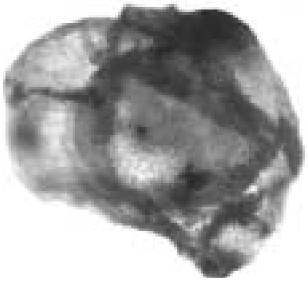
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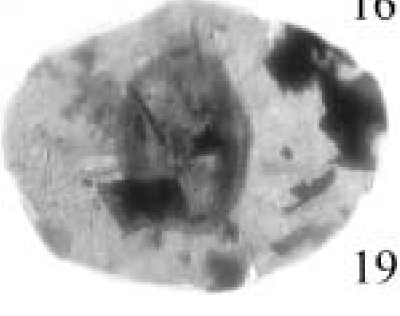
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Description.–Spores radial, trilete. Amb subcircular to convexly subtriangular. Proximal hemisphere usually depressed and distal hemisphere strongly convex. Laesurae straight, simple, length two-thirds to three-quarters of spore radius, with imperfect, usually indistinct curvaturae. Exine 3-4 µm thick, sculptured with minute grana *c*. 0.5 µm high, or micropunctate with characteristic spongy aspect. Exoexine slightly detached from the intexine, but some specimens show a distinct internal body. Exoexine slightly thickened equatorially, appearing as a narrow cingulum.

Dimensions.–Equatorial diameter: 50(70)83 µm (55 specimens).

Comparisons.–The specimens illustrated by Azcuy and Jelin (1980, Pl. 2, Fig. 7) and Archangelsky *et al*. (1987, Pl. 12, Fig. 8) are consonant with *Grossusporites microgranulatus.*

Distribution.–This species is widely distributed in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001). Mascasín, upper and lower levels.

Genus *Spelaeotriletes* Neves and Owens, 1966

Type species.–*Spelaeotriletes triangulus* Neves and Owens, 1966.

Spelaeotriletes ybertii (Marques Toigo)
Playford and Powis, 1979
emend. Playford *et al.*, 2001
Plate 3, Fig. 9

Description.–Spores radial, trilete, cavate. Amb subtriangular to subcircular, margin irregular. Laesurae straight with lips up to 2 µm high, length three-quarters of spore radius. Exoexine *c*. 2 µm thick, sculptured with coni (1-1.5 µm in basal width, 1-2.5 µm high), grana (1-2 µm in basal width, 1-2 µm high) verrucae (1-3 µm in basal width, 0.8-2 µm high), and bacula (2.5 µm high) discrete or conjoined basally to form short cristae. These elements bear apically a narrow spine c. 1 µm long, not always preserved because of its fragility. Contact faces virtually laevigate. Intexine laevigate, usually discernible as slightly darker inner body with indistinct margin.

Dimensions.–Equatorial diameter: 62(75)82 µm (7 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina. Mascasín, lower level.

Genus *Cannanoropollis* Potonié and Sah, 1960

Type species.–*Cannanoropollis janakii* Potonié and Sah, 1960.

Cannanoropolis densus (Lele)
Bose and Maheshwari, 1968
Plate 3, Fig. 14

1980 *Parasaccites densus* (Lele), Azcuy and Jelin, Pl. 2, Fig. 11.
1987 *Cannanoropollis densus* Rocha Campos and Archangelsky, Pl. 12, Fig. 11.

Description.–Pollen grain monosaccate, radial, trilete. Amb subcircular to oval with slightly undulate margin. Corpus outline (polar view) subcircular to oval, exine thick, darker than saccus. Laesurae slightly asymmetric, approximately one-fifth of corpus radius in length. Saccus with strong folds, attached equatorially, proximally and subequatorially distally. Cappula subcircular to oval, conforming with amb corpus.

Dimensions.–Overall equatorial diameter: 70 µm; corpus diameter: 50 µm; overall diameter equatorial: corpus diameter: 1.4; maximum saccus width: 19 µm (1 specimen).

Comparisons.–The saccus of *Cannanoropollis. janakii* lacks strong folds and the corpus is similar in colour to the saccus. *Cannanoropollis mehtae* (Lele) Bose and Maheshwari, 1968, has a smaller corpus than *C. densus*.

Distribution.–This species is widely distributed in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001), Mascasín, lower level.

Cannanoropolis janakii Potonié and Sah, 1960
Plate 3, Fig. 13

Description.–Pollen grains monosaccate, radial, trilete. Amb circular. Laesurae usually unclear, length c. one-fifth of corpus radius. Corpus outline (in polar view) near-circular, conformable with amb. Corpus without folds and sometimes with low verrucae on proximal surface. Saccus without strong folds.

Dimensions.–Overall equatorial diameter: 62-120 µm; corpus diameter: 46-89 µm; overall equatorial diameter:corpus diameter: 1.35; maximum saccus width: 15-28 µm (5 specimens).

Comparisons.–*C. korbaensis* (Bharadwaj and Tiwari) Foster, 1975, has a narrower saccus and, according to Playford and Dino (2000), is generally larger, with a somewhat less distinct corpus and conspicuous radial plications in the saccus.

Distribution.–Santa Máxima (Ottone, 1989), Guandacol (Ottone and Azcuy, 1990; Ottone 1991), Malanzán (Gutiérrez and Limarino, 2001) and Agua Colorada (Gutiérrez, 1993) Formations. Mascasín, lower level.

Genus *Plicatipollenites* Lele, 1964

Type species.–*Plicatipollenites indicus* Lele, 1964 [= *Plicatipollenites malabarensis* (Potonié and Sah) Foster, 1975].

Plicatipollenites malabarensis (Potonié and Sah) Foster, 1975
Plate 3, Fig. 16

Description.–Pollen grains monosaccate, radial, trilete. Amb circular to subcircular. Corpus outline (polar orientation) circular to subcircular, with a continuous circular, peripheral fold. Laesurae distinct to indistinct. Saccus finely endoreticulate (in well-preserved specimens) and relatively narrow.

Dimensions.–Overall equatorial diameter: 84(108)137 µm; corpus diameter: 54(72)88 µm; overall equatorial diameter: corpus diameter: 1.34(1.5)1.56; maximum saccus width: 19(23)32 µm (13 specimens).

Comparisons.–*Plicatipollenites densus* Srivastava, 1970 has a thick corpus exine, of darker colour than the saccus.

Distribution.–This species has widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001), Mascasín, lower level.

Plicatipollenites trigonalis Lele, 1964
Plate 3, Fig. 17

Description.–Pollen grain monosaccate, radial, trilete. Amb circular to subcircular. Corpus outline subcircular (polar aspect) with a peripheral system of 3 folds delimiting a triangle. Laesurae indistinct. Corpus exine sculptured with low verrucae. Saccus with relatively fine endoreticulum.

Dimensions.–Overall equatorial diameter: 120 µm; corpus diameter: 70 µm; equatorial diameter: corpus diameter: 1.7 (1 specimen).

Comparisons.–*Plicatipollenites trigonalis* Lele, 1964 is characterized by the triangular fold system of its corpus.

Distribution.–This species is widely distributed in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001). Mascasín, upper level.

Genus *Potonieisporites* (Bharadwaj) Bharadwaj, 1964

Type species.–*Potonieisporites novicus* Bharadwaj, 1964.

Potonieisporites barrelis Tiwari, 1965
Plate 3, Fig. 19

Description.–Pollen grains monosaccate, monolete, bilateral. Amb transversely oval. Corpus longitudinally elongate, longer sides convex and minor sides straight. Laesurae indistinct to fairly distinct, straight, length *c.* one-fourth corpus breadth. Corpus folds conspicuous, peripheral, parallel and sited symmetrically on either side of longitudinal axis. Saccus with relatively fine endoreticulum.

Dimensions.–Overall breadth: 150-153 µm; overall length: 117-145 µm; corpus breadth: 60-80 µm; corpus length: 77-105 µm (2 specimens).

Comparisons.–*Potonieisporites methoris* (Hart) Foster, 1975, has a transversely elongate corpus and *Potonieisporites brasiliensis* (Nahuys *et al.*) Archangelsky and Gamerro, 1979, has a near-circular corpus; therefore, they are distinguishable from *P. barrelis*.

Distribution.–Agua Colorada (Gutiérrez, 1993) Formation, Cuenca Tarija (Di Pasquo *et al.*, 2001), Mascasín, lower level.

Potonieisporites brasiliensis (Nahuys *et al.*) Archangelsky and Gamerro, 1979
Plate 3, Fig. 15

Description.–Pollen grains monosaccate, dilete or trilete, bilateral. Amb transversely oval. Corpus (polar orientation) circular to subcircular. Laesurae asymmetric, length *c.* one-quarter of corpus breadth, sometimes indistinct. Two peripheral semilunar folds disposed longitudinally on either side of corpus. Saccus with fine endoreticulum (evident in better preserved specimens only).

Dimensions.–Overall breadth: 125(164)185µm; overall length: 82(122)144µm; corpus breadth: 62(80)95µm; corpus length: 68(82)94µm (9 specimens).

Comparisons.–*P. methoris* (Hart) Foster, 1975, and *P. neglectus* Potonié and Lele, 1961, differ in having a transversely elongated corpus. *P. barrelis* and *P. magnus* Lele and Karim, 1971, are differentiable from *P. brasiliensis* in having a longitudinally elongate corpus.

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from

Argentina (Césari and Gutiérrez, 2001). Mascasín, lower level.

Potonieisporites jayantiensis Lele and Karim, 1971
Plate 4, Fig. 1

Description.–Pollen grains monosaccate, trilete, bilateral, transversely elongate. Corpus outline hexagonal to subhexagonal, with two parallel semilunar folds, each one close to the longitudinal corpus margin. Laesurae asymmetric, indistinct to fairly distinct, length *c.* one-fourth corpus breadth. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 136(169)190 µm; overall length: 80(110)130 µm; corpus breadth: 65(83)95 µm; corpus length: 65(67)100 µm (6 specimens).

Comparison.–Limitisporites hexagonalis Bose and Maheshwari, 1968 resembles *P. jayantiensis,* but is bisaccate with the saccus clearly separated from the corpus, having at the most, a slender exinal bridge.

Distribution.–Mascasín, lower and upper levels.

Potonieisporites lelei Maheshwari, 1967
Plate 4, Fig. 3

Description.–Pollen grains, monosaccate, trilete bilateral, transversely elongate. Corpus subcircular to slightly oval, with one peripheral fold. Laesurae indistinct to fairly distinct, asymmetric. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 87-141 µm; overall length: 67-100 µm; corpus breadth: 50-83 µm; corpus length: 41-73 µm (3 specimens).

Comparisons.–P. magnus Lele and Karim, 1971, is similar to *P. lelei* but has a longitudinally elongate corpus.

Distribution.–Agua Colorada Formation (Gutiérrez 1993), Mascasín, lower level.

Potonieisporites magnus Lele and Karim, 1971
Plate 4, Fig. 5

Description.–Pollen grains monosaccate, trilete, bilateral, longitudinally elongate. Corpus outline oval, longitudinally elongate, with two parallel arcuate folds, each close to the longitudinal corpus margin and often coalescing at the ends, demarcating a distal area conforming in outline with the corpus. Laesurae asymmetric sometimes indistinct, lenght *c.* one-fifth of corpus breadth. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 166-172 µm; overall length: 119-122 µm; corpus breadth: 83-84 µm; corpus length: 95-103 µm (3 specimens).

Comparisons.–Potonieisporites seorsus Playford and Dino, 2000, is distinguishable from *P. magnus* in having a rectangular leptoma. *P. barrelis* is differentiable in having a longitudinally elongate corpus, but with the two larger sides convex and the minor sides straight. The specimens illustrated by Azcuy and Jelin (1980, Pl. 2, Fig. 1) and Archangelsky *et al*. (1987, Pl. 2, Fig. 2) as *Potonieisporites magnus* are consonant with our specimens.

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001), Cuenca Tarija (Di Pasquo *et al*., 2001). Mascasín, lower level.

Potonieisporites methoris (Hart) Foster, 1975
Plate 4, Fig. 6

Description.–Pollen grains monosaccate, bilateral, longitudinally elongate. Laesura indistinct. Corpus outline oval transversely elongate with two semilunar longitudinal folds on either side. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 145-186 µm; overall length: 85-116 µm; corpus breadth: 80-102 µm; corpus length: 52-70 µm (3 specimens).

Comparisons.–*Potonieisporites congoensis* Bose and Maheshwari, 1968 and *P. neglectus* Potonié and Lele, 1961, are distinguishable from *P. methoris* in having a fold system composed of four folds. *P. barrelis* and *P. magnus* differ from *P. methoris* in having a longitudinally elongate corpus.

Distribution.–Bajo de Véliz (Gutiérrez and Césari, 2000), Agua Colorada (Gutiérrez, 1993) Formations. Mascasín, lower and upper levels.

Potonieisporites neglectus Potonié and Lele, 1961
Plate 4, Fig. 4

Description.–Pollen grains, monosaccate, trilete, bilateral, transversely elongate. Corpus subrhomboidal to subtrapezoidal. Laesurae asymmetric, length *c.* one-fourth corpus of breadth. Corpus with two longitudinal folds and one or two smaller transverse folds crossed. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 155-172 µm; overall length: 113-118 µm; corpus breadth: 74-92 µm; corpus length: 86-95 µm (3 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from

Argentina (Césari and Gutiérrez, 2001), Mascasín, lower level.

Potonieisporites novicus Bharadwaj, 1954
Plate 4, Fig. 10

Description.–Pollen grains, monosaccate, trilete, bilateral, transversely elongate. Corpus circular to subcircular, with four folds or more defining a polygonal distal leptoma. Laesurae asymmetric, length *c.* one-fourth of corpus breadth. Saccus with fine endoreticulum.

Dimensions.–Overall breadth: 155-162 µm; overall length: 113-125 µm; corpus breadth: 86-92 µm; corpus length: 83-92 µm (2 specimens).

Comparisons.–*Potonieisporites bilateralis* Singh, 1964 has a subtriangular corpus and *Potonieisporites elegans* (Wilson and Kosanke) Habib, 1966, has a triangular leptoma, therefore, they are distinguishable from *P. novicus*.

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001), Cuenca Tarija (Di Pasquo *et al.*, 2001). Mascasín, lower level.

Potonieisporites sp. cf. *P. densus* Maheshwari, 1967
Plate 4, Fig. 18

Description.–Pollen grains monosaccate, monolete, bilateral. Amb transversely oval; corpus subcircular to subrhomboidal in polar view. Laesurae indistinct. Corpus folding mostly peripheral, parallel to sides of corpus, conforming with the corpus outline. Saccus laevigate, with fine endoreticulum.

Dimensions.–Overall breadth: 114 µm; overall length: 73 µm; corpus breadth: 60 µm; corpus length: 59 µm (1 specimen).

Comparisons.–The only specimen recovered from the Mascasín material appears to show a closer similarity to *P. densus* than to any other species.

Distribution.–Mascasín, upper level.

Potonieisporites sp. cf. *P. triangulatus* Tiwari, 1965
Plate 4, Fig. 19

Description.–Pollen grains monosaccate, monolete, bilateral, transversally elongate. Corpus subcircular to subtriangular with three peripheral folds, parallel to sides of corpus, crossed, delimiting a triangular area. Laesura indistinct. Saccus laevigate, with fine endoreticulum.

Dimensions.–Overall breadth: 137µm; overall length: 82µm; corpus breadth: 60µm; corpus length: 50µm (1 specimen).

Comparisons.–The single specimen described herein is closely similar to *Potonieisporites triangulatus*, but we refer it as a “cf.” representative of the species.

Distribution.–Mascasín, upper level.

Genus *Caheniasaccites* (Bose and Kar) Archangelsky and Gamerro, 1979

Type species.–*Caheniasaccites flavatus* Bose and Kar, 1966.

Caheniassaccites densus Lele and Karim emend. Gutiérrez, 1993
Plate 4, Fig. 8

Description.–Pollen grains monosaccate, trilete, bilateral, transversely elongate, with a bisaccate appearance due to radial plications of the saccus along longitudinal sides of corpus. Corpus transversely oval to subcircular, darker coloured than saccus. Laesurae usually distinct, slightly asymmetric, length *c.* one-fifth of corpus breadth. Saccus attachment subequatorial, cappula conforming with corpus outline, accompanied by radial folds.

Dimensions.–Overall breadth: 75(122)155 µm; overall length: 38(80)86 µm; corpus breadth: 53(54)61 µm; corpus length: 36(42)50 µm (8 specimens).

Comparisons.–*Caheniassaccites ovatus* Bose and Kar emend. Gutiérrez, 1993, differs from *C. densus* in the lighter coloured and thinner walled corpus. *C. verrucosus* (Gonzalez-Amicón) Gutiérrez, 1993, and *C. granulatus* Lele and Chandra, 1974, differ in the corpus sculptured by verrucae and grana respectively.

Distribution.–Santa Máxima (Ottone, 1989), Bajo de Veliz (Gutiérrez and Césari, 2000), El Imperial (García, 1996) and Agua Colorada, (Gutiérrez, 1993) Formations. Mascasín, lower and upper levels.

Forma A
Plate 4, Fig. 15

Description.–Pollen grains protosaccate, radial, trilete, monosulcate? Amb circular to subcircular. Corpus outline subcircular; exine sculptured with low verrucae. Distally showing an elliptical area delimited by conspicuously wrinkled inner margins of saccus. Saccus relatively narrow.

Dimensions.–Equatorial diameter 66-88 µm, diameter body 76 µm, sulcus length 75 µm, saccus width 6-8 µm (2 specimens).

Comparisons.–The morphological attributes of the specimens are clearly distinguishable from known species of pollen grains. These specimens might possibly be aberrant representatives of some species present in the Mascasin assemblages.

Distribution.–Mascasín, lower and upper levels.

Forma B
Plate 4, Fig. 13

Description.–Pollen grain radial, monosaccate, bilateral. Corpus outline, in polar view, transversely elongate, with a transverse, central, thickening fully transecting the corpus. Saccus of uniform width, with medium endoreticulum.

Dimensions.–Overall breadth: 95 µm; overall length: 76 µm; corpus breadth: 65 µm; corpus length: 35 µm, thickening width: 8-10 µm (1 specimen).

Distribution.–Mascasín, lower level.

Genus *Limitisporites* (Leschik) Schaarschmidt, 1963

Type species.–*Limitisporites rectus* Leschik, 1956.

Limitisporites hexagonalis
Bose and Maheshwari, 1968
Plate 4, Fig. 2

Description.–Pollen grains bisaccate, monolete, bilateral, slightly diploxilonoid. Corpus outline subhexagonal, surface with very low verrucae; distal sacci attachments comprising two longitudinal crescentic folds. Laesurae *c.* 10 µm. Sacci may have a narrow lateral connection along transverse corpus margin.

Dimensions.–Overall length: 180 µm; overall breadth: 68-74 µm; corpus length: 61-78 µm; corpus breadth: 65-74 µm (2 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001). Mascasín, lower level.

Limitisporites rectus Leschik, 1956
Plate 4, Fig. 16

1980 *Vestigisporites* sp. A, Azcuy and Jelin, Pl. 2, Fig. 3.
1987 *Vestigisporites* sp., Archangelsky *et al.,* Pl. 12, Fig. 16

Description.–Pollen grains bisaccate, bilateral, monolete, haploxylonoid to diploxylonoid. Amb transversely oval. Corpus outline subcircular in polar view. Distal sacci attachments comprising two well defined crescent folds. Laesurae, transverse, simple, length one-fourth corpus diameter. Sacci semicircular, usually three-fifths to two-thirds corpus diameter.

Dimensions.–Overall length: 105-143 µm; overall width: 53-87 µm; corpus length: 50-83 µm; corpus width: 53-87 µm; saccus width: 32-67 µm; saccus height: 61-87 µm (5 specimens).

Comparisons.–*Limitisporites monosaccoides* Bose and Maheshwari, 1968 differs in having a transversely elongate corpus. The specimens from Mascasín well illustrated by Azcuy and Jelin (1980, Pl. 2, Fig. 3) and Archangelsky *et al*. (1987, Pl. 12, Fig. 16) referred to *Vestigisporites* sp. are included in *L. rectus*.

Distribution.–Mascasín, lower and upper levels.

Limitisporites sp. cf. L. *monosaccoides* Bose and Maheshwari, 1968
Plate 4, Fig. 21

Description.–Pollen grains bisaccate, bilateral, monolete, haploxilonoid. Amb subquadrangular. Corpus outline subquadrangular in polar view, conforming with amb. Laesurae indistinct. Sacci sometimes united by thin exinal bridges around corpus.

→

PLATE 4–*1, Potonieisporites jayantiensis* Lele and Karim, 1971. *2, Limitisporites hexagonalis* Bose and Maheshwari, 1968. *3, Potonieisporites lelei* Maheshwari, 1967. *4, Potonieisporites neglectus* Potonié and Lele, 1961. *5, Potonieisporites magnus* Lele and Karim, 1971. *6, Potonieisporites methoris* (Hart) Foster, 1975. *7, 14, Protohaploxypinus amplus* (Balme and Hennelly) Hart 1964. *8, Caheniasaccites densus* (Lele and Karim) Gutiérrez, 1993. *9, Protohaploxypinus limpidus* (Balme and Hennelly) Balme and Playford, 1967. *10, Potonieisporites novicus* Bharadwaj, 1954. 11. *Limitisporites* sp. x500. *12, Striatoabieites* sp. *13,* Forma B. *15,* Forma A. *16, Limitisporites rectus* Leschik, 1956 x450. *17, Tetraporina punctata* (Tiwari and Navale) Kar and Bose, 1976, x400. *18, Vittatina* sp. *19, Potonieisporites* cf. *Potonieisporites triangulatus* Tiwari, 1965. *20, Protohaploxypinus* sp. *21, Limitisporites* cf. *Limitisporites monosaccoides* Bose and Maheshwari, 1968. All specimens from the Estratos de Mascasín, x300 unless stated otherwise.

PLATE 4


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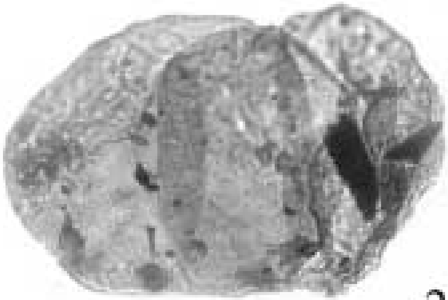
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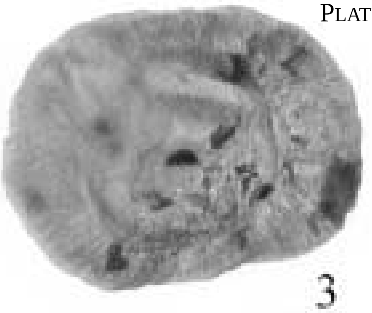
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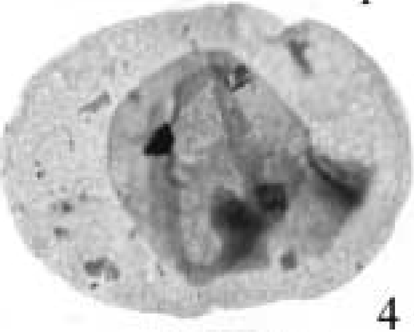
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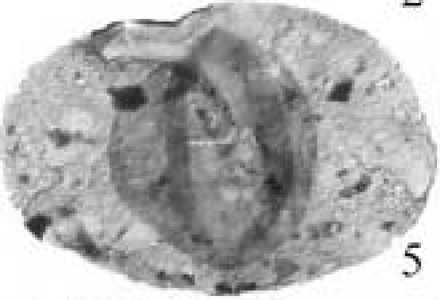
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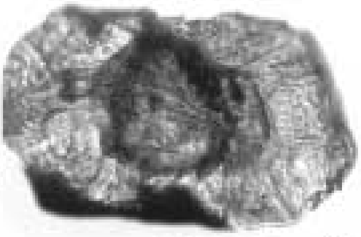
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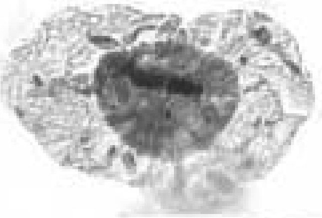
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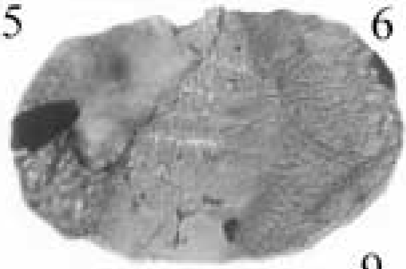
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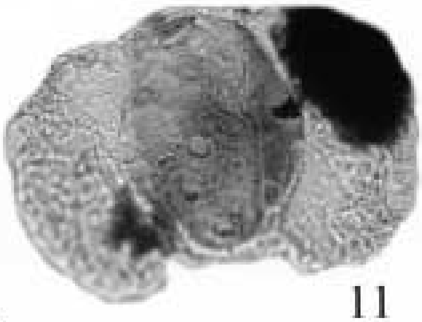
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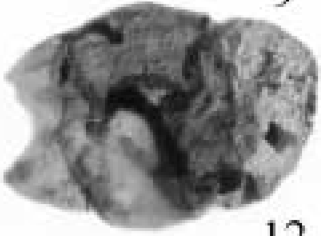
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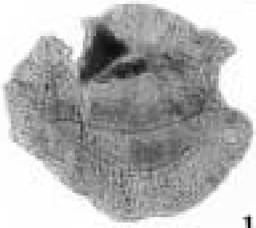
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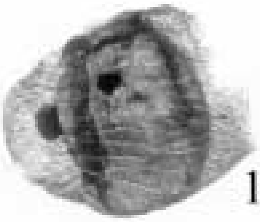
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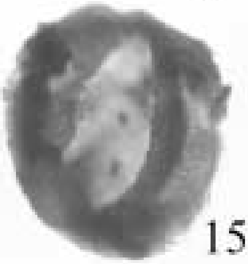
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Dimensions.–Overall length: 117-160; total width: 45-71 µm; corpus length: 56-96 µm; corpus widht:45-71 µm; saccus width: 28-35 µm; saccus height: 50-80 µm (2 specimens).

Comparisons.–The specimens are similar to the originally described, in the corpus oval transversely elongate and its subcuandrangular rounded outline. *Limitisporites elongatus* Lele and Karim, 1971 has a transversely elongate corpus, but the latter is marginally thickened.

Distribution.–Mascasín, lower level.

Limitisporites sp.
Plate 4, Fig. 11

Description.–Pollen grains bilateral, bisaccate, monolete, slightly diploxilonoid. Amb and corpus transversely oval. Laesurae indistinct. Saccus semicircular in polar view, united by thin exinal bridges (1-2 µm).

Dimensions.–Overall length: 108 µm; overall breadth: 65 µm; corpus length: 50 µm; corpus breadth: 62 µm; corpus width: 30 µm; maximum high saccus: 72 µm (1 specimens).

Comparisons.–Limitisporites parvus Klaus, 1963 is similar in having a transversely elongate corpus but differs in the smaller total size.

Distribution.–Mascasín, lower level.

Genus *Protohaploxypinus* (Bharadwaj) Morbey, 1975

Type species.–Protohaploxypinus latissimus (Luber) Samoilovich, 1953.

Protohaploxypinus amplus (Balme and Hennelly) Hart, 1964
Plate 4, Figs. 7, 14

Description.–Pollen grains bisaccate, taeniate, haploxylonoid to slightly diploxylonoid, bilateral. Corpus subcircular transversely elongate in polar view, divided into 7-12 taeniae, each 3-9 µm wide. Cappula rectangular in polar view, flanked by narrow semilunar or straight longitudinal folds marking distal saccus attachments. Saccus laevigate, with fine endoreticulum.

Dimensions.–Overall breadth: 97-130 µm; corpus breadth: 42-95 µm; corpus length: 42-85 µm; saccus breadth: 30-35 µm; saccus length: 64-81 µm (6 specimens).

Comparisons.–Our material is consonant with *Protohaploxypinus amplus*, the slight differences in the total number of taeniae could be the result of considering the bifurcated taeniae as one or two units. *Protohaploxypinus limpidus* (Balme and Hennelly) Balme and Playford, 1967 differs in the lesser number of taeniae. Archangelsky *et al*. (1987, Plate 12, Figure 5) illustrated as *Protohaploxypinus riojanus* Azcuy and Jelin a specimen from Mascasín well consonant with those described here. *P. riojanus* is an invalid name according to the ICBN because it was never described.

Distribution.–Mascasín, lower and upper levels.

Protohaploxypinus limpidus (Balme and Hennelly) Balme and Playford, 1967
Plate 4, Fig. 9

Description.–Pollen grains bisaccate, taeniate, bilateral, haploxylonoid. Corpus subcircular to transversely elongate in polar view. Cappa divided into 7-9 transverse, subparallel or wedged taeniae. Cappula rectangular, flanked by narrow longitudinal folds that are usually indistinct. Sacci laevigate, with relatively fine endoreticulum.

Dimensions.–Overall breadth: 110(137)163 µm; corpus breadth: 50(57)66 µm; corpus length: 60(68)90 µm; saccus breadth: 40(50)52 µm; saccus length: 80(85)90 µm (10 specimens).

Comparisons.–Protohaploxypinus amplus (Balme and Hennelly) Hart, 1964, is distinguishable from *P. limpidus* by its usually larger number of taeniae. *Protohaploxypinus perfectus* (Naumova) Samoilovich, 1953, has a lesser number of taeniae and size.

Distribution.–Mascasín, lower and upper levels.

Protohaploxypinus sp.
Plate 4, Fig. 20

Description.–Pollen grains bisaccate, taeniate, slightly diploxylonoid. Corpus outline subcircular to transversely oval in polar view, wall thick and darker than the sacci. Cappa divided into 8-10 subparallel taeniae, each 1.5-10 µm wide, separated by narrow clefts. Sacci subcircular in polar aspect, with prominent semilunar folds. Sacci may have narrow lateral connection along transverse corpus margin.

Dimensions.–Overall breadth: 110-133 µm; corpus breadth: 42-65 µm; corpus length: 46-65 µm; saccus breadth: 28-35 µm; saccus length: 52-57 µm (5 specimens).

Comparisons.–*Protohaploxypinus limpidus* differs in not having a thicker and darker corpus than the sacci. *P. amplus* is distinguishable by its overall outline and thinner walled corpus. *Protohaploxypinus bharadwajii* Foster, 1979, has a transversely elongate corpus. *Protohaploxypinus hartii* Foster, 1979, features a subrectangular corpus with a lesser number of taeniae.

Distribution.–Mascasín, lower and upper levels.

Genus *Striatoabieites* (Zoricheva and Sedova) Hart, 1964

Type species.–*Striatoabieites brickii* Sedova, 1956.

Striatoabieites sp.
Plate 4, Fig. 12

Description.–Pollen grain bisaccate, bilateral, taeniate, diploxylonoid. Corpus distinct, oval longitudinally elongate in polar view. Cappa divided into 9-10 transverse subparallel taeniae, sometimes bifurcant, usually 4-9 µm wide. Sacci laevigate, with fine endoreticulum.

Dimensions.–Overall breadth: 127 µm; corpus breadth: 45 µm; corpus length: 74 µm; saccus breadth: 26 µm; saccus length: 62 µm (1 specimen).

Comparisons.–*S triatoabieites multistriatus* (Balme and Hennelly) Hart, 1964, is distinguishable by its transversely elongate corpus. *S. anaverrucosus* Archangelsky and Gamerro, 1979, has a greater number of taeniae.

Distribution.–Mascasín, lower level.

Genus *Vittatina* (Luber) Wilson, 1962

Type species.–*Vittatina subsaccata* Samoilovich, 1953.

Vittatina sp.
Plate 4, Fig. 18

Description.–Pollen grain bilateral, taeniate, haploxylonoid. Amb subcircular, longitudinally elongate. Proximal surface with 11-12 transverse subparallel taeniae separated by narrow clefts.

Dimensions.–Overall breadth: 80 µm; overall length: 95 µm; corpus breadth: 60 µm; corpus length: 95 µm (1 specimen).

Comparisons.–The only specimen identified is poorly preserved but resembles *Vittatina* sp. described by Césari *et al.* (1995), although the specimen from the Chacorparaná Basin is distinguishable by the higher number of taeniae.

Distribution.–Mascasín, upper level.

Genus *Portalites* Hemer and Nygreen, 1967

Type species.–*Portalites confertus* Hemer and Nygreen, 1967.

Portalites gondwanensis Nahuys, Alpern and Ybert, 1968
Fig. 2, 2

Description.–Amb oval to subcircular. Exine two-layered, inner layer laevigate, usually folded, forming a sometimes perceptible internal body. Some specimens show a simple pore. Sculpture of small coni, sometimes blunt, and verrucae that towards the central area lose individual entity given a spongy appearance.

Dimensions.–Equatorial diameter: 73(79)81 µm; pore: 6 µm in diameter; sculpture 1.5-2 µm basal wide and 1.5-2 µm high (11 specimens).

Distribution.–This species has a widespread distribution in Upper Paleozoic palynofloras from Argentina (Césari and Gutiérrez, 2001), Cuenca Tarija (Di Pasquo and Azcuy, 1997). Mascasín lower and upper levels.

Genus *Spongocystia* Segroves, 1967

Spongocystia sp.
Fig. 2, 1

1987 *Microreticulatisporites* sp. Archangelsky *et al.*, Pl. 12, Fig. 15.

Description.–Amb circular to subcircular, apparently without laesurae; some specimens with an indistinct pore 4-7 µm in diameter. Thin inner central body usually subcircular. Exine sculptured with fovea variable in shape, 1 µm in diameter (some are up to 3 µm).

Dimensions.–Equatorial diameter: 71(77)93 µm, diameter of central body: 54(57)68 µm; fovea 0.8-3 µm in diameter (6 specimens).

Comparisons.–Vestispora (Wilson and Hoffmeister) Wilson and Venkatachala, 1963, while resembling *Spongocystia* has a proximal operculum that when detached exposes the trilete laesurae. *Portalites* Hemer and Nygreen, 1967, displays a positive sculpture; *Haplocystia* Segroves, 1967, includes microfossils with a two-layered wall, outer wall bearing a negative reticulum. The specimen from Mascasín well, illustrated by Archangelsky *et al.* (1987, Pl. 12, Fig. 15), is identical to our species.

Distribution.–Mascasín, lower level.

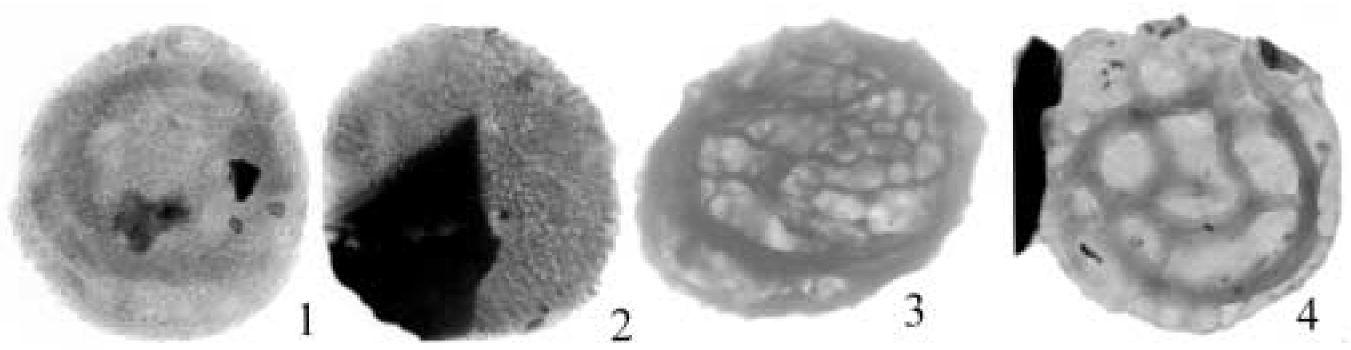

FIGURE 2–*1, Spongocystia* sp. *2, Portalites gondwanensis* Nahuys, Alpern and Ybert, 1968. *3, Maculatasporites* sp. 1. *4, Macualtasporites* sp. 2. All specimens from the Estratos de Mascasín, x500.

Genus *Tetraporina* (Naumova) Naumova, 1950

Type species.–*Tetraporina antigua* Naumova, 1950 (designated by Potonié 1960).

Tetraporina punctata (Tiwari and Navale) Kar and Bose, 1976
Plate 4, Fig. 17

Description.–Spore alete, amb subsquare with rounded apices, lateral lower sides concave and bigger sides straight. Exine thin approximately 1 µm, smooth.

Dimensions.–Axis: smaller 62 µm; bigger axis: 70 µm (1 specimen).

Discussion.–According to Gutiérrez and Limarino (2001) we consider that the shape of the lateral sides has little systematic value.

Distribution.–Malanzán (Azcuy, 1975*b;* Gutiérrez and Limarino, 2001), Lagares (Menéndez and Azcuy, 1969) and El Imperial (García, 1996) Formations, Las Mochas (Césari *et al.*, 1995). Mascasín, upper level.

Genus *Maculatasporites* Tiwari, 1964

Type species.–*Maculatasporites indicus* Tiwari, 1964.

Remarks.–Maculatasporites includes microfossil without any apparent dehiscence mechanism, amb circular, oval or rounded triangular, with wall reticulate, lumina variable in shape and size.

Maculatasporites sp. 1
Fig. 2, 3

Description.–Amb oval, without visible laesurae or dehiscent aperture. Exine bearing muri 1-2.5 µm wide and 2-4 µm high enclosing lumina variable in outline (circular, polygonal or irregular) among different specimens. Muri tapering to the tops and sometimes with projections up to 6 µm high and 3 µm wide. Several specimens are separated into two halves by a ridge.

Dimensions.–Equatorial diameter: 118(130)135 µm; muri: 1-2.5 µm high and 2-4 µm wide; lumina 5-25 µm in diameter. (7 specimens).

Distribution.–Mascasín, lower level.

Maculatasporites sp. 2
Fig. 2, 4

Description.–Amb circular to subcircular without visible dehiscence aperture. Exine bearing muri 3-5 µm high and 1.5-3 µm wide of variable thickness and width on same specimen. On central area of one hemisphere the muri enclosing irregular lumina. Muri thinner and lower towards the equatorial zone. Exine 0.5-0.8 µm thick, scabrate.

Dimensions.–Equatorial diameter: 70(76)85 µm; zone: 12-18 µm in maximum width; muri 3-5 µm high and 1.5-3 µm wide; lumina 11-32 µm wide and 4-17 µm high. (8 specimens).

Comparisons.–These specimens have lumina developed only on the central area of one hemisphere and hence are assigned provisionally to *Maculatasporites*.

CONCLUSIONS

Quantitative analysis

The relative abundance of spores, pollen grains and specifically taeniate pollen grains allow us to differentiate the lower and upper assemblages. The lower association is composed of 82.5% spores, 17.2% pollen grains (bisaccate and monosaccate), and 0.3% taeniate pollen grains. Among the spores, *Grossusporites microgranulatus* is the predominant species accompanied by *Apiculiretispora sparsa*, *Vallatisporites pauper* and *Apiculatasporites caperatus*. Other species are much less abundant. Among the pollen grains, *Potonieisporites* is the predominant genus.

The upper association includes 55% spores, 42% pollen grains and 3% taeniate species. Many of the genera from the lower association are recognized in the upper association. In this assemblage there is an important increase of the pollen grains and a small amount of the taeniate grains. The preservation of this association is very poor and the majority of the pollen grains cannot be referred to species because they lack the corpus. Among the spores, *Grossusporites microgranulatus* is present but not as a predominant species; *Cyclogranisporites plicatus, Verrucosisporites cordubensis* and *Vittatina* sp. appear in this level and some *incertae sedis* elements characteristics of the lower level disappear.

Biostratigraphic conclusions

We refer both the lower and upper assemblages from the Mascasín well to the *Raistrickia densa-Convolutispora muriornata* (DM) Biozone according to the biostratigraphic scheme proposed by Césari and Gutiérrez (2001). The DM Biozone was subdivided into three subbiozones and the assemblages here studied cannot be assigned to the subbiozone A by the presence of taeniate pollen grains. The subbiozone C differs from B by the presence of acritarchs and a larger proportion of taeniate pollen grains. The upper association of Mascasín, with an increase of pollen grains and especially of taeniate species, suggests a younger age than the lower palynoflora. This is consonant with the stratigraphical position, 100 m above the lower fossiliferous level. Therefore, we propose that the upper association could be correlated with the subbiozone C and the lower association with the subbiozone B.

The Interval Biozone *Fusacolpites fusus-Vittatina subsaccata,* Permian in age, is characterized by abundant species of taeniate pollen grains represented by *Fusacolpites fusus, Hamiapollenites fusiformis, Marsupipollenites striatus*, among other that are absent in our samples. Therefore, following Césari and Gutiérrez (2001) we conclude that the palynoflora from the interval 3,423-3,429 m, originally chosen by Azcuy and Jelin (1980) and Azcuy (1986) as unique example of a distinctive biostratigraphic unit assigned to the Late Carboniferous, is in fact equivalent to many assemblages characteristic of the DM Biozone, more precisely to the subbiozone B. This biostratigraphic unit is characterized by the palynological assemblages from the Tupe Formation and correlative lithostratigraphical units (Césari and Gutiérrez, 2001).

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Appendix: Register of illustrated specimens

Species/type	**Plate/ figure**	**Slide number**	**England finder**
Calamospora hartungiana	1/1	5613/2	F 50/4
Leiotriletes tenuis	1/2	5612/4	R20/4
Leiotriletes sp. 1	1/3	5613/1	Z48/2
Punctatisporites glaber	1/4	5613/12	D60/4
Punctatisporites gretensis	1/5	5613/1	Z20/2
Punctatisporites sp. cf. *P*. sp. A	1/6	5612/9	N54
Retusotriletes anfractus	1/7	5612/10	X59/2
Granulatisporites varigranifer	1/8	5612/10	M30/4
Cyclogranisporites plicatus sp. nov. Holotype	1/9	5613/1	Y28/1
	1/10	5313/1	B46/3
Granulatisporites cf. *G. varigranifer*	1/11	5613/1	V23/4
Granulatisporites sp.	1/12	5613/3	X30/4
Lophotriletes sp. cf. *L. discordis*	1/13	5612/7	V20/1
Converrucosisporites sp.	1/14	5612/9	Q23/4
Apiculatasporites caperatus	1/15	5612/10	H30/1
Apiculiretusispora sparsa	1/16	5612/10	Q36/4
Apiculatisporis densus sp. nov. Holotype	1/17	5612/6	P20/4
	1/18	5612/10	R42/1
Verrucosisporites cordubensis	1/19	5613/3	W22
Apiculiretusispora ralla	2/1-2	5612/9	T47/3
Lophotriletes sp. cf. *L. rectus*	2/3	5612/9	L50
Horriditriletes uruguaiensis	2/4	5612/3	M57/4
Vallatisporites ciliaris	2/5	5612/8	S48/3
Dibolisporites variatus sp. nov. Holotype	2/6	5612/10	H53/1
	2/8	5612/10	A46/2
Raistrickia cephalata	2/9,13	5612/8	W54/4
Lophotriletes sp. *L. intermedius*	2/10	5613/3	U22/1
Raistrickia sp.	2/11	5612/5	V52/2
Convolutispora sp. 1	2/12	5612/1	R22/4
Lophotriletes sp. *L. rarus*	2/14	5612/7	G52/1
Convolutispora cf. *C. candiotensis*	2/15	5612/12	S43/2
	2/17	5612/6	Z52/1
Convolutispora muriornata	2/16	5613/1	U24/3
Convolutispora sp. 2	2/18	5613/1	U21/4
Foveosporites pellucidus	2/19	5612/5	R42
Dictyiotriletes cortaderensis	3/5	5612/5	S54/1
Dictyotriletes sp.	3/1	5612/2	U37/2
Cristatisporites sp cf. *C. pseudozonatus*	3/2	5613/2	D29/3
Vallatisporites pauper	3/4,8	5612/19	S56/4

Appendix: Register of illustrated specimens

Species/type	Plate/ figure	Slide number	England finder
Kraeuselisporites volkheimeri	3/6	5612/12	N36/4
Microreticulatisporites punctatus	3/3,7	5612/1	R23/3
Spelaeotriletes ybertii	3/9	5612/7	Y23/3
Grossusporites microgranulatus	3/11	5612/6	E17/2
	3/12	5612/13	N40
Cannanoropolis janakii	3/13	5612/12	M29/2
Cannanoropolis densus	3/14	5612/7	X40/2
Potonieisporites brasiliensis	3/15	5612/17	S27/4
Plicatipollenites malabarensis	3/16	5612/12	G31/4
Plicatipollenites trigonalis	3/17	5613/1	O23/2
Potonieisporites cf. *P. densus*	3/18	5613/2	P20/4
Potonieisporites barrelis	3/19	5612/20	J53/3
Potonieisporites jayantiensis	4/1	5612/7	M47/2
Limitisporites hexagonalis	4/2	5612/15	D39/3
Potonieisporites lelei	4/3	5612/15	X50/3
Potonieisporites neglectus	4/4	5612/13	N39/3
Potonieisporites magnus	4/5	5612/13	U33/2
Potonieisporites methoris	4/6	5613/1	X22/1
Caheniassaccites densus	4/8	5612/15	V43/4
Protohaploxypinus limpidus	4/9	5613/3	V27/2
Potonieisporites novicus	4/10	5612/12	K49/2
Striatobieites sp.	4/11	5612/7	J55
Striatobieites sp.	4/12	5612/12	K50
Forma B	4/13	5612/17	Y22/4
Protohaploxypinus amplus	4/7	5612/2	G35/1
	4/14	5612/6	A53/1
Forma A	4/15	5612/22	M54/1
Limitisporites rectus	4/16	5612/12	N44/1
Tetraporina punctata	4/17	5613/2	N35/3
Vittatina sp.	4/18	5613/2	S46/4
Potoniesporites cf. *P. triangulatus*	4/19	5613/2	Z34/1
Protohaploxypinus sp.	4/20	5612/12	J55/3
Limitisporites cf. *L. monosaccoides*	4/21	5612/5	F37/1
Spongocystia sp.	2/A	5612/6	A59/4
Portalites gondwanensis	2/B	5612/15	F28/3
Maculatasporites sp. 1	2/C	5612/15	T29
Maculatasporites sp. 2	2/D	5612/15	X39

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AN EARLY PERMIAN PALYNOFLORA FROM THE ITARARÉ SUBGROUP, PARANÁ BASIN, BRAZIL

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Abstract

A well-preserved palynoflora is recorded from the upper Itararé Subgroup in the northeastern portion of the Brazilian Paraná Basin, Tietê Municipality, São Paulo State. Among the 45 species identified, 3 are recorded for the first time from the Brazilian Paraná Basin, i. e. cf. *Alatisporites* sp., *Pteruchipollenites indarraensis* (Segroves) Foster, 1979, and a new combination: *Horriditriletes spinobaculosus* (Marques-Toigo) comb. nov. The palynoflora is dominated by gymnospermous taeniate and polyplicate pollen grains (mainly *Protohaploxypinus, Illinites* and *Vittatina*), which constitute up to 72% of the total assemblage. Trilete spores, mainly referable to Filicopsida and Lycopsida, are subordinate, reaching 15 to 42%. Non-taeniate bisaccate and monosaccate pollen grains (Coniferales, Cordaitales) are minor constituents. Algae (*Botryococcus braunii* and *Tasmanites* sp.) and *incertae sedis* (*Deusilites tenuistriatus* and *Portalites gondwanensis*) also occur. The spore-pollen assemblages are referable to the *Vittatina costabilis* Interval Zone of the Paraná Basin, particularly to the *Protohaploxypinus goraiensis* Subzone, dated as Sakmarian/Artinskian (Early Permian). Freshwater conditions, with a minor brackish influence, a possible lagoonal facies, are suggested.

Key words: Palynology, Early Permian, Paraná Basin, Itararé Subgroup, Brazil.

Resumen

Se presenta el estudio palinológico de un afloramiento en las cercanías de la ciudad de Tietê, Estado de São Paulo, Brasil. La palinoflora, obtenida de la porción superior del Subgrupo Itararé en el sector nordeste de la Cuenca Paraná, está compuesta por 45 especies. Entre ellas, tres han sido registradas por primera vez en la Cuenca: cf. *Alatisporites* sp., *Pteruchipollenites indarraensis* (Segroves) Foster, 1979, así como una nueva combinación: *Horriditriletes spinobaculosus* (Marques-Toigo) comb. nov. Los granos de polen teniados y poliplicados vinculados a las gimnospermas son los más abundantes (hasta 72%) y diversificados, principalmente especies de *Protohaploxypinus, Illinites* y *Vittatina*. Las esporas están subordinadas y no superan el 42% del total, predominando aquellas de afinidad con las filicópsidas y licópsidas. Granos de polen monosacados y bisacados no teniados, vinculados a las coniferales y cordaitales, son escasos. El grupo de las algas está representado por *Botryococcus braunii* y *Tasmanites* sp. Además, *Deusilites tenuistriatus* y *Portalites gondwanensis,* considerados como *incertae sedis,* fueron reconocidos. La palinoflora puede ser atribuida a la Zona *Vittatina costabilis* de la Cuenca Paraná, especialmente la Subzona *Protohaploxypinus goraiensis,* considerada como Sakmariense/Artinskiense (Pérmico Temprano). El ambiente de deposición se interpreta como de carácter continental, con alguna influencia salobre, sugirindo facies lagunal.

Palabras clave: Palinología, Pérmico Temprano, Cuenca Paraná, Subgrupo Itararé, Brasil.

INTRODUCTION

The Upper Carboniferous and Lower Permian strata of the Brazilian Paraná Basin comprise a thick sedimentary succession related to glacial and post glacial environments, within a major transgressive/regressive cycle, represented by the Tubarão and Passa Dois groups. Animal remains (both vertebrate and invertebrate), plant megafossils and palynomorphs are relatively common in this succession. Palynofloras allow biostratigraphy, correlations as well as environmental inferences. The palynological data are more abundant from the southern portion of the basin, with coal-bearing strata.

In this context, a comprehensive study has been made in order to refine the palynological and palaeobotanical knowledge of the Paraná Basin, especially for the Tubarão Group from the northeastern part of this basin, which involves São Paulo and Paraná States. Both surface and subsurface samples were used and new palynological and palaeobotanical finds have been recorded, allowing a certain amount of taxonomic revision as well as new biostratigraphic proposals.

The present paper deals with the palynology of surface samples collected in the Tietê area, São Paulo State, from the upper Itararé Subgroup. Biostratigraphy, correlation and palaeoenvironmental significances are discussed.

GEOLOGICAL AND PALAEONTOLOGICAL SYNOPSIS

The intracratonic Paraná Basin occupies ca. 1,400,000 km^2 in Brazil (1,100,000 km^2), Uruguay, Argentina and Paraguay. A succession of ca 5,000 m is involved altogether, representing six supersequences (Milani, 1997) as follow: Rio Ivaí (related to the Rio Ivaí Group of Ordovician/Silurian age), Paraná (Paraná Group, Devonian), Gondwana I (Tubarão and Passa Dois groups, Carboniferous/Permian), Gondwana II (Triassic), Gondwana III (São Bento Group, Jurassic/Cretaceous) and Bauru Supersequence (Bauru Group, Cretaceous) (see Figure 1).

The Itararé Subgroup, the basal unit of the Tubarão Group, includes continental and marine sediments, deposited under glacial and post glacial conditions, comprising thick mainly clastic sediments, such as sandstones, diamictites, rhythmites, mudstones, siltstones, shales, conglomerates and coals. Its deposits are thicker in the North Brazilian Paraná Basin and are correlated, in part, to subsurface strata in Argentina (Chacoparaná Basin) and Uruguay (San Gregorio Formation).

A synopsis of the palaeontological contents of the Itararé Subgroup is given by Petri & Souza (1993), concerning vertebrates, invertebrates, plant megafossils, palynomorphs and ichnofossils. Marine faunas are mainly represented by brachiopods, bivalves, echinoderms, gastropods, agglutinated Foraminifera, and fish remains, which are relatively abundant and diverse. These records testify to marine influence at various stratigraphical levels.

Plant remains related to pre-glossopterids are recorded from the lower and middle portions of the Itararé Subgroup. The *Glossopteris* Flora is recovered from the upper Itararé Subgroup, and is most abundant in the Guatá Subgroup, particularly in coal-bearing strata of the Rio Bonito Formation. Besides, the phytobiostratigraphic schemes proposed (Rösler, 1978; Guerra-Sommer & Cazzulo-Klepzig, 1993) are restricted to local sectors of the basin.

Palynomorphs are very abundant throughout this succession. The palynostratigraphic scheme presented by Daemon & Quadros (1970) remains the most complete one for the Brazilian Paraná Basin, but significant contributions have come also from Marques-Toigo (1991) and Souza (2000), who dealt with regional successions in the southern and northeastern portions, respectively. Souza & Marques-Toigo (2001,

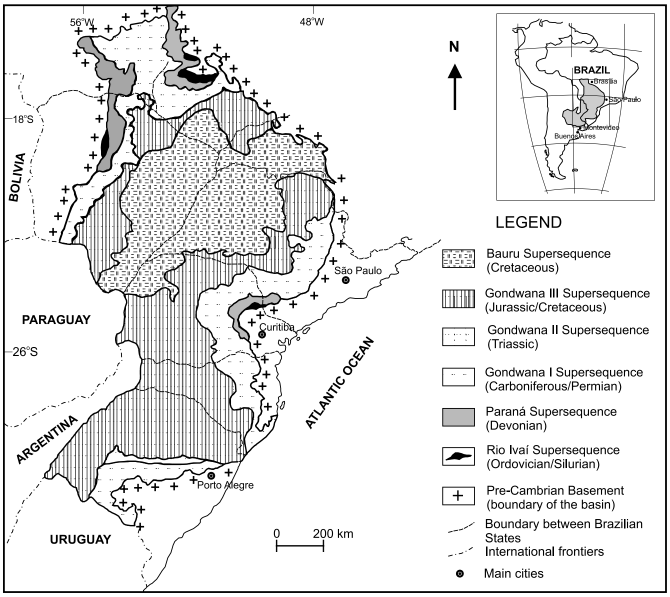


FIGURE 1–Location and distribution of Paraná Basin Stratigraphical Supersequences (after Milani, 1997 and Souza & Marques-Toigo, 2003).

2003) presented an integrated palynological scheme. According to these authors, the palynological succession of the Paraná Basin comprises four interval zones, designated, from the base upward, as the *Ahrensisporites cristatus, Crucisaccites monoletus, Vittatina costabilis* and *Lueckisporites virkkiae* Zones, spanning the highest Carboniferous and part of the Permian.

PROVENANCE AND TECHNIQUES

This study is based on material from an outcrop on the left bank of the Capivari River, Tietê Municipality, São Paulo State, at latitude 22° 59.3’ S and longitude 47° 45.05’ W, located 400 m upstream from the bridge on the old road of Piracicaba to Tietê (Figure 2.1). Palaeobotanical samples were collected by M. E. Longhim and R. Rohn. Leaves of *Gangamopteris, Rubidgea, Noeggerathiopsis, Koretrophyllites,* seeds attributed to *Samaropsis,* as well as fructifications were recorded (Rohn *et al.,* 2000). The palynological contents of some of the collected samples were analysed, including a previous study by Callegari (2001), and a synthesis by Souza *et al.* (2003). The combined results are presented herein.

The outcrop comprises about 3.5 m of exposed strata consisting of a basal diamictite, followed by fine-grained sandstones, mudstones and siltstones (Figure 2.2). Palynological samples correspond to a grey mudstone with fine sandy and argillaceous intercalations, with carbonised plant remains, indicated as number “3” in Figure 2.2.

Samples were processed in the “Instituto Geológico” of São Paulo State (IG/SMA) following the standard palynological techniques consisting of the chemical removal of carbonates and silicates. Palynomorphs between 10 and 250 µm were concentrated by sieving and twelve slides were mounted and analysed. Visual examination for taxonomic identification was taken using a light microscope (Zeiss/Jenaval). Digital photographs were taken using a Zeiss Axiophot Microscope. The slides are housed in the Instituto Geológico, under codes IG-P: 373A-B, 374-A-B, 375A-C, 376A-B, and 377A-C.

PALYNOLOGY

Contents

Forty-five species of palynomorphs were recovered, i. e. 15 species of spores, 26 of pollen, two of algae and two *incertae sedis,* as listed. Three are new for the Brazilian Paraná Basin, and a new combination is proposed: *Horriditriletes spinobaculosus* (Marques-Toigo) *comb. nov.* A systematic description is provided of these three elements.

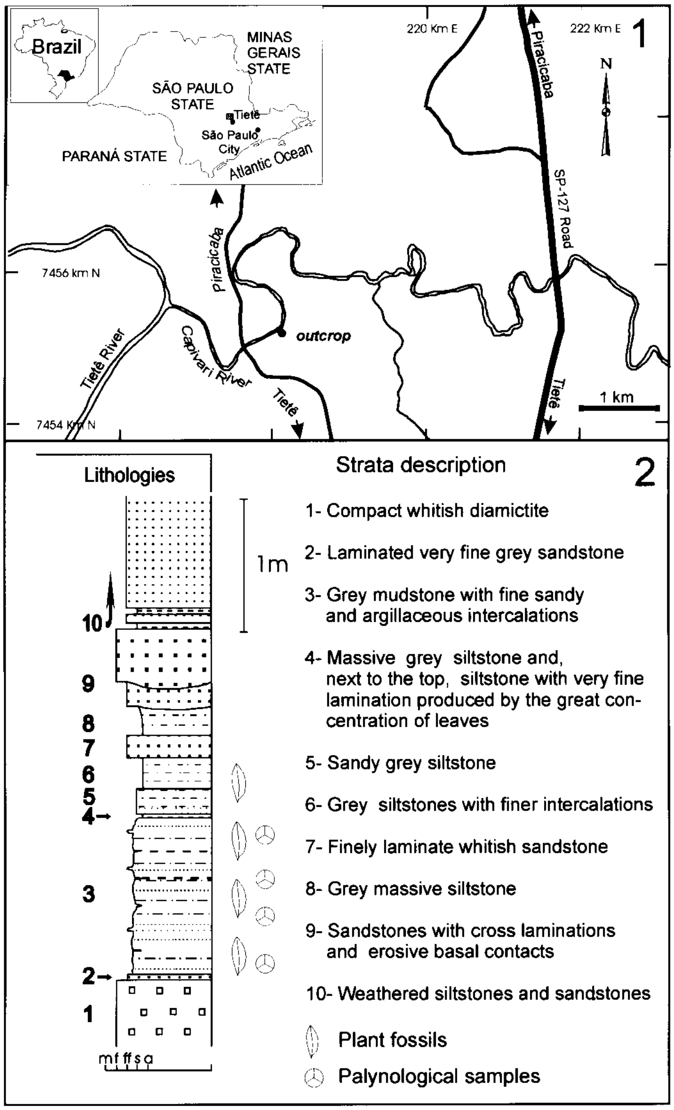


Figure 2–*1*, Location of the studied area; *2*, Stratigraphic succession (after Rohn *et al.*, 2000).

Spores:

Anteturma Proximegerminantes Potonié, 1970.

Turma Triletes Reinsch *emend.* Dettmann, 1963.

Suprasubturma Acavatitriletes Lüber *emend.* Dettmann, 1963.

Subturma Azonotriletes Dettmann, 1963.

Infraturma Laevigati Bennie & Kidston *emend.* Potonié, 1970.

Genus *Leiotriletes* Naumova *emend*. Potonié & Kremp, 1954.

Leiotriletes virkkii Tiwari, 1965 [Plate 1.1].

Genus *Punctatisporites* Ibrahim 1933 *emend*. Potonié & Kremp, 1954.

Punctatisporites gretensis Balme & Hennelly, 1956 [Plate 1.2].

Infraturma RETUSOTRILETI Streel, 1964.

Genus *Retusotriletes* Naumova *emend*. Streel, 1964.

Retusotriletes sp. cf. *R. anfractus* Menéndez & Azcuy, 1969.

Infraturma APICULATI Bennie & Kidston *emend.* Potonié, 1956.

Subinfraturma GRANULATI Dybová & Jachowicz, 1957.

Genus *Converrucosisporites* Potonié & Kremp, 1954.

Converrucosisporites confluens (Archangelsky & Gamerro) Playford & Dino, 2002 [Plate 1.5].

Subinfraturma VERRUCATI Dybová & Jachowicz, 1957.

Genus *Verrucosisporites* Ibrahim 1933 *emend*. Smith, 1971.

Verrucosisporites microtuberosus (Loose) Smith & Butterworth, 1967 [Plate 1.3].

Verrucosisporites morulatus (Knox) Smith & Butterworth, 1967 [Plate 1.4].

Subinfraturma BACULATI Dybová & Jachowicz, 1957.

Genus *Horriditriletes* Bharadwaj & Salujha, 1964.

Horriditriletes ramosus (Balme & Hennelly) Bharadwaj & Salujha, 1964.

Horriditriletes spinobaculosus (Marques-Toigo) *comb. nov*. [Plate 1.6 and 1.7].

Horriditriletes uruguaiensis (Marques-Toigo) Archangelsky & Gamerro, 1979.

Suprasubturma LAMINATITRILETES Smith & Butterworth, 1967.

Subturma ZONOLAMINATITRILETES Smith & Butterworth, 1967.

Infraturma CINGULICAVATI Smith & Butterworth, 1967.

Genus *Lundbladispora* Balme 1963 *emend.* Playford, 1965.

Lundbladispora braziliensis (Pant & Srivastava) Marques-Toigo & Pons *emend.* Marques-Toigo & Picarelli, 1984 [Plate 1.9].

Lundbladispora riobonitensis Marques-Toigo & Picarelli, 1984 [Plate 1.8].

Genus *Vallatisporites* Hacquebard, 1957.

Vallatisporites arcuatus (Marques-Toigo) Archangelsky & Gamerro, 1979 [Plate 1.10].

Genus *Cristatisporites* Potonié & Kremp 1954 *emend.* Butterworth *et al.*,1964.

Cristatisporites microvacuolatus Dias-Fabrício *emend.* Picarelli & Dias-Fabrício, 1990.

Cristatisporites morungavensis Dias-Fabrício *emend.* Picarelli & Dias-Fabrício, 1990 [Plate 1.11].

Infraturma PATINATI (Butterworth & Williams) Smith & Butterworth, 1967.

Genus *Alatisporites* Ibrahim *emend*. Smith & Butterworth, 1967.

cf. *Alatisporites* sp. [Plate 1.12].

Pollen grains:

Anteturma VARIEGERMINANTES Potonié, 1970.

Turma SACCITES Erdtmann, 1947.

Subturma MONOSACCITES Chitaley *emend.* Potonié & Kremp, 1954.

Infraturma DIPOLSACCITI Hart *emend.* Dibner, 1971.

Genus *Cannanoropollis* Potonié & Sah, 1960.

Cannanoropollis densus (Lele) Bose & Maheshwari, 1968 [Plate 1.14].

Cannanoropollis janakii Potonié & Sah, 1960 [Plate 1.13].

Cannanoropollis perfectus (Bose & Maheshwari) Dias-Fabrício, 1981 [Plate 1.15].

Genus *Plicatipollenites* Lele, 1964.

Plicatipollenites malabarensis (Potonié & Sah) Foster, 1975 [Plate 1.17].

Plicatipollenites trigonalis Lele, 1964 [Plate 1.16].

Genus *Potonieisporites* Bhardwaj 1954 *emend.* Bharadwaj, 1964.

Potonieisporites brasiliensis (Nahuys, Alpern & Ybert) Archangelsky & Gamerro, 1979.

Potonieisporites congoensis Bose & Maheshwari, 1968 [Plate 1.19].

Potonieisporites novicus Bhardwaj 1954 *emend.* Poort & Veld, 1997 [Plate 1.18].

Genus *Caheniasaccites* Bose & Kar 1966 *emend.* Azcuy & Di Pasquo, 2000.

Caheniasaccites flavatus (Bose & Kar) *emend.* Azcuy & Di Pasquo, 2000.

Subturma DISACCITES Cookson, 1947.

Infraturma DISACCITRILETI Leschik *emend*. Potonié, 1958.

Genus *Limitisporites* Leschik 1956 *emend.* Schaarschmidt, 1963.

Limitisporites rectus Leschik, 1956.

Limitisporites vesiculosus Schaarschmidt, 1963 [Plate 2.1].

Infraturma DISACCIATRILETI Leschik, 1956.

Genus *Pteruchipollenites* Couper, 1958.

Pteruchipollenites indarraensis (Segroves) Foster, 1979 [Plate 2.2].

Infraturma STRIATITI Pant, 1954.

Genus *Protohaploxypinus* Samoilovich 1953 *emend*. Morbey, 1975.

Protohaploxypinus amplus (Balme & Hennelly) Hart, 1964 [Plate 2.4].

Protohaploxypinus bharadwajii Foster, 1979 [Plate 2.8].

Protohaploxypinus goraiensis (Potonié & Lele) Hart, 1964 [Plate 2.6].

Protohaploxypinus limpidus (Balme & Hennelly) Balme & Playford, 1967 [Plate 2.5].

Protohaploxypinus micros (Hart) Hart, 1964 [Plate 2.3].

Protohaploxypinus perfectus (Naumova) Samoilovich, 1953 [Plate 2.7].

Genus *Striatopodocarpites* Zoricheva & Sedova *ex* Sedova *emend*. Hart, 1964.

Striatopodocarpites antiquus (Leschik) Potonié 1958 [Plate 2.9].

Genus *Striatoabieites* Zoricheva & Sedova *ex* Sedova *emend*. Hart, 1964.

Striatoabieites multistriatus (Balme & Hennelly) Hart, 1964.

Infraturma CIRCUMSTRIATITI Lele & Makada, 1972.

Genus *Illinites* Kosanke 1950 *emend.* Azcuy, Di Pasquo & Ampuero, 2002.

Illinites unicus Kosanke 1950 *emend.* Jansonius & Hills, 1976 [Plate 2.12].

Turma PLICATES Naumova *emend.* Potonié, 1960.

Subturma POLIPLICATES Erdtman, 1962.

Infraturma COSTATI Jansonius, 1963.

Genus *Vittatina* Lüber *ex* Samoilovich 1953 *emend.* Wilson, 1962.

Vittatina corrugata Marques Toigo, 1974 [Plate 2.14].

Vittatina costabilis Wilson, 1962 [Plate 2.13].

Vittatina saccata (Hart) Jansonius, 1962.

Vittatina cf. *V. vittifera* (Lüber & Valtz) Samoilovich, 1953 [Plate 2.11].

Vittatina wodehousei (Jansonius) Hart, 1964 [Plate 2.10].

Algae:

Division PRASINOPHYTA Round, 1971.

Order PTEROSPERMATALES Schiller, 1925.

Family TASMANITACEAE Sommer *emend.* Sommer & Van Boekel, 1963.

Genus *Tasmanites* Newton, 1875.

Tasmanites sp.

Division CHLOROPHYTA Pascher, 1914.

Class CHLOROPHYCEAE Kützing, 1843.

Order CHLOROCOCCALLES Marchand *emend*. Pascher, 1915.

Family BOTRYOCOCCACEAE Wille, 1909.

Genus *Botryococcus* Kützing, 1849.

Botryococcus braunii Kützing, 1849 [Plate 2.15].

Incertae sedis:

Genus *Deusilites* Hemer & Nygreen, 1967.

Deusilites tenuistriatus Gutiérrez, Césari & Archangelsky, 1997 [Plate 2.16].

Genus *Portalites* Hemer & Nygreen, 1967.

Portalites gondwanensis Nahuys, Alpern & Ybert, 1968 [Plate 2.17].

Systematic palynology

Genus *Horriditriletes* Bharadwaj & Salujha, 1964

Type species.–*Horriditriletes curvibaculosus* Bharadwaj & Salujha, 1964.

Horriditriletes spinobaculosus (Marques-Toigo)
comb. nov.
Plate 1.6 and 1.7

1974 *Acanthotriletes spinobaculosus,* Marques-Toigo, p. 602, Pl. I, Figs. 1 and 1a.
2002 ? *"Acanthotriletes" menendezii* (sic), Dino & Playford, p. 26, Fig. 3.8.

Emended diagnosis.–Spores radial trilete. Amb triangular, with straight or slightly concave sides. Laesurae simple or labrate (1-4 µm high and wide overall), extending 4/5 or up to equator. Exine 1-1.5 µm thick, bearing predominantly spinose sculpture (1.5-2.4 µm in basal diameter and 2-3 µm in height); a few coni (2 µm in basal diameter and height) and bacula (1-3 µm in basal diameter and up to 2.8 µm in height), which are only sometimes present, and rare verrucae (up to 1 µm in basal diameter). Elements 0.5-3 µm apart.

Holotype.–From Marques-Toigo (1974, Pl. I, Figs. 1 and 1a); slide MP-P 615, coordinates (under Zeiss Microscope 4315857): 91.0 x 2.8 (housed at Instituto de Geociências of the Universidade Federal do Rio Grande do Sul).

Locus typicus.–Paso de Las Bochas, Rio Negro, Uruguay.

Stratum typicus.–San Gregorio Formation, Early Permian of Uruguay.

Description.–Spores radial trilete. Amb triangular with straight or slightly convave sides and rounded angles. Laesurae distinct, simple or accompanied by labra, ca. 1 to 4 µm in both height and wide, extending at least 4/5 of distance to equator. Exine 1-1.5 µm thick, sculptured irregularly with spinae (mainly), occasional coni and bacula and rare verrucae. Sculptural elements are scarcely on proximal side.

Dimensions (on 14 specimens).–Equatorial diameter 34-53 µm (including sculptural elements).

Discussion.–Foster (1979, p. 38) clarified the diagnosis of this genus as follows: "Spores radial, trilete, acavate. Amb triangular with rounded apices and straight, slightly convex or concave sides. Laesurae simple; length 1/2-3/4 of spore radius; sometimes flanked by a laevigate, faintly darkened margo. Comprehensively sculptured: bacula are predominant elements, but they are invariably admixed with a few spinae and coni". Some Gondwana species with spinae, coni, bacula and verrucae, in varying proportions, have been attributed to this genus, and *Acanthotriletes spinobaculosus* Marques-Toigo, 1974, is referred to it here. It is noted that *Acanthotriletes* Naumova 1939 ex Naumova 1949 was erected to accommodate spores with a circular amb, which, furthermore, has been shown to be based on an acritarch (see Jansonius & Hills, 1976, card 25 and Backhouse, 1991, p. 259), making the use of this genus unsuitable.

Distribution.–First recorded only from the type locality, San Gregorio Formation in Uruguay, which is correlated to the upper Itararé Subgroup in Brazil, it is now known from the northeastern Paraná Basin as well.

Comparisons.–In *Horriditriletes superbus* (Foster) Césari, Archangelsky & Seoane, 1995, the sculptural elements are larger, with spines reaching up to 3-5 µm height. *H. gondwanensis* (Tiwari & Moiz) Foster, 1975 has more markedly concave sides. *H. curvibaculosus* Bharadwaj & Salujha 1964 and *H. ramosus* (Balme & Hennelly) Bharadwaj & Salujha, 1964 are sculptured mainly with bacula, *H. uruguaiensis* (Marques-Toigo) Archangelsky & Gamerro, 1979 with spinae and verrucae, and *H. tereteangulatus* (Balme & Hennelly) Backhouse, 1991 with short spines. Based on the illustration, the specimen assigned to *"Acanthotriletes" menendezii* González-Amicon 1973 by Dino & Playford (2002) from the Late Carboniferous of the Parnaíba Basin is very similar and possibly identical to *H. spinobaculosus*. The real *Acanthotriletes menendezii* González-Amicon, 1973 is larger in overall equatorial diameter (52-59 µm) and bears spines and bacula up to 5 and 6.5 µm in height, respectively.

Genus *Alatisporites* Ibrahim *emend*. Smith & Butterworth, 1967

Type species.–*Alatisporites pustulatus* Ibrahim, 1932.

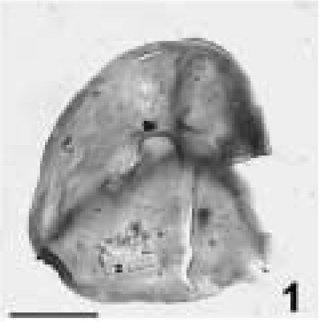
cf. *Alatisporites* sp.
Plate 1.12

Description.–Spore radial trilete, with three pseudosacci. Intexine body triangular in outline, with rounded apices and straight to slightly concaves sides. Laesurae straight, extending to margin of body, with lips up to 7 µm wide. Exoexine smooth. Three globous pseudosacci, intramicroreticulate, about 1 µm thick, are raised from the interradial area and extend over the radial area, overlapping about 4/5 of the body radius on the distal face.

→

PLATE 1–*1, Leiotriletes virkkii* Tiwari, 1965 (Slide: IG-P: 373A, England Finder coordinate: P34-3); *2, Punctatisporites gretensis* Balme & Hennelly, 1956 (376B, O42); *3, Verrucosisporites microtuberosus* (Loose) Smith & Butterworth, 1967 (375C, F34-3); *4, Verrucosisporites morulatus* (Knox) Smith & Butterworth, 1967 (377B, K34); *5, Converrucosisporites confluens* (Archangelsky & Gamerro) Playford & Dino, 2002 (377A, R39-3); *6* and *7, Horriditriletes spinobaculosus* (Marques-Toigo) *comb. nov.* (6: 377C, F38; 7: 377C, U42); *8, Lundbladispora riobonitensis* Marques-Toigo & Picarelli, 1984 (375C, G48); *9, Lundbladispora braziliensis* (Pant & Srivastava) Marques-Toigo & Pons *emend.* Marques-Toigo & Picarelli, 1984 (376A, H52); *10, Vallatisporites arcuatus* (Marques-Toigo) Archangelsky & Gamerro, 1979 (377C, N38); *11, Cristatisporites morungavensis* Dias-Fabrício *emend.* Picarelli & Dias-Fabrício, 1990 (373B, C54-1); *12,* cf. *Alatisporites* sp. (375A, J34-1); *13, Cannanoropollis janakii* Potonié & Sah, 1960 (373A, C28-2); *14, Cannanoropollis densus* (Lele) Bose & Maheshwari, 1968 (375A, L51); *15, Cannanoropollis perfectus* (Bose & Maheshwari) Dias-Fabrício, 1981 (376B, J54-4); *16, Plicatipollenites trigonalis* Lele, 1964 (377C, O55); *17, Plicatipollenites malabarensis* (Potonié & Sah) Foster, 1975 (377B, G49-3); *18, Potonieisporites novicus* Bhardwaj 1954 *emend.* Poort & Veld, 1997 (376A, L47-2); *19, Potonieisporites congoensis* Bose & Maheshwari, 1968 (376A, L41). Bar scale corresponds to 20 µm.

Plate 1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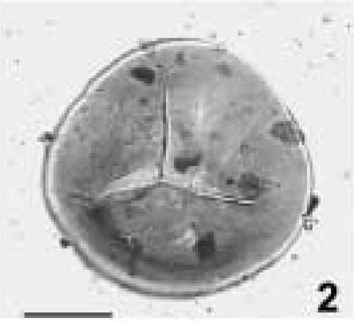
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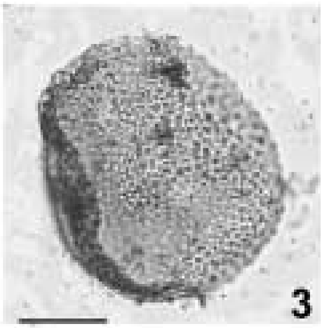
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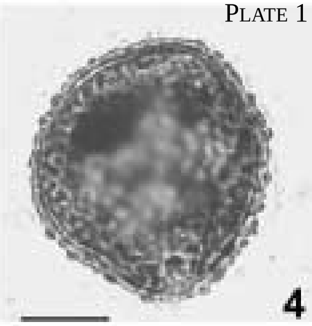
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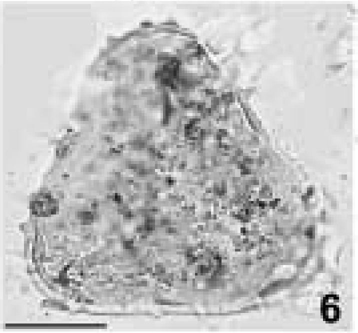
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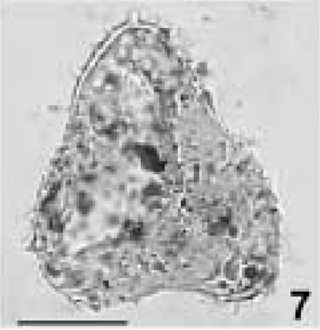
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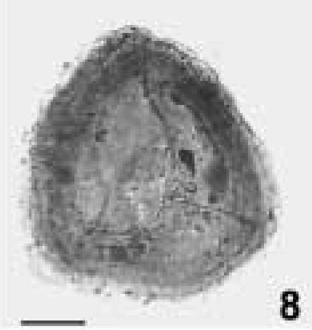
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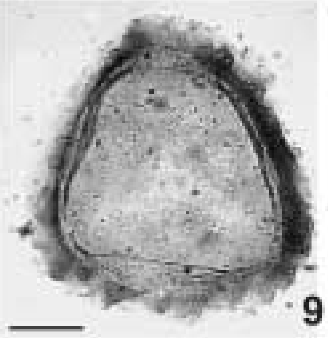
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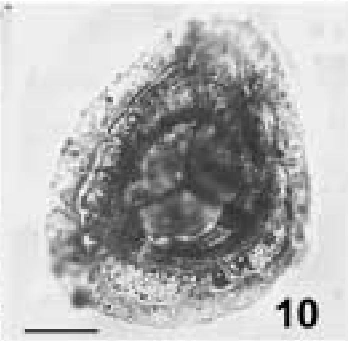
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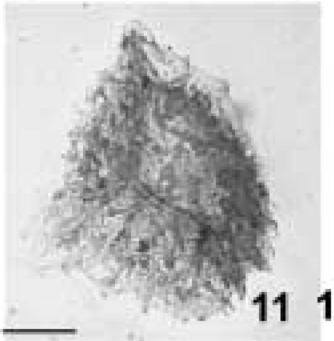
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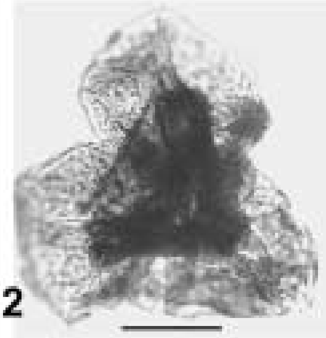

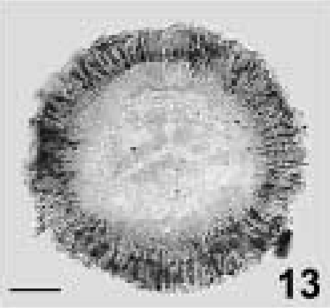
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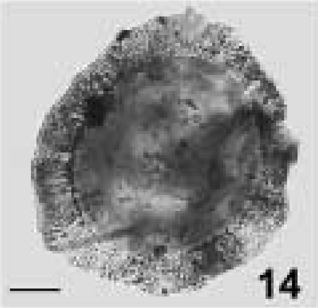
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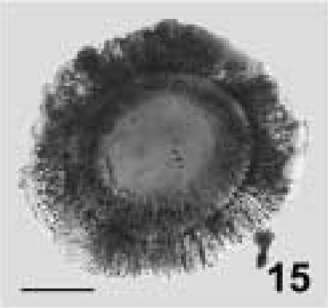
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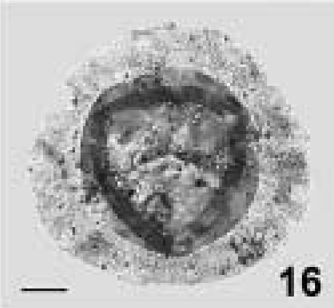
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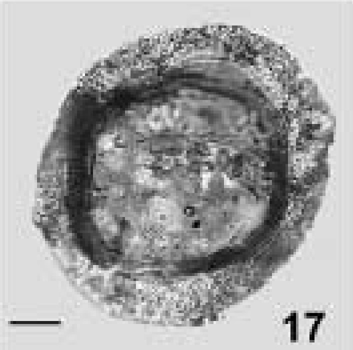
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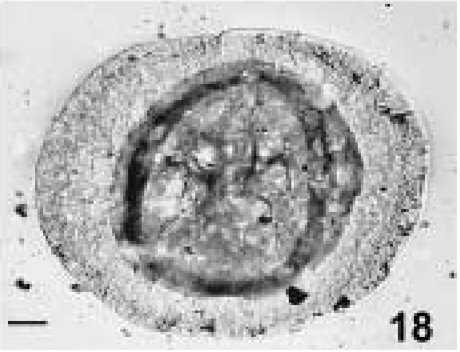
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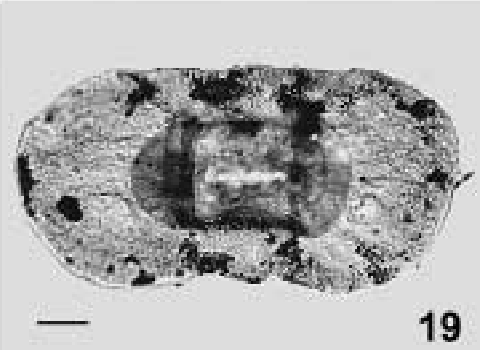
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Dimensions.–Overal equatorial diameter 76 µm, central body 43 µm (one specimen).

Discussion.–According to the original diagnosis, *Alatisporites* (Ibrahim) Smith & Butterworth, 1967 comprises trilete spores "in which the exoexine is separated and expanded from the intexine body proximally between the laesura and distally (except in polar region), to form pseudosacci" (Smith & Butterworth, 1967, p. 279). The pseudosacci, in variable number, are developed in the interradial areas. Only one specimen was found in the material studied, having three pseudosacci developed around the radial area.

Genus *Pteruchipollenites* Couper, 1958

Type species.–Pteruchipollenites thomasii Couper, 1958.

Pteruchipollenites indarraensis (Segroves) Foster, 1979
Plate 2.2

1969 *Alisporites indarraensis*, Segroves, p. 191-192, Pl. 6, Figs. A-E.
1979 *Pteruchipollenites indarraensis,* Foster, p. 75, Pl. 25, Figs. 5-8.
For additional synonymy see Anderson (1977, p. 114) and Foster (1979, p. 75).

Description.–Disaccate pollen grains, asulcate, haploxyponoid with transversely oval outline. Corpus oval in the transversal axis. Sacci intramicroreticulate, crescentic in outline, connected laterally by discrete folds; finely intrareticulate.

Dimensions.–Total width 46 and 63 µm; saccus width 37 and 38 µm; corpus width 26 and 30 µm, length 38 and 39 µm (in two specimens).

Discussion.–According to Anderson (1977, p. 114), this species is comparable to that designated as *Alisporites nuthalensis* Clarke, 1965 as recorded by Daemon & Quadros (1970), recovered from the I_2 to L_2 subintervals of the Paraná Basin (specimens number P331C in Daemon & Quadros, op. cit.). It is noted that *Alisporites nuthalensis* was considered a synonymy of *Alisporites splendens* (Leschik) Foster, 1979, which possesses a distal sulcus.

Previous records.–Permian of Australia (Segroves, 1969; Foster, 1979) and Africa (Anderson, 1977).

Main characteristics of the Palynoflora

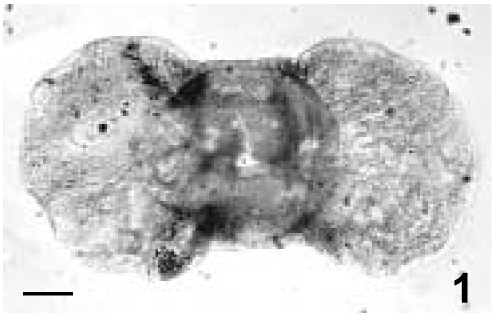
Gymnospermous taeniate and polyplicate pollen grains are dominant with 40 to 72% of the total assemblage, recorded from the four levels analysed. Most frequent species are of *Protohaploxypinus*, *Illinites* and *Vittatina*, which are quite diversified. Subordinate pteridophytic trilete spores constitute 15 to 42 %. Filicopsida *(Punctatisporites, Horriditriletes)* and Lycopsida *(Lundbladispora, Vallatisporites* and *Cristatisporites)* are most abundant. Non-taeniate bisaccate and monosaccate pollen grains *(Cannanoropollis, Plicatipollenites, Potonieisporites,* and *Limitisporites)* are found as minor constituents.

Microplanktonic elements are relatively abundant and are represented by Chlorophyta *(Botryococcus braunii)* and Prasinophyta (*Tasmanites* sp.). These algal species were recorded in variable proportions, reaching up to 10.5% and 5.3%, at different levels of the succession.

→

PLATE 2–*1, Limitisporites vesiculosus* Schaarschmidt, 1963 (Slide: IG-P: 376B, England Finder coordinate: S47-2); *2, Pteruchipollenites indarraensis* (Segroves) Foster, 1979 (373B, Q37-3); *3, Protohaploxypinus micros* (Hart) Hart, 1964 (376B, Q44); *4, Protohaploxypinus amplus* (Balme & Hennelly) Hart, 1964 (376B, V42-3); *5, Protohaploxypinus limpidus* (Balme & Hennelly) Balme & Playford, 1967 (376A, U37-3); *6, Protohaploxypinus goraiensis* (Potonié & Lele) Hart, 1964 (373B, G55-4); *7, Protohaploxypinus perfectus* (Naumova) Samoilovich, 1953 (376B, N43-4); *8, Protohaploxypinus bharadwajii* Foster, 1979 (376B, E45-3); *9, Striatopodocarpites antiquus* (Leschik) Potonié, 1958 (373B, M31); *10, Vittatina wodehousei* (Jansonius) Hart, 1964 (377C, S45); *11, Vittatina* cf. *V. vittifera* (Lüber & Valtz) Samoilovich, 1953 (373B, N31) (longitudinally folded); *12, Illinites unicus* Kosanke 1950 *emend.* Jansonius & Hills, 1976 (376A, J38-1); *13, Vittatina costabilis* Wilson, 1962 (377B, L38-4); *14, Vittatina corrugata* Marques Toigo, 1974 (373A, P33-4); *15, Botryococcus braunii* Kützing, 1849 (373A, K43-2); *16, Deusilites tenuistriatus* Gutiérrez, Césari & Archangelsky, 1997 (377A, Y42-1); *17, Portalites gondwanensis* Nahuys, Alpern & Ybert, 1968 (377C, P39). Bar scale corresponds to 20 µm.

PLATE 2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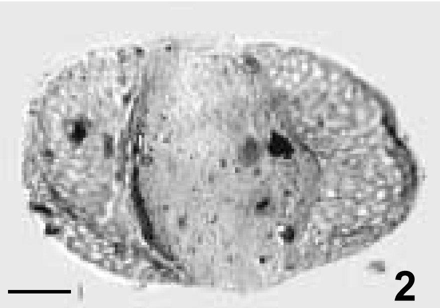
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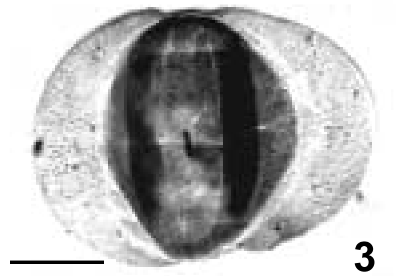
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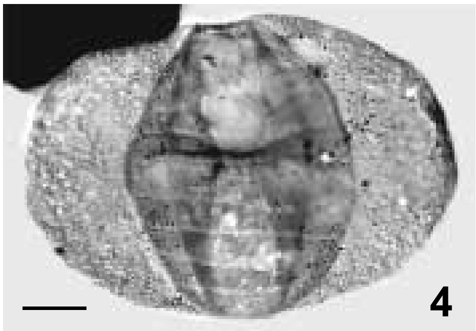
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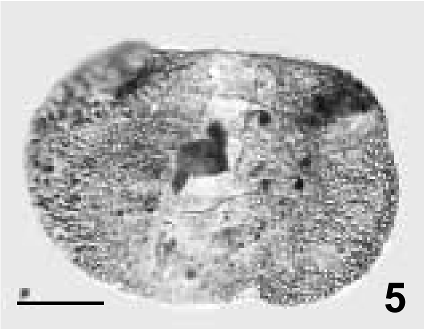
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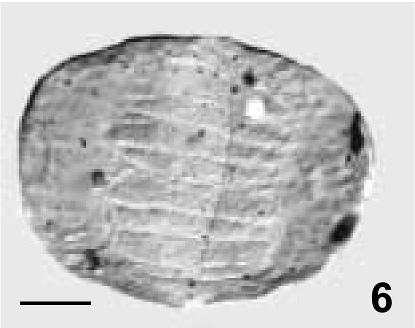
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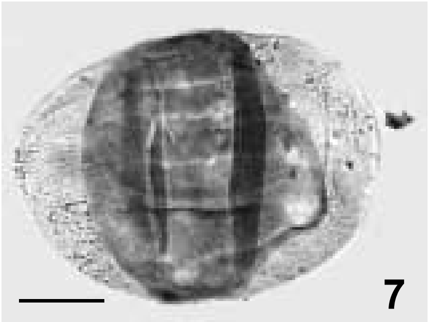
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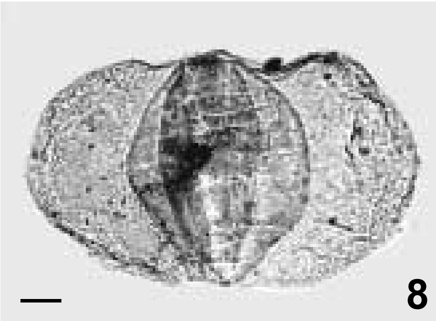
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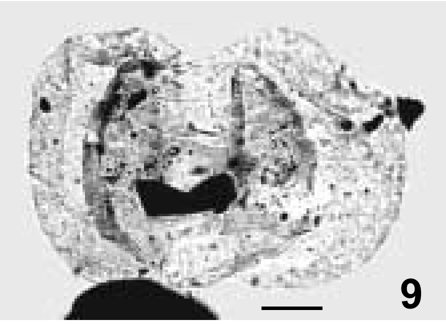
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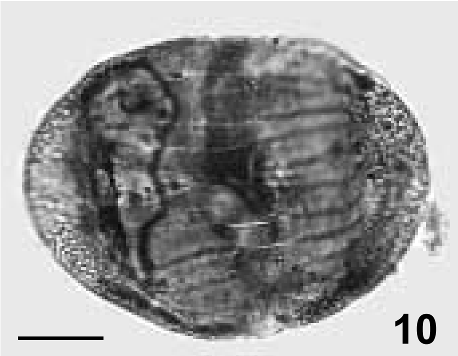
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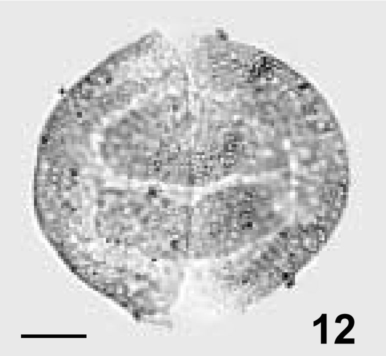
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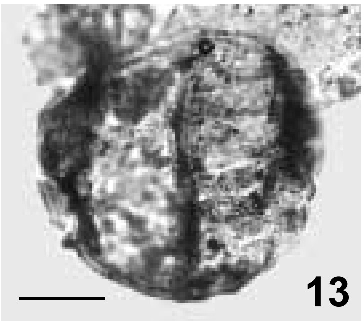
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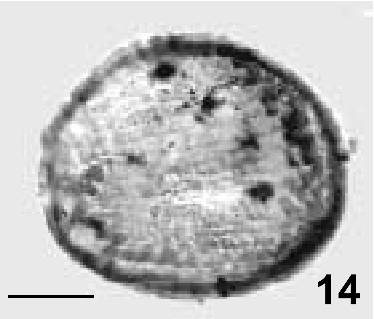
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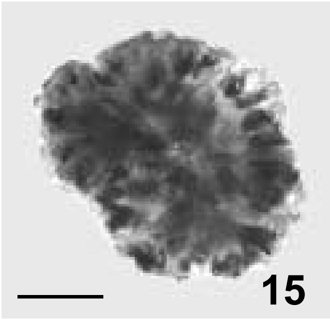
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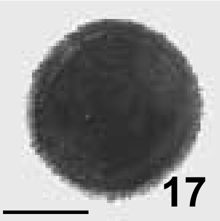
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Portalites gondwanensis was recorded only at the lowest level, reaching up to ca. 10%. *Deusilites tenuistriatus* occurs associated with the two species of algae in the material studied herein, at the lower two levels, with about 6.4 % and 2.1%.

CONCLUSIONS

Biostratigraphy, age and correlation

Four palynozones were recognised from the Upper Palaeozoic of the Paraná Basin, i. e. the *Ahrensisporites cristatus*, *Crucisaccites monoletus*, *Vittatina costabilis* and *Lueckisporites virkkiae* Interval Zones, in this stratigraphic order (Souza & Marques-Toigo, 2001, 2003). The *Vittatina costabilis* Interval Zone is marked by the appearance of polyplicate pollen grains of the genus *Vittatina*, bisaccate taeniate species of *Protohaploxypinus* (e. g., *P. micros, P. goraiensis*) and *Illinites unicus*, as well as a granulate spore *Converrucosisporites confluens (=Granulatisporites confluens)*. This Zone is subdivided in the subzones of *Protohaploxypinus goraiensis* and *Hamiapollenites karroensis*. Species restricted to the *Protohaploxypinus goraiensis* Subzone, of Early Permian age (Sakmarian/Artinskian), are recorded in the studied material. These are *Protohaploxypinus goraiensis, P. micros, Illinites unicus* and *Converrucosisporites confluens*. Diagnostic species of the subsequent subzone, such as *Hamiapollenites karroensis* and *Striatopodocarpites fusus* have not been found. With regard to the scheme proposed by Daemon & Quadros (1970), the palynoflora corresponds to the H_3 to I intervals.

Within the Paraná Basin, similar or equivalent palynofloras are known from São Paulo, in Cerquilho (Souza *et al.*, 2001), Serra dos Paes (Souza *et al.*, 1999), from Santa Catarina State (Pons, 1976a, 1976b); these are related to the Itararé Subgroup and possibly the basal part of the Guatá Subgroup (Cerquilho). In the State of Rio Grande do Sul, palynofloras from the Itararé as well as from the Rio Bonito Formation are very similar and are all included in the *Protohaploxypinus goraiensis* Subzone (e. g., Ybert, 1975; Dias, 1993).

Elsewhere in South America, similar palynofloras seem to be present in the Chaco-Paraná Basin, related to the Lower *Cristatisporites* Zone (Vergel, 1993; Archangelsky & Vergel, 1996) and in central-western Argentina, *Fusacolpites fusus-Vittatina subsaccata* Interval Biozone (Césari & Gutiérrez, 2000). These comparisons are based on the presence of species stratigraphically restricted, but considerable quantitative differences are observed, attributed to paleoecological control.

Palaeoenvironmental considerations

Continental and marine environmental conditions exist in the upper Itararé Subgroup, as deduced from sedimentary structures, lithofacies and fossil contents. The palynoflora was retrieved from a grey mudstone horizon with sandy and argillaceous layers, bearing carbonised plant remains. Well preserved leaves were recorded from immediately below and above this horizon.

Deusilites tenuistriatus is known from non-marine low salinity environments, characterised by *Botryococcus*, as in Argentina, and also in association with marine fossils, as in the Brazilian Paraná Basin (Souza, 1998). This genus is usually regarded to be an acritarch, but it might also correspond to the phycomata of a prasinophyte. *Portalites gondwanensis* has a controversial biological affinity, being considered variously as an alga, acritarch or *incertae sedis*. Elsik (1996) considered it to be fungal in origin. This species is very common in the coal-bearing strata of the Paraná Basin and may suggest a paralic environment for the lowermost level studied, where reaches up to about 10%. Fossil records of *Tasmanites*, a prasinophycean alga, are from inshore environments, shallow lagoons and deltaic areas, as well as ocean sediments, just like the modern alga (Guy-Ohlson, 1996).

The abundance of land-derived plant debris as well as the dominance of terrestrial palynomorphs and the presence of *Botryococcus* show the influence of freshwater conditions. However, the presence of *Tasmanites* in low numbers might suggest moderate salinity to brackish conditions in lagoonal or deltaic environments.

ACKNOWLEDGEMENTS

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LATE CRETACEOUS TO EARLY TERTIARY POLLEN GRAINS FROM OFFSHORE TANO BASIN, SOUTHWESTERN GHANA

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Abstract

Miospores recovered from the interval 6,700 ft-1,260 ft (2,042 m-384 m) in well ST-8 offshore Tano Basin (Ghana) have been studied and discussed. The miospore assemblage is dominated by angiospermic pollen. Pteridophytic or trilete spores are mainly laevigate forms whilst the sculptured forms are few in the assemblage. Pollen taxa are largely monocolpates with other subordinate apertural types, showing appreciable variation in the exine. The miospore association, together with fungal and algal spores, provides evidence of freshwater swamp or marsh environment. The monocolpates are attributed to the palmae and belong to the tropical-subtropical Senonian Palmae Province of Africa and South America (ASA) region. The assemblage is indicative of a warm and humid climate. Stratigraphically significant miospore taxa point out to Campanian to Eocene age for the sediments.

Key words: Monocalpates, palmae, angiosperms, pteridophytes, Ghana.

Resumen

Se han estudiado y discutido mioesporas extraídas en el intervalo entre 6.700 y 1.260 pies (entre 2.042 m y 384 m) del sondeo litoral ST-8 de la Cuenca de Tano (Ghana). La asociación de mioesporas está dominada por polen de angiospermas. Esporas triletes o de pteridofitas se presentan como formas levigadas, mientras son muy pocas las formas ornamentadas. Los taxones de polen son principalmente polenes monocolpados con otros grupos subordinados de diferente tipo apertural, mostrando una variación importante en la exina. La asociación de mioesporas, junto a la de esporas de algas y hongos, nos facilitan evidencias de la presencia de medios dulceacuícolas pantanosos. Los pólenes de tipo monocolpados puede ser atribuidos a palmaceas, incluidas en la provincia Palmae, provincia subtropical-tropical africana de edad Senoniense situada en la región Sudamericana (ASA). La asociación es indicativa de clima húmedo y cálido. Estratigraficamente, los taxones de mioesporas más representativos nos indican una edad desde el Campaniense al Eoceno.

Palabras clave: Monocolpados, palmáceas, angiospermas, pteridofitas, Ghana.

INTRODUCTION

Campanian to Eocene sediments used for this study was obtained from the interval 6,700 ft-1,260 ft (2,042 m-384 m) of exploratory oil well ST-8 offshore Tano Basin. The well is located offshore in the Gulf of Guinea, at latitude 04º 43' 37.43" N and longitude 03º 00' 08.22" W (Fig. 1). The sediments are mainly limestones, shales, calcareous shale, sandstones and sandy shales.

In this study, some taxa of palynomorphs which appear for the first time but with few specimens are determined as form genera, whilst forms already described by previous authors have been commented on and compared with other forms in the ASA region to deduce the age of the sediments. The palynological studies will contribute the knowledge of tropical stratigraphy and provide information on sequential patterns of vegetation developments at those times, in this particular region.

GEOLOGICAL SETTING OF THE TANO BASIN

Kitson (1928) grouped the sedimentary rocks of the Tano Basin as the ‘Apollonian System’. These are Cretaceous to Eocene in age and occupy the southwest corner of Ghana and larger portion of southeast Côte d’Ivoire. The basin covers an area of 1,165 km^2 between the mouths of the Ankobra River to the east, and the Tano River to the west. The rocks onshore consist of alternating sands, clays and limestones with gentle dips overlying the Precambrian metamorphosed Birimian System composed of schist, phyllite and greywackes. At depth, the sands and clays are more compact and pass into sandstones and shales. The only prominent stratigraphic marker of the area is a series of fossiliferous limestones and clays with bivalves, gastropods, foraminifera and ostracods dated Cenomanian-Maastrichtian (Cox, 1952). Khan (1970) and recent reports from some borehole data indicate Aptian –Oligocene age.

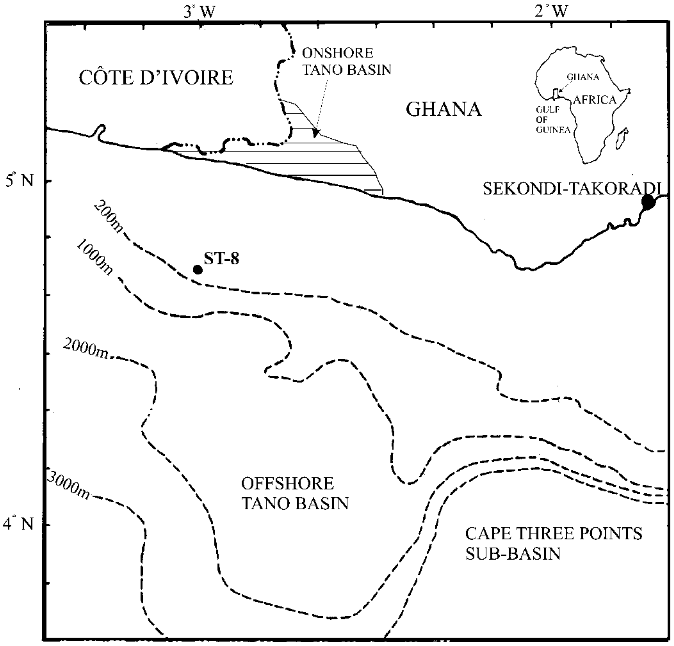

FIGURE 1–Map of offshore Tano Basin showing location of exploratory oil well ST-8 (modified after Offshore Activity Map of GNPC, 1994).

Offshore, seismic surveys of the Ocean Drilling Programme (ODP) and Submersible Deep Dives (Equanaute Survey) revealed a 130 km long NE-SW trending marginal ridge. This ridge is associated with the Côte d’Ivoire –Ghana transform margin (CIG), which resulted from the continental break up due to transform motion, and subsequent opening, of the Atlantic Ocean during Early Cretaceous times (Mascle *et al.*, 1988). Larmarche (1997) indicated that the ridge has sedimentary sequence continuous with the synrift sediments of the Ivorian Basin. Guiraud *et al.* (1997) identified three lithofacies which constituted the main components of the CIG sedimentary wedge. These are dark clays, yellowish siltstones and interbedded greenish fine sandstone, and grey coarse sandstone and microconglomerates. These lithfacies have been observed in boreholes drilled in the Tano Basin. A shallow marine deltaic environment has been suggested for the synrift deposits of the CIG ridge. Oboh-Ikuenobe *et al.* (1998) and Masure *et al.* (1998) assigned an age ranging from Late Albian to the Pleistocene to sediments drilled from the passive margin of the sedimentary sequence. Similar ages (Aptian-Oligocene) have been reported from borehole data in the study area (i. e. Tano basin).

MATERIALS AND METHODS

Shales, calcareous shale, sandstones and sandy shales were examined for palynomorphs. The standard laboratory techniques for the extraction of palynomorphs from sediments (Phipps and Playford, 1984) were followed. Heavy mineral separation was done in Zinc Bromide (ZnB_2) with S. G. of 2.0. The palynomorphs were strewn in Polyvinyl Alcohol (PVA) on slides and cured in ultra violet light (UV). Karl Zeiss Axiolab microscope fitted with a MC 80 camera was used for optical microscopy and photomicroscopy.

SYSTEMATIC PALEONTOLOGY

The suprageneric classification of miospores follows Potonié and Kremp (1954, 1955, 1956), Potonié (1956, 1958, 1960) and Dettmann (1963) and Smith and Butterworth (1967). Nomenclature follows the rules on priority and typification accepted by the International Code of Botanical Nomenclature (ICBN, Stafleu, 1978). The Genera File of fossil Spores and Pollen Grains edited by Jansonius and Hill (1976-1980) was consulted. Systematic descriptions are mainly of newly described pollen form species. The rarity of specimens in some cases has not allowed the formal description of these forms. These forms will be formally described as more specimens become available. No attempt is made to re-describe taxa that have already been adequately described by previous workers. However, remarks are made for some previously described taxa.

ANTETURMA Pollenites Potonié, 1931
SUBTURMA Monocolpates Iversen and Troels-Smith, 1950
Genus *Auriculiidites* Elsik 1964 ex Elsik and Thanikaimoni, 1970
Auriculiidites reticulatus Elsik, 1964
Plate 1, Figures 1, 2

Remarks.–The specimens are monosulcate with two auricula outgrowths at the ends of the grain and with a reticulate surface ornamentation. *Pediculisporis* Belsky *et al.*, 1965 also shows auricula-like structures, but these are at the ends of club-like projections at the ends of grain.

Occurrences.–Campanian-Early Maastrichtian, Venezuela; Campanian-Maastrichtian, Nigeria; Campanian, Peru; Early Maastrichtian, Egypt, Sudan; Maastrichtian, Somalia; Senonian, Gabon.

Auriculiidites sp.
Plate 1, Figure 3

Description.–Oval monosulcate pollen grain with auriculate structures at the extremities of the grain. Sulcus long, extending to diameter of the grain; exine thin, 1.5 µm-2.0 µm thick, microreticulate; muri 0.2-0.35 µm thick, lumina 0.3-0.5 µm wide.

Dimensions.–Equatorial diameter excluding auriculate structures 35-50 µm, mean 42 µm (5 specimens measured).

Remarks.–The microreticulate ornamentation and the overall smaller size differentiate this species from *A. reticulatus*.

Occurrence.–Campanian-Maastrichtian of present study.

Genus *Spinizonocolpites* Muller, 1968
Spinizonocolpites baculatus Muller, 1968
Plate 1, Figures 22, 28

Remarks.–Grains are separated by a continuous equatorial colpus into two slightly equal parts. *S. baculatus* differs from *S. echinatus* Muller, 1968 by baculate processes rather than the echinate processes.

Occurrences.–Maastrichtian, Egypt, Sudan; Maastrichtian, Cote d'Ivoire; Maastrichtian-Paleocene, Venezuela; Maastrichtian-Eocene, Nigeria; Late Maastrichtian, Senegal, Cote d'Ivoire; Campanian-Maastrichtian, Brazil; Maastrichtian-Paleocene, Carribean, Borneo.

Spinizonocolpites echinatus Müller, 1968
Plate 1, Figures 11, 12, 13

Remarks.–Specimens are morpologically similar to *Spinizonocolpites intraregulatus* Muller *et al.*, 1987, in overall size and nature of processes. However *S. intraregulatus* show intraregulate surface ornamentaion whereas *S. echinatus* has smooth to finely reticulate ornamentation. *S. echinatus* also has closely spaced processes and with expanded or bulbous bases.

Occurrences.–Eocene, Venezuela; Late Maastrichtian, Somalia; Maastrichtian, Egypt, Sudan; Tertiary, Gabon, Cameroun; Campanian-Maastrichtian, Egypt; Campanian-Maastrichtian, Brazil; Maastrichtian-Eocene, Nigeria; Maastrichtian-Paleocene, Carribean, Borneo.

Genus *Longapertites* Van Hoeken-Klinkenberg, 1964
Longapertites vaneedenburgi Germeraad, Hopping and Muller, 1968
Plate 1, Figure 5, 7

Remarks.–*L. vaneendenburgi* is distinct from *L. marginatus* Van Hoeken-Klinkenberg, 1964 by the former having an elongate and semi circular shape. *L. vaneendenburgi* also differs from *L. marginatus* in the absence of a coarse reticulate pattern on the proximal side and from *L. proxapertitoides* Van der Hammen & Garcia de Mutis, 1965 (Plate 1, Figure 10), in the finely perforate wall.

Occurrences.–Late Maastrichtian, CIG transform margin; Maastrichtian-Eocene, Nigeria; Eocene, India; Campanian-Maastrichtian, Brazil; Maastrichtian-Eocene, Venezuela.

Longapertites marginatus Van Hoeken-Klinkenberg 1964
Plate 1, Figure 4, 6

Remarks.–Specimens are triangular in shape with a long curved sulcus, almost encircling the grain. Distal side is V-shaped, proximal side straight to moderately convex; exine microreticulate or finely perforate.

Occurrences.–Late Maastrichtian, Cote d'Ivoire; Campanian-Eocene, Nigeria; Eocene, India.

Genus *Mauritiidites* Van Hoeken-Klinkenberg, 1964
Mauritiidites crassibaculatus Van Hoeken-Klinkenberg, 1964
Plate 1, Figure 8

Remarks.–Specimens are monosulcate with sulcus extending about two thirds of grain diameter. Exine thin with short baculate processes. Salami (1985) has shown by Scanning Electron photomicrographs that the exine between individial baculae is finely pilate and granulate.

Occurrences.–Campanian-Eocene, Nigeria; Late Maastrichtian, Somalia.

Genus *Proxapertites* Van der Hammen, 1956
Proxapertites cursus Van Hoeken-Klinkenberg, 1966
Plate 1, Figures 23, 26, 29

Remarks.–Van der Hammen (1956) considered the pollen of *Proxapertites* as dyads with contiguous apertural faces. Muller (1968) however, found neither an evidence of a membrane covering the so-called 'aperture' nor a double membrane in the fossil grains interpreted as dyads. Observation from the present study has confirmed the opinion of Muller that, there is but a single membrane uniting the two halves of the pollen.

Occurrences.–Maastrichtian-Eocene, Nigeria; Maastrichtian, Egypt, Sudan; Early Tertiary, Cameroun; Paleocene-Eocene, India; Paleocene, Venezuela; Late Maastrichtian, Borneo, Carribean.

Proxapertites operculatus Van der Hammen, 1956
Plate 1, Figure 24, 25

Remarks.–*Proxapertites operculatus* has finer reticulum with much smaller or narrower lumina (<0.5 µm) than that of *P. cursus* (1.5 µm).

Occurrences.–Early Tertiary, Cameroun; Maastrichtian-Eocene, Nigeria; Paleocene-Eocene, Venezuela; Paleocene-Oligocene, India; Paleocene, Brazil; Maastrichtian-Paleocene, British Guiana; Maastrichtian, Carribean, Borneo.

Genus *Retimonocolpites* Pierce, 1961
Retimonocolpites sp.
Plate 2, Figure 35, 36

Description.–Pollen grain elliptical to elongate in shape; colpus extending to about two thirds of pollen grain diameter. Exine reticulate, 1 µm thick. Lumina 0.5-1.5 µm wide; muri 0.5-1 µm thick.

Dimensions.–Equatorial diameter 42-60 µm, mean 50 µm (6 specimens measured).

Occurrence.–Campanian-Maastrichtian of present study.

SUBTURMA Triptyches Potonié, 1970
INFRATURMA Isotricolpati Potonié, 1970
Genus *Retitricolpites* Van der Hammen, 1956
Retitricolpites sp. cf. *R. Americana* Wymstra, 1964
Plate 2, Figures 6, 7, 8

Remarks.–The specimens sre comparable to *R. Americana* Wymstra, 1964 known from the Eocene of Nigeria (Van Hoeken-Klinkenberg, 1966).

Occurrence.–Paleocene-Eocene of present study.

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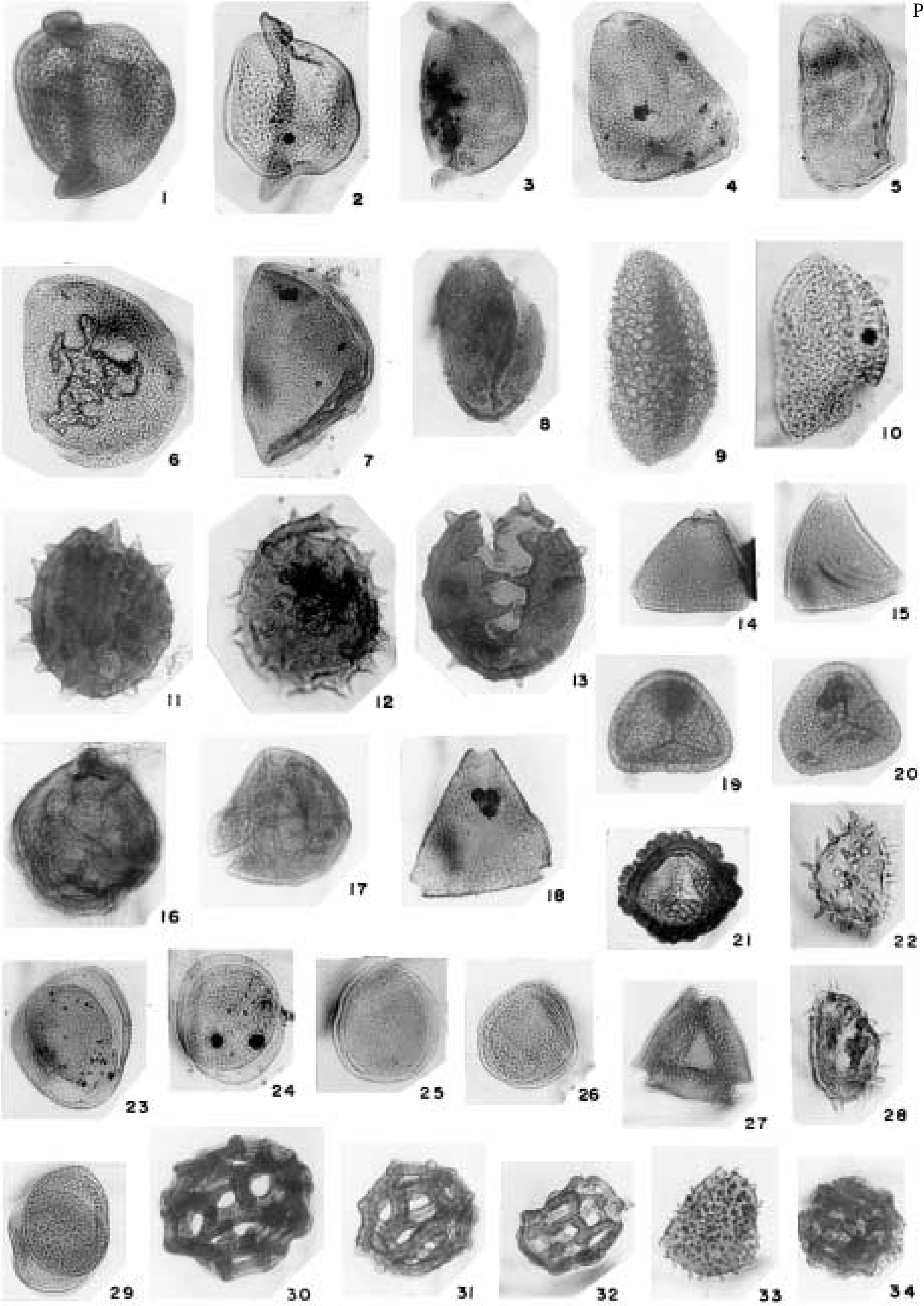
PLATE 1–All figures x 660. *1, 2, Auriculiidites reticulates* Elsik, 1964. *3, Auriculiidites* sp. *4, 6, Longapertites marginatus* Van Hoeken-Klinkenberg, 1964. *5, 7, Longapertites vaneendenburgi* Germeraad, Hopping and Muller, 1968. *9, Longapertites* sp. cf. *Longapertites* sp. 3 Lawal and Moullade, 1986. *10, Longapertites proxapertitoides* Van der Hammen and Garcia de Mutis, 1965. *8, Mauritiidites crassibaculatus* Van Hoeken-Klinkenberg, 1964. *11, 12, 13, Spinizonocolpites echinatus* Muller, 1968. *14, 15, 33, Echitriporites trianguliformis* Van Hoeken-Klinkenberg, 1964. *16, 17, Zlivisporis blanensis* Pacltova, 1959. *18, Proteacidites dehaani* Germeraad, Hopping and Muller, 1968. *19, 20, Foveotriletes margaritae* (Van der Hammen) Germeraad, Hopping and Muller, 1968. *21, Cingulatisporites ornatus* Germeraad, Hopping and Muller, 1968. *22, 28, Spinizonocolpites baculatus* Muller, 1968. *23, 26, 29, Proxapertites cursus* Van Hoeken-Klinkenberg, 1966. *24, 25, Proxapetites operculatus* Van der Hammen, 1956. *27. Triporites* sp. 1. *30, 31, 32, 34, Buttinia andreevi* Boltenhagen, 1967.

PLATE 1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Retitricolpites sp.
Plate 2, Figure 5

Description.–Pollen grain circular to subcircular; tricolpate. 3 colpi bordered by longitudinal thickening occupy about 2/3 of pollen diameter. Exine 0.5-1 µm thick, reticulate. Lumina 1-3 µm wide, muri 0.5-1 µm thick.

Dimension.–45-50 µm, mean 48 µm. (6 specimens measured).

Occurrence.–Eocene of present study.

SUBTURMA Polyptyches Potonié, 1970
INFRATURMA Stephanocolpati Potonié, 1970
Genus *Retistephanocolpites* Leidelmeyer, 1966 emend. Germeraad *et al.*, 1968
Retistephanocolpites williamsi Germeraad *et al.*, 1968
Plate 2, Figures 1, 2, 3

Remarks.–Leidelmeyer (1966) described *Retistephanocolpites* as a reticulate pollen grain with 4-5 colpi. According to Germeraad *et al.* (1968), *R. williamsii* is polycolpate with 6-7 colpi. Thanikaimoni *et al.* (1984), however, indicated that their study shows that *R. williamsii* is polycolporate but the endoapertures are readily visible only in meridional view. No pores have been observed in the specimens studied.

Occurrences.–Maastrichtian-Eocene, Nigeria; Paleocene – Eocene, India; Campanian-Maastrichtian, Egypt.

Retistephanocolpites sp.
Plate 2, Figure 32

Description.–Pollen grain circular in polar view with 4-5 colpi of almost equal length. Colpi 5 µ-12 µm long . Exine 0.5-1 µm thick, tectate and reticulate. Lumina 0.5 µm wide with muri 0.2-0.3 µm thick.

Dimensions.–Equatorial diameter 40-42 µm, mean 41 µm. (6 specimens measured).

Remarks.–The forms observed in core ST-8 are reticulate with 4-5 colpi, which is consistent with the original description of *Retistephanocolpites* by Leidelmeyer (1966).

Occurrence.–Maastrichtian-Paleocene of present study.

TURMA Porosa Potonié, 1970
SUBTURMA Triporines Potonié, 1970
Genus *Proteacidites* Cookson, 1950 ex Couper, 1953
Proteacidites dehaani Germeraad *et al.*, 1968
Plate 1, Figure 18

Remarks.–This species was used as a zonal marker for the *Proteacidites dehaani* Zone by Germeraad *et al.* (1968). According to them, *P. dehaani* and *Buttinia andreevi* do not extend beyond the Maastrichtian/Danian boundary. Salami (1984, 1985), however, reported *P. dehaani* from Maastrichtian-Eocene beds in Nigeria.

Occurrences.–Maastrichtian, Nigeria, Carribean, Cameroun; Maastrichtian-Eocene, Nigeria; Campanian, Egypt.

Genus *Echitriporites* Van Hoeken-Klinkenberg, 1964
Echitriporites trianguliformis Van Hoeken-Klinkenberg, 1964
Plate 1, Figures 14, 15, 33

Remarks.–There are two morphotypes of this species, the finely echinate or spinose form and the coarsely echinate or spinose one (Plate 1, Figure 33). The finely echinate forms with spines 0.5 µm high and pores 7.5-10 µm wide are most common in the Late Cretaceous/Tertiary samples examined. The coarsely echinate forms with spinae 2-3 µm high and 2-2.5 µ wide at base, pores 5-7.5 µm wide are also comparable to *Proteacidites longispinosum* of Jardiné and Magloire (1965).

Occurrences.–Campanian-Eocene, Nigeria; Maastrichtian, Senegal, Ivory Coast; Maastrichtian, Egypt; Campanian-Maastrichtian, Brazil; Maastrichtian, Somalia; Maastrichtian-Eocene, Venezuela; Maastrichtian-Eocene, Carribean.

Genus *Triporites* Cookson ex Couper emend. Potonié, 1960
Triporites sp. 1
Plate 1, Figure 27

Description.–Pollen grain triangular to subtriangular in shape with sides linear to slightly convex. 3 pores are positioned on the vertices of the grain. Pores 7-12 µm wide. Exine 1.5 µm thick, scabrate to granulate.

Dimensions.–Equatorial diameter 37-48 µm, mean 42 µm. (6 specimens measured).

Occurrence.–Campanian-Maastrichtian of the present study.

Triporites sp. 2
Plate 2, Figures 30, 31

Description.–Pollen grain triangular to subtriangular in shape with convex sides; equator bears three pores with distinct protruding annulus. Pores 7-10 µ wide; exine 1-1.5 µ thick, psilate to scabrate.

Dimensions.–Equatorial diameter 50-58 µm, mean 52 µm. (5 specimens measured).

Remarks.–The protruding pores with annulus of this specimen differentiate it form *Triporites* sp. 3 (Plate 2, Figure 4) with its sunken pores.

Occurrence.–Eocene of the present study.

SUBTURMA Polyporines Potonié, 1970
Genus *Pachydermites* Germeraad *et al.*, 1968
Pachydermites diederixi Germeraad *et al.*, 1968
Plate 2, Figures 20, 21, 22

Remarks.–Specimens are oblate. Pores four or five, 7-10 µm wide, rounded, sunken and irregular in outline. Sizes variable 35-40µm in diameter.

Occurrences.–Eocene-Miocene, Nigeria; Eocene-?Miocene, Gabon, Cameroun; Tertiary, India; Miocene-Quaternary, northern South America.

SUBTURMA Azonolete Potonié, 1970
INFRATURMA Tuberini Potonié, 1970
Genus *Buttinia* Boltenhagen, 1967
Buttinia andreevi Boltenhagen, 1967
Plate 1, Figures 30, 31, 32, 34

Remarks.–Pollen grain reticulate with variably shaped pores or lumina (circular, elliptical, oblate) about 8-15 µm wide; muri 3-4 µm thick.

Occurrences.–Campanian-Maastrichtian, Brazil; Late Campanian-Maastrichtian, Nigeria; Campanian-Maastrichtian, Côte d'Ivoire; Maastrichtian-?Danian, CIG transform margin; Maastrichtian, Somalia; Campanian-Maastrichtian, Venezuela, Colombia; Late Maastrichtian, Senegal; Maastrichtian, Carribean.

SUBTURMA Ptychotriporines Potonié, 1960
Genus *Bombacacidites* Couper, 1960
Bombacacidites sp.
Plate 2, Figures 13, 14

Description.–Pollen grain radially symmetrical, subtriangular in shape with colpi and pore situated in invaginations of the outline; isopolar as seen in polar view; tricolporate, colpi 12-25 µm long, costate; pores small, distinct in some cases. Exine 2-2.5 µm thick, tectate, multicollumellate and reticulate.

Dimensions.–Equatorial diameter (42-48) µm, mean 46 µm. (6 specimens measured).

Remarks.–Specimen differs in shape from *B. annae* which is subrounded in polar view. Specimen however, has close resemblance with *Bombax ceiba* which also shows multicollumellate structure.

Occurrence.–Eocene of the present study.

Genus *Retitricolporites* Van der Hammen emend. Van der Hammen and Wymsta, 1964
Retitricolporites irregularis Van der Hammen and Wymstra, 1964
Plate 2, Figures 9, 10, 12

Remarks.–Tricolporate pollen with irregular shape of lumina and considerable variation in coarseness of ornamentation.

Occurrences.–Eocene, Venezuela; Eocene-Miocene, Nigeria; Oligocene-Miocene, British Guiana.

Retitricolporites sp. 1
Plate 2, Figures 15, 16

Description.–Pollen radially symmetrical, subtriangular in shape; isopolar in polar view. Tricolporate pollen with short colpi 10-15 µm long, faintly costate; pores 5-7 µm wide and distinct. Exine 1-2 µm thick; tectate, reticulate. Muri 1 µm thick; lumina 1-1.5 µm wide.

Dimensions.–Equatorial diameter 37-50 µm, mean 45 µm. (6 specimens measured).

Remarks.–In this specimen the pores are distinct and the reticulate exine and lumina more regular.

Occurrence.–Paleocene-Eocene of present study.

Retitricolporites sp. 2
Plate 2, Figure 28

Description.–Grain subrounded to rounded in shape; tricolporate with three conspicuous costate colpi, 17 µm long and porae 5 µm wide. Exine 1 µm thick, tectate and reticulate; lumina 1 µm wide, with muri <1 µm.

Dimensions.–Equatorial diameter 50-54µm, mean 51 µm (4 specimens measured).

Occurrence.–Eocene of present study.

SUBTURMA Stephanocolporate Faegri and Iversen, 1950
Genus *Psilastephanocolporites* Leidelmeyer, 1966
Psilastephanocolporites sp.
Plate 2, Figure 24, 25

Description.–Grain prolate or elliptical; stephanocolporate with 6 conspicuous colpi and porae. Colpi

30 µm long, porae 5-7 µm wide; Exine 1.5 µm thick; tectate, psilate to scabrate.

Dimensions.–Equatorial diameter 45-62 µm, mean 57 µm. (10 specimens measured).

Remarks.–There are two forms of *Psilastephanocolporites* sp. One form has 6 colpi and 6 porae and a larger mean size 57 µm, whilst the other shows 4 colpi and 4 porae and a smaller mean size 43 µm (Plate 2, Figure 29).

Occurrence.–Paleocene-Eocene of present study.

Genus *Retistephanocolporites* Van der Hammen
and Wymstra, 1964
Retistephanocolporites sp.
Plate 2, Figures 19, 23

Description.–Pollen grain subcircular; stephanocolporate; reticulate; with 6 colpi and 6 porae. Colpi 15-25 µm long, porae 5-10 µm wide; lumina 1-1.5 µm wide, with muri 1 µm. Exine 1-1.5 µm thick.

Dimensions.–Equatorial diameter 40-50 µm, mean 42 µm (5 specimens).

Occurrence.–Eocene of present study.

TURMA Monolete Ibrahim, 1933
SUBTURMA Azonomonoletes Luber, 1935
INFRATURMA Sculpatomonoleti Dybová and
Jachowicz, 1957
Genus *Verrucatosporites* Germeraad *et al.*, 1968
Verrucatosporites usmensis Germeraad *et al.*, 1968
Plate 2, Figures 17, 18

Remarks.–Specimens are monolete, bean shaped or elliptical with low verrucae and rounded tops on the distal convex side. *V. usmensis* described is morphologically similar to *Polypodiites* sp of Salami (1983, 1988). Rull (1997) has indicated that *Polypodium* spores are morphologically identical to *Verrucatosporites*.

Occurrences.–Eocene-Miocene, Nigeria; Eocene, Venezuela; Late Tertiary, Cameroun, Gabon; Oligocene-?Quaternary, British Guiana.

ANTETURMA Sporites H. Potonié, 1893
TURMA Triletes Reinsch emend. Dettmann, 1963
SUBTURMA Azonotriletes Luber emend.
Dettmann, 1963
INFRATURMA Murornati Potonié and Kremp, 1954
Genus *Zlivisporis* Pacltova, 1959
Zlivisporis blanensis Pacltova, 1959
Plate 1, Figures 16, 17

Remarks.–Distal surface of specimen bears muroid ridges which anastomose in places to form a recticulum. The author agrees with Salami's assertion that a distinct cingulum as purported by Pacltova (1959) is absent, and that a residual perisporal or outer thin membrane is rather present. No distinct cingulum was observed in the specimens studied.

Occurrences.–Campanian-Maastrichtian, Côte d'Ivoire; Campanian-Maastrichtian, Brazil; Late Campanian-Maastrichtian, Nigeria; Maastrichtian, Somalia; Maastrichtian, Venezuela.

Genus *Foveotriletes* Van der Hammen, 1954 ex.
Potonie, 1956
Foveotriletes margaritae (Van der Hammen)
Germeraad *et al.*, 1968
Plate 1, Figure 19, 20

Remarks.–The foveolate distal surface is characteristic of this species. This specimen differs from *Filtrotriletes nigeriensis* Van Hoeken-Klinkenberg, 1966 in its thinner wall, shorter less pronounced trilete mark.

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PLATE 2–All figures x 660. *1, 2, 3, Retistephanocolpites williamsii* Germeraad, Hopping and Muller, 1968. *4, Triporites* sp. 3. *5, Retitricolpites* sp. *6, 7, 8, Retitricolpites* sp. cf. *R. ameicana* Wymstra, 1964. *9, 10, 12, Retitricolporites irregularis* Van der Hammen and Wymstra, 1964. *11, Scabratriporites* sp. cf. *S. simpliformis* Van Hoeken-Klinkenberg, 1966. *13, 14, Bombacacidites* sp. *15, 16, Retitricolporites* sp. 1. *17, 18, Verrucatosporites usmensis* Germeraad, Hopping and Muller, 1968. *19, 23, Retistephanocolporittes* sp. *20, 21, 22, Pacydermites diederexi* Germeraad, Hopping and Muller, 1968. *24, 25, 29, Psilastephanocolporites* sp. *26, Triplanosporites sinuosus* Pflug in Thomson and Pflug, 1953. *27, Distaverrusporites* sp. *28, Retitricolporites* sp. 2. *30, 31, Triporites* sp. 2. *32, Retistephanocolpites* sp. *33, Polypodiaceosporites* sp. *34, Laevigatosporites* sp. *35, 36, Retimonocolpites* sp. *37, Praedapollis africanus.*

PLATE 2


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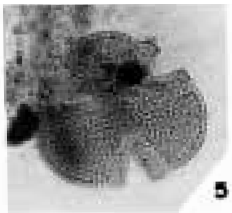
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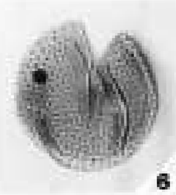
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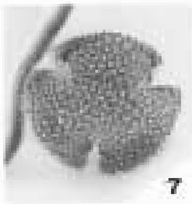
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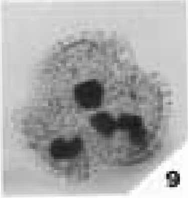
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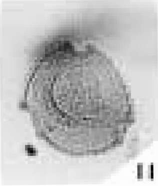
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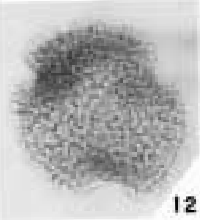
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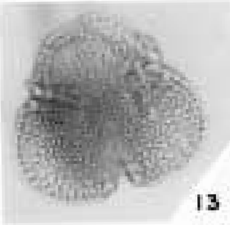
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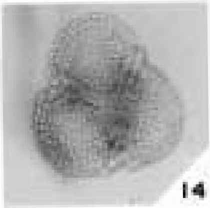
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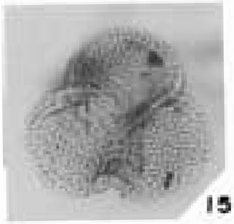
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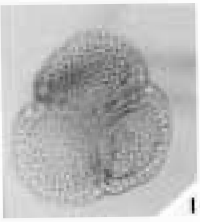
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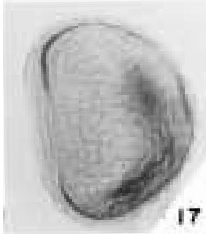
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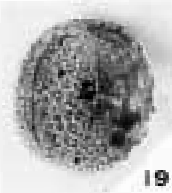
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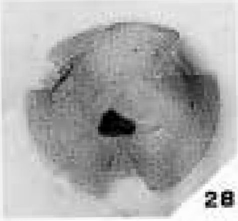
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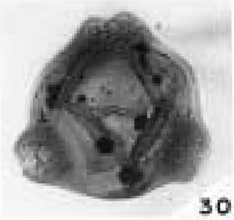
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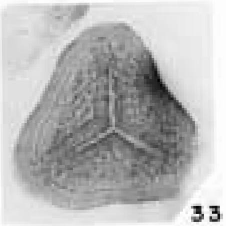
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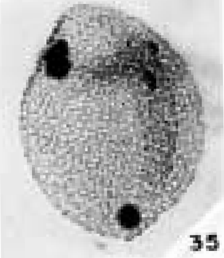
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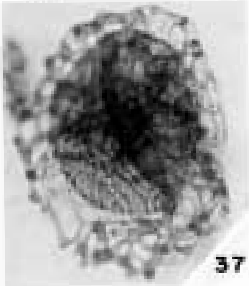
37

Occurrences.–Maastrichtian-Eocene, Nigeria; Maastrichtian, Somalia; Campanian-Maastrichtian, Côte d'Ivoire; Campanian-Maastrichtian, CIG transform margin; Maastrichtian-Eocene, Venezuela, Colombia; Paleocene, Brazil.

INFRATURMA Verrucati Dybová and Jachowicz, 1968
Genus *Distaverrusporites* Muller, 1968
Distaverrusporites sp.
Plate 2, Figure 27

Description.–Amb subtriangular to subcircular; Lasurae extends to about four fifths of spore radius; proximal surface smooth, distal surface verrucate. Verrucae 5 µm high, 4-5 µm wide at base; equatorial margin of spore looks scalloped by verrucae sticking out.

Dimensions.–Equatorial diameter 40-50 µm, mean 45 µm. (6 specimens measured).

Occurrence.–Campanian-Maastrichtian of present study.

SUBTURMA Zonotriletes Waltz, 1935
INFRATURMA Cingulati Potonié and Klaus, 1954
Genus *Cingulatisporites* Thomson in Thomson and Pflug emend. Hiltman, 1967
Cingulatisporites ornatus Van Hoeken-Klinkenberg, 1964
Plate 1, Figure 21

Remarks.–Distal surface of specimen covered by low verrucae. The cingulum is split into several clavate or baculate structures.

Occurrence.–Campanian-Maastrichtian, Nigeria.

RESULTS OF PALYNOLOGICAL INVESTIGATION

Table 1 shows the distribution of Late Cretaceous and Lower Tertiary pollen assemblage recovered from sediments in well ST-8 offshore Tano Basin. The assemblage is characterized by large species diversity and consists of forms that show varying sculptures of exine as well as types of apertures. Monosulcate pollen grains constitute the most abundant group with the largest species diversity. *Spinizonocolpites, Proxapertites, Longapertites* and *Mauritiidites,* have been attributed to the palmae (van der Hammen, 1954, 1957, van Hoeken-Klinkenberg, 1964, Muller, 1968; Nichol *et al.,* 1973; Thanikaimoni *et al.,* 1984; Schrank, 1987; El Beialy, 1995). These taxa are long considered to be elements of mangrove environment of the humid tropics (Herngreen, 1998; Schrank, 1987, 1994; Digbehi *et al.,* 1996). *Mauritiidites crassibaculatus* occurs rarely (1-5 specimens) in the samples studied as compared to Colombia (South America) where they have been reported as dominant elements of the palynological assemblage (Van der Hammen, 1957). This rare occurrence has been reported also in Nigeria (Salami, 1983, 1985) and this may probably indicate the restricted occurrence of the *Mauritia* type of palm in the floral composition at this time. Herngreen (1975) reported the absence of *Spinizonocolpites*, common in the Late Cretaceous and Tertiary assemblage of most tropical areas (Germeraad *et al.*, 1968), from the Brazilian assemblage. This probably suggests that minor floral differences occurred in the Late Cretaceous and Tertiary assemblages of tropical areas. Two forms of *Echitriporites trianguliformis* (fine and coarse echinate) have been recovered from the sediments. The finely echinate form is common in the Senonian, in contrast to observations by Herngreen (1975), who reported the presence of only the coarse form from Brazilian Senonian materials. Tricolporates (psilate), tricolpates and triporates constitute other important elements in addition to the monocolpates. Pteridophytic spores are dominated by laevigate trilete and monolete forms, whereas stephanocolpates mainly *Retistephanocolpites* spp. though low in the assemblage were significant in the Lower Tertiary.

Retistephanocolpites attributed to the family Ctenolophonaceae, fits into the scenario of a wet tropical coastal vegetation. In recent vegetation, the Ctenolophonaceae represents trees living in humid swamps forest environment and along river banks (Schrank, 1990, 1994; Thanikaimoni *et al.*, 1984; El Beialy, 1995).

There is a mixed occurrence of freshwater (nonbrackish) forms in different proportions. These include *Laevigatosporites*, *Polypodiaceiosporites*, *Pachydermites diederexi*, *Verrucatosporites usmensis*. These taxa are common in the upper reaches of the well. According to Rull (1997) and Germeraad *et al.* (1968) the presence of *P. diederexi*, *V. usmensis* and *Laevigatosporites* spp., indicate a swampy fresh water or brackish water environment.

PALEOECOLOGICAL INTERPRETATION

The microfloral assemblage of the Late Cretaceous and Early Tertiary sediments from the Tano Basin is dominated by monocolpate pollen grains (especially of

AGE	DEPTH IN FEET	SPORES AND POLLEN																															
		Retitricopites sp	*R.* cf. *americana*	*Retimonocolpites* sp.	*Triporites* sp 1	*Triporites* sp 2	*Zlivisporis blanensis*	*Auriculiidites reticulatus*	*A.* sp	*Foveotriletes margaritae*	*Spinizonocolpites echinatus*	*S. baculatus*	*Proxapertites cursus*	*P. operculatus*	*Longapertites marginatus*	*L. vaneendenburgi*	*Echitriporites trianguliformis*	*Proteacidites dehaani*	*Mauritiidites crassibaculatus*	*Retitricolporites irregularis*	*R.* sp. 1	*R.* sp. 2	*Buttinia andreevi*	*Retistephanocolpites williamsii*	*R.* sp	*Psilastephanocolporites* sp	*Retistephanocolporites* sp	*Pachydermites diederexi*	*Bombacacidites* sp	*Verrucatosporites usmensis*	*Polypodiaceosporites* sp	*Distaverrusporites* sp	*Cingulatisporites ornatus*
EOCENE	1260																																
	1400																																
	1500																									●				●			
	1550																			●								●					
	1650													●														●		●			
	1830																			●								+			●		
	2090																									●	●	●		●	●		
	2150												●															+			●		
	2370	●				●				●			●													●		+		●	×		
	2490										●	●		●										●						●			
	2550					●														+						+				●			
	2670													●						+											●		
	2740									●		●	●	●													+	●	●	+			
	2800										+									+				□		+				●	×		
	3020											●									●	●					●						
	3090					●				●			●	●	●				×	+							×		●	+			
	3210	●									●			●	●					●		●						+	●	●			
	3270					●					●	●	●	●			●		×	+	●			□		+	×		●	●			
	3390		●							●	+		●	●	●									+		●							
	3450										+		●		●					+				●					×	●			
	3510											●	●							●	×	●		●					×	●			
	3590		●			×						●					●		×	●						×		+		●			
	3650	●																		●	●	●						●		●			
PALEO - CENE	3780													+											●								
	4000		●							+							●																
	4170									+	+		+		●				×		●					●							
	4400			●								●			+				×														
	4420		●	●								●		+			●				×				●	●							
CAMPANIAN - MAASTRICHTIAN	4470						●			□			+		+		+																
	4530							●															●										
	4760				●					●					+		□	●					+										●
	4840							●			+				●								●		×							●	
	5080			×			●			●			+						×						×								●
	5140							●	●		●			+			+						+									●	
	5260		●	●	●		+				●	●							×						●								●
	5320						●		●								+	●														●	●
	5380			●	●			+		+		●	●	●									+		●							●	
	5500								●	+																							●
	5620			●			●			+																						●	
	5740				●					+	●					×	●																
	5800			×													●		×				●									●	●
	5860	●					+	+		●								●															
	6040				●				●	●							●																
	6220			●			●										●						●										
	6280				●			●																									
	6400							●																									
	6700	●																															

× = 1-5 (Rare) ● = >5-10 (Few) + = >10-20 (Common) □ = >20 (Abundant)

TABLE 1–Miospore distribution within samples from well ST-8.

the palmae type), trilete and monolete pteridophytic spores. The presence along side this assemblage of abundant algal and fungal spore is suggestive of mangrove and/or swamp vegetation. The trilete and monolete forms are structurally and sculpturally comparable to some of the extant forms of the families Cyatheaceae, Polypodiaceae and/or Schizeaceae, some of which are known to inhabit fresh water swamps and marshes. The pteridophytic spores which inhabited the swamp environment, were most probably fringed by monocolpate pollen taxa with affinities to modern palms such as *Spinizonocolpites, Proxapertites, Longapertites, Mauritiidites, Retimonocolpites* and *Retitricolpites*.

Monocolpate fossil pollen taxa mentioned above have been recorded from Palmae Province of Senegal and Ivory Coast (Jardiné and Magloire, 1965), Brazil (Herngreen, 1975), Nigeria (Edet and Nyong, 1994; Salami, 1982, 1984, 1985, 1988, 1990), Northern Somalia (Schrank, 1994), Egypt (Schrank, 1987; El Beialy, 1995), Sudan (Schrank, 1987), northern South America (Muller *et al.,* 1987), Venezuela, Colombia, Nigeria, Carribean, Borneo (Germeraad *et al.,* 1968) and India (Thanikaimoni *et al.*, 1984).

The fossil palms mentioned above fit into the Late Cretaceous Palmae Province of Africa, South America and India described by Herngreen and Chlonova (1981) and Herngreen *et al.* (1996). The province is characterized by a high frequency of taxa attributed to the palmae, and by the absence of pollen grains belonging to the Normapolles-group. There are no bisaccate pollen grains in the palynoflora which is also a typical feature of the Senonian Palmae Province, as pointed out by Jardiné and Magloire (1965). The Palmae Province suggests a hot tropical to subtropical climate and the assemblages are interpreted as indicative of a warm and humid climate (Herngreen, 1998).

AGE OF SAMPLES STUDIED

Assignment of an age to the sediments from the upper part of well ST-8 in the Tano Basin has been based on the stratigraphical ranges of the following selected taxa.–*A. reticulatus, B. andreevi, Z. blanensis, E. trianguliformis, P. cursus, P. operculatus, L. marginatus, S. echinatus, S. baculatus, M. crassibaculatus, R. williamsii, F. margaritae, V. usmensis, R. irregularis* and *P. diederexi* (Table 2). These taxa have comparable age ranges to those described by previous workers from West and North Africa (Nigeria, Senegal, Côte d'Ivoire, Gabon, Egypt, Somalia, Sudan), South America (Colombia, Venezuela, Brazil, Peru, British Guiana, Surinam), Asia (India, Borneo), Carribean. The ranges have been compiled from published works by Van der Hammen (1954), Van Hoeken-Klinkenberg, (1964, 1966), Elsik (1964), Jardine and Magloire (1965), Muller *et al.* (1987), Edet and Nyong (1994), Salami (1982, 1984, 1985, 1988, 1990), Schrank (1987, 1994), Boltenhagen (1965), Nwachukwu *et al.*, (1992), El Beialy (1995), Herngreen (1975, 1981), Digbehi *et al.* (1996), Rull (1997), Oboh-Ikuenobe *et al.* (1998), Masure *et al.* (1998), Germeraad *et al.* (1968), Schrank and Ibrahim (1995), Jan du Chêne and Salami (1978), Van der Hammen and Garcia de Mutis (1965), Thanikaimoni *et al.* (1984), Van der Hammen and Wymstra (1964), Herngreen *et al.* (1996).

The overlap in the stratigraphic ranges of the above mentioned taxa points to Campanian to Eocene age for the sediments between the intervals 6,700-1,260 ft (2,042-384 m) of well ST-8 in the Tano Basin.

CONCLUSIONS

Miospores recovered from sediments in well ST-8 are diverse in species and well preserved. The miospore assemblage consists principally of angiospermic pollen, especially those of the monocolpate type and pteridophytic spores.

The monocolpate assemblage bears strong affinity to the palmae, which inhabit mangrove or swamp environment of warm and humid climates. The assemblage is typical of the Senonian Palmae Province of Africa and South America (ASA) region.

The pteridophytic spores are comparable to extant forms, some which are known to inhabit fresh water swamps and marshes. The presence of abundant fungal and algal spores further support this environment. It is suggested that the palmae group surrounded the pteridophytic spores, which inhabited the swamps, on the fringes.

Stratigraphically significant miospore species indicated Campanian to Eocene age for the sediments.

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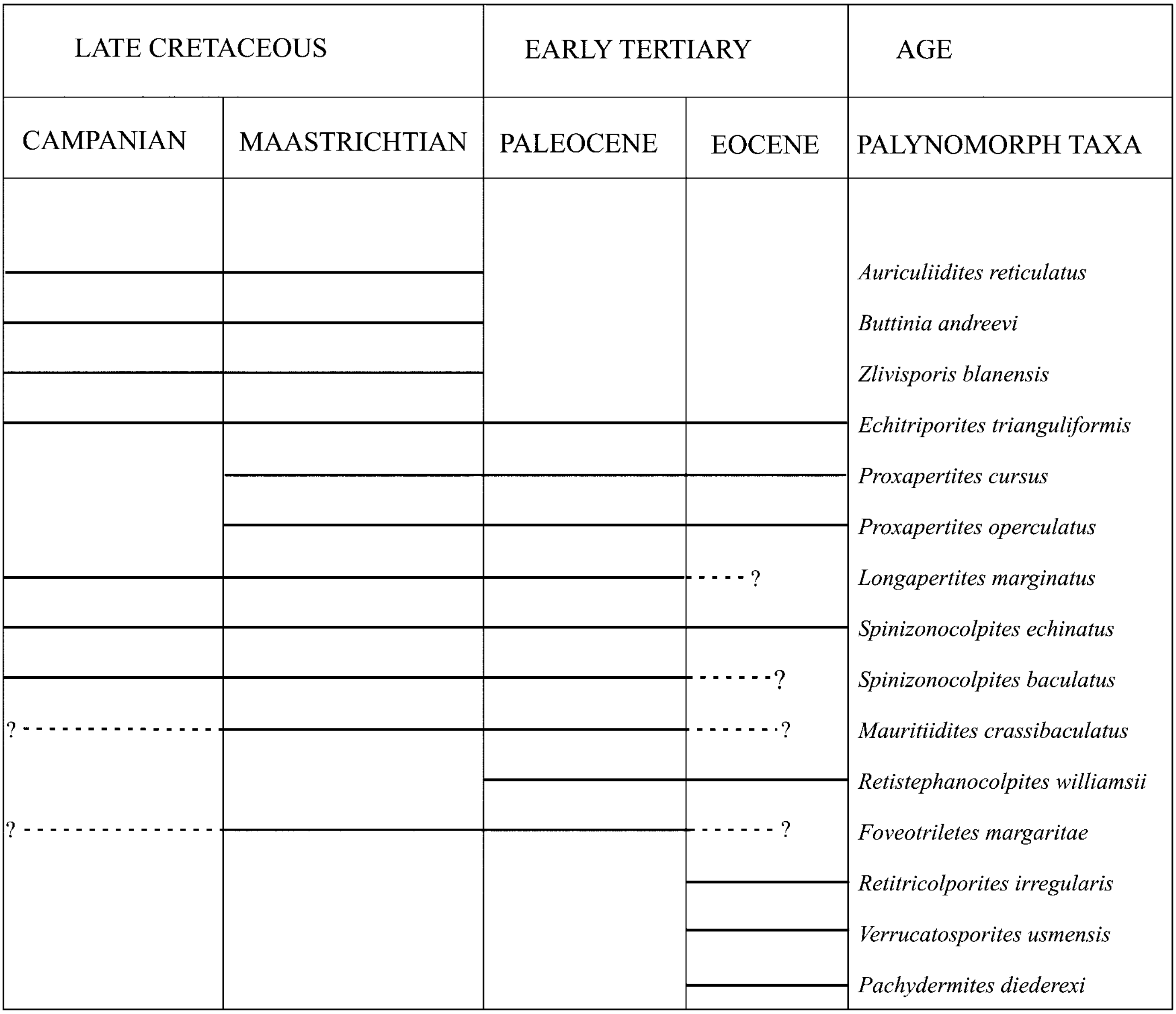

TABLE 2–Composite stratigraphical ranges of selected species of palynomorphs species of palynomorphs from well ST-8 offshore Tano Basin (adapted from various authors).

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NOVEDADES TAXONÓMICAS, DIVERSIDAD Y SIGNIFICADO EVOLUTIVO DEL POLEN DE MALVACEAE EN EL TERCIARIO DE ARGENTINA

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Resumen

Se presentan once formas de palinomorfos de Malvaceae (tribu Malveae) que provienen de sedimentos del Mioceno medio, de la Formación San José, en la provincia de Tucumán, Argentina. Por primera vez, en una localidad fosilífera argentina, se registra una alta diversidad de polen de dicha familia. Se crea un género nuevo, *Malvapantocolporites* gen. nov., para reunir granos de polen oligopantocolp(oid)orados y cinco especies nuevas: *Malvapantocolporites rafaelii* sp. nov., *M. sanjosesii* sp. nov., *M. silvinites* sp. nov., *Malvacipolloides tucumanensis* sp. nov. (granos tricolporados) y *Echiperiporites santamariana* sp. nov. (granos periporados); se citan, además, cuatro especies previamente conocidas: *Malvacipolloides comodorensis* Barreda, 1993; *Baumannipollis evae* Anzótegui y Cuadrado, 1996; *B. variaperturatus* Barreda, 1993; *B. chubutensis* Barreda, 1993, y dos que permanecen con nomenclatura abierta, *Baumannipollis* sp. 1 y *B.* sp. 2. Como resultado, se incrementa a cinco los géneros y a 19 las especies registradas en Argentina. Se analiza este grupo de palinomorfos, junto con los hallados previamente en el país, teniendo en cuenta, entre otras, las características de las aperturas, de estructura y escultura de la exina, del tamaño y forma, siguiendo el criterio evolutivo de Christensen. Se demuestra que evolutivamente coincide, en general, con el mencionado esquema y se evalúa el grado de desarrollo que, a nivel polínico, habría alcanzado la familia Malvaceae (tribu Malveae) en el Terciario de la República Argentina.

Palabras clave: Palinología, Malvaceae, taxonomía, evolución, Mioceno, Argentina.

Abstract

[Taxonomy, diversity and evolutive significance of pollen of Malvaceae in the Tertiary of Argentina]. Eleven palynomorphs of Malvaceae (tribe Malveae) from the Middle Miocene San José Formation from the province of Tucumán, Argentina are described. For the first time such a high diversified assemblage is found at one single locality in the country. A new genus, *Malvapantocolporites* gen. nov., is erected to include oligopantocol(oid)porate grains as well as five new species, *Malvapantocolporites rafaelii* sp. nov., *M. sanjosesii* sp. nov., *M. silvinites* sp. nov. [oligopantocol(oid)porate grains], *Malvacipolloides tucumanensis* sp. nov. (tricolporate grains) y *Echiperiporites santamariana* sp. nov. (periporate grains). Also four previously known *Malvacipolloides comodorensis* Barreda, 1993; *Baumannipollis evae* Anzótegui & Cuadrado, 1996; *B. variaperturatus* Barreda, 1993; *B. chubutensis* Barreda, 1993, and two in open nomenclature, *Baumannipollis* sp. 1 and *B.* sp. 2, which are briefly described. As a result now there are five genera and nineteen species recorded in Argentina. Following Christensen's evolutive criteria, the whole group is analyzed taking into account their apertures, exine structure and sculpture, size and form among other characters showing that in general it is coincident with them. Finally, the evolutive palynological degree of the Malvaceae (tribe Malveae) in Argentina is evaluated.

Key words: Palynology, Malvaceae, taxonomy, evolution, Miocene, Argentina.

INTRODUCCIÓN

En el Terciario de Argentina se han reconocido hasta el momento cuatro géneros y doce especies de palinomorfos de Malvaceae. Con este aporte se suma un género nuevo, *Malvapantocolporites* gen. nov., para designar a granos de polen oligopantocolp(oid)orados y cinco especies nuevas. *Malvapantocolporites rafaelii* sp. nov., *M. sanjosesii* sp. nov., *M. silvinites* sp. nov., *Malvacipolloides tucumanensis* sp. nov. (granos tricolporados) y *Echiperiporites santamariana* sp. nov. (granos periporados); se citan, además, cuatro especies ya conocidas: *Malvacipolloides comodorensis* Barreda, 1993, *Baumannipollis evae* Anzótegui y Cuadrado, 1996, *B. variaperturatus* Barreda, 1993, y *B. chubutensis* Barreda, 1993, y dos especies, *Baumannipollis* sp. 1, *B.* sp. 2, que permanecen con nomenclatura abierta. Por lo tanto, se incrementan a cinco los géneros hallados en el país y a 19 las especies. Los palinomorfos que se presentan en este trabajo provienen de la Formación San José, en el km 107 (Quebrada de Amaicha), provincia de Tucumán, Argentina (Fig. 1). Este conjunto de especies representa una novedad en la paleopalinología argentina, ya que ninguna asociación fósil del Neógeno registra tan alta diversidad y abundancia en una sola localidad fosilífera. La asociación que los contiene está constituida por, aproximadamente, un centenar de especies de origen continental; en la que las magnoliofitas son dominantes sobre las pinofitas, pteridofitas, briofitas y algas (Mautino y Anzótegui, 2002a).

Los granos de polen de Malvaceae se caracterizan porque son equinados, con un mamelón bajo las espinas (*basal cushion*, en Christensen, 1986) constituido por columelas de mayor altura que en el resto de la exina (Martín, 1974; Christensen, *op. cit.*); debido a ello el contorno de los granos en corte óptico es ondulado. Para diferenciar los taxones, en este trabajo, se tuvo en cuenta el tipo y número de aberturas, presencia de anillo en los poros u ora, tamaño y densidad de las espinas, espesor de la exina (subespinal e interespinal), diámetro de los mamelones y, por último, forma y tamaño de los granos. Por primera vez se hace referencia a la presencia de colpoides (colpos con márgenes difusos que sólo superan en pocos micrones el diámetro de los poros) en las aberturas compuestas de los granos fósiles de esta familia. Tanto en las descripciones como en el Cuadro 2, las especies han sido ordenadas, teniendo en cuenta las tendencias evolutivas propuestas por Cristhensen *(op. cit.)* en granos de polen actuales de 120 especies de Malvaceae y las de Punt (1975) para granos de polen fósil en general. Este último autor considera que las aberturas constituyen caracteres primarios, en tanto son secundarios los de la estructura y escultura y, por último, los de la forma y tamaño del grano; sostiene además, que las tendencias evolutivas, para ser válidas, deberían estar basadas en datos paleobotánicos. Siguiendo este criterio, aquí se realiza el análisis de las características de los palinomorfos fósiles de Argentina y se demuestra que evolutivamente coinciden, en general, con el esquema propuesto por Christensen *(op. cit.)*. En cuanto al origen de la familia, esta autora propone que la condición trizonocolporada es la más primitiva y postula que Malvaceae es una familia que se originó en el sur del continente de Gondwana.

La familia Malvaceae es cosmopolita, contiene 82 géneros y 1.550 especies, en Argentina cuenta con 35 géneros y 208 especies (Cuadrado, tesis en preparación); se encuentra compuesta por cuatro tribus: Malveae A. St.-Hil., Hibisceae Rchb., Gossypieae Alef. y Malvavisceae C. Presl., e integrada, mayoritariamente, por hierbas, subarbustos, arbustos y algu-

Caracteres del polen de Malvaceae

Ancestrales	**Derivados**
Tricolporados	Porados
2-4 zonoporados	Pantoaperturados
Poros grandes (> de 5 µm)	Pequeños (hasta 5 µm)
Aberturas con anillo	Aberturas sin anillo
Aberturas sin opérculos	Aberturas operculadas
Espinas monomórficas	Espinas dimórficas
Espinas cortas (hasta 10 µm)	Espinas largas (> de 10 µm)
Mamelón presente	Mamelón ausente
Gránulos ausentes o escasos	Densamente granulado
Sexina tan gruesa como la nexina	Sexina más delgada que la nexina
Tamaño medio (25 a 50 µm)	Tamaño muy grande (100 a 200 µm)
Granos suboblatos	Granos esferoidales

CUADRO 1–Caracteres evolutivos propuestos por Christensen (1986) para los granos de polen de Malvaceae. Modificado de Zamaloa y Romero (1990).

TABLE 1–Evolutionary characters proposed by Christensen (1986) in Malvaceous pollen grains. Adapted from Zamaloa and Romero (1990).

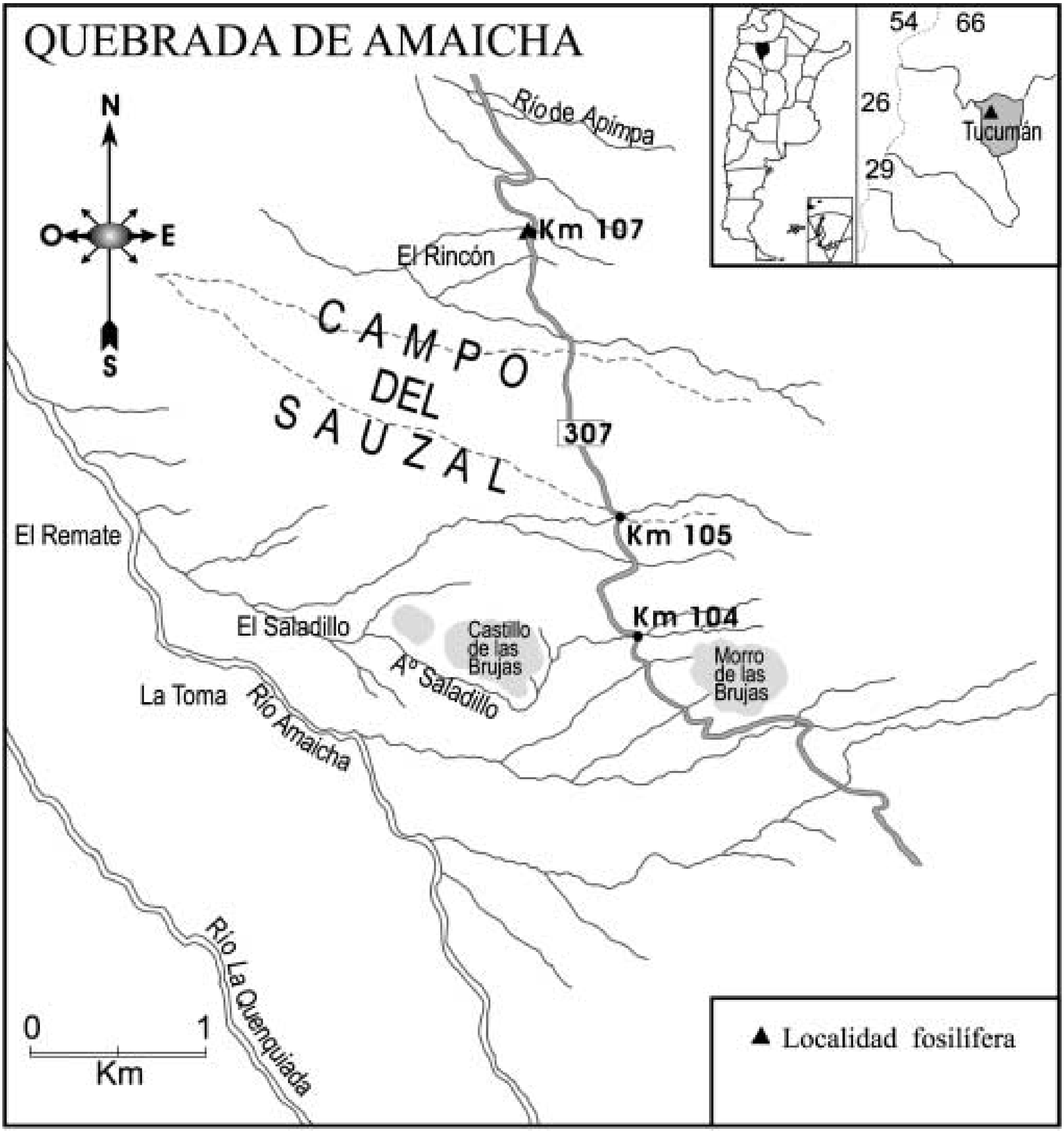

FIGURA 1–Mapa de ubicación de la localidad fosilífera.
FIGURE 1–Locality map of the fossiliferous locality.

nos árboles, que se desarrollan en ambientes acuáticos, riparios, de sabana, o xerófitos, en regiones tropicales, subtropicales y templadas. El estudio de los granos de polen de las 208 especies de la flora argentina (Cuadrado, *op. cit.*) permitió caracterizar palinológicamente las tribus de la siguiente manera:

Malveae, comprende granos de polen oligoaperturados (menos de 14 aberturas), 3-4 o más estefanocolporados, pantocolp(oid)orados en posición espiraloide o en espiral, porados en posición espiralada; Hibisceae, tiene granos pantocolp(oid)orados de 17-31 aberturas en posición espiralada y ora con engrosamientos anulares; Gossypieae reúne granos porados (25 a 30) en disposición espiralada y con engrosamientos anulares, y finalmente Malvavisceae contiene granos colporados y porados con elevado número de aberturas. En este trabajo, todos los granos de polen fósil, por sus afinidades con taxones actuales, están incluidos en la tribu Malveae, a pesar de que la tribu es euripalínica la identificacion de los taxones fósiles con géneros y especies actuales se torna difícil, porque en muchos casos los caracteres palinológicos, especialmente las aberturas, son compartidas entre varios géneros. Debido a ello es imposible, con estas especies fósiles, efectuar inferencias sobre el hábito de los vegetales parentales y sus preferencias paleoecológicas. Por lo tanto, en este aporte se realizan solamente especulaciones evolutivas.

Contexto geográfico y geológico

El km 107 se encuentra sobre la ruta provincial 307, en la quebrada de Amaicha y próximo a la población Ampimpa, en la provincia de Tucumán. La Formación San José se halla en la base del Grupo Santa María y está constituida por pelitas verdes y margas verde-amarillentas de origen lacustre (Bossi y Palma, 1982). Las facies lacustres se pierden hacia el sur a la altura de Ampajango y siguen hacia el norte hasta el río Pedregoso, donde comienzan a ser reemplazados por facies fluviales (Bossi *et al.*, 1998). En la quebrada de Amaicha (Bossi *et al.*, 1984) la secuencia responde a un modelo fluvial con canales de baja jerarquía.

Cronológicamente, esta formación corresponde al Mioceno medio, definido por datos estratigráficos, de facies, radimétricos en tobas y por estudios paleontológicos (Bossi *et al.*, 1998). La base de la formación descansa en suave discordancia angular sobre la Formación Saladillo y en el techo se halla la Formación Las Arcas.

MATERIALES Y MÉTODOS

Los palinomorfos analizados presentan buen estado de preservación y provienen de un perfil que abarca aproximadamente 80 m de espesor; del perfil se han obtenido 20 muestras fértiles que proceden principalmente de la parte basal (4 m) del afloramiento. Los niveles con palinomorfos también contienen impresiones de hojas, moluscos y ostrácodos (Herbst *et al.*, 2000; Anzótegui, 2002; Morton y Herbst, 2003).

Las muestras han sido procesadas siguiendo el método convencional de eliminación de silicatos con ácido fluorhídrico y oxidación con ácido nítrico; el montaje se realizó en glicerina-gelatina. Los preparados palinológicos están depositados en la colección CTES-PMP (Corrientes-Preparados Microscópicos Paleontológicos) de la Facultad de Ciencias Exactas y Naturales y Agrimensura de la Universidad Nacional del Nordeste (UNNE) bajo los números 1839, 1841, 1926, 1942, 1945, 1948, 1949, 1952, 2267, 2268. Las muestras fueron analizadas con un microscopio óptico Leitz Diaplan y las fotografías tomadas con cámara Leitz Orthomat y en un microscopio Olympus BX 40 con cámara Olympus SC 35, película de 100 y 120 ASA; las del microscopio electrónico de barrido fueron tomadas en un equipo Jeol de la Universidad Nacional del Nordeste. Los palinomorfos ilustrados con este último medio fueron seleccionados mediante *picking*.

El sistema taxonómico utilizado para el ordenamiento de los palinomorfos es el de Iversen y Troels-Smith (1950), y para los taxones actuales el de Cronquist, Takhtajan y Zimmermann (1966). La familia Malvaceae se encuentra comprendida en el orden Malvales Lind., 1833 y en la Subclase Dillenidae Takhtajan, 1966.

Se describen solamente las especies nuevas y las que permanecen con nomenclatura abierta; en las que son previamente conocidas se incluyen dimensiones, material estudiado, comentarios y afinidad botánica. Las medidas se toman de la siguiente manera: 1, en el tamaño de los granos se excluyen las espinas; 2, el rango de la distancia interespinal se considera desde la base de una espina a otra; 3, se mide la exina en las zonas interespinal y subespinal (hasta la base de la espina) y 4, el diámetro del mamelón en foco superior.

En el Cuadro 2, en las especies ya conocidas, se incluyen solamente los datos y dimensiones brindadas originalmente por sus autores, a fin de evitar confusiones se omiten los aportados en este trabajo (ejemplo: espesor de la exina en las zonas sub e interespinal, distancia interespinal, diámetro del mamelón, entre otros). Se propone además, siguiendo las ideas de Christensen (1986), que para delimitar los granos oligoaperturados de Malvaceae, se considere como máximo 14 aberturas.

Taxones fósiles		Formación y edad	Principales características	Este trabajo
Géneros	**Especies**			
Malvacipolloides Anzótegui y Garralla, 1986 (granos tricolporados)	*M. densiechinata* Anzótegui y Garralla, 1986	1	DE: 45-50 µm. Suboblato. Ora: 3 x 5 µm diámetro, con anillo. Colpo: 10 x 1 µm. Espinas: 5-6 µm de alto, distancia interespinal de 4 µm. Exina de 3 µm.	
	Tipo "*Sphaeralceae* sp." Anzótegui y Garralla, 1986		DE: 35-55µm. Suboblato. Ora: 5 µm diámetro, con anillo. Espinas: 3-5 µm de alto, distancia interespinal 2-3 µm. Exina de 1,5-2 µm.	
	M. comodorensis Barreda, 1993	2, 3, 4, 5, 6, 7	DE: 15-25 µm. Suboblato. Ora 1-1,7 µm diámetro, con anillo. Colpos: 4-5 µm de largo. Espinas: 1,2-2,2 µm de alto, distancia interespinal 0,5-1,7 µm. Exina: 1,4-1,7 µm.	X
	M. tucumanensis sp. nov.	8	DE: 35-56 µm. Suboblato. Ora: 1,4-3 µm diámetro, con anillo. Espinas: 2-3 µm de alto, distancia interespinal 1,5-2 µm. Exina: 3 µm en la zona interespinal y 4-4,8 µm en la zona subespinal.	X
Baumannipollis Barreda, 1993 (granos estefano colporados)	*B. evae* Anzótegui y Cuadrado, 1996	9	DE: 36-42 µm. Esferoidal. Tetracolporado. Ora: 2 µm diámetro, con anillo. Colpos: 7 x 1 µm. Espinas: 3-3,5 µm de alto, distancia interespinal 0,5 µm. Exina:1,4 µm.	X
	B. variaperturatus Barreda, 1993	2, 4, 5, 7, 8, 10, 11	DE: 20-40 µm. Esferoidal. 3-4 o 5 pentacolporado. Ora: 2,8-4 µm diámetro, con anillo. Colpos: 4,5-7 µm. Espinas: 1,7-3 µm de alto, distancia interespinal 2,5-6,5 µm. Exina: 0,8-1,5 µm.	X
	Baumannipollis. sp. Barreda *et al.*, 1998	6	DE: 30-34 µm. Esferoidal. Tetra a pentacolporado. Exina: 2,3-3 µm, nexina 4 a 5 veces más gruesa que la sexina.	
	B. chubutensis Barreda, 1993	2, 3, 4	DE: 40-75 µm. Esferoidal a suboblato. 7-8 colporos. Ora: 4-4,5 x 7,4-8 µm con anillo. Colpos: 8,5-10 µm. Espinas: 3,4-6 µm de alto, distancia interespinal 1-6 µm. Exina: 1,7-2,8 µm.	X
	Baumannipollis. sp.1		DE: 49-51 µm. Esferoidal a suboblato. Tetracolporados. Ora: 3,5-4 µm diámetro, con anillo. Espinas: 3-3,5 µm, distancia interespinal 1,5-2 µm. Exina: 2,8 µm en la zona interespinal y 3,5 µm en la zona subespinal.	X
	Baumannipollis. sp.2		DE: 70-77 µm. Esferoidal a suboblato. 4 colporos, (posiblemente más). Ora: 3 µm diámetro, con anillo. Espinas: 2,8 µm de alto, distancia interespinal 3-3,5µm. Exina: 2 µm en la zona interespinal y 3,5 µm en la subespinal.	X
Malvapantocolporites gen. nov. (granos oligo-pantocolpo(oid)orados)	*Malvapantocolporites rafaelii* gen. et sp. nov.		DE: 42-45 µm. Esferoidal. Oligo-pantocolp(oid)orado. Ora de 1,4-2 µm diámetro. Espinas de 3 µm de alto, distancia interespinal de 1,4-2,1 µm. Exina: 2 µm en la zona interespinal y 4,2 en la zona subespinal.	X
	Malvapantocolporites sanjosesii gen. et sp. nov.		DE: 31-45 µm. Esferoidal. Oligo-pantocolpo(oid)orado. Ora: 3-5 µm diámetro con anillo. Espinas de 2-2,5 µm de alto, distancia interespinal de 2-3µm. Exina: 1,5 µm en la zona interespinal y 2 µm en la zona subespinal.	X

Taxones fósiles		**Formación y edad**	**Principales características**	**Este trabajo**
Géneros	**Especies**			
Malvapantocolporites gen. nov. (granos oligo-pantocolpo(oid)orados)	*Malvapantocolporites silvinites* gen. et sp. nov.		DE: 40-42 µm. Esferoidal. Oligo-pantocolpo(oid)orado. Ora: 3-3,5 µm diámetro, con anillo. Espinas de 2,5-3 µm de alto, distancia interespinal de 3-5,5 µm. Exina: 3 µm en la zona interespinal y 4,5 µm en la zona subespinal.	X
Malvacipollis Harris, 1965 (granos porados *estefanoaperturados*	*M. argentina* Zamaloa y Romero, 1990	12	DE: 30-42 µm. Suboblato a esferoidal. Poros con anillo. Espinas: 2-3.5 µm de alto. Exina: 2 µm.	
	M. subtilis Stover, 1973 (en Stover y Partridge, 1973)	13	DE: 25 µm. Suboblato a esferoidal. Estefanoaperturado. Espinas: 2-4 µm de alto. Exina, sexina: 1-2,5 µm y nexina delgada.	
	Malvacipollis sp.	13	DE: 35 µm. Esferoidal. Estefanoaperturado. Poros: 4,5-5 µm diámetro, con anillo. Espinas: 2-2,5 µm de alto; distancia interespinal: 2,5 µm. Exina: 1,5 µm.	
Echiperiporites Harris, 1965 (granos periporados)	*E. parviechinatus* Anzótegui y Cuadrado, 1996	8, 9	DE: 35-40 µm. Esferoidal. Poros: 1,4 µm diámetro. Espinas de 2 µm de alto, distancia interespinal de 3,5-4 µm. Exina de 1,5 µm.	
	E. santamariana sp. nov.		DE: 47-60 µm. Esferoidal. Poros: 4-5 µm diámetro, con anillo. Espinas de 3-3,5 µm de alto, distancia interespinal de 3,5 µm. Exina: 2,1µm en la zona interespinal y 3,5 µm en la zona subespinal.	X
	Echiperiporites sp.	8	DE: 40-44 µm. Esferoidal. Poros: 2 µm diámetro. Espinas de 3-4 µm de alto, distancia interespinal de 2-3 µm. Exina de 2-2,5 µm.	

CUADRO 2–Especies de Malvaceae halladas en sedimentos argentinos, desde el Eoceno al Mioceno. DE = Diámetro ecuatorial. Los números de la columna 2 corresponden a: 1- Formación Paraná: Mioceno superior, Anzótegui y Garralla (1986). 2- Formación Chenque: ¿Oligoceno-Mioceno, Barreda (1993). 3- Cuenca del Colorado: Mioceno medio a Plioceno, Guler *et al.* (2001). 4- Formación Chinches: Mioceno, Ottone *et al.* (1998). 5- Área golfo de San Jorge: Oligoceno sup. Mioceno inf., Barreda y Palamarczuk (2000a). 6- "Serie del Yeso": Mioceno medio, Barreda *et al*. (1998). 7- Formación Monte León: Mioceno, Barreda y Palamarczuk (2000b). 8- Formación Chiquimil: Mioceno Superior, Mautino *et al.* (1997), Mautino y Anzótegui (2002b) y Herbst *et al.* (2000). 9- Formación Palo Pintado: Mioceno superior, Anzótegui y Cuadrado (1996). 10- Plataforma Continental Argentina: Oligoceno-Mioceno, Palamarczuck y Barreda (2000). 11- Formación San Julián: Oligoceno, Barreda (1997). 12- Formación Cullén: Eoceno sup.-Oligoceno medio, Zamaloa y Romero (1990). 13- Cuenca del Colorado: Eoceno-Mioceno, Guerstein (1990).

TABLE 2–Malvaceae species found in Argentinian sediments, from Eocene to Miocene. DE = Equatorial diameter. Numbers in column 2 correspond to: 1- Paraná Formation: Later Miocene, Anzótegui and Garralla (1986). 2- Chenque Formation: ¿Oligocene-Miocene, Barreda (1993). 3- Colorado Basin: Medium Miocene to Pliocene, Guler *et al.* (2001). 4- Chinches Formation: Miocene, Ottone *et al.* (1998). 5- San Jorge Gulf Area: Later Oligocene-Lower Miocene, Barreda and Palamarczuk (2000a). 6- "Serie del Yeso": Middle Miocene, Barreda *et al*. (1998). 7- Monte León Formation: Miocene, Barreda and Palamarczuk (2000b). 8- Chiquimil Formation: Miocene, Mautino *et al.* (1997), Mautino and Anzótegui (2002b) and Herbst *et al.* (2000). 9- Palo Pintado Formation: Later Miocene, Anzótegui and Cuadrado (1996). 10- Argentina Continental Plataform: Oligocene-Miocene, Palamarczuck and Barreda (2000). 11- San Julián Formation: Oligocene, Barreda (1997). 12- Cullén Formation: Later Eocene-Middle Oligocene, Zamaloa and Romero (1990). 13- Colorado Basin: Eocene-Miocene, Guerstein (1990).

DESCRIPCIONES SISTEMÁTICAS

TRICOLPORATAE Iversen y Troels-Smith, 1950
Género *Malvacipolloides* Anzótegui y Garralla, 1986
Especie tipo: *Malvacipolloides densiechinata* Anzótegui y Garralla, 1986

Malvacipolloides tucumanensis sp. nov.
(Lám. 1, Figs. 1-2 y Lám. 2, Figs. 1, 2 y 3)

1997. *Malvacipollis* sp. Mautino *et al.:* 127, Figura 4.
2000. *Malvacipollis* sp. Herbst *et al.:* 272, Cuadro 2.
2002b. *Malvacipollis argentina* Zamaloa y Romero; en Mautino y Anzótegui: 265, Figura I.

Diagnosis.–Pollen grains isopolar, suboblate in equatorial view, tricolporatae, zonaperturate. Colpi short, ora 1,4-3 µm diameter with annulus. Exine tectate, echinate; underneath the spines 4-4,8 µm thick and between spines zone 3 µm thick. Spines 2-3 µm long and 1,5-2 apart with basal cushion.

Holotipo.–CTES-PMP 1841d: 43,5/100,5.

Paratipo.–CTES-PMP 1841c: 40/101,4.

Localidad y estrato tipo.–Km 107, Quebrada de Amaicha, Formación San José, provincia de Tucumán.

Edad.–Mioceno medio.

Material estudiado.–CTES-PMP 2268a: 44/98; 1952d: 45/106,3; 1952e: 31/104,5; 1841c: 44,5/103,6; 1944b: 36,6/108,1; 1926^{a}: 41/109,3; 42,5/113; 1942b: 45,5/106,4; 1942c: 38,7/100; 2265c: 44,7/102,9; 2267g: 33,5/108,5; 1841e: 36,4/108,5.

Derivatio nominis.–El epíteto específico, tucumanensis, alude a la provincia en la que se hallaron los fósiles.

Descripción.–Granos de polen de 35-56 µm de diámetro, isopolares, suboblatos y de ámbito subcircular. Tricolporados; colpos cortos de 6-7 µm de largo, ora de 1,4-3 µm de diámetro, con anillo de 2,8-3,5 µm de espesor. Tectados, equinados. Exina en la zona subespinal de 4-4,8 µm de espesor (sexina 2-2,8 µm, nexina 2 µm); en la zona interespinal de 3 µm de espesor (sexina de 2 µm y nexina de 1 µm). Téctum granulado. Espinas de 2-3 µm de altura, mamelones de 3-3,5 µm de diámetro y distancia interespinal 1,5-2 µm.

MEB: Revela que las espinas poseen la base ensanchada, que el téctum es perforado y confirma que es granulado.

Comparaciones.–*Malvacipolloides comodorensis* Barreda 1993 del Oligoceno?-Mioceno de Argentina, se diferencia de *Malvacipolloides tucumanensis* sp. nov. porque el tamaño de los granos y el espesor de la exina son menores (15-25 µm y 1,4-1,7 µm, respectivamente), además, la nexina está más engrosada que la sexina; *Malvacipolloides densiechinata* Anzótegui y Garralla 1986 y *Sphaeralceae* sp. Anzótegui y Garralla, 1986 ambas del Mioceno de Argentina, se diferencian porque tienen las espinas más altas (5-6 µm), y el espesor de la exina es menor (1,5-3 µm). En *Sphaeralceae* sp. los ora y los mamelones son más grandes (5 µm), y las espinas están dispuestas formando bandas diagonales y paralelas. *Echitricolporites maristellae* Muller *et al.,* 1987, del Mioceno de Venezuela, se diferencia porque las espinas son más largas (4 µm).

Las diferencias antes mencionadas justifican la creación de esta nueva especie.

Afinidad botánica.–Malveae A. St.-Hil.

Malvacipolloides comodorensis Barreda, 1993
(Lám. 1, Fig. 3)

Dimensiones.–Diámetro del grano 23-25 µm; espesor exina de 1,4 µm en la zona subespinal y 0,7 µm en la interespinal; espinas de 1,4 µm o menos de alto; mamelones de 1,4-2 µm de diámetro; distancia interespinal 0,7-1 µm.

Principal material estudiado.–PMP CTES 1926f: 37,4/98,2; 1841f: 37,5/96,5.

Afinidad botánica.–Malveae A. St.-Hil.

Stephanocolporatae Iversen y Troels-Smith, 1950
Género *Baumannipollis* Barreda, 1993
Especie tipo: *Baumannipollis chubutensis* Barreda, 1993

Baumannipollis chubutensis Barreda, 1993
(Lám. 1, Fig. 4)

Dimensiones.–Diámetro del grano 50-63 µm; 7 a 8 colporos, ora de 4 µm de diámetro. Espesor de la exina en la zona subespinal de 3,5 µm (sexina de 2,8 µm y nexina de 0,7 µm), en la zona interespinal de 2,1 µm. Espinas 3,5-6 µm de alto, mamelones de 3,5-4 µm de diámetro y distancia interespinal de 1,5-2 µm.

Principal material estudiado.–CTES-PMP 1952b: 41,9/107,5; 2268c: 35,5/104; 2267d: 41,4/102,3; 1945c: 36,2/99,8; 2268a: 36,7/97,5; 2269e: 40/107; 2268a: 38,5/1007.

Afinidad botánica.–Malveae A. St.-Hil.

Baumannipollis variaperturatus Barreda, 1993
(Lám. 1, Fig. 5)

Dimensiones.–Diámetro del grano 48-56 µm (estas dimensiones son mayores que las brindadas por Barreda, 1993); colpos de 8 µm de largo, ora de 3 µm de diámetro con anillo de 1,4 µm de espesor (los palinomorfos aquí hallados son solamente tricolporados). Espesor de la exina en la zona subespinal de 2,8 µm (sexina de 2 µm y nexina de 0,7 µm), en la interespinal es de 2,1 µm de espesor (sexina de 1,4 µm y nexina de 0,7 µm). Espinas supratectales de 2-3,5 µm de alto, mamelones de 2 µm de diámetro y distancia interespinal de 3-6 µm.

Principal material estudiado.–CTES-PMP 1946f: 38/104,1; 1946h: 34,5/96; 1949c: 37,5/108; 2268d: 29,5/101,9; 1948c: 39,5/108,2; 1948b: 45,5/104,2; 1948b: 46,9/102,5; 1942f: 38,2/106; 1948d: 48,3/101; 1948f: 39/95; 31,5/104,5; 2267g: 38,2/110,5.

Afinidad botánica.–Malveae A. St.-Hil. *Bastardia* sp.

Baumannipollis evae Anzótegui y Cuadrado, 1996
(Lám. 1, Fig. 6; Lám. 2, Fig.4)

Dimensiones.–Diámetro del grano 35-38 µm; 4 colporos, colpos cortos de 3,5-6 µm, ora de 1,4 µm, anillo de 2 µm de espesor. Exina en la zona subespinal de 2 µm de espesor (sexina de 1,5 µm y nexina de menos de 0,5 µm), en la interespinal es de 0,7-1 µm, de espesor (no se diferencia sexina de nexina). Téctum granulado. Espinas supratectales de 3-3,5 µm de alto, mamelones de 3-3,5 µm de diámetro y distancia interespinal de 1-1,5 µm, mayor que en la diagnosis de la especie (0,5 µm de separación).

MEB: Confirma que el téctum es microgranulado.

Principal material estudiado.–CTES-PMP 1945e: 48,5/103,9; 1839a: 35,9/95,8; 1942c: 42,5/108,4; 2268e: 40,5/101,2; 1942e: 47,22/100; 45/107,5; 1942f: 39/100,6; 1946f: 43/99,9; 42/99.

Afinidad botánica.–Malveae A. St.-Hil.

Baumannipollis sp. 1
(Lám. 1, Fig. 7; Lám. 2, Fig. 5)

Descripción.–Granos de polen de 49-51 µm de diámetro, isopolares suboblatos, tetracolporados; ora de 3,5-4 µm de diámetro, con anillo de 2-3 µm de espesor. Espesor de la exina en la zona subespinal de 3,5 µm (sexina de 2 µm y nexina de 1,5 µm), en la zona interespinal de 2,8 µm (sexina y nexina de 1,4 µm de espesor cada una). Espinas de 3-3,5 µm de alto, mamelones de 2-3 µm de diámetro y distancia interespinal de 1,5-2µm.

MEB: permite observar microgránulos sobre el téctum.

Principal material estudiado.–CTES-PMP 2268e 43,5/101,7; 2268f: 45,5/100; 1945d: 41,2/96,4; 1952d: 38,2/99,5M 2267e: 42,5/106; 2268g: 36,4/97,5; 1926f: 37,3/101,5; 1949d: 42,8/98,4; 43/101,5; 1949e: 41/110,5; 1949f: 40/106,1.

Comparaciones.–*Baumannipollis evae* Anzótegui y Cuadrado (1996) del Mioceno de Argentina, se diferencia de *B.* sp. 1. porque el tamaño de los granos y el grosor de la exina son menores (36-42 µm y 1,4 de espesor respectivamente). *Baumannipollis chubutensis* Barreda, 1993, del Oligoceno?-Mioceno de Argentina, se diferencia porque tiene mayor número de aberturas (7 a 8 colporos), mientras que *Baumannipollis variaperturatus* Barreda, 1993, y *Baumannipollis* sp. en Barreda *et al.*, 1998, son granos tricolporados a pentacolporados, se diferencian porque en la primera, la distancia interespinal es mayor (2,5-6,5 µm) y en la

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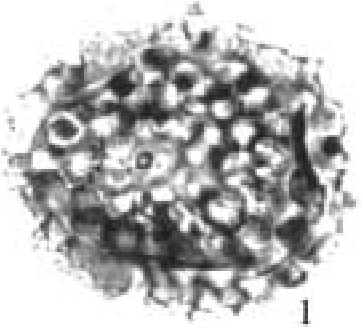
LÁMINA 1–Vista general de los granos. *1, 2, Malvacipolloides tucumanensis* sp. nov. *1,* Holotipo. Escala = 17,7µm. *2,* Paratipo. Escala = 18,5 µm. *3, Malvacipolloides comodorensis* Barreda. Escala = 14,2 µm. *4, Baumannipollis chubutensis* Barreda. Escala=37,7 µm. *5, Baumannipollis variaperturatus* Barreda. Escala = 33 µm. 6, *Baumannipollis evae* Anzótegui y Cuadrado. Escala = 21 µm. *7, Baumannipollis* sp. 1 Escala = 26,3 µm. *8, Baumannipollis* sp. 2. Escala = 44 µm. *9, Malvapantocolporites rafaelii* sp. nov. Escala = 25 µm. *10, Malvapantocolporites sanjosesii* sp. nov. Escala = 23 µm. *11, Malvapantocolporites silvinites* sp. nov. Escala = 23 µm. *12, Echiperiporites santamariana* sp. nov. Escala = 28,5 µm.

PLATE 1–General view of the pollen grains. *1, 2, Malvacipolloides tucumanensis* sp. nov. *1,* Holotipe. Scale bar= 17,7µm. *2,* Paratype. Scale bar = 18,5 µm. *3, Malvacipolloides comodorensis* Barreda. Scale bar= 14,2 µm. *4, Baumannipollis chubutensis* Barreda. Scale bar = 37,7 µm. *5, Baumannipollis variaperturatus* Barreda. Scale bar= 33 µm. *6, Baumannipollis evae* Anzótegui y Cuadrado. Scale bar= 21 µm. *7, Baumannipollis* sp. 1. Scale bar= 26,3 µm. *8, Baumannipollis* sp. 2. Scale bar = 44 µm. *9, Malvapantocolporites rafaelii* sp. nov. Scale bar= 25 µm. *10, Malvapantocolporites sanjosesii* sp. nov. Scale bar = 23 µm. *11, Malvapantocolporites silvinites* sp. nov. Scale bar= 23 µm. *12, Echiperiporites santamariana* sp. nov. Scale bar= 28,5 µm.

LÁMINA 1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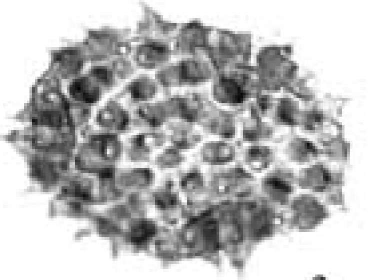
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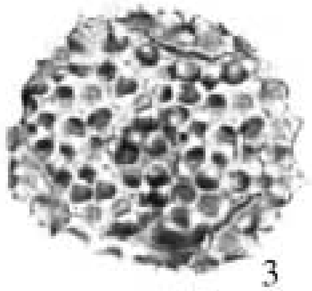
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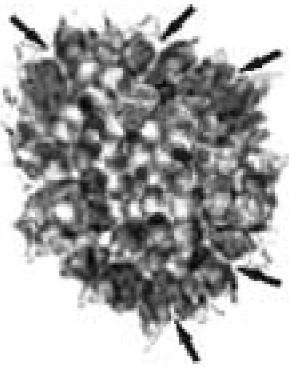
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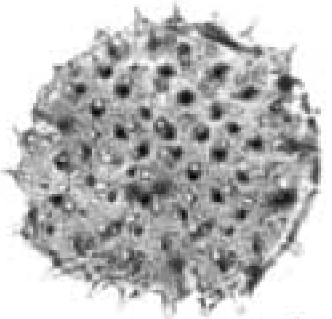
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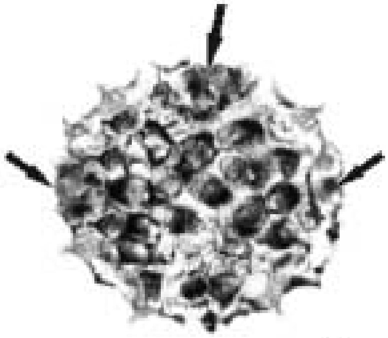
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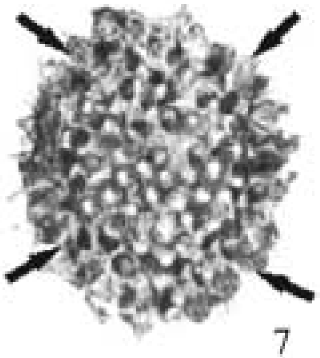
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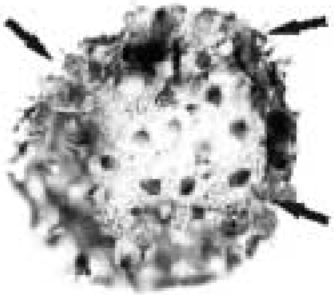
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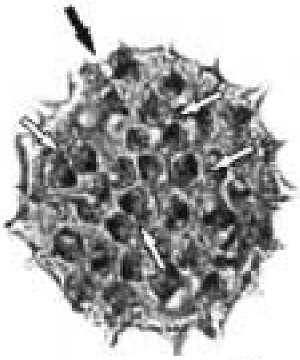
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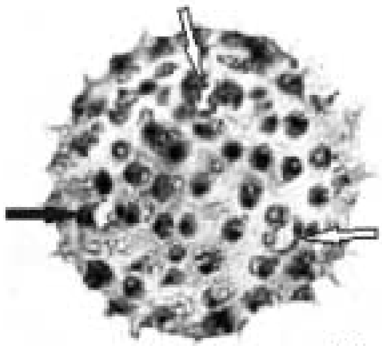
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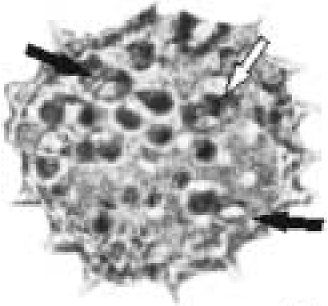
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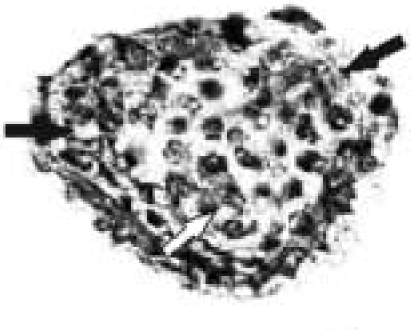
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segunda el espesor de la nexina, sobrepasa cuatro o cinco veces al de la sexina.

Afinidad botánica.–Malveae A. St.-Hil.

Baumannipollis sp. 2
(Lám. 1, Fig. 8; Lám. 2, Fig. 6; Lám. 3, Fig. 1)

Descripción.–Granos de polen de 70-77 µm de diámetro, isopolares, suboblatos, estefanocolporados, penta a hexacolporados. Ora de 3 µm de diámetro. Colpos cortos apenas sobrepasan el diámetro de los ora. Tectados, equinados. Exina en la zona subespinal de 3,5 µm de espesor y en la zona interespinal de 2 µm. Espinas supratectales de 2,8 µm de alto; mamelones de 4 µm de diámetro y distancia interespinal de 3-3,5 µm.

MEB: revela que el téctum es perforado, suavemente rugulado con escasos microgránulos, características que se repiten en la base del mamelón.

Principal material estudiado.–CTES-PMP 1942c: 41,9/102; 2268d: 46,4/106,9; 1949d: 39,5/102,5.

Comparaciones.–*Baumannipollis chubutensis* Barreda, 1993, y *B. evae* Anzótegui y Cuadrado, 1996, se diferencian de *B.* sp. 2, principalmente por el número de aberturas, la primera presenta siete a ocho y la segunda cuatro colporos.

Esta especie se deja con nomenclatura abierta porque se han hallado pocos ejemplares y algunos mal preservados.

Afinidad botánica.–Malveae A. St.-Hil., *Modiolastrum* sp.

PERICOLPORATAE Iversen y Troels-Smith, 1950
Género *Malvapantocolporites* gen. nov.
Especie tipo: *Malvapantocolporites rafaelii* sp. nov.

Diagnosis.–*Pollen grains spheroidal, apolar. Oligoaperturate, pantocolp(oid)orate, ora with or without annulus. Exine tectate, echinate. Spines with basal cushion.*

Discusión.–Se crea el género *Malvapantocolporites* gen. nov. para reunir granos de polen, oligopantocolp(oid)orados, afines a Malvaceae, dado que no existe un morfogénero que incluya estos caracteres. Los morfogéneros que corresponden a granos de polen de Malvaceae son: *Malvacipolloides* Anzótegui y Garralla 1985 en el que se incluyen granos tricolporados; *Baumannipollis* Barreda, 1993, para estefanocolporados y *Echiperiporites* (Hammen y Wymstra, 1964) Anzótegui y Cuadrado, 1996, para periporados.

Derivatio nominis.–El nombre genérico se refiere a la afinidad botánica con las Malvaceae y al tipo de aberturas que caracterizan a estos palinomorfos.

Malvapantocolporites rafaelii sp. nov.
(Lám. 1, Fig. 9; Lám. 3, Figs. 2, 5, 8 y 10)

Diagnosis.–*Pollen grains apolar, sphaeroidal, oligopantocolp(oid)orate. Ora small 1,4-2 µm diameter. Exine tectate, echinate, underneath the spines 4,2 µm thick and between spines zone 2 µm thick. Spines 3 µm long and 1,4-2,1 µm apart with basal cushion.*

Holotipo.–PMP 2268a: 41,8/107,1.

Paratipo.–PMP 1942a: 44,7/107,1.

Localidad y estrato tipo.–Km 107, Formación San José, noroeste de la provincia de Tucumán.

Edad.–Mioceno medio.

Material estudiado.–PMP 2267g: 45,5/100,6; 44,1/105,4; 1942f: 38,8/106,4;1946e: 41,8/100; 1942c: 45,8/106,5; 2268e: 42,8/98,8; 35,5/100.

Derivatio nominis.–El epíteto específico está dedicado al destacado paleobotánico doctor Rafael Herbst.

Descripción.–Granos de polen de 42-45 µm de diámetro, ora de 1,4-2 µm de diámetro con anillo de 1,4 µm. Las aberturas se encuentran en disposición espiralada. El espesor de la exina en la zona subespinal es de 4,2 µm (sexina de 2,8 µm; nexina de 1,4 µm), en la zona interespinal 2 µm (sexina y nexina de 1 µm de espesor cada una). Téctum granulado. Espinas de 3 µm

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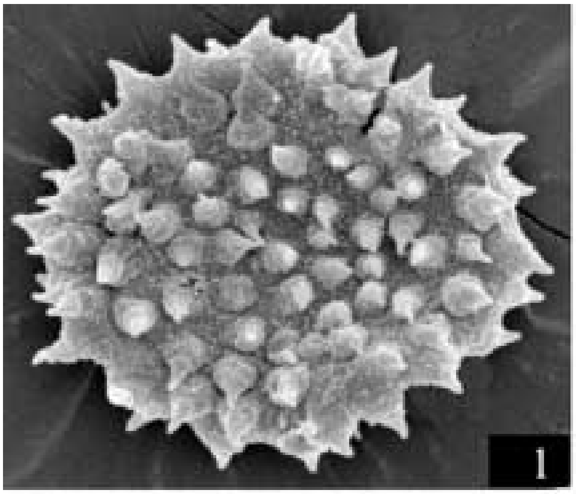
LÁMINA 2–MEB: *1, 2, 4-6,* Vista general de los granos. *3,* detalle de la abertura. *1-3, Malvacipolloides tucumanensis* sp. nov. (1: x 3.000. Escala = 6 µm; 2: x 2.500. Escala = 9 µm; 3: x 10.000. Escala = 2 µm). *4, Baumannipollis evae* Anzótegui y Cuadrado (x 2.700. Escala = 6 µm). *5, Baumannipollis* sp. 1 (x 1.800. Escala = 8 µm). *6, Baumannipollis* sp. 2. (x 1.400. Escala = 12,5 µm).

PLATE 2–MEB: *1, 2, 4-6,* General view of grains. *3,* aperture detail. *1-3, Malvacipolloides tucumanensis* sp. nov. (1: x 3,000. Scale bar= 6 µm; 2: x 2,500. Scale bar= 9 µm; 3: x 10,000. Scale bar= 2 µm). *4, Baumannipollis evae* Anzótegui and Cuadrado (x 2,700. Scale bar= 6 µm). *5, Baumannipollis* sp.1 (x 1,800. Scale bar= 8 µm). *6, Baumannipollis* sp. 2. (x 1,400. Scale bar= 12.5 µm).

LÁMINA 2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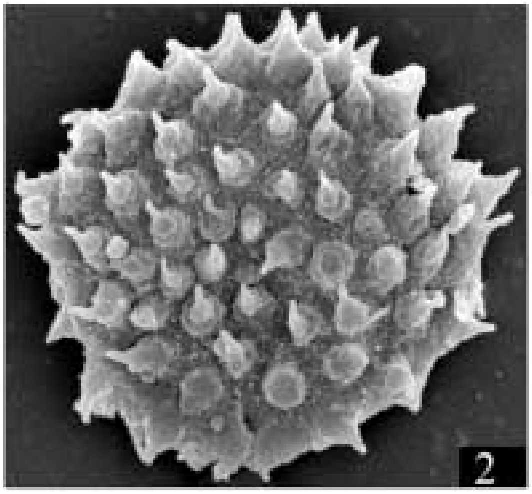
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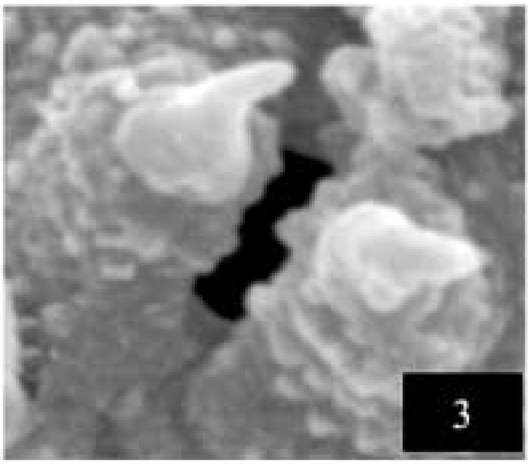
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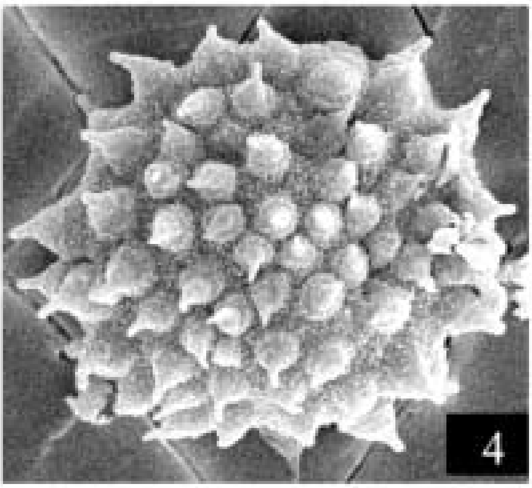
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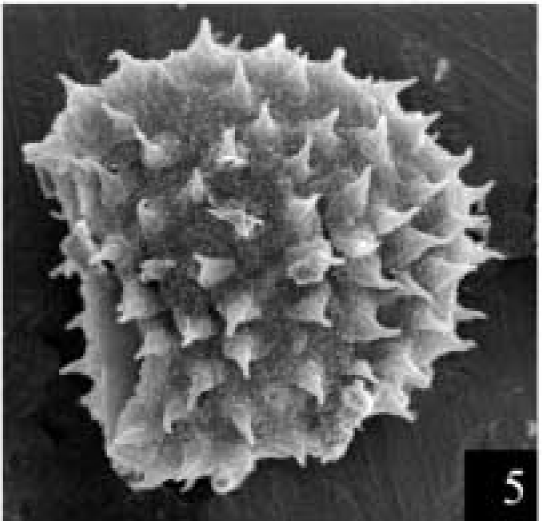
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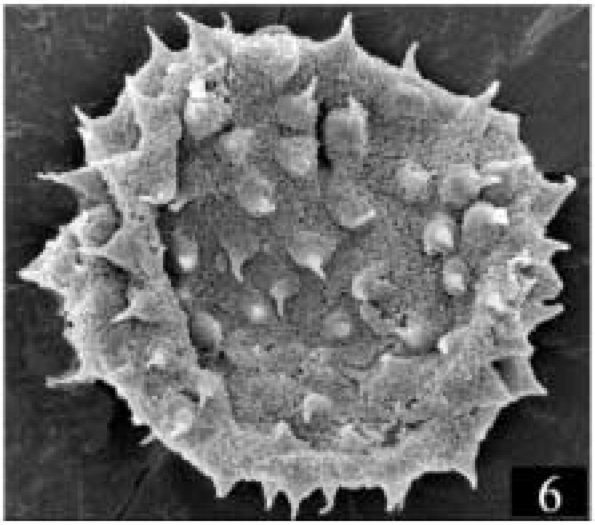
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de alto, mamelones de 3-3,5 µm de diámetro y distancia interespinal de 1,4 a 2,1 µm.

MEB: revela que el téctum es perforado y microequinulado, características que se repiten en los mamelones.

Comparaciones.–La presencia de aberturas oligopantocolp(oid)oradas, con disposición espiralada, el téctum visiblemente granulado y las espinas con ápices agudos y mamelones pronunciados, diferencian a esta especie de *Baumannipollis evae* Anzótegui y Cuadrado, 1996 (tetracolporado), a pesar de que comparten el tamaño general de los granos y la altura de las espinas; y de *Malvacipolloides tucumanensis* sp. nov. (tricolporado) con la que comparte tamaño del grano, espesor de la exina, altura de las espinas y diámetro de los mamelones.

Afinidad botánica.–Malveae A. St.-Hil.

Malvapantocolporites sanjosesii sp. nov.
(Lám. 1, Fig. 10; Lám. 3, Figs. 3 y 4)

Diagnosis.–*Pollen grains apolar, spheroidal, oligopantocol(oid)orate, ora 3-5 µm diameter, with annulus, colpoid short. Exine tectate, echinate, underneath the spines 2 µm thick and between spines zone 1,5 µm thick. Spines 2-2,5 µm long and 2-3 µm apart with basal cushion.*

Holotipo.–CTES-PMP 1948f: 37,3/94,5.

Paratipo.–CTES-PMP 2267g: 45,5/100,6.

Localidad y estrato tipo.–Km 107, Formación San José, noroeste de la provincia de Tucumán.

Edad.–Mioceno medio.

Material estudiado.–CTES-PMP 1946f: 46,5/104,5; 1948a: 45,4/109,5; 1839c: 44,5/100; 1841d: 44/108,2; 1841f: 37/96,5; 2265c: 38,9/101,3; 1944b: 41,5/107,5; 1945c: 39,6/106,4; 1839a: 37/101,5; 1948f: 37,3/94,5; 2267g: 45,5/100,6.

Derivatio nominis.–Alude a la Formación San José de la que provienen los palinomorfos.

Descripción.–Granos de polen de 31-45 µm de diámetro, ora de 3 a 5 µm de diámetro, con anillo de 1,5-3 µm de espesor y colpoides cortos apenas sobrepasan el diámetro de los poros. El espesor de la exina en la zona subespinal es de 2 µm y en la interespinal es de 1,5 µm (debido al reducido grosor de la exina es imposible discriminar el espesor de la sexina y nexina). Téctum granulado. Espinas de 2-2,5 µm de alto, mamelones de 2 µm de diámetro y distancia interespinal de 2 a 3 µm.

MEB: se observan gránulos en la exina y escaso desarrollo de los mamelones confirmando lo observado al MO.

Comparaciones.–Estos palinomorfos tienen ora con anillos delicados y los colpoides son visibles únicamente cuando se los analiza minuciosamente con el microscopio óptico y con el microscopio electrónico de barrido. La exina es delgada y los mamelones de las espinas tienen poco desarrollo; estas características los diferencian de *Malvapantocolporites rafaelii* sp. nov., porque en esta especie al microscopio óptico, los colpoides son fácilmente perceptibles, los ora más pequeños y el mamelón de las espinas posee mayor diámetro, al igual que el espesor de la exina, pero son menores las dimensiones de la distancia interespinal.

Por las diferencias mencionadas se crea esta nueva especie.

Afinidad botánica.–Malveae A. St.-Hil.

Malvapantocolporites silvinites sp. nov.
(Lám. 1, Fig. 11; Lám. 3, Fig. 7 y 9)

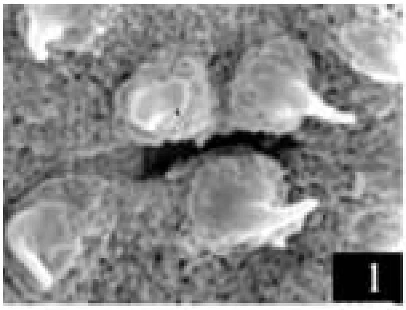
Diagnosis.–*Pollen grain apolar, spheroidal, oligopantocol(oid)orate, ora 3-5 µm diameter, with annulus, colpoid short. Exine tectate, echinate underneath*

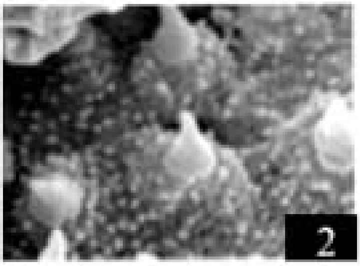
→

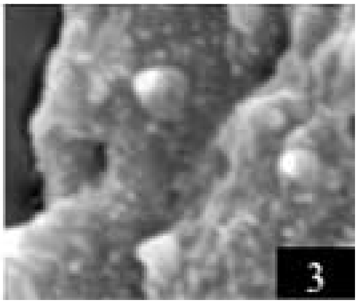
LÁMINA 3–MEB: *1-3, 8-10,* Detalle de las aberturas. *4-7,* Vista general de los granos. *1, Baumannipollis* sp. 2. (x 6.000. Escala = 3 µm) *2, 5, 8* y *10, Malvapantocolporites rafaelii* sp. nov. (5: x 2.200; *2, 8* y *10,* x 10.000. Escala = 5 µm, 2 µm y 4 µm respectivamente). *3, 4, M. sanjosesii* sp. nov. (3: x 10.000. Escala = 4 µm; 4: x 2.300. Escala = 6 µm). *6, Echiperiporites santamariana* sp. nov. (x 2.200. Escala = 8 µm). *7, 9, M. silvinites* sp. nov. (7: x 2.200. Escala = 6 µm); (9: x 10.000. Escala = 4 µm).

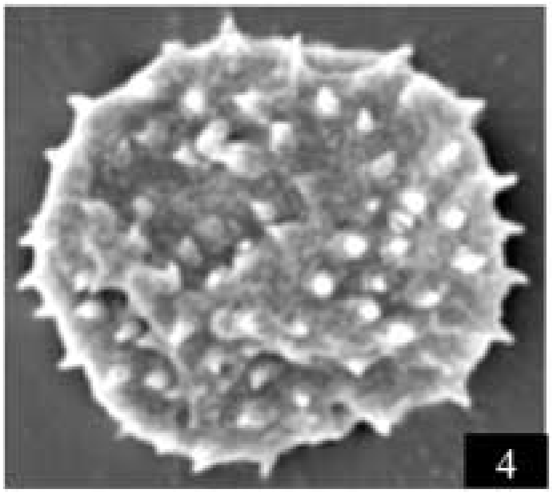
PLATE 3–MEB: *1-3, 8-10,* Aperture detail. *4-7,* general view. *1, Baumannipollis* sp. 2. (x 6,000. Scale bar = 3 µm) *2, 5, 8* and *10, Malvapantocolporites rafaelii* sp. nov. (5: x 2,200; 2.8 and 10: x 10,000. Scale bar = 5 µm, 2 µm y 4 µm respectively).*3, 4, M. sanjosesii* sp. nov. (3: x 10,000. Scale bar = 4 µm; 4: x 2,300. Scale bar = 6 µm). *6, Echiperiporites santamariana* sp. nov. (x 2,200. Scale bar = 8 µm). *7, 9, M. silvinites* sp. nov. (7: x 2,200. Scale bar = 6 µm; 9: x10,000. Scale bar = 4 µm).

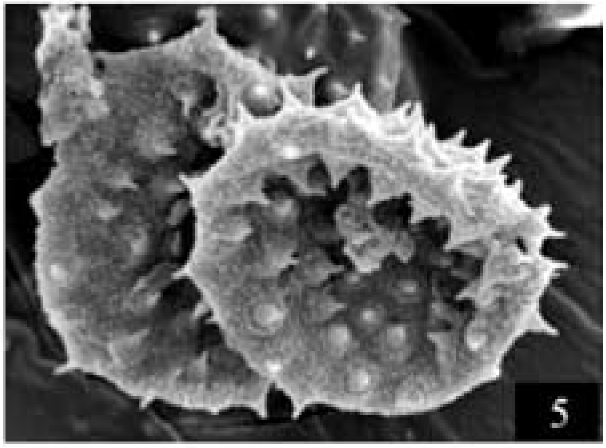
LÁMINA 3

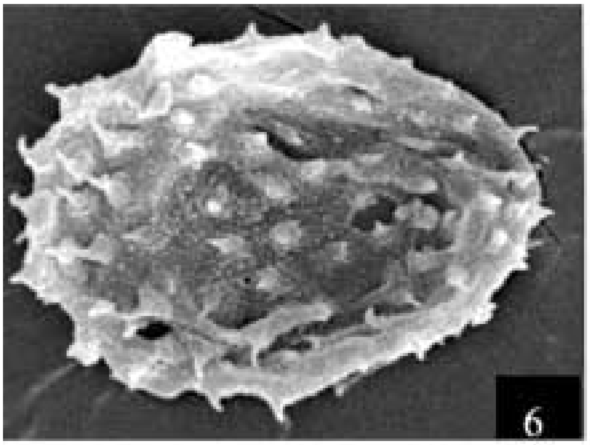


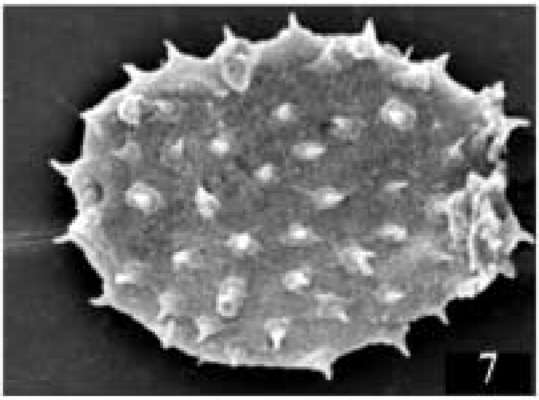


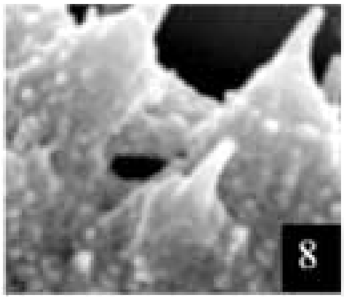


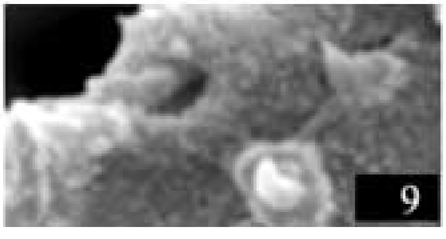


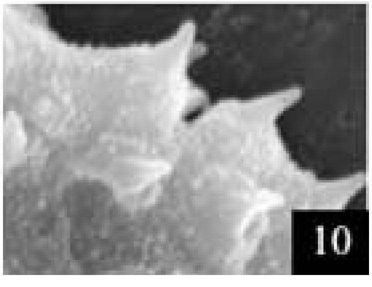












the spines zone 4,5µm thick and between spines 3 µm thick. Spines 2,5-3 µm µm long and de 3-5,5 µm apart with basal cushion.

Holotipo.–CTES-PMP 1945e: 37/103,7.

Paratipo.–CTES-PMP 2276g: 44,1/105,4.

Localidad y estrato tipo.–Km 107, Formación San José, noroeste de la provincia de Tucumán.

Edad.–Mioceno medio.

Material estudiado.–CTES-PMP 2265c: 38,9/101,3; 1944b: 41,5/107,5; 1945c: 39,6/106,4; 1839a: 37/101,5.

Derivatio nominis.–Dedicado a la palinóloga Dra. Silvina Garralla.

Descripción.–Granos de polen de 40-42 µm de diámetro. Ora de 3-3,5 µm de diámetro, con anillo de 2 µm, colpoides que apenas sobrepansan el diámetro de los ora. Espesor de la exina de 4,5 µm en la zona subespinal (sexina de 2,8 µm y nexina de 1,5µm) y en la interespinal de 3 µm (sexina mide 2 µm y la nexina 1 µm). Espinas de 2,5-3 µm de alto, mamelones de 2,5-3 µm y distancia interespinal de 3-5,5 µm.

MEB: permite apreciar que la exina es perforada con microgránulos.

Principal material estudiado.–CTES-PMP 1945e: 37-103,7; 1942e: 47/100; 39,1/106,1; 2266d: 37,9/100,2; 43,2/99,6; 2268e: 37,3/98; 2268f: 31/98,2.

Comparaciones.–Estos ejemplares tienen ora bien definidos y colpoides cortos, angostos y apenas marcados, espinas de tamaño mediano y exina de espesor considerable; estas características los diferencian de *Malvapantocolporites rafaelii* sp. nov. que presenta menores dimensiones en los ora y en la distancia interespinal aunque mayor diámetro de los mamelones. *Malvapantocolporites sanjosesii* sp nov. se distingue de *M. silvinites* sp. nov. fundamentalmente porque posee menor espesor de la exina (2 µm en la zona subespinal y 1,5 µm en la interespinal), de la distancia interespinal (2-3 µm) y mayor diámetro de los ora (3-5 µm), además con el MEB el téctum posee gránulos y escaso desarrollo de los mamelones, en cambio en *M. silvinites* sp. nov. el téctum además de gránulos tiene perforaciones.

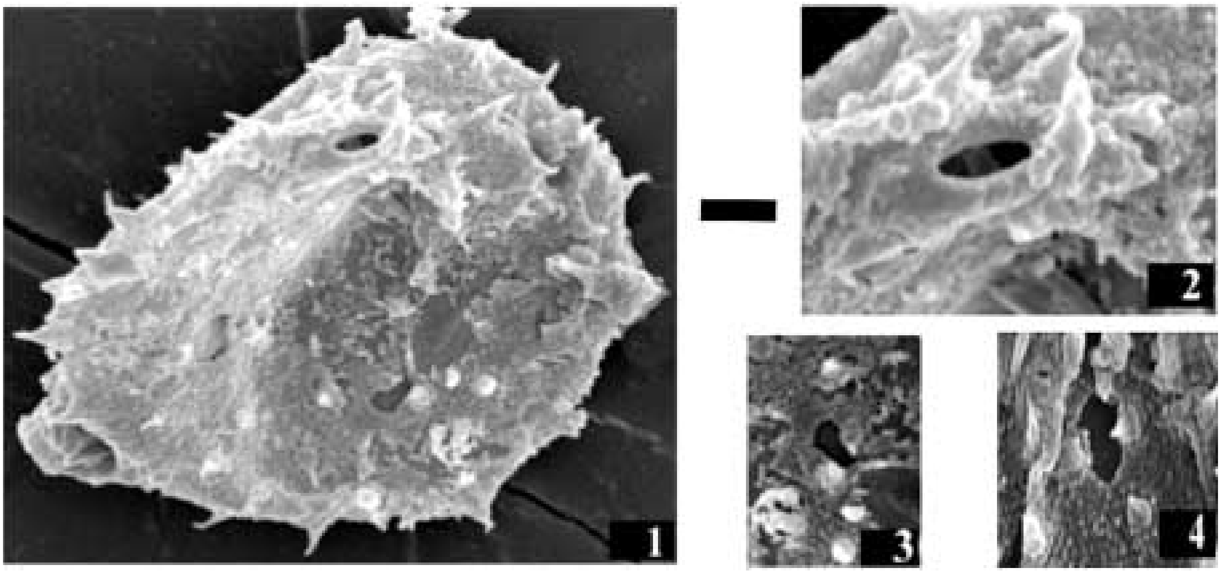


Figura 2–MEB: En *1,* Vista general. En *2-4,* detalle de las aberturas (x 10.000; en 2 Escala = 4 µm, en 3 = 7 µm, en 4 = 5 µm). *1-4,* E. *santamariana* sp. nov. 1. Grano con la sexina desprendida (1: x 2.000. Escala = 8 µm).

Figure 2–MEB. *1,* General view. *2-4,* aperture details (x 10,000; in 2 Scale bar =4 µm, in 3 =7 µm, in 4= 5 µm). *1-4,* E. *santamariana* sp. nov. 1. Grain with loose sexine (1: x 2,000. Scale bar = 8 µm).

Por las diferencias anteriormente mencionadas se erige esta nueva especie.

Afinidad botánica.–Malveae A. St.-Hil.

PERIPORATAE Iversen y Troels-Smith, 1950
Género *Echiperiporites* (Hammen y Wymstra, 1964)
Anzótegui y Cuadrado, 1996
Especie tipo: *Echiperiporites akanthos* van der Hammen y Wymstra, 1964

Echiperiporites santamariana sp. nov.
(Lám. 1, Fig. 12; Lám. 3; Fig. 6
y Fig.-texto 2, Figs. 1 a 4)

Diagnosis.–*Pollen grain apolar, spheroidal, periporatae, oligoporatae. Ora 4,5-5 µm diameter, with annulus. Tectate, echinate, underneath the spines 3,5 µm thick and between spines zone 2,1 µm thick. Spines 3-3,5 µm long and de 3,5 µm apart with basal cushion.*

Holotipo.–CTES-PMP 2268a: 49,8/103.

Paratipo.–CTES-PMP 1949b: 43,1/99,4.

Localidad y estrato tipo.–Km 107, Formación San José, noroeste de la provincia de Tucumán.

Edad.–Mioceno medio.

Material estudiado.–CTES-PMP 1952d: 44,6/97,3; 1952a: 38,5/106,5; 1841c: 37,9/106,5, 1841a: 47,3/103,2; 2268c: 45,2/102; 1948e: 31,4-99,1; 1952d: 44,2/98,5.

Derivato nominis.–El nombre se refiere al Valle Santa María, donde se halla la localidad km 107.

Descripción.–Granos de polen de 47-60 µm de diámetro, apolares, esferoidales. Periporados, oligoporados. Poros con disposición espiralada, de 4-5 µm de diámetro, con anillo de 2,8 µm. Exina tectada, equinada. El espesor de la exina en la zona subespinal es de 3,5 µm (sexina de 2,8 µm, nexina de 0,7 µm de espesor) y en la interespinal de 2,1 µm (1,4 µm en la sexina y 0,7 µm en la nexina). Espinas supratectales de 3-3,5 µm de alto, mamelones de 2,8 µm de diámetro y distancia interespinal de 3,5 µm.

MEB: revela que el téctum tiene gránulos.

Comparaciones.–*Echiperiporites santamariana* sp. nov. se diferencia de *Echiperiporites estelae* Germeraad *et al.*, 1968, del Terciario de áreas tropicales, porque tanto el diámetro de los granos (55-87 µm), el tamaño de las espinas (6-9 µm) y la distancia interespinal (6 a 10 µm) son mayores; por el contrario *Echiperiporites parviechinatus* Anzótegui y Cuadrado, 1996, del Mioceno de Argentina y *Echiperiporites akanthos* Hammen y Wymstra, 1964 del Oligoceno-Mioceno de British Guiana tienen menor tamaño (35-40 µm, uno y 15-24 µm el otro) y las espinas son de menor altura (2 µm y 0,5-1 µm, respectivamente); además, *Echiperiporites parviechinatus* tiene menor diámetro en los poros (1,4 µm).

Por las diferencias mencionadas se justifica la creación de esta nueva especie.

Afinidad botánica.–Malveae A. St.-Hil., *Sida* sp.

DISCUSIÓN

Las tendencias evolutivas para la familia Malvaceae, presentadas por Christensen (1986), están resumidas en el Cuadro 1, elaborado por Zamaloa y Romero (1990), en el que se han introducido algunos datos adicionales a fin de brindar mayores precisiones. Siguiendo este criterio, en el Cuadro 2 se distribuyen los palinomorfos de Malvaceae argentinos, a fin de señalar sus diferencias y tendencias evolutivas. Como los palinomorfos aquí presentes se encuentran comprendidos en la tribu Malveae, que es la que contiene los estados ancestrales de los caracteres palinológicos, las consideraciones evolutivas inferidas corresponden particularmente a esta tribu. Las siguientes observaciones para las especies del km 107 surgen de los datos contenidos en los Cuadros 1 y 2. En cuanto a las aberturas (carácter de importancia primaria), se encuentran granos colporados en *Malvacipolloides comodorensis* Barreda, 1993 y *M. tucumanensis* sp. nov. (tricolporados) y en todas las especies de *Baumannipollis* (estefanocolporados). El estado derivado (evolucionado) de ese carácter se halla en los pantoporados (*Echiperiporites santamariana* sp. nov.) y se considera como estado intermedio a los oligocolp(oid)orados del género nuevo *Malvapantocolporites* gen. nov., en el que los colpos muestran una considerable reducción. No obstante, la mayoría de los granos tiene tamaño mediano (25-50 µm, excepto *Baumannipollis* sp. 2, que mide 77 µm) son de forma oblata, con espinas cortas (menores a 5 µm), monomórficas, con mamelones y ora anillados, estados señalados como primitivos o ancestrales por Christensen *(op. cit.)*. Por el surge que, tanto los granos colporados como los oligocolp(oid)orados (*Malvapantocolporites silvinites* sp. nov., *M. sanjosesii* sp. nov., *M. rafaelii* sp. nov.) y los pantoporados (*Echiperiporites santamariana* sp. nov.) están acompañados de estados ancestrales; aunque un estado que no se corresponde con el esquema de Christensen *(op. cit.)* es el pequeño tamaño de los poros (5 µm o menos). En el contexto de las especies argentinas, la mayoría también presenta esta tendencia, con excepción de *Malvacipolloides comodorensis* Barreda (1993) y *Baumannipollis* sp. Barreda *et al.* (1998), que presentan la nexina más gruesa que la sexina, un estado derivado, de acuerdo con Christensen (1986). No obstante, las especies de *Malvacipollis* (3-8 estefanoaperturadas) halladas en Argentina (*M. argentina* Zamaloa y Romero; *M. subtilis* Stover y *Malvacipollis* sp., en Cuadro 2) y que corresponden a los registros más antiguos (Eoceno-Oligoceno) escaparían de este esquema. Siguiendo a Christensen (1986) y por la experiencia adquirida por una de las autoras (G. A. C.), como resultado del análisis de las 208 especies actuales argentinas (inédito), ninguna especie posee granos de polen con escasos poros ubicados en el ecuador; por el contrario, todos los granos con estas características son colporados; de esto surge la necesidad de que estas especies sean sometidas a revisión. Es posible que en las formas fósiles mencionadas, los colpos o colpoides sean cortos y se encuentren enmascarados por la abundante escultura y/o el grosor de la exina; tal como ocurrió con las especies de la Formación Chiquimil (*Malvacipollis* sp., Mautino *et al.*, 1997, *Malvacipollis* sp., Herbst *et al.*, 2000, y *Malvacipollis argentina* Zamaloa y Romero; en Mautino y Anzótegui, 2002b), que pasaron a sinonimia de *Malvacipolloides tucumanensis* sp. nov., en este trabajo. De esta manera, las especies de *Malvacipollis* cabrían, por la edad y características, en el esquema propuesto en el Cuadro 1. Del Cuadro 2, también se desprende que *Malvacipolloides comodorensis* Barreda, 1993 y *Baumannipollis variaperturatus* Barreda, 1993 son las especies de mayor distribución en el Mioceno de Argentina, seguidas por *B. chubutensis* Barreda, 1993.

CONCLUSIONES

En Argentina el registro más antiguo de granos de polen de Malvaceae se produce en el Eoceno (con tres especies), diversificándose considerablemente en el Mioceno con 19. Coincidentemente, la mayoría presenta estados ancestrales de los caracteres, mostrando estados derivados en las aberturas; por ello se infiere que los cambios más rápidos se produjeron en este carácter, en contraste con los restantes (con algunas excepciones) que se mantuvieron estables hasta el Mioceno. Por consiguiente, el esquema propuesto por Christensen (1986) se refleja positivamente en mayor o menor medida en los granos de polen fósiles de Argentina. Por último, la diversidad de granos de polen de Malvaceae (tribu Malveae) encontrados en distintas formaciones del Mioceno de Argentina confirmaría que la familia se encontraba en plena radiación. Cabe la posibilidad de que los estados más derivados de los caracteres aperturales y esculturales (polipantoaperturado, espinas largas y dimórficas) no fueron hallados todavía en el registro fósil o que los mismos aún no se produjeron en la familia en esa época. La hipótesis de Christensen (1986) acerca de que el origen de las Malvaceae se habría producido en el sur del continente de Gondwana quedaría avalada con los recientes hallazgos.

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APORTACIONES DEL ANÁLISIS POBLACIONAL DE OSTRÁCODOS: LA EVOLUCIÓN PALEOAMBIENTAL DEL SECTOR SUDOCCIDENTAL DEL PARQUE NACIONAL DE DOÑANA DURANTE EL HOLOCENO SUPERIOR

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Resumen

El análisis de los ostrácodos extraídos en dos testigos tomados en el sector sudoccidental del Parque Nacional de Doñana permite deducir su evolución durante el Holoceno Superior. En los últimos 2.400-2.300 años BP se ha producido la transición desde un lagoon, habitado básicamente por *Cyprideis torosa* (Jones), *Loxoconcha elliptica* (Brady) y *Leptocythere castanea* (Sars), hasta la actual laguna de aguas dulces, con numerosos individuos de *Cyprinotus salinus* (Brady) y *Herpetocypris chevreuxi* (Sars). En este período, diversos eventos energéticos (¿tormentas, *tsunamis?)* han quedado reflejados en un aumento en la proporción de adultos de *Cyprideis torosa* y en los porcentajes de especies marinas.

Palabras clave: Ostrácodos, cambios ambientales, Holoceno superior, SO España.

Abstract

[Contributions of the ostracode population analysis: paleoenvironmental evolution of the southwestern sector of the Doñana National Park (SW Spain) during the Late Holocene]. The ostracode analysis of two cores collected in the southwestern area of the Doñana National Park permits to deduce its evolution during the Late Holocene. In the last 2,400-2,300 years BP, there was a transition from a lagoon, inhabited mainly by *Cyprideis torosa* (Jones), *Loxoconcha elliptica* (Brady) and *Leptocythere castanea* (Sars), to the present-day fresh-water pond, with numerous individuals of *Cyprinotus salinus* (Brady) and *Herpetocypris chevreuxi* (Sars). In this period, different energetic events (storms?, tsunamis?) have been deduced from both the higher adult proportions of *Cyprideis torosa* and the introduction of marine species.

Key words: Ostracodes, environmental changes, Late Holocene, SW Spain.

INTRODUCCIÓN

El análisis de las poblaciones de los ostrácodos se basa en métodos estadísticos simples que requieren la determinación del porcentaje de las diferentes mudas en cada muestra, la razón entre el número de adultos y de juveniles o la diversidad específica (Whatley, 1983; 1988). Estas técnicas se han revelado como una interesante herramienta en el estudio de diversas características (paleo-)ambientales, como las tasas de sedimentación (Pokornyi, 1965), o bien han sido aplicadas al estudio sedimentológico de yacimientos petrolíferos (Oertli, 1970) o en la interpretación hidrodinámica de medios actuales y fósiles (Brouwers, 1988; Ruiz *et al.*, 1998).

La mayoría de estas investigaciones se han centrado en especies dulceacuícolas o propias de zonas de transición marino-continental. En estos últimos medios, *Cyprideis torosa* (Jones) es una de las especies más representativas en lagunas costeras, lagoons, estuarios, deltas y zonas infralitorales someras (Vesper, 1972; Heip, 1976; Carbonel *et al.,* 1981). En este estudio, se analizan sus poblaciones en dos testigos continuos obtenidos en el Parque Nacional de Doñana. Su estudio intentará evaluar su potencial como trazador de los posibles cambios ambientales que ha sufrido su sector meridional durante el Holoceno superior.

EL PARQUE NACIONAL DE DOÑANA

El río Guadalquivir (560 km) drena una cuenca de 57.000 km^2, formada principalmente por rocas sedimentarias terciarias. Su desembocadura está parcialmente cerrada por un conjunto de flechas litorales (Fig. 1: p. ej., La Algaida) que delimitan un amplio estuario interior (1.800 km^2). Este estuario incluye al Parque Nacional de Doñana, una Reserva Unesco de la Biosfera que comprende 50.720 ha y representa uno de los últimos sectores relativamente poco antropizados del estuario.

Los procesos hidrodinámicos del estuario están controlados por el régimen fluvial, el flujo mareal, la acción de las olas y las corrientes de deriva litoral. Este río es la principal fuente de sedimentos de la costa sudoccidental española, con un caudal anual medio de 164 m^3 s^{-1}. El régimen mareal es mesomareal y semidiurno, con un rango medio de 3,6 m (Borrego *et al.,* 1993). Las olas dominantes procedentes del suroeste, con una energía moderada debido a que el 75% de ellas no superan los 0,5 m de altura. Finalmente, las corrientes de deriva litoral transportan sedimentos desde la costa portuguesa hacia el este, aportando sobre todo arenas a la construcción de las flechas litorales (Cuena, 1991).

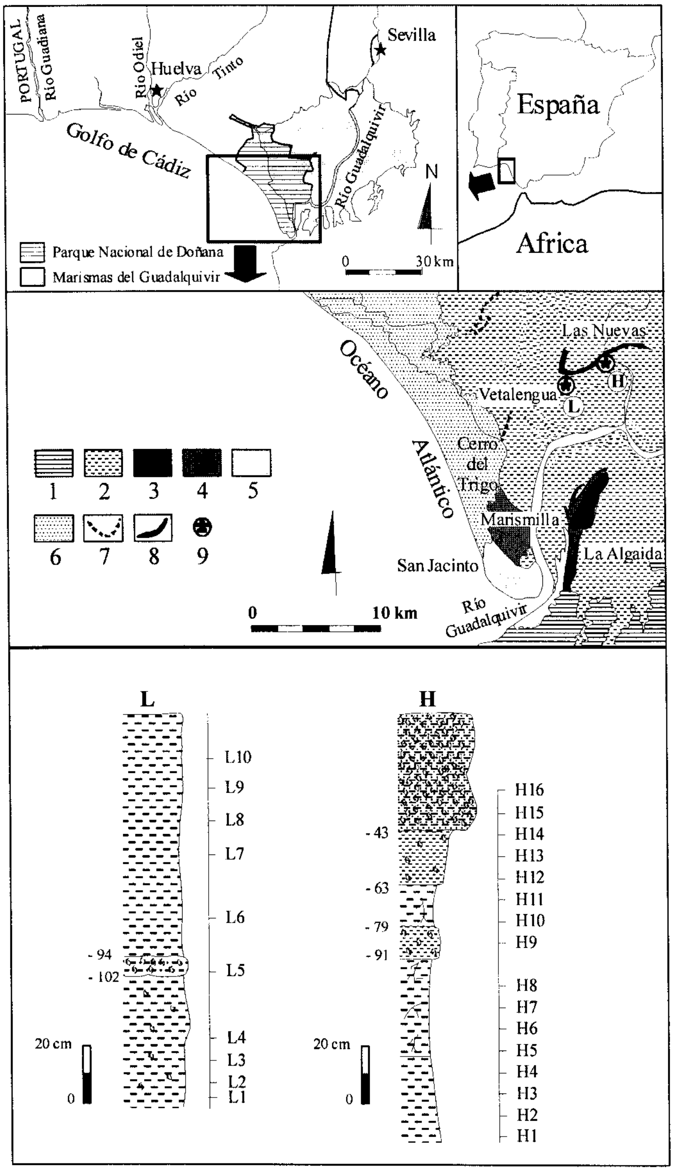

FIGURA 1–Localización geográfica y geomorfología de la desembocadura del río Guadalquivir. Clave: 1: sustrato Pliocuaternario; 2: marismas; 3-5: fases de progradación en las flechas litorales; 6: sistemas cuaternarios de dunas; 7: cordones litorales; 8: cordones estuarinos; 9: testigos estudiados.

FIGURE 1–Geographical setting and geomorphology of the Guadalquivir River mouth. Key: 1: Plio-Quaternary substrate; 2: marshes; 3-5: progradational phases of the littoral spits; 6: Quaternary dune systems; 7: littoral ridges; 8: estuarine ridges; 9: location of the cores studied.

Diversos estudios se han concentrado en la evolución holocena de este estuario, sugiriendo una cronología de eventos de progradación y erosión basada en la datación radiométrica de conchas recogidas en las flechas litorales (Zazo *et al.,* 1994; Lario *et al.,* 1995; Goy *et al.,* 1996; Rodríguez-Ramírez, 1996; Rodríguez-Ramírez *et al.,* 1996; Dabrio *et al.,* 1999). A partir del máximo transgresivo flandriense (ca. 6.500 años BP; Zazo *et al.,* 1994), se han reconocido cuatro fases principales de progradación: ca. 6.500-4.400 años BP, ca. 4.200-2.550 años BP, ca. 2.300-800 años BP y ca. 500 años BP hasta la actualidad. Estas fases están divididas por eventos erosivos entre ca. 4.500-4.200 años BP, ca. 2.600-2.300 años BP and ca. 1.100-1.000 años BP. Otros estudios han investigado las facies estuarinas holocenas (Borrego, 1992; Morales, 1993) y la reconstrucción de la evolución sedimentaria estuarina basada en testigos contínuos (Borrego *et al.*, 1999; Dabrio *et al.*, 2000).

METODOLOGÍA

Un total de 26 muestras fueron seleccionadas en dos testigos continuos obtenidos en el sector meridional del Parque Nacional de Doñana, cuya litología fue descrita durante la campaña de campo. En cada una de ellas, se extrajeron 15 g de sedimento y se levigaron a través de un tamiz de 63 µm. Se separaron 300 valvas y carapazones de ostrácodos en aquellas muestras que lo permitieron, con extrapolación al peso total para el cálculo de la abundancia. En las muestras con menor número de individuos, se procedió al contaje e identificación de todos los ostrácodos presentes.

Para el análisis de las poblaciones de *Cyprideis torosa*, se procedió inicialmente a la medida de la longitud y anchura de las valvas presentes, para poder identificar el tamaño de las diferentes mudas. A continuación, se calcularon la proporción de esta especie en relación con el número total de ostrácodos y los porcentajes relativos de cada muda.

Se ha realizado una datación del testigo L en los laboratorios Beta Analytic (Miami, EE. UU.). La edad de dos niveles del testigo H puede deducirse por correlación lateral con otro testigo estudiado por Rodríguez-Ramírez (1996) en la misma área. En ambos casos, se utilizaron conchas de *Cardium edule* para el análisis isotópico. Los datos fueron calibrados con el programa Calib versión 4.3 (Stuiver y Reimer, 1993; Stuiver *et al.*, 1998). Los resultados finales corresponden a edades calibradas (ca.) usando intervalos de 2θ, con la aplicación de un efecto reservorio de (–440 + 85 años), de acuerdo con los datos obtenidos por Lario (1996) y Dabrio *et al*. (1999, 2000) para este área. Las edades de los eventos analizados a continuación serán las más probables del intervalo calibrado (Van der Kaars *et al.*, 2001).

RESULTADOS Y DISCUSIÓN

Descripción de los testigos

El testigo L (Fig. 1: 148 cm) está compuesto por arcillas con escaso contenido arenoso. Los cambios de color observados permiten distinguir entre un horizonte inferior (color 10YR 5/3 de la escala Munsell) y los 44 cm superiores (color 5Y 4/2). Estas arcillas contienen una escasa macrofauna [*Venerupis decussatus* (Linneo), *Cardium edule* (Linneo), *Crassostrea angulata* (Lamarck)] y frecuentes fragmentos de equinodermos. Entre ellas, aparece una capa limosa (–102 a –94 cm) con abundantes valvas de bivalvos *(Crassostrea angulata, Venerupis decussatus)*, que constituyen más del 20% en peso del sedimento.

El testigo H (Fig. 2: 162 cm) presenta un intervalo inferior (–162 a –129 cm) caracterizado por la presencia de arcillas azules masivas con escasa macrofauna. Sobre ellas se disponen un horizonte (–129 a –63 cm) con similar litología y abundantes fragmentos de fanerógamas. Esta homogeneidad litológica sólo está interrumpida por un nivel limoso (Fig. 1: –91 a –79 cm) con fragmentos aislados del bivalvo *Cardium edule*.

El tercer intervalo (–63 a –43 cm) está representado por arcillas con frecuentes conchas de bivalvos [*Cardium edule, Spisula solida* (Linneo)] y gasterópodos (*Rissoa* sp.) Los últimos 43 cm están formados por arenas amarillas con numerosos bivalvos bien preservados (sobre todo *Cardium edule*), con conchas dispuestas en cuerpos masivos lumaquélicos o formando sets paralelos. Estos caracteres y su estructura geomorfológica son similares a los diversos niveles de *cheniers* observados en el sector (Rodríguez Ramírez, 1996).

Evolución de las asociaciones de ostrácodos

Cyprideis torosa (Jones) es la principal especie en las muestras analizadas, con porcentajes superiores al 50% del total de los ostrácodos en la mayoría de ellas (Tab. 1). El número de individuos por muestra es elevado (>1.000) en el tramo inferior del testigo L (muestras L1 a L6) y en la muestra basal del testigo H. En ambos casos, esta especie se encuentra acompañada con numerosas valvas de *Loxoconcha elliptica* (Brady), *Leptocythere castanea* (Sars) y, en menor medida, *Cytherois fischeri* (Sars). Esta asociación es típica de lagunas costeras salobres del Mediterráneo y Atlántico (Carbonel, 1980; Ruiz *et al.*, 2000).

Esta abundancia se mantiene, e incluso aumenta (>10.000 individuos/muestra) en la parte inferior del testigo L, con una asociación similar a la anterior. La capa limosa intercalada supone un punto de inflexión a partir del cual se produce una disminución progresiva de individuos hasta la muestra L8. Ello podría ser indicativo de una progresiva emersión de la zona. En las dos muestras superiores, es difícil calcular el número de individuos, debido a la gran cantidad de fragmentos de valvas presentes, correspondientes principalmente a *Cyprinotus salinus* (Brady), *Ilyocypris gibba* (Ramdohr) y *Herpetocypris chevreuxi* (Sars). En la actualidad, esta asociación se encuentra en lagunas dulces temporales o lucios del Parque Nacional de Doñana (Ruiz *et al.,* 1996). Estas lagunas son muy someras (<1 m) y contienen aguas alcalinas (pH = 7-10,6) con importantes variaciones de la temperatura anual (8-10 ºC en diciembre-enero y 25-30 ºC durante el verano) (Serrano y Toja, 1995).

El testigo H presenta un declive muy pronunciado de las poblaciones de ostrácodos desde la muestra H2, llegando a desaparecer o presentar valores muy bajos (<25 individuos/muestra) en la parte media del testigo (H5 a H11). *Cyprideis torosa* es la especie mayoritaria de este tramo, llegando a ser la única especie representada en algunas muestras. En el *chenier* superior, el número de valvas se incrementa, con una asociación formada principalmente por *C. torosa* (64-81%) acompañada de numerosas especies marinas (*Pontocythere elongata* (Brady), *Callistocythere rastrifera* (Ruggieri), *Urocythereis oblonga* (Brady), *Carinocythereis whitei* (Baird)), frecuentes en la plataforma somera del Golfo de Cádiz (Ruiz *et al.,* 1997).

Análisis de poblaciones de *Cyprideis torosa*

El análisis biométrico realizado ha permitido diferenciar las ocho mudas juveniles y las formas adultas de esta especie. Además, se ha podido constatar la existencia de una correlación lineal acusada (R^2 = 0,9755; p = 0,00 para n = 200) entre la anchura y la altura del caparazón a lo largo del crecimiento (Fig. 2). Entre las mudas A-8 a A-3, existe un crecimiento apro-

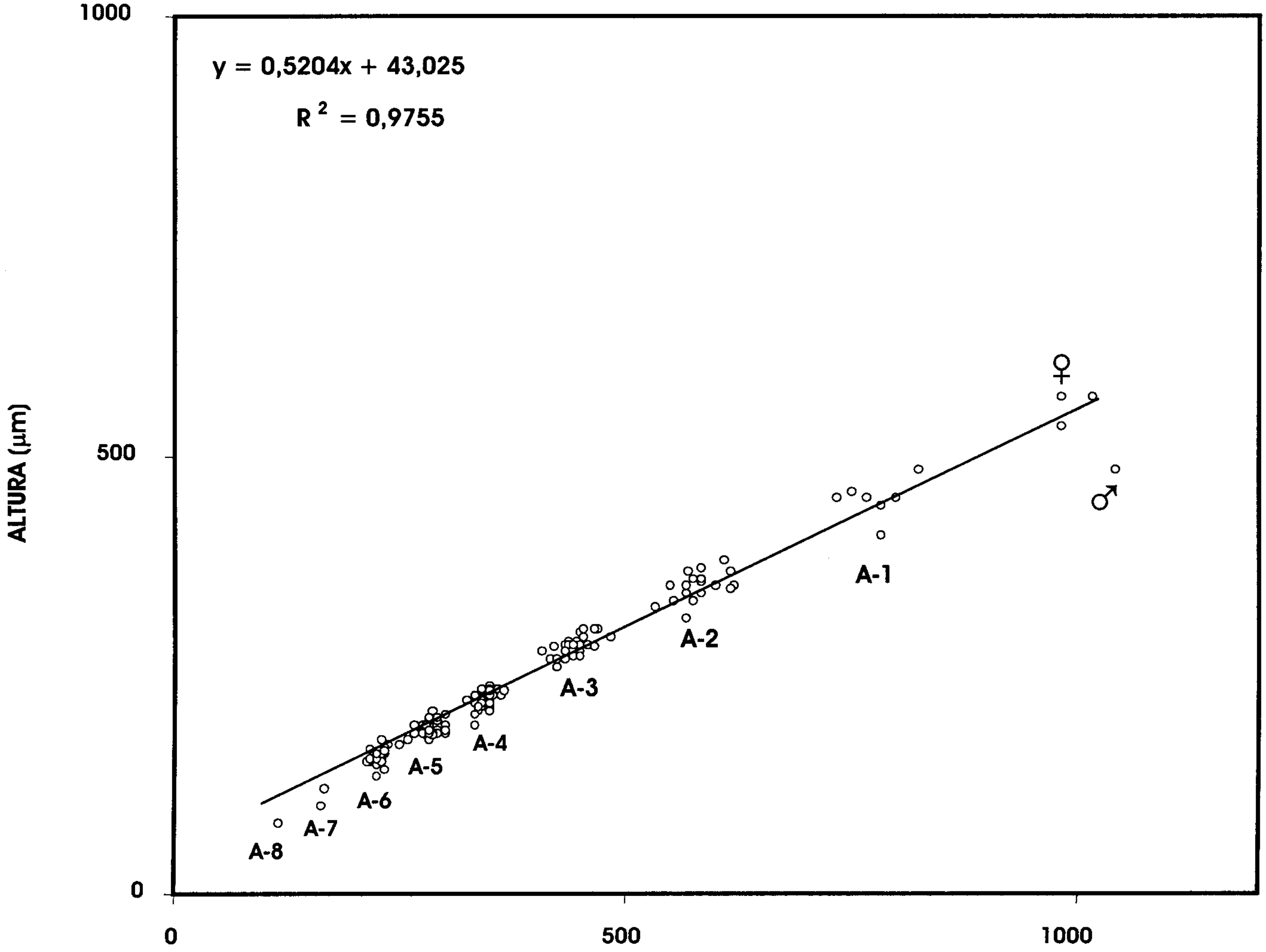

FIGURA 2–Análisis morfométrico de los estadios ontogenéticos de *Cyprideis torosa.*
FIGURE 2–Morphometric analysis of the ontogenetic phases of *Cyprideis torosa.*

ximado del 23-28% en las dimensiones del caparazón entre mudas sucesivas, incrementándose este valor (30-33%) en las últimas mudas y en el paso al estadio adulto.

El tramo inferior del testigo L (L1 a L3) presenta altas proporciones de las mudas intermedias (A-2 a A-6), estando presentes también las primeras mudas. Esta distribución sería típica de medios de baja energía (Whatley, 1988). En el nivel limoso intercalado y las muestras inmediatas (L4 a L6), se produce un aumento del número de adultos y una disminución de las primeras mudas, coincidiendo con los mayores porcentajes de especies marinas. Ello indicaría un aumento del nivel energético ambiental, con destrucción de las mudas intermedias e introducción de esta fauna marina. En los niveles superiores, dominan las últimas mudas juveniles (A-1 a A-3), si bien aparecen numerosas valvas con evidencias de erosión superficial o fracturas parciales.

Las muestras inferiores del testigo H (H1 a H3) están dominadas por mudas intermedias (A-2 a A-6), con escasos porcentajes de adultos y ausencia de formas marinas. Su significado sería similar al intervalo inferior del testigo L. Estas proporciones se invierten en la muestra H4, con dominio de hembras adultas y las últimas mudas juveniles, así como una presencia significativa de especies marinas someras (p. ej., *Carinocythereis whitei*). En el resto del testigo, esta especie apenas está representada en los tramos arcillosos, en tanto que los intervalos arenosos contienen abundantes ejemplares de adultos y las últimas mudas juveniles, sobre todo en las muestras procedentes del *chenier* superior. En este tramo (H12 a H16), aparecen importantes porcentajes de formas marinas *(Carinocythereis whitei, Pontocythere elongata, Urocythereis oblonga)*. Todo ello indicaría un depósito en condiciones de alta energía (Whatley, 1988).

MUESTRA	Nº Individuos	% Cyprideis torosa	% Especies marinas	Adultos	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	Otras especies
H16	1810	69,4	13,6	23,4	38,5	32,1	6						*C. rastrifera, P. elongata, U. oblonga, C. whitei*
H15	418	65,3	18,7	33,8	41	21	3,1	1,1					
H14	42	64,3	16,7	55,6	33,3	11,1							
H13	24	70,8	28,5	41,2	29,4	23,5			5,9				
H12	57	80,7	12,3	54,3	25,7	14,3	5,7						*Loxoconcha elliptica*
H11	1	100	0		100								No
H10	2	100	0		50	50							
H9	21	90,5	4,8	47,4	31,6	21							*Cytheretta adriatica, Semicytherura incongruens*
H8	1	100	0			100							No
H7	15	100	0		6,7	26,7	40	26,7					
H6	0	0	0										*Loxoconcha elliptica*
H5	3	33,3	0			100							
H4	24	79,2	8,3	31,6	42,1	21,1	5,2						*Carinocythereis whitei, Leptocythere macallana*
H3	262	52,7	0	3,3	2,4	13,1	28,5	34,1	14,6	4			*Loxoconcha elliptica, Leptocythere castanea*
H2	621	40,3	0		3,3	14,9	12,4	24	22,3	19,8	3,3		
H1	4243	82,8	0	0,5	3,7	10	20,5	28,9	23,7	11,6	1,1		
L10	261?	1,5?	0		100								*Cyprinotus salinus, Herpetocypris chevreuxi, Ilyocypris gibba*
L9	48?	16,7?	0	25	25	37,5	12,5						
L8	124	83,9	0	3,8	17,3	40,4	26,9	9,6	2				*L. elliptica, Cypris bispinosa, Ilyocypris gibba*
L7	514	63,8	0,2	5,8	18,4	30,4	27,1	13,5	4,3	0,5			*L. elliptica, L. castanea*
L6	3534	73,5	1,8	6,8	16,1	32,2	26,3	14,4	1,7	2,5			
L5	3146	67	1,6	7,9	16,9	27	22,2	16,4	7,9	1,7			*L. elliptica, L. castanea, C. fischeri*
L4	10506	61,7	1,4	7,3	20	29,1	24,5	13,6	1,8	3,7			
L3	16780	54	1	3,9	11,6	18,7	22,6	18,1	16,1	7,1	1,3	0,6	
L2	12040	48,2	1,3	5,3	8,6	12,5	20,4	24,3	15,8	9,2	3,9		
L1	8725	66,3	0	4,9	9,8	28	18,9	17,7	15,8	4,9			

TABLA 1–Análisis poblacional de las muestras seleccionadas en este estudio. Especies marinas: *Callistocythere rastrifera, Pontocythere elongata, Urocythereis oblonga, Carinocythereis whitei, Cytheretta adriatica, Semicytherura incongruens.*

TABLE 1–Population analysis of the samples selected in this study. Marine species: *C. rastrifera, Pontocythere elongata, Urocythereis oblonga, Carinocythereis whitei, Cytheretta adriatica, Semicytherura incongruens.*

EVOLUCIÓN DEL SECTOR ESTUDIADO DURANTE EL HOLOCENO SUPERIOR

Una comparativa entre las asociaciones presentes de ostrácodos, la distribución ontogénica de *Cyprideis torosa* y la edad calibrada más probable de las dataciones efectuadas permiten inferir la evolución de este sector del Parque Nacional de Doñana durante el Holoceno superior. Esta evolución puede ser dividida en 4 fases (Fig. 3):

a) Fase I (>ca. 2.300 años BP). Esta zona formaría parte de un lagoon relativamente restringido, tranquilo y somero, donde el fondo arcilloso estaría poblado, entre otros grupos, por bivalvos *(Cardium edule)* y ostrácodos *(Cyprideis torosa, Loxoconcha elliptica, Leptocythere castanea).* En este fondo se depositarían las muestras L1 a L4 y, probablemente, la H1. Además, en esta fase se produciría la emersión paulatina del sector adyacente al testigo H, con presencia creciente de fanerógamas (muestras H2 y H3).

b) Fase II (~ca. 2.300-2.250 años BP). Se produce un primer evento de energía media (¿tormenta?), que ocasiona la introducción de fauna marina en el sistema lagunar y una selección de adultos en las poblaciones de *Cyprideis torosa.*

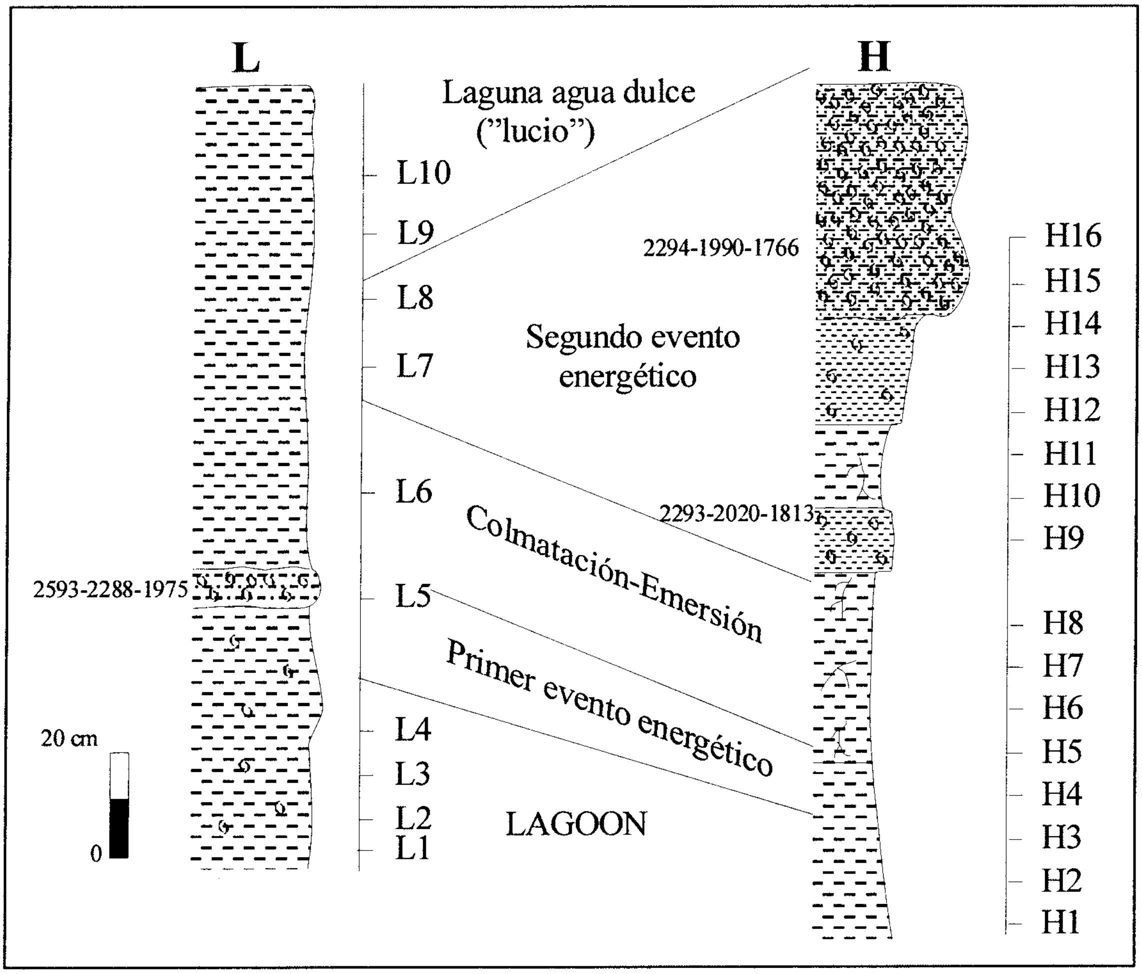

FIGURA 3–Correlación y reconstrucción paleoambiental de los testigos estudiados, con inclusión de las edades calibradas obtenidas. (2593-2288-1975): edad máxima calibrada - edad media (más probable) calibrada - edad mínima calibrada.

FIGURE 3–Correlation and palaeoenvironmental reconstruction of the studied cores, including the calibrated ages obtained. (2593-2288-1975): maximum calibrated age - mean calibrate age (highest probability) - minimum calibrate age.

Coincidiría con el final de una fase erosiva definida en este litoral por Zazo *et al.* (1994). En los testigos, esta inestabilidad quedaría reflejada en el nivel limoso intercalado del testigo H (muestra L5) y, probablemente, en la disminución de las poblaciones de *Cyprideis torosa* y un leve aumento de formas marinas resedimentadas en el testigo L (muestra H4).

c) Fase III (~ca. 2.250-2.000 años BP). Se produce una colmatación y emersión de la zona, probablemente debido a su aislamiento paulatino por el crecimiento de las flechas litorales próximas (Fig. 1). El sector oriental (testigo H) se encontraría ya emergido (muestras H5 a H8), en tanto que la progresiva somerización conllevaría un importante descenso de *Cyprideis torosa* (muestras L5 y L6) en el sector occidental.

d) Fase IV (~ca. 2.000 años BP). Hace unos dos mil años, se produjo una serie de fuertes eventos energéticos que ocasionaron el depósito de los niveles de *cheniers* del testigo H, que permanecerá emergido desde entonces (muestras H9 y siguientes).

e) Fase V (ca. 2.000 años BP - actualidad). El testigo L refleja la transición desde el lagoon inicial hasta la laguna temporal actual de aguas dulces, con dominio de ostrácodos de conchas frágiles (*Cypris, Herpetocypris*) en sus muestras superiores (muestras L9 y L10).

CONCLUSIONES

El estudio de las asociaciones de ostrácodos presentes en dos testigos obtenidos en el sector suroccidental del Parque Nacional de Doñana ha permitido efectuar una aproximación a la evolución paleogeográfica de este sector durante los últimos 2.400 años, aproximadamente. En el período comprendido entre los 2.400 y 2.000 años BP, este sector estaba inicialmente ocupado por un lagoon relativamente tranquilo, donde las poblaciones de ostrácodos estaban dominadas por *Cyprideis torosa*. Esta situación se tornaba inestable de forma puntual por la acción de eventos energéticos (¿tormentas?, ¿*tsunamis*?), cuya evidencia queda reflejada en los testigos en niveles limosos intercalados dentro de la litología arcillosa dominante o en la presencia de *cheniers*. En ambos casos, se aprecia un aumento de los porcentajes de adultos de esta especie y la introducción significativa de formas marinas resedimentadas. Finalmente, se produce la emersión de todo el sector, parte del cual queda aislado formando una depresión ocupada en la actualidad por una laguna de aguas dulces, localmente denominada lucio.

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THE MARINE OSTRACODA OF PITCAIRN, OENO AND HENDERSON ISLANDS, SOUTHERN PACIFIC

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Abstract

Forty-three species are recorded from nine samples collected during the Sir Peter Scott Expedition to the Pitcairn Islands. Only one sample was from Pitcairn Island, one from Oeno Atoll and 7 from Henderson Island. All but one of the 43 species occurs at Henderson Island, 9 at Pitcairn Island, but only 2 at Oeno Atoll. Twenty-six (60.5%) of the species are endemic, being confined to the Pitcairn group; 9 species (21%) occur only in the Pitcairns and at Easter Island; 2 (5%) species also occur elsewhere in the Indo-Pacific and at Easter Island and another 2 species also occur elsewhere in the Indo-Pacific but not at Easter Island. Four of the species belong to those species that are virtually pandemic throughout global tropical seas. Of those 26 species confined to the Pitcairn Group, 9 are new as is one genus. These are: *Neonesidea apostasis* sp. nov., *Neonesidea blighi* sp. nov., *Thesceloscythere labyrinthos* gen. et sp. nov., *Loxoconcha dictyoklostos* sp. nov., *Loxoconcha hendersonislandensis* sp. nov., *Tenedocythere apios* sp. nov., *Tenedocythere stasiotes* sp. nov., *Xestoleberis macrocicatricosa* sp. nov., and *Xestoleberis macrorrhinos* sp. nov. The remaining 17 species are left in open nomenclature. Despite the great oceanic distances that separate the two areas, the Pitcairn Group fauna clearly indicate closest affinities with Easter Island, rather than with that of islands much nearer to the NW.

Key words: Ostracoda, Pacific, Pitcairn Group, endemism, zoogeography.

Resumen

Se identificaron un total de 43 especies de ostrácodos procedentes de 9 muestras recogidas durante la expedición de sir Peter Scott a las islas del grupo Pitcairn. Una de las muestras procede de la isla de Pitcairn, otra de Oeno Atoll y 7 de la isla de Henderson. Cuarenta y dos especies fueron registradas en la isla de Henderson, 9 aparecen en la isla de Pitcairn y únicamente 2 en Oeno Atoll. Vientiseis especies (60,5%) son endémicas del grupo de Pitcairn, 9 especies (21%) aparecen únicamente en el grupo de Pitcairn y la isla de Pascua, y 2 especies (5%) se encuentran en el Grupo de Pitcairn, en algunas otras localidades indopacíficas y también en la isla de Pascua. Otra dos especies se han citado en algunas otras localidades indopacíficas, pero no aparecen en la isla de Pascua. Cuatro especies pertenecen a un grupo de ostrácodos que son casi pandémicas en todos los mares tropicales. De las 26 especies endémicas, 9 son nuevas y también un género: *Neonesidea apostasis* sp. nov., *Neonesidea blighi* sp. nov., *Thesceloscythere labyrinthos* gen. et sp. nov., *Loxoconcha dictyoklostos* sp. nov., *Loxoconcha hendersonislandensis* sp. nov., *Tenedocythere apios* sp. nov., *Tenedocythere stasiotes* sp. nov., *Xestoleberis macrocicatricosa* sp. nov. y *Xestoleberis macrorrhinos* sp. nov. Las 17 especies endémicas restantes se mantienen en nomenclatura abierta debido el escaso material obtenido. A pesar de las enormes distancias oceánicas que separan las dos áreas, la fauna del grupo Pitcairn indica más afinidades con la fauna de la isla de Pascua que con las de las islas más cercanas, hacia el noroeste.

Palabras clave: Ostrácoda, Pacífico, grupo de Pitcairn, endemismo, zoogeografía.

INTRODUCTION

This paper is one of a series, undertaken by the senior author and various of his postgraduate students and colleagues, designed to extend our knowledge of the benthonic Ostracoda of the Indo-Pacific, Australia, Indonesia and adjacent areas. This work concentrates on the systematics and taxonomy of the various faunas and on their zoogeography, particularly their migrational history. Whatley (1986) and Titterton & Whatley (1988b) began this endeavour based on a study of the fauna of the Solomon Islands and an analysis of the existing literature. Since this date, important studies by a number of authors in the region have provided much more detailed and comprehensive data, although the zoogeographical provincial structures outlined by Titterton & Whatley remain more or less intact. Among the important contributions of the last decades are Behrens (1991a, b, 1992, Great Barrier Reef), Cabioch *et al*. (1986, New Caledonia), Dewi (1997, Java Sea), Howe & McKenzie (1989, NW Australia), Jellinek (1993, Kenya), Mostafawi (1992, Malaysia), Titterton & Whatley (1988a, Solomon Islands), Whatley *et al*. (1995, 1996, Northern Australia), Whatley & Keeler (1989, Reunion Island), Whatley & Zhao (1987, 1988, Malacca Straits), Whatley (2000), Whatley & Jones (1999), Whatley *et al*. 2000 (Easter Island), Whatley & Roberts 1995, Whatley *et al*., 1995 (Pitcairn Group), Yassini *et al*. (1993, Eastern Australia), Yassini & Jones (1995, Eastern Australia), Zhao & Whatley (1989, Malaysia). The only previous account of the marine benthonic ostracods of Pitcairn, Oeno and Henderson islands is by Whatley and Roberts (1995), which formed part of a major study of the biogeography, ecology, and prehistory of the Pitcairn islands as part of the Sir Peter Scott Commemorative Expedition to the islands, sponsored by the Linnean Society of London. Whatley and Roberts reported a total of 33 species from the three island making up the group.

The islands of the Pitcairn Group; the volcanic Pitcairn Island, the small coral islands of Ducie and Oeno Atolls and the raised coral island of Henderson Island, lie between Lat 23.9º S and 24.7º S and 124.7º W and 130.7º W, within the huge 75 Mkm of the South Pacific Ocean. The group lies in a very isolated part of the South Pacific. For example, the most easterly island, Ducie Atoll, is 1,000 km (869 n. miles) west of Easter Island, while the most northerly and westerly, Oeno Atoll, is 450 km (391 n. miles) east of the Minerve reefs and the Gambier Islands. Indeed, the entire group, in the context of a Pacific Ocean basin, are extremely remote being some 4,500 km (3911 n. miles) from both New Zealand and South America. An excellent account of the Plate Tectonic setting of the group, their origin and of the presence in the area of guyots and seamounts, is given by Spencer (1995) in his introduction to the Sir Peter Scott Memorial Volume (Benton & Spencer, 1995).

Pitcairn Island is a volcanic island rising to 347 m (1,144 ft) above seal level. Its coast is dominated by precipitous cliffs and has only two practicable landings for small boats. It is the only permanently inhabited island of the three. Henderson Island, which is a raised coral atoll, ascending to 33.5 m (110 ft) above sea level and rising from a sea bed depth of some 3,500 m, (13,264 ft) is situated some 168 km (146 n. miles) NW of Pitcairn, while Oeno is a small atoll, approximately 4 km (2.5 miles) in diameter and situated 104 km (90 n. miles) NW of Pitcairn.

THE OSTRACODA

The study is based on nine samples. Seven were collected from Henderson and one each from Pitcairn and Oeno. The samples from Oeno Atoll and Pitcairn Island yielded rather few ostracods, while those from Henderson Island contained a large fauna. From these samples, Whatley & Roberts (1995), in a very preliminary study, recovered the rather small fauna of 33 species. Our subsequent study, conducted without time constraints has revealed a further 10 species.

Forty-three species is, in the context of the SW Pacific, a low diversity fauna. By contrast, 150 species were recovered by Titterton (1984) from the Solomon Islands and 50 to 60 species were registered by McKenzie (1986) as a norm for a number of South Sea Islands. The diversity of the even more remote single island of Easter Island (31 spp. Whatley *et al.*, 2000) is notably less, which given the greater isolation, cooler water and lack of reefs there, is not surprising. The reason for the relatively low diversity ostracod fauna of the Pitcairn Group, must be due largely to their relative isolation, although this is much less arguable than for Easter Island. It could also be due to the paucity of samples. However, although Whatley & Jones, (1999), Whatley, (2000) and Whatley *et al*. (2000) studied more samples from Easter Island, they were from a much smaller geographical area which, given the relationship between area and diversity should have nullified any difference. Also certain samples from the Pitcairn Group, notably from North Beach, Henderson Island, were so rich in both individuals and species, including very small species (those most easily overlooked) and juveniles, that we believe, with Whatley & Roberts (1995), that if diversity was in fact actually higher, such samples would have revealed it.

Whatley & Roberts (1995), in their analysis of the Pitcairn Group fauna, divided it into four groups. With the discovery of an additional 10 species, we have found it more appropriate to use the following 5 groups:

1. Endemic species. Those species confined to the Pitcairn Group. 26 species, 60.5% of the fauna. *Cytherelloidea* sp. 1., *Cytherelloidea* p. 2., *Cytherelloidea* sp. 3., *Neonesidea apostasis* sp. nov., *Neonesidea blighi* sp. nov., *Anchistrocheles* sp. aff. A. *fumata* (Brady), *Hansacypris* sp., *Cyprideis* sp., *Semicytherura* sp., *Paracytheridea* sp., *Thesceloscythere labyrinthos* gen. et sp. nov., *Parakrithella* sp., *Loxoconcha dictyoklostos*, *Loxoconcha hendersonislandensis* sp. nov., *Paradoxostoma* sp. 1, *Paradoxostoma* sp. 2, *Paradoxostoma* sp. 3., *Paradoxostoma* sp. 4, *Pellucistoma* sp. *Tenedocythere apios* sp. nov., *Tenedocythere stasiotes* sp. nov., *Tenedocythere* sp. 1, *Tenedocythere* sp. 2., *Xestoleberis macrocicatricosa* sp. nov., *Xestoleberis macrorrhinos* sp. nov., *Xestoleberis* sp.
2. Species known only from the Pitcairn Group and Easter Island. 9 species, 21% of the fauna: *Neonesidea supercaudata* Whatley *et al.*, *Cytheroma aphanes* Whatley *et al.*, *Loxoconchella catarrhopos* Whatley *et al.*, *Loxocorniculum mayburyae* Whatley *et al.*, *Paradoxostoma ballistica* Whatley *et al.*, *Xestoleberis entrichos* Whatley *et al.*, *Xestoleberis insulanos* Whatley *et al.*, *Xestoleberis kyrtonos* Whatley *et al.*, *Xestoleberis polys* Whatley *et al.*
3. Species known elsewhere in the Indo-Pacific and Easter Island. 2 species, 5% of the fauna: *Neonesidea tenera* (Brady), *Peripontocypris magnafurcata* Wouters.
4. Species known elsewhere in the Indo-Pacific but not at Easter Island. 2 species, 5%: *Cytherelloidea fijiensis* (Brady), *Cletocythereis watsonae* Jellineck.
5. Species that are world wide in their distribution throughout the tropics but which do not occur at Easter Island. 4 species. 10% of the fauna: *Triebelina sertata* (Triebel), *Macrocyprina maculata* (Brady), *Kotoracythere inconspicua* (Brady), *Tenedocythere transoceanica* (Teeter).

The distribution of the Ostracoda between the three islands in the Pitcairn Group is as follows: Henderson Island 42 spp. (all species occur there except *Parakrithella* sp.). Pitcairn Island 9 spp. Oeno Atoll 2 spp. This is clearly mainly a function of the sampling, as 7 samples were collected from Henderson Island but only one each from Pitcairn and Oeno.

The Samples

The samples from the eulittoral zone were collected by hand and were either of sediment or algae. Other samples, from the sublittoral, were collected by SCUBA diving. As provided to the senior author, the samples were labelled in the following manner:

(1A) 120 feet (36.5 m) below the reef, North Beach, Henderson Island.
(1B) 120 (36.5 m) feet below the reef, North Beach, Henderson Island.
(2) 80 feet (24 m) beyond fringing reef, North Beach, Henderson Island.
(3) North beach, attached to algae, Henderson.
(4) 40 (12 m) m feet deep off east Beach Henderson.
(5) Beach sediment, North Beach, Henderson.
(6) Seaweed, North Beach Henderson.
(7) Beach sediment, North Beach, Henderson.
(8) Seaweed, Oeno Atoll.
(9) Attached to seaweed, Pitcairn Island.

SYSTEMATIC DESCRIPTIONS

The type specimens of all new taxa are housed in the ostracod collections of the Department of Palaeontology, Natural History Museum, London as the Pitcairn Island Collection under catalogue numbers prefixed PI. In all cases, specimens are of adults unless otherwise stated. All dimensions are given in millimetres, and the size convention for adults is as follows: <0.40 very small, 0.40-0.50 small, 0.50-0.70 medium, 0.70-1.00 large, >1.0 very large. Other conventions used throughout are: LV = left valve, RV = right valve, C = carapace, A = adult, rpc = radial pore canal, npc = normal pore canal. All new taxa are fully described. A short diagnosis is given of *nomina aperta* species and other poorly known species are re-described. Distances are given in kilometres and nautical miles.

Class OSTRACODA Latreille, 1806
Order PODOCOPIDA Müller, 1894
Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Sars, 1866
Genus *Cytherelloidea* Alexander, 1929

Remarks.–The four species of Platycopida, recorded from Pitcairn Island differ markedly from the large platycopid faunas of Australia (e. g., Whatley *et al.*, 1995) and the Solomon Islands (Titterton, 1984 MS). For example, the only genus present is *Cytherelloidea* and its species seem to be confined to Oceania. The sole platycopid to occur at Easter Island, *Cytherelloidea keiji* McKenzie subspecies *pasquaensis* Whatley *et al.* is not recorded in the Pitcairn Group, which is surprising since *C. keiji* is fundamentally an Australian species and might have been thought to have used the Pitcairns as a 'stepping stone' in its migration *en route* to Easter Island (Whatley, 2000).

Cytherelloidea fijiensis (Brady, 1890).
(Pl. 1; Figs. 1-3)

1890 *Limnicythere fijiensis* Brady, p. 505, Pl. 2, Figs. 33, 34.
1902 *Limnicythere fijiensis* Brady. Chapman, p. 427.
1986 *Cytherelloidea fijiensis* Brady. McKenzie, p. 94, Pl. 1, Fig. 8.
1995 *Cytherelloidea fijiensis* (Brady). Whatley & Roberts, Fig. 1.30.
1999 *Cytherelloidea fijiensis* (Brady). Eagar, p. 605, Pl. 1, Fig. 14 (*non* Fig. 13).

Material.–Four specimens.

Distribution.–In the present study found in samples 1A and 6, both from Henderson Island. Brady recorded the species from the following localities in Fiji: "Levuka, between tide-marks: Rambé Island and Vuna Point, Taviuni, between tide-marks; Mango Island, pools on the fringing reef; Loma-Loma, in shore sand". McKenzie (1986) creates and illustrates a lectotype of this species. Chapman records but does not illustrate this species from Avalau Islet, Funafutu, where he describes it as "fairly common in the beach sand".

Dimensions.–

		Length	Height
Female LV PI 01	Sample 1A	0.43	0.25
Female RV PI 02	Sample 1A	0.43	0.27
Male LV PI 03	Sample 4	0.46	0.25

Description.–Medium. Elongate subovate to reniform in lateral view. Irregularly cuneate in dorsal view, with constriction just anterior of mid-length. Anterior margin very widely rounded, with extremity at mid-height and enhanced by plicated frill. Posterior margin rather truncated and oblique, with extremity well above mid-height. Dorsal margin straight to very slightly convex and sloping towards the posterior. Ventral margin with broad median concavity. Greatest height at anterior cardinal angle; greatest length just above mid-height; greatest width in posterior 1/3. RV slightly larger than LV. A smooth rib extends from an antero-dorsal position, closely paralleling the anterior, ventral and in some specimens posterior margins. There is a deep sulcus in the position of the adductor muscles and several other less strongly depressed areas, together with a central complex of elevated areas. The remainder of the surface is reticulo-punctate with strong, deep, oval fossae with an overall irregularly concentric disposition. There is a well-marked ventro-lateral tumidity, which bears faint, parallel longitudinal lineations. Internal features as for genus.

Remarks.–The lectotype illustrated by McKenzie (1986, Pl. 1, Fig. 8 Hancock Museum Registration Number B455, from Vuna Point, Taviuni, Fiji) is less coarsely ornamented than the present material, and has more smooth areas centrally and antero-centrally. Brady gave a length for this species of 0.5 mm, which is rather larger than the present material. This species is less well rounded posteriorly than *Cytherelloidea rugosa* (Brady) from Australia (0.57 mm); from *C. poikilokosmena* (Behrens, 1991a) from the Great Barrier Reef (0.46-0.49 mm) it differs in being much larger and less strongly excavated anteriorly. In an incomplete unpublished preprint MS by Cronin, a species (0.51-0.53 mm) illustrated from the Pacific islands of Kwajalein, Onotoa, Pingelap and Pohnpei is probably the same taxon as the present material. Eagar (1999) illustrates what he claims are two specimens of this species from Kuria and Tarawa atolls in the Gilbert Islands. However, while one form (Pl. 1, Fig. 14) is almost certainly this species (L = 0.50 mm), the other, larger and much more strongly ornamented specimen (Pl. 1, Fig. 130, probably represents another species. In the present study. The present material is somewhat smaller than the type collection and possibly represents A-1 juveniles. The species occurs in association with intertidal algae and in the sublittoral at 120' (36.5 m) below the reef of Henderson Island.

Cytherelloidea sp. 1
(Pl. 1; Fig. 4)

1995 *Cytherelloidea* sp. 1 Whatley & Roberts, Fig. 1.31.

Material.–2 specimens.

Diagnosis.–Medium. Elongate subrectangular with rounded anterior and subtruncated posterior margins. Dorsal margin sinuous; ventral margin with wide, shallow concavity. Anterior margin with plicated frill and more proximal smooth rib which extends around the entire margin and becomes very sinuous antero-dorsally. Ornament of strong smooth ribs, a largely smooth central area surrounded by circular to cribrose reticulo-punctation.

Distribution.–Sample 1A, Henderson Island.

Dimensions.–

	Length	Height
Male LV PI 04	0.59	0.31

Remarks.–This species is significantly larger and less heavily reticulo punctate that *C. fijiensis.* It is also larger, less truncated posteriorly and with less well developed reticulo-punctation than *Cytherelloidea* sp. 2. It also differs from that species in its rib pattern.

Cytherelloidea sp. 2
(Pl. 1; Fig. 5)

1995 *Cytherelloidea* sp. 2 Whatley & Roberts, Fig. 1.32.

Material.–Three specimens.

Diagnosis.–Medium. Elongate subrectangular with well-rounded anterior and more narrowly rounded posterior margins. Dorsal margin slightly sinuous; ventral margin with wide, shallow concavity. Anterior margin with plicated frill and more proximal smooth rib which extends around the entire margin, except posteriorly and postero-dorsally, and becoming rather sinuous antero-dorsally. Ornament with strong smooth or slightly ornamented ribs, a smooth central area surrounded by circular to cribrose reticulo-punctation.

Distribution. Confined to sample 1B, Henderson Island.

Dimensions.–

	Length	Height
?Male LV PI 05	0.52	0.29

Remarks.–The species was encountered only in the sublittoral, at 120’ below the reef. It differs from *Cytherelloidea* sp. 1 in being smaller, less truncated posteriorly and in its smaller smooth central area and more pronounced peripheral reticulo-punctation. It is a little similar to *C. keiji* (McKenzie, 1967) from Australian waters, but has a different pattern of ribs, especially dorso-laterally. It also differs from *C. keiji pasquaensis* Whatley *et al.*, 2000, the Easter Island subspecies on grounds of ornament.

Cytherelloidea sp. 3
(Pl. 1; Fig. 6)

Material.–One specimen.

Diagnosis.–Very small. Subrectangular to subovate with well rounded anterior margin, and posterior margin with bluntly pointed apex well above mid-height and very truncated postero-dorsal slope. Dorsal margin very gently arched; ventral margin with pronounced median concavity. Anterior margin with plicated frill and a distal smooth rib that is paralleled by a similar, more proximal rib. Neither rib extends beyond the anterior region. A short oblique rib defines the muscle scar pit antero-dorsally and a deep depressed area occurs mid postero-laterally. The surface ornament is strongly reticulo-punctate, the fossae being deep and oval to subcribrose.

Distribution.–Sample 1B, Henderson Island.

Dimensions.–

	Length	Height
RV PI 06	0.28	0.16

Remarks.–This species differs from the other three species of *Cytherelloidea* in this study, and other species of the genus known to the authors, in its very small size and in its very different ornament, especially the two parallel ribs anteriorly. The very small size of the material would suggest that it was juvenile. However, with its proportionally thick shell, strong ornament and well-developed internal characters, it seems to represent an adult. While probably new, it is left in open nomenclature due to its rarity.

Suborder PODOCOPINA Sars, 1866
Superfamily BAIRDIACEA Sars, 1888
Family BAIRDIIDAE Sars, 1888
Subfamily BAIRDIINAE Sars, 1888
Genus *Neonesidea* Maddocks, 1969
Neonesidea tenera (Brady), 1886
(Pl. 1; Figs 7-9)

1886 *Bairdia tenera* Brady, p. 304, Pl. 39, Figs. 13-15.

1905 *Bairdia inornata* Scott, A. p. 372, Pl. 1, Figs. 11, 12.
1969 *Neonesidea tenera* (Brady); Maddocks, p. 33, Pl. 2, Fig. 4.
1988 *Neonesidea tenera* (Brady); Watson MS, p. 50, Pl. 1, Fig. 11, Pl. 12, Figs. 9, 10, Pl. 14, Figs. 11-15.
1995 *Neonesidea tenera* (Brady), Whatley & Roberts, p. 362, Fig. 1.1.
1999 *Neonesidea tenera* (Brady). Whatley & Jones, Pl. 1 Figs. 9, 10.
2000 *Neonesidea tenera* (Brady). Whatley, Jones & Wouters, p. 85, Pl. 2, Figs. 1-4.
2000 *Neonesidea tenera* (Brady). Whatley, p. 150.
non 1890 *Bairdia tenera* Brady, Brady, p. 493, Pl. 1, Figs. 11, 12.
non 1894 *Bairdia inornata* Scott, A., Scott, T. p. 136, Pl. 14, Figs. 40, 41.

Material.–One hundred and ninety-five specimens.

Distribution.–In the present study it occurred in samples 1A, 1B, and 2-7 from Henderson Island and sample 9 from Pitcairn Island. Given its abundance, its absence from the single sample at Oeno Atoll is inexplicable. This species is know from Ceylon (Sri Lanka) where it was described by Brady and subsequently by Scott (1905) and Maddocks (1969). Watson (1988) recorded it widely in the Palau Seribu of the Java Sea and Whatley and Roberts (1995) have previously recorded it from Henderson Island. It also occurs at Easter Island where it was the most abundant species (Whatley *et al.*, in press).

Dimensions.–

(Sample 4)	Length	Height
LV PI 07	0.72	0.40
RV PI 08	0.69	0.41
LV A-1 juv. PI 109	0.60	0.32

Remarks.–With its laterally compressed carapace and densely hirsute or punctate surface, it is not difficult to recognise. The Easter Island and Pitcairn group populations, despite their isolation, do not materially differ in size or shape from other populations of the species. The species differs in both size and shape from the two hirsute species *Neonesidea michaelseni* Hartmann 1982 and *N. lenitiphila* Hartmann, 1984, both from Rangiroa Atoll in the Taumotu islands, the former being also recorded from West Australia. In the present study the species was recovered from algae and sediments in the eulittoral and down to 120’ depth in the sublittoral.

Neonesidea supercaudata Whatley, Jones and Wouters, 2000.
(Pl. 1, Figs. 10-17)

1995 *Neonesidea* sp. 2. Whatley & Roberts, p. 363, Fig. 1.4.
1995 *Neonesidea* sp. 3. Whatley & Roberts, p. 363, Fig. 1.5.
1999 *Neonesidea* sp. Whatley & Jones, Pl. 1, Figs. 11, 12.

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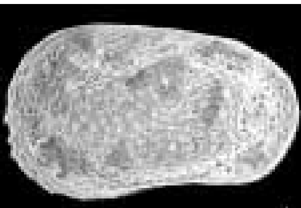
PLATE 1–(All external lateral views unless otherwise stated). *1-3*, *Cytherelloidea fijiensis* (Brady, 1890). *1*, female LV, PI 01, x 93. *2*, female RV PI 02, x 93. *3*, male LV, PI 03, x 89. *4*, *Cytherelloidea* sp. 1. Female LV, PI 04, x 68. *5*, *Cytherelloidea* sp. 2. ?Male LV, PI 05, x77. *6*, *Cytherelloidea* sp. 3. RV, PI 06, x 139. *7-9*, *Neonesidea tenera* (Brady, 1886). *7*, LV, PI 07, x 76. *8*, RV, PI 08, x 56. *9*, A-1 juv. LV, PI 09, x 63. *10-17*, *Neonesidea supercaudata* Whatley *et al.*, 2000. *10*, female LV, x 49. *11*, female RV, PI 11, x 45. *12*, female LV, PI 12, x 45. *13*, female LV, PI 13, internal view, x 48. *14*, female C, PI 14, oblique dorsal view, x 53. *15*, male LV, PI 15, x 51. *16*, male RV, PI 16, x 45. *17*, A-1 juv. (proto male) LV, PI 17, x 54. *18-24*, *Neonesidea apostasis* sp. nov. *18*, holotype RV, PI 18, x 58. *19*, paratype LV, PI 19, x 56. *20*, paratype RV, PI 20, x 49. *21*, paratype LV, PI. 21, internal view, x 45. *22*, paratype RV, PI 22, internal view, x 57. *23*, paratype RV, PI *23*, x 58. *24*, paratype C, PI 24, dorsal view.

PLATE 1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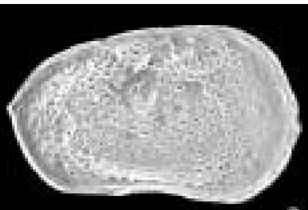
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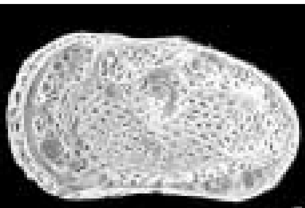
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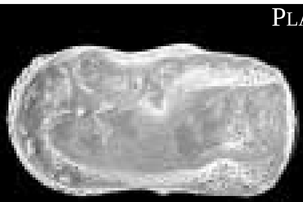
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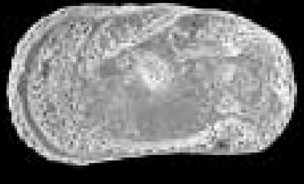
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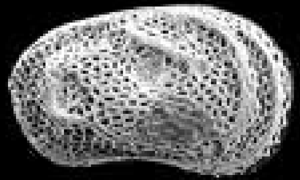
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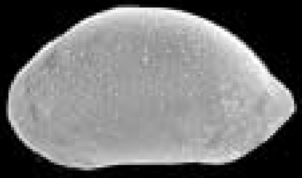
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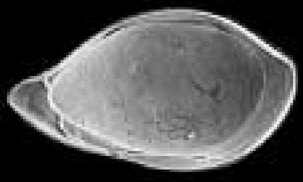
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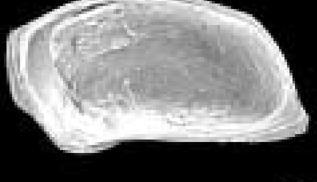
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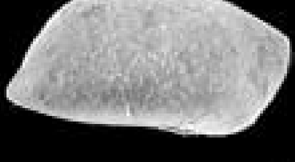
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2000 *Neonesidea supercaudata* Whatley, Jones & Wouters, p. 85, Pl. 2, Figs. 5-10.
2000 *Neonesidea supercaudata* Whatley, Jones & Wouters. Whatley, p. 150.

Material.–One hundred and thirty one specimens.

Distribution.–Previously thought to be confined to Easter Island. In the present study it was encountered in samples 1A, 1B, 2, 3, 4, 5, 6 & 7 from Henderson Island.

Dimensions.–

		Length	Height
Female LV PI 10	Sample 1A	0.78	0.42
Female RV PI 11	Sample 1A	0.80	0.41
Female LV PI 12	Sample 2	0.74	0.40
Female LV PI 13	Sample 1A	0.84	0.46
Female C	Sample 1A	0.78	0.42
Male LV PI 15	Sample 4	0.81	0.32
Male RV PI 16	Sample 2	0.84	0.31
A-1 juv. LV PI 17	Sample 4	0.69	0.28

Remarks.–This species is very similar in shape and outline to an undescribed species recorded by Watson (1988 MS) from the Palau Seribu of the Java Sea. However, the Indonesian species is much larger (length 1.12-1.20; height 0.54-0.67). The sexual dimorphism in this species is very strong. So much so that *Neonesidea* sp. 2 of Whatley and Roberts from the Pitcairn group is the male of this species while their *Neonesidea* sp. 3 is the female, they having thought initially that the two sexes belonged to different species. The elongate nature of the male, especially caudally, is very pronounced. In the present study the species was recovered from algae and sediments in the eulittoral down to the sublittoral at 120’ (36.5 m) below the reef. Some specimens in the present material bear long setae (see Pl. 1, Fig. 16).

Neonesidea apostasis sp. nov.
(Pl. 1; Figs. 18-24; Pl. 2, Fig. 1)

1995 *Neonesidea* sp. 1 Whatley & Roberts, Figs. 1, 3.

Derivatio nominis.–Gr. *αποστασις* a defection. With reference to the *Bounty* mutineers who came to Pitcairn Island after the mutiny.

Holotype.–RV PI 18.

Type locality.–Sample 4. Sediment sample from a, depth of 40 feet off east Beach, Henderson Island.

Material.–Twenty-nine specimens.

Diagnosis.–A large angular subrhomboidal species of *Neonesidea* with subparallel oblique postero-dorsal and antero-ventral slopes and acute subventral posterior apex. Surface micropunctate due to dense npc.

Description.–Large. Subrhomboidal. Thin-shelled. Anterior margin with long, slightly convex, oblique antero-ventral slope extending postero-ventrally from a pronounced subdorsal apex. This slope is embellished in well-preserved specimens, by a short, median, dentate flange and is subparallel to the long postero-dorsal of the posterior margin, the apex of which is acute, especially in the RV, and subventral. Dorsal margin straight in RV, very gently convex in LV. Ventral margin with very slight oral concavity and pronounced angle with anterior margin. Surface very minutely punctate. Inner lamella wide anteriorly and posteriorly. Hinge adont, short and inclined towards the posterior. Muscle scars and other internal features as for genus.

Distribution.–Confined to the type locality.

Dimensions.–

	Length	Height
Holotype RV PI 18	0.72	0.37
Paratype LV PI 19	0.71	0.36
Paratype RV PI 20	0.73	0.38
Paratype LV PI 21	0.76	0.40
Paratype RV PI 22	0.75	0.40
Paratype RV PI 23	0.69	0.38
Paratype C PI 24	0.78	0.46
Paratype C PI 25	0.78	0.46

Remarks.–This species in its overall morphology somewhat resembles some species of *Aponesidea* Maddocks, 1986, and in shape it is somewhat similar to *Mydionobairdia* Titterton & Whatley, 1988a. However, in its central musculature it clearly belongs to *Neonesidea*. With its subrhomboidal shape it is quite distinctly different from other bairdiaceans in the present study.

Neonesidea blighi sp. nov.
(Pl. 2; Figs. 2-8)

1995 *Neonesidea* sp. aff. *N. gerda* Whatley & Roberts, Fig. 1.2.

Derivatio nominis.–Named for Captain William Bligh RN, the much maligned captain of H. M. S. *Bounty,* whose feat in navigating an open ships boat some 5,000 miles to Timor after having been cast adrift by mutineers, is thoroughly deserving of recognition.

Material.–Nine adult specimens.

Holotype.–RV PI 26.

Type locality.–Sample 1A, Henderson Island.

Diagnosis.–A large species of *Neonesidea* with sharp caudal process, particularly in LV, and apex at about mid-height. Punctate except for smooth central area.

Description.–Large. Sexual dimorphism not observed. LV subtriangular, RV subpyriform. Anterior margin asymmetrically rounded; anterodorsal slope straight, posteroventral slope convex, and delimited by a pronounced angle above mid-height. Posterior margin with sharp termination at about mid-height; most pronounced in RV; posterodorsal slope straight to slightly concave, posteroventral slope straight to gently convex, and bearing minute denticles in some specimens. Ventral margin straight in LV, medianly concave in RV. Inner lamella of medium width, with narrow crescentic vestibula at each end. Rpc numerous, straight and simple. Adductor scars in a zigzag pattern.

Distribution.–Confined to Henderson Island where it occurred in samples 1A, 1B and 2.

Dimensions.–

		Length	Height	Width
Holotype				
RV PI 26	Sample 1A	0.93	0.50	
Paratype				
LV PI 27	Sample 1A	0.89	0.50	
Paratype				
RV PI 28	Sample 1A	0.93	0.50	
Paratype				
LV PI 29	Sample 1A	0.85	0.47	
Paratype				
RV PI 30	Sample 1B	0.87	0.42	
Paratype				
C PI 31	Sample 2	0.89		0.43
Paratype				
C PI 32	Sample 2	0.91		0.43

Remarks.–Found only in the sublittoral at depths down to 120’ (86.5 m) below the reef. This species differs from a species from the Java Sea referred to by Watson (1988) in MS as *Neonesidea* sp. aff *N. gerda* (Benson & Coleman, 1963). The Indonesian species is notably larger (1.14-1.24 mm) and is entirely smooth. It does, however, have the same zigzag arrangement of the adductor scars. This latter species, together with *N. gerda* and *N. longisetosa* (Brady, 1902), both from the Caribbean, and the present species are very similar in shape and seem to constitute a distinct group within the genus.

Genus *Triebelina* van den Bold, 1946
Triebelina sertata (Triebel, 1948)
(Pl. 2; Figs. 9-10)

(*pars*) 1946 *Triebelina indopacifica* van den Bold, p. 74.
1948 *Triebelina* sp. cf. *Triebelina cubensis* Bold. Kingma, p. 69, Pl. 7, Fig. 4.
1948 *Triebelina sertata* Triebel, p. 19, Figs. 1-4.
1960 *Triebelina sertata* Triebel. Puri, p. 132, Pl. 6, Figs. 3, 4.
1968 *Triebelina sertata* Triebel. Guha, p. 59, Pl. 5, Fig. 1.
1969 *Triebelina sertata* Triebel. Maddocks, Pl. 61, Figs. 31, 32b-e.
1971 *Triebelina sertata* Triebel. Allison & Holden, p. 178, Fig. 8.
1973 *Triebelina sertata* Triebel. McKenzie, p. 48, Pl. 1, Figs. A-B.
1975 *Triebelina sertata* Triebel. Teeter, p. 52, Figs. 1 a-f.
1974 *Triebelina sertata* Triebel. Keij, p. 356, Pl. 2, Figs. 6-12.
1980 *Triebelina sertata* Triebel. Bonaduce *et al.*, Pl. 1, Fig. 13.
1980 *Triebelina sertata* Triebel. Hanai *et al.*, p. 118.
1981 *Triebelina sertata* Triebel. Jain, Pl. 1, Fig. 3.
1984 *Triebelina sertata* Triebel. Titterton, p. 129, Pl. 4, Figs. 3, 4; Pl. 26, Figs. 9-14.
1984 *Triebelina sertata* Triebel. Hartmann, p. 125, Pl. 4, Figs. 6, 7.
1986 *Triebelina sertata* Triebel. Cabioch *et al.*, p. 25, Pl. 8, Figs. 1, 2.
1988 *Triebelina sertata* Triebel. Titterton & Whatley, p. 140, Pl. 9, Figs. 9-14.
1988 *Triebelina sertata* Triebel. Watson, p. 81, Pl. 18, Figs. 8, 9.
1988 *Triebelina sertata* Triebel. Taylor, p. 34, Pl. 2, Figs. 4, 5.
1989 *Triebelina sertata* Triebel. Whatley & Keeler, p. 66, Pl. 1, Fig. 3.
1989 *Triebelina sertata* Triebel. Arthur, p. 31, Pl. 2, Figs. 14, 15.
1993 *Triebelina sertata* Triebel. Jellinek, p. 109, Pl. 2, Figs. 34-36.
1995 *Triebelina sertata* Triebel. Whatley & Roberts, Fig. 1.6.
?1976 *Triebelina crumena* (Stephenson). Holden, p. F15, Pl. 1, Figs. 5, 6.
?1986 *Triebelina truncata* (Brady). McKenzie, Pl. 1, Fig. 12.

Material.–Thirty-two specimens.

Distribution.–Found in all samples from Henderson and Pitcairn Islands but absent from Oeno Atoll.

Dimensions.–

	(Sample 1)	Length	Height
LV PI 33		0.57	0.31
RV PI 34		0.57	0.31

Remarks.–The species was recovered in the present study from a wide spectrum of phytal and sedimentary environments in the eulittoral and sublittoral. *Triebelina sertata* is one of a small group of ostracods which enjoy a virtual cosmopolitan pan-tropical distribution, as can be seen from its extensive synonomy. It occurs in the Caribbean and the Gulf of Mexico, very extensively throughout the Indo-Pacific, as far north as the South China Sea, and east to Clipperton Island. It occurs in the Red Sea (Bonaduce *et al.*, 1980) but apparently not in the Mediterranean. This distribution was commented on by Whatley & Roberts (1995) who first recorded the species from the Pitcairn group. The species is known from the late Miocene to Recent and its absence from the Mediterranean is probably due to the closure of that part of the Tethys during the Messinian. It does not occur at Easter Island (Whatley, 2000; Whatley & Jones, 1999; Whatley *et al.*, 2000) due probably to a combination of the remoteness of that island and its cooler water temperature. Cronin (pers. comm) has recorded the species in a number of Equatorial Pacific islands, such as Arno, Guam, Kwajelein, Majuro, Onotoa, Palau, Pingelap, Pohnpei, and Truk, which further emphasizes the ubiquity of its distribution within the tropics.

Genus *Anchistrocheles* Brady & Norman, 1889

Anchistrocheles sp. aff. *A. fumata* (Brady, 1890)

(Pl. 2; Figs. 11-17)

1890 *Anchistrocheles fumata* Brady, p. 497, Pl. 3, Figs. 13, 14.

1995 *Anchistrocheles fumata* (Brady). Whatley & Roberts, Fig. 1.7.

Material.–Sixteen specimens.

Description.–Very large. Elongate subrhomboidal to subreniform in lateral view obliquely truncated, with subdorsal apex. Posterior margin with tightly rounded postero-ventral part and apex below mid-height, and with long straight to slightly convex antero-dorsal slope. Dorsal margin almost straight in adults but strongly convex in juveniles. Ventral margin with strong oral incurvature. LV larger than RV with overlap all round except at the end margins. Smooth. Internal characters as for genus.

Distribution.–The species occurred in samples 1A, 1B, 2, 3, 4, 6 from Henderson Island and sample 9 from Pitcairn Island.

Dimensions.–

		Length	Height
C PI 35	Sample 1B	1.86	0.95
RV PI 36	Sample 2	1.86	0.91
LV juv. PI 37	Sample 2	0.59	0.27
RV juv. PI 38	Sample 2	0.42	0.19
LV juv. PI 39	Sample 4	0.25	0.13
LV juv. PI 40	Sample 4	0.24	0.13
LV juv. PI 41	Sample 2	0.23	0.12

→

PLATE 2–(All external lateral views unless otherwise stated). *1, Neonesidea apostasis* sp. nov. Paratype C, PI 25, dorsal view, x 50. *2-8, Neonesidea blighi* sp. nov. *2,* holotype RV, PI 26, x 40. *3,* paratype LV, PI 27, x 46. *4,* paratype RV, PI 28, x 40. *5,* paratype LV, PI 29, internal view, x 43. *6,* paratype RV, PI 30, internal view, x 43. *7,* paratype C, PI 31, dorsal view, x 47. *8,* paratype C, Pi 32, dorsal view, x 44. *9, 10, Triebelina sertata* van den Bold, 1946. *9,* LV, PI 33, x 70. *10,* RV, PI 34, x 72. *11-17, Anchistrocheles* sp. aff. *A. fumata* (Brady, 1890). *11,* C, PI 35, right lateral view, x 48. *12,* RV, PI 36, internal view, x 48. *13,* same specimen, detail of muscle scars, x 350. *14,* juv. C, PI 38, right lateral view, x 95. *15,* juv. RV, PI 39, x 160. *16,* juv. LV, PI 40, x 162. *17,* juv. LV, PI 41, x 178. *18, Peripontocypris magnafurcata* Wouters, 1997. LV, PI 42, x 74. *19, 20, Hansacypris* sp. 19, LV, PI 43, x 144. *20,* C, PI 44, right lateral view, x 109. *21, 22, Macrocyprina maculata* (Brady, 1866). *21,* RV, PI 45, x 40. *22,* RV, PI 46, x 39. *23, Cyprideis* sp. Female RV, PI 47, x 45. *24, Cytheroma aphanes* Whatley *et al.*, 2000. juv. RV, PI 48, x 170.

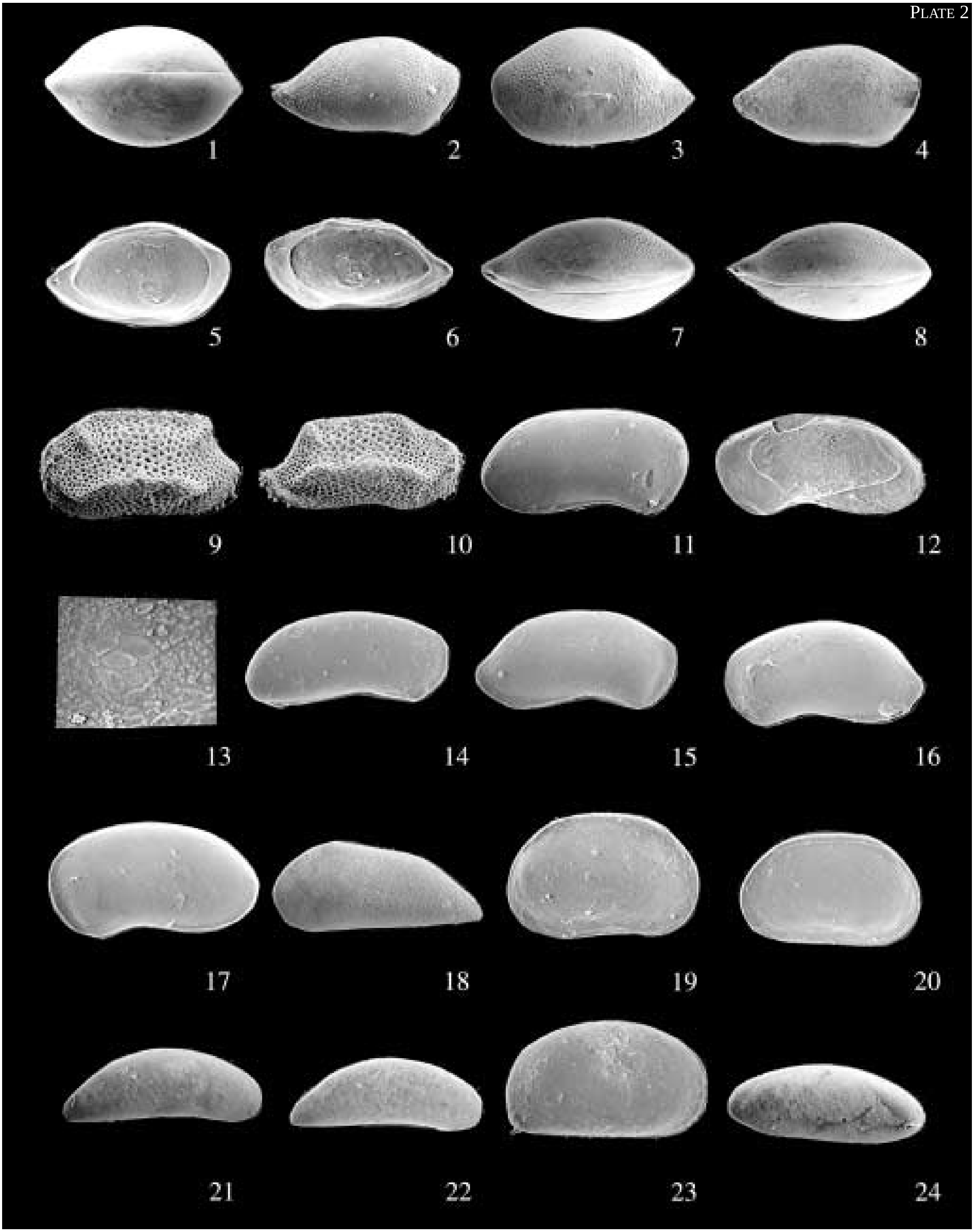
PLATE 2
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Remarks.–The species was recovered from eulittoral algae and from sublittoral sediments down to a depth of 120’ (86.5 m). This material may not comprise a single species as there is a very large size range from the largest to the smallest specimens encountered. There is also some degree of morphological variation. For example, the small juvenile RV PI 39, has an upturned apex to the dorsal margin, not seen in other specimens. However, definite adults only occur in one size (PI 35 and PI 36) and this effectively precludes the recognition of more than one taxon. The species certainly resembles *A. fumata* Brady, which he described from shore pools at Lufi-Lufi, Samoa. Brady’s description of the soft parts suggests that his material was adult, yet it was only 0.75 mm long. Since the largest specimens in the present material are more than twice as long (1.86 mm), they clearly represent a different species. Maddocks (1969, p. 111) records *A. fumata* from Madagascar and her material ranged from 0.6 to 0.61 mm in length, while the material illustrated by Cabioch *et al.* (1986) from New Caledonia was approximately 0.8 mm in length. This confirms that, at least the adults in the present material are not of *A. fumata*.

Superfamily CYPRIDACEA Baird, 1845
Family PONTOCYPRIDIDAE Müller, 1894
Genus *Peripontocypris* Wouters, 1997
Peripontocypris magnafurcata Wouters, 1997
(Pl. 2; Fig. 18)

1997 *Peripontocypris magnafurcata* sp. nov. Wouters.
1999 Pontocyprid gen. et sp. nov. Whatley & Jones, Pl. 1, Figs. 6, 7.
2000 *Peripontocypris magnafurcata* Wouters. Whatley, Jones & Wouters, p. 84., Pl. 1, Figs. 18, 19.
2000 *Peripontocypris magnafurcata* Wouters. Whatley, p. 150.

Material.–Two specimens.

Distribution. Wouters encountered this species at Easter Island and also in the Maldive Islands and northern Papua New Guinea. The present material is from samples 1B and 7 both from Henderson Island. Whatley & Roberts did not encounter this species in their original survey of Pitcairn Island.

Dimensions.–

		Length	Height
LV PI 42	Sample 1B	0.57	0.24

Remarks.–The species was recovered from the eulittoral and from sublittoral sediments at a depth of 120’ (86.5 m).

Family PARACYPRIDIDAE Sars, 1923
Subfamily RENAUDCYRIDINAE McKenzie, 1980
Genus *Hansacypris* Wouters, 1984
Hansacypris sp.
(Pl. 2; Figs. 19, 20)

1995 *Chejudocythere* sp. Whatley & Roberts, Fig. 1.9.

Material.–Two specimens.

Diagnosis.–A very small species of *Hansacypris* with end margins well rounded and dorsal and ventral margins almost straight and parallel.

Distribution.–Confined to sample 4, Henderson Island.

Dimensions.–

	Length	Height
RV PI 43	0.26	0.17
LV PI 44	0.33	0.21

Remarks.–The present material is probably new but is retained in open nomenclature due to its rarity and its probable juvenile nature. It resembles an unpublished species of *Hansacypris* from the Java Sea (Watson, 1988) but is proportionally higher. From *H. aspera* Wouters, 1984, it differs in being much higher and less elongate. Although the genus is usually associated with brackish water, the present material was encountered in a fully marine environment at a depth of 40’ (12 m), probably as a consequence of *post-mortem* transportation.

Family MACROCYPRIDIDAE Müller, 1912
Genus *Macrocyprina* Triebel, 1960
Macrocyprina maculata (Brady), 1866
(Pl. 2; Figs. 21, 22)

1866 *Cytherideis (Cytherideis) maculata* sp. nov. Brady, p. 367, Pl. 57, Figs. 12a-b.
?1880 *Macrocypris maculata* (Brady). Brady, p. 44, Pl. 1, Figs. 2a-d.
1977 *Macrocypris maculata* (Brady). Maddocks, p. 148.
1980 *Macrocypris* sp. 1. Williams MS, p. 47, Pl. 2, Figs. 9, 10.
1984 *Macrocypris* sp. aff. *M. decora* Titterton MS, p. 135, Pl. 4, 8, 10; Pl. 27, Fig. 2.

1988 *Macrocyprina maculata* (Brady). Watson, MS, p. 85, Pl. 4, Figs. 1-5.
1990 *Macrocypris maculata* (Brady). Maddocks, p. 119 [*nomen dubium*].
1995 *Macrocyprina* sp. aff. *M. maculata* (Brady). Whatley & Roberts, Fig. 1.8.
2001 *Macrocypris maculata* (Brady). Titterton, Whatley & Whittaker, p. 34, Pl. 1, Figs. 15-17.

Material.–Two specimens.

Diagnosis.–Elongate, arcuate, subtriangular in lateral view. Anterior margin very narrow, directed downwards; dorsal margin strongly and evenly arched, maximum height central; ventral margin broadly concave. Inner lamella wide, broad anterior and posterior vestibulae. Valve smooth, translucent with three opaque patches, one sub-central, and two large patches at anterior and posterior.

Distribution.–Confined to sample1B, Henderson Island.

Dimensions.–

	Length	Height
RV PI 45	0.10	0.38
RV PI 46	0.95	0.34

Remarks.–Encountered in sediments at a depth of 120’ (86.5 m). Brady (1880) recorded this species from depths of 15-150 fathoms from Simon’s Bay, South Africa; Kerguelen Island and Prince Edward Island, southern Indian Ocean; off East Mancoer Island, Bass Strait and off Amboyna in the South China Sea. It is doubtful whether the same species was recorded at all these stations (Watson, 1988 MS, pers. comm.). Brady originally recorded the species from Western Australia, the West Indies (Turks Island). It also occurs in Quaternary (Williams, 1980 MS) and Recent (Titterton, 1984 MS) sediments from the Solomon Islands and around Pulau Seribu, in the Java Sea (Watson, 1988 MS). Titterton *et al*. (2001, p. 34, 35) discuss the relationship between this species and *M. decora* (Brady, 1866) and give their reasons for not agreeing with Maddocks (1990) who considered both Brady’s species as *nomina dubia*.

Superfamily CYTHERACEA Baird, 1850
Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus *Cyprideis* Jones, 1857

Cyprideis sp.
(Pl. 2; Fig. 23)

1995 *Cyprideis* sp. Whatley & Roberts, Fig. 1.10.

Material.–One female RV.

Diagnosis.–A large species of *Cyprideis* with shape and outline typical of a female RV of the genus. Smooth to very weakly and irregularly punctate and with small postero-dorsal spine.

Distribution.–Confined to sample 4, Henderson Island.

Dimensions.–

	Length	Height
Female RV PI 47	0.89	0.51

Remarks.–The genus is normally encountered in brackish water. The present material, from a fully marine environment at 40’ (12 m) depth, is presumably the result of *post-mortem* transportation, although the authors know of no bodies of brackish water on Henderson Island. This species is much larger and less strongly ornamented than *C. australiensis* Hartmann (1978) from Western Australia. It is more similar in all respects to *C. beconensis* (LeRoy, 1943) described initially from the Neogene of California and subsequently from the Recent of Mexico (Benson, 1959) and the Quaternary of Midway Island (Holden, 1976). Williams (1980 MS) describes a large fauna of what may be the same species from the subsurface Quaternary of the Indespensible Reefs, offshore Guadalcanal.

Family CYTHEROMATIDAE Elofson, 1939
Genus *Cytheroma* G. W. Müller, 1894
Cytheroma aphanes Whatley, Jones and Wouters, 2000
(Pl. 2, Fig. 24; Pl. 3, Fig. 1)

1995 *Cytherois* sp. Whatley & Roberts, Fig. 1.22.
1999 *Cytheroma* sp. 1. Whatley & Jones, Pl. 2, Fig. 6.
1999 *Cytheroma* sp. 2. Whatley & Jones, Pl. 2, Fig. 7.
2000 *Cytheroma aphanes* Whatley, Jones and Wouters, p. 86, Pl. 2, Figs. 18-21.

Material.–Two specimens.

Distribution.–The species was originally recorded by Whatley and Roberts (1995) from the Pitcairn group, where it occurred in a single sample from Henderson Island. Whatley and Jones (1999) and Whatley *et al*. (2000) subsequently encountered the species at Easter Island. In the present study it occurred in samples 1A and 7, from Henderson Island.

Dimensions.–

	Length	Height
RV juv. PI 48	0.23	0.09
RV PI 49	0.50	0.20

Remarks.–The species differs only in size and shape and in its possession of the small antero-dorsal depression from *Cytheroma whatleyi* Yassini & Jones, 1995 from the Recent of SE Australia [= *Cytheroma* sp. 1 Whatley & Downing, 1984, from the Middle Miocene of SE Australia]. It is also superficially similar to *Paracytherois* sp. Zhao & Whatley 1989 from the west coast of Malaysia. The adult specimen is slightly larger than the largest material from Easter Island. The species was recovered in the present study from sediments in the intertidal and sublittoral at 120' (86.5 m).

Family CYTHERURIDAE Müller, 1894
Subfamily CYTHERURINAE Müller, 1894
Genus *Semicytherura* Wagner, 1957
Semicytherura sp.
(Pl. 3; Figs. 2, 3)

1995 *Semicytherura* sp. Whatley & Roberts, Fig. 1.14.

Material.–Two LV.

Diagnosis.–A small species of *Semicytherura* with very robust ornament of ribs, reticulae and puncta. The large ala is rounded terminally and 4 strong ribs converge across the anterior surface to the anterior margin. Internal features as for genus.

Distribution.–Confined to sample 5, Henderson Island.

Dimensions.–

	Length	Height
LV juv. PI 50	0.29	0.16
LV PI 51	0.48	0.26

Remarks.–The two specimen are from beach sediment in the intertidal zone. *Semicytherura* is an uncommon genus in much of the Indo-Pacific. For example, the very large faunas described by Titterton (1984 MS) and Williams (1980 MS) from the Solomon Islands and an even larger fauna from the Java Sea described by Watson (1988 MS) did not contain a single member of the genus. The relatively impoverished fauna of Easter Island does, however, include two species of *Semicytherura, S. rapanuiensis* and *S. cooki* Whatley *et al.* (2000). The latter two species differ from the present one in the nature of their ornament and especially their alae. The very *Cytheropteron* like present species does not resemble any member of the genus known to the authors and is certainly new. It is left in open nomenclature due to its rarity.

Subfamily PARACYTHERINAE Puri, 1957
Genus *Paracytheridea* Müller, 1894
Paracytheridea sp.
(Pl. 3; Figs. 4, 5)

1995 *Paracytheridea* sp. Whatley & Roberts, Fig. 1.11.

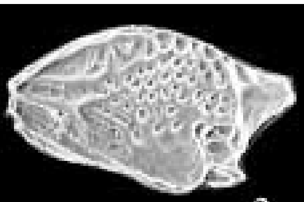
Material.–Three specimens.

→

PLATE 3–(All external lateral views unless otherwise stated). *1, Cytheroma aphanes* Whatley *et al.*, 2000. RV, PI 49, x 80. *2, 3, Semicytherura* sp. 2, juv. LV, PI 50, 140. *3,* LV PI 51, x 85. *4, 5, Paracytheridea* sp. *4,* LV, PI 52, x 103. *5,* C, PI 53, dorsal view, x 94. *6-15, Thelescocythere labyrinthos* gen. et sp. nov. *6,* holotype C, PI 112, left lateral view, x 81. *7,* paratype C, PI 113, right lateral view, x 83. *8,* paratype RV, PI 114, x 86. *9,* paratype RV, PI 115, x 89. *10,* paratype LV, PI 116, x 81. *11,* paratype LV, PI 117, internal view, x 92. *12,* same specimen, detail of anterior hinge, x 160. *13,* paratype RV, PI 118, internal view, x 85. *14,* paratype LV, PI 119, internal view, x 85. *15,* paratype C, PI 120, dorsal view, x 85. *16, 17, Parakrithella* sp. *16,* C, PI 80, right lateral view, x 76. *17,* C, PI 81, left lateral view, x 103. *18, 19, Loxoconchella catarrhopos* Whatley *et al.*, 2000. *18,* C, PI 82, right lateral view, x 76. *19,* C, PI 83, right lateral view, x 81. *20-24, Loxocorniculum mayburyae* Whatley *et al.*, 2000. *20,* female RV, PI 84, x 87. *21,* same specimen, internal view, x 81. *22,* female LV, PI 85, x 93. *23,* female LV, PI 86, x 100. *24,* female LV, PI 87, x 100.

PLATE 3


1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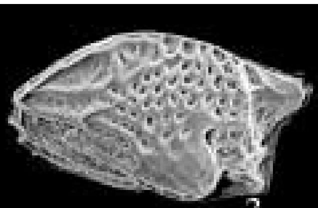
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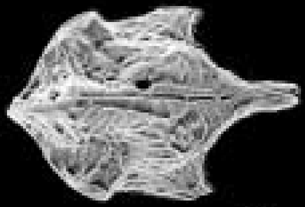
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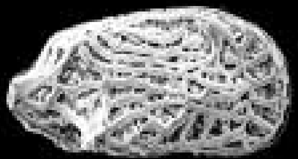
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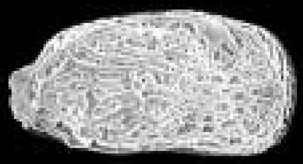
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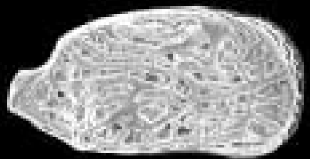
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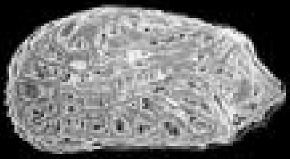
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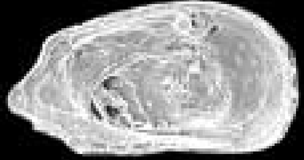
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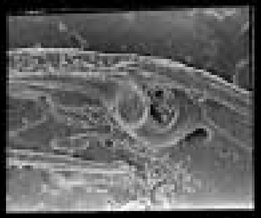
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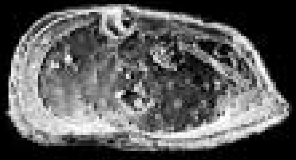
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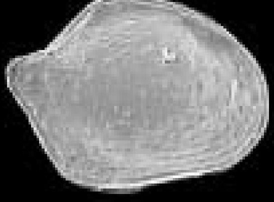
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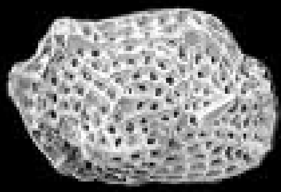
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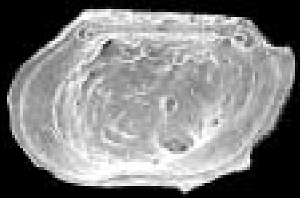
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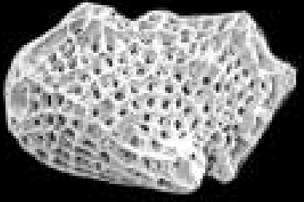
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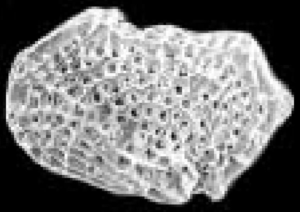
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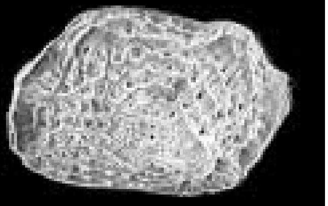
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Diagnosis.–A very small to small species of *Paracytheridea*, with very pointed and upturned, subdorsal caudal process. Surface ornament of numerous narrow, sharp but not strongly elevated ribs and secondary papillation. All the major tubercles are ribbed.

Distribution.–Only found in samples 1B and 2, Henderson Island.

Dimension.–

	Length	Height	Width
LV PI 52	0.39		0.20
C PI 53	0.43		0.28
LV PI 54	0.39	0.20	

Remarks.–Found only in sublittoral sediment down to 120' (86.5m). This species is considerably smaller than *P. reunionensis* Whatley & Keeler (1989) (adults 0.48-0.49 long) is much more acuminate posteriorly and has a different shape, outline and ornament. *P. gynaikokratia* Behrens (1991a) from the Great Barrier Reef is much larger (0.51 long) and has sharp crest like ribs. The lectotype of *Paracytheridea longicaudata* (Brady, 1890) from Sava-Sava Bay, Vanua Levu, Fiji has been re-illustrated by McKenzie (1986, Pl. 1, Fig. 19) and this is shown to be much more inflated in the posterior third than the present species. *P*. aff. *remanei* Hartmann, 1964 of Gabioch *et al*. (1986) from Quaternary reefs in New Caledonia, while similar in shape and size, is distinguished from the present species by the very sharp crest-like ribs on the lateral surface. The closest species is one illustrated in an unpublished MS, kindly given to the authors by Dr. Cronin, as *P*. cf. *aquabaensis* Bonaduce *et al*. (1978). The pattern of ornamentation and the shape and outline is virtually identical, although Cronin's species is rather larger. He records this species from Pohnpei and Truk.

Family HEMICYTHERIDAE Puri, 1953
Subfamily UROCYTHERIDEINAE
Hartmann & Puri, 1974
Genus *Thesceloscythere* gen. nov.

Derivatio nominis.–Gr. *φεσκελοσ* marvelous, wonderful + *Cythere.* With reference to the very attractive ornament of this taxon.

Type species.–*Thesceloscythere labyrinthos* gen. et sp. nov.

Diagnosis.–A medium sized genus of the Urocytherideinae characterised by its strong multicostate ornament with anastomoses, with coarsely reticulate and micropunctate intercostal areas. Hinge holamphidont and very robust with recurved antero-terminal element, smooth median element and multilobate postero-terminal element in RV. Three adductor scars of which the median in divided.

Description.–See type species.

Remarks.–Although it was not our intention to create yet another monotypic ornate ostracod genus, all our endeavours to accommodate this species in a previously described generic taxon have failed. Indeed, the only genus in the Hemicytheridae that resembles it in any way is *Chapmanella* Neil (1994) and the two seem quite closely related despite certain notable differences in morphology. It is probable that the Miocene *Chapmanella* is ancestral to the present genus, at present known only from the Recent. *Thescelocythere* differs from *Chapmanella* in lacking a massive antero-marginal rim and, therefore, in being much more laterally compressed anteriorly in dorsal view. In *Chapmanella*, the intercostal areas are crossed by riblets at right angles to the main ribs while, in the present genus, the ribs themselves often anastomose, and the intercostal areas are subdivided by much stronger riblets, at many different angles to the main ribs and the solum of these areas is micropunctate. *Thescelocythere* also has another distinct feature in that the longitudinal ribs, at about the level of the eye tubercle are reduced in number, this point being marked by an interrupted riblet which parallels the anterior margin. Anterior of this arcuate riblet, only 6 ribs proceed towards the anterior margin in a fan-shaped array, all to be terminated in a narrow marginal rib both proximate to and parallel with the anterior margin. *Chapmanella* is also much more rectangular, with a straight dorsal margin and a well-marked anterior cardinal angle, while in the present genus the anterior cardinal angle is more rounded and, especially in the RV, the dorsal margin being slightly convex, lends a much less rectangular aspect to the carapace. Internally, the holamphidont hinge is very long in *Chapmanella* and the various elements are not strongly developed. By contrast the hinge of *Thescelocythere* is much shorter and all the elements are notably more robust, the posterior terminal element in the RV being multilobate. Neil (1994, p. 26) describes the anterior tooth in the RV as being rounded, while in the present species it is vertically arcuate being boss-like dorsally and tapering into a recurved, ventrally then posteriorly directed and terminally pointed structure below. Also, the median element in the RV of *Chapmanella* is locellate but smooth in the present taxon. Neil (1994, p. 26) describes the muscle scars of *Chapmanella flexicostata*

(Chapman, 1914) the genotype as: “3 small subcircular frontal scars in a triangular configuration; an oblique row of 4 adductors – dorsal subrounded, dorsomedian clearly divided, ventromedian elongate, ventral ovate to subrounded” but states that some variation exists from this basic pattern. However, in the sole illustrated specimen which reveals muscle scars (Pl. 10, Fig. 3) the frontal scars far from being in a “triangular configuration” are in a vertical row, as in the present species (see paratype PI 118, Pl. 3, Fig. 13). The major difference, however, is in the adductors, as in *Thescelocythere* there seem to be only 3, of which the central scar is subdivided. *Chapmanella* also lack the true caudal process of *Thescelocythere*.

Thesceloscythere labyrinthos sp. nov.

(Pl. 3; Figs. 6-15)

1995 Gen. et sp. nov. Whatley & Roberts, Fig. 1. 33.

Derivatio nominis.–Gr. *λαβυρινφοσ* a labyrinth or maze. With reference to the labyrinthine ornament of this species.

Holotype.–Carapace PI 112.

Type locality.–Sample 1A, Henderson Island.

Material.–Forty-five specimens.

Diagnosis.–As for genus.

Description.–Medium. Subovate to subrectangular in lateral view. Sub hastate in dorsal view. Moderately well calcified. Anterior margin broadly rounded and enhanced in well preserved specimens by numerous small marginal denticles, especially antero-ventrally; apex at mid-height. Posterior margin with genuine caudal process and seen on inner margin of LV (paratytpes PI 117, PI 119 , Pl. 3). The posterior apex is blunt and at about mid-height and both the postero-dorsal and postero-ventral slopes are concave, especially the former. Dorsal margin slightly convex seen in lateral view, antero-cardinal angle rounded’ postero-cardinal angle strongly marked. Ventral margin largely obscured in lateral view by valve tumidity but with shallow oral concavity. Greatest height at mid-height, greatest height at the anterior cardinal angle; greatest width in posterior $^1/_4$. Ornament of strong, smooth ribs with oval profile. Most ribs are longitudinal or slightly oblique to the horizontal and many are of similar strength. Some ribs are long and extend most of the length of the valve, other anastomose. and the solum of these areas is micropunctate. The longitudinal ribs, at about the level of the eye tubercle are reduced in number, this point being marked by an interrupted riblet which parallels the anterior margin. Anterior of this arcuate riblet, only 6 ribs proceed towards the anterior margin in a fan-shaped array, all to be terminated in a narrow margin rib both proximate to and parallel with the anterior margin. Intercostal areas coarsely reticulate or, especially anteriorly, the space contains small circular tubercles. Similar small tubercles more rarely occur on the ribs. There is a large but not strongly prominent eye tubercle from which two short ribs extent ventrally and antero-ventrally respectively. A complex of ribs give rise to a strong postero-ventral sub-alar process. All npc’s occur in sola. Inner lamella of median width. Hinge holamphidont and robustly developed with recurved antero-terminal element, smooth median element and multilobate postero-terminal element in RV. Muscle scars comprise three oval frontal scars in a vertical row, a single small mandibular scar and only three adductor scars of which the central scar is divided. Sexual dimorphism not clearly distinguishable.

Distribution.–Occurring at Henderson (samples 1A, 1B, 2-4) and Pitcairn (sample 9) islands.

Dimensions.–(All from sample 1A).

	Length	Height	Width
Holotype C PI 112	0.48	0.25	
Paratype C PI 113	0.47	0.25	
Paratype RV PI 114	0.46	0.24	
Paratype RV PI 115	0.45	0.24	
Paratype LV PI 116	0.47	0.25	
Paratype LV PI 117	0.44	0.23	
Paratype RV PI 118	0.45	0.24	
Paratype LV PI 119	0.44	0.24	
Paratype C PI 120	0.47		0.25

Remarks.–Found in the intertidal attached to seaweed and in subtidal sediments down to 120’ (36.5 m). See also for genus.

Family KRITHIDAE Mandelstam, 1958

Genus *Parakrithella* Hanai, 1959

Parakrithella sp.

(Pl. 3; Figs. 16, 17)

Material.–Two specimens.

Diagnosis.–A very small species of *Parakrithella* with the typical shape and outline of the genus. The dorsal margin, however, more than usually sinuous.

Distribution.–Found only in sample 9 from Pitcairn Island.

Dimensions.–

	Length	Height
C PI 80	0.37	0.18
C PI 81	0.38	0.18

Remarks.–Confined to a single intertidal algal sample; the genus is regarded as being essentially phytal in habit. This seems to be a new species of the genus but is left in open nomenclature due to its rarity. It is considerably smaller than other species known to the authors. For example, *P. peregrinata* Whatley *et al.* (2000) from Easter Island ranges between 0.45 and 0.48 in length. The present material is thought to be adult because of the sinuosity of the dorsal margin which reflects an adult hingement.

Subfamily LOXOCONCHINAE Sars, 1925
Genus *Loxoconchella* Triebel, 1954
Loxoconchella catarrhopos Whatley,
Jones and Wouters, 2000
(Pl. 3; Figs. 18, 19)

1995 *Loxoconchella* sp. cf. *L. pulchra* McKenzie. Whatley & Roberts, Pl. 1, Fig. 17.
1999 *Loxoconchella honoluluensis* (Brady) subsp. nov. Whatley & Jones, p. 338, Pl. 1, Fig. 21.
2000 *Loxoconchella catarrhopos* Whatley, Jones and Wouters, p 89, Pl. 3, Figs. 15-18.

Material.–Three specimens.

Distribution.–This species is apparently confined to Easter Island and the Pitcairn group where it occurs only at Henderson Island in sample 1B. While very abundant at Easter Island, it is rare in the present study.

Dimensions.–

	Length	Height
C PI 82	0.50	0.35
C PI 83	0.45	0.34

Remarks.–This species differs from *L. pulchra* McKenzie (1967) from SE Australia in its smaller first generation puncta and in its much better developed micropuncta.

Genus *Loxocorniculum* Benson
& Coleman, 1963
Loxocorniculum mayburyae Whatley,
Jones and Wouters, 2000
(Pl. 3; Figs. 20-24; Pl. 4, Figs. 1, 2)

1995 *Loxocorniculum* sp. nov. Whatley & Roberts, Fig. 1.18.
1999 *Loxocorniculum* sp. Whatley & Jones, Pl. 1, Figs. 22, 23.
2000 *Loxocorniculum mayburyae* sp. nov. Whatley, Jones and Wouters, p. 90, Pl. 3, Figs. 19-22; Pl. 4, Figs. 1-4.

Material.–One hundred and ninety-six specimens. This is the most abundant species in the study.

Distribution.–Confined to Easter Island and the present study where it occurred in all the samples from Henderson and Pitcairn islands and Oeno Atoll.

Dimensions.–

	Length	Height
Female RV PI 84	0.45	0.30
Female LV PI 85	0.44	0.28
Female LV PI 86	0.40	0.28
Female LV PI 87	0.40	0.28
Female RV PI 88	0.41	0.28
Male LV PI 89	0.42	0.23

Remarks.–This species belongs to the *L. huahineensis* group of Hartmann 1984, which is widely distributed in the SW and Central Pacific and Australia with such species as the nominative species, *L. parahuaheenensis* Behrens, 1991a, and *L. fischeri minima* Teeter 1975 of Cabioch *et al.*, 1986, from the Pacific Islands, the Great Barrier Reef and New Caledonia respectively. All differ in details of shape, size and ornament from the present species which is much less tuberculate than *L. huahineensis*, and has quite different reticulation than *L. parahuaheensis* or *L. fischeri minima*. The present material is of exactly the same size as the type material from Easter Island. The two populations differ, however, in that the latter material has more regular ornament while that of the present specimens is substantially more variable, especially in the detail of the mid-lateral reticulum. In the present study the species was recovered from a range of intertidal sediment and phytal environments and from sediment samples down to 120’ (36.5 m) in depth.

Genus *Loxoconcha* Sars, 1866

Loxoconcha dictyoklostos sp. nov.

(Pl. 4; Figs. 3-6)

1995 *Loxocorniculum* cf. *L. microreticulata* Whatley & Roberts. Fig. 1.19.

Holotype.–Female RV, PI 90, sample 4.

Derivatio nominis.–Gr. *δικτυοκλωστος* woven in meshes. With reference to the reticulate ornament of this species and in particular alluding to the enclosure of the central puncta by reticulae.

Material.–Eleven specimens, all valves.

Diagnosis.–A medium sized, elongate subrectangular species of *Loxoconcha* with peripheral ornament of relatively coarse reticulation around the free margin and surrounding a central area of weak primary reticulation and dense secondary punctation.

Description.–Medium. Elongate subrectangular in lateral view. Sexually dimorphic, but not strongly so; males a little more elongate than females. Anterior margin broadly and regularly rounded with apex at mid-height. Posterior margin with long, convex postero-ventral slope and short, concave postero-dorsal slope; apex well above mid height. Dorsal margin straight and ventral margin with only slight oral concavity. Greatest length above mid-height; greatest height at the anterior cardinal angle; greatest width in posterior 1/3. Ornament comprising a concentric band of coarse reticulation bordering the free margin which encloses a central area of very weak reticulation enclosing a strong, dense secondary punctation. Free marginal area almost smooth but with some muri from the strong reticulation and some parallel striation. Eye tubercle low but prominent. Internal features as for genus. Hinge gongylodont but not strongly developed.

Distribution.–Confined to sample 4, from a depth of 40’ (12 m) off East Beach, Henderson Island.

Dimensions.–

	Length	Height
Holotype, female RV PI 90	0.61	0.35
Paratype, male RV PI 91	0.66	0.37
Paratype, female LV PI 92	0.61	0.36
Paratype, male LV PI 93	0.66	0.36

Remarks.–This species resembles and is evidently related to a Recent species from the Solomon Islands described by Titterton (1984 MS) and this manuscript name was inadvertently used by Whatley & Roberts to compare the present species. The Solomon Island species will be published shortly (Titterton & Whatley, in prep.)

Loxoconcha hendersonislandensis sp. nov.

(Pl. 4; Figs. 7-9)

1995 *Loxoconcha* sp. Whatley & Roberts, p. 363, Pl. 1, Fig. 16.

Holotype.–Female carapace, PI 94.

Derivatio nominis.–L. From the type locality, Henderson Island in the Pitcairn Group.

Type locality.–Sample 4, East Beach, Henderson Island.

Material.–Ten specimens.

Diagnosis.–A medium sized, subrhomboidal species of *Loxoconcha* with strongly marked sexual dimorphism and postero-ventral keel, and with an ornament of central circular puncta surrounded by concentrically orientated rows of puncta defined in parts by feeble concentric ribs.

Description.–Medium. Markedly sexually dimorphic, the males being considerably more elongate than the females. Subrhomboidal in lateral view. Anterior well rounded with apex at or just below mid-height. Posterior margin with long, convex postero-ventral slope and much shorter, straight or slightly concave postero-dorsal slope and blunt apex at about 1/3 height. Dorsal margin of female convex anterodorsally and straight postero-dorsally; straight in male. Ventral margin with marked oral concavity antero-ventrally, but with pronounced convex keel postero-ventrally. Greatest length above mid-height; greatest height just behind mid-length, greatest width medianly. Eye tubercle large but not prominent. Ornament centrally of circular puncta, surrounded by concentrically orientated rows of puncta separated in some cases by feeble concentric ribs. Anterior and posterior margins and the keel smooth. Internal features as for genus.

Distribution.–From samples 1B, 2 and 4, Henderson Island.

Dimensions.–

	Length	Height
Holotype female carapace, PI 94	0.60	0.41
Paratype female carapace, PI 95	0.63	0.44
Paratype male carapace, PI 96	0.66	0.48

Remarks.–Recovered only from intertidal sediments between 40’ and 120’ (12-36.5 m) in depth. Superficially, this species is remarkably similar to the genotype, *Loxoconcha rhomboidea* (Fischer) from North West Europe and the North Atlanticb but is rather larger, has less well developed concentric subperipheral ribs and also differs somewhat in shape.

Family PARADOXOSTOMATIDAE
Brady & Norman, 1884
Genus *Paradoxostoma* Fischer, 1855
Paradoxostoma ballistica Whatley, Jones & Wouters, 2000
(Pl. 4; Figs. 10-11)

1995 *Paradoxostoma* sp. 2. Whatley & Roberts, Fig. 1.21.
1999 Paradoxostoma sp 1. Whatley & Jones, Pl. 2, Figs. 1, 2.
2000 *Paradoxostoma ballistica* Whatley, Jones & Wouters, p. 94, Pl. 4, Figs. 5-8.

Material.–Five specimens.

Distribution.–Occurring in samples 6 and 9, from Henderson and Pitcairn Islands. It also occurs at Easter Island.

Dimensions.–

	Length	Height
Male C, PI 97	0.69	0.24
Female C, PI 98	0.70	0.26

Remarks.–Recovered only from intertidal algae in the present study. Previously described from Easter Island.

Paradoxostoma sp. 1
(Pl. 4; Figs. 12, 13)

Material.–2 specimens.

Diagnosis.–A medium, subovate species of *Paradoxostoma* with a well rounded anterior margin and a bluntly pointed posterior margin in which the postero-ventral slope is long and strongly convex and the postero-dorsal slope is shorter and concave; apex above mid-height. Dorsal margin regularly convex. Ventral margin with shallow antero-median concavity.

Distribution.–Found only in sample 2, Henderson Island.

Dimensions.–

	Length	Height
RV PI 99	0.65	0.32
RV PI 100	0.64	0.34

Remarks.–This species is almost certainly new but is left in open nomenclature due to paucity of material.

Paradoxostoma sp. 2
(Pl. 4; Fig. 14)

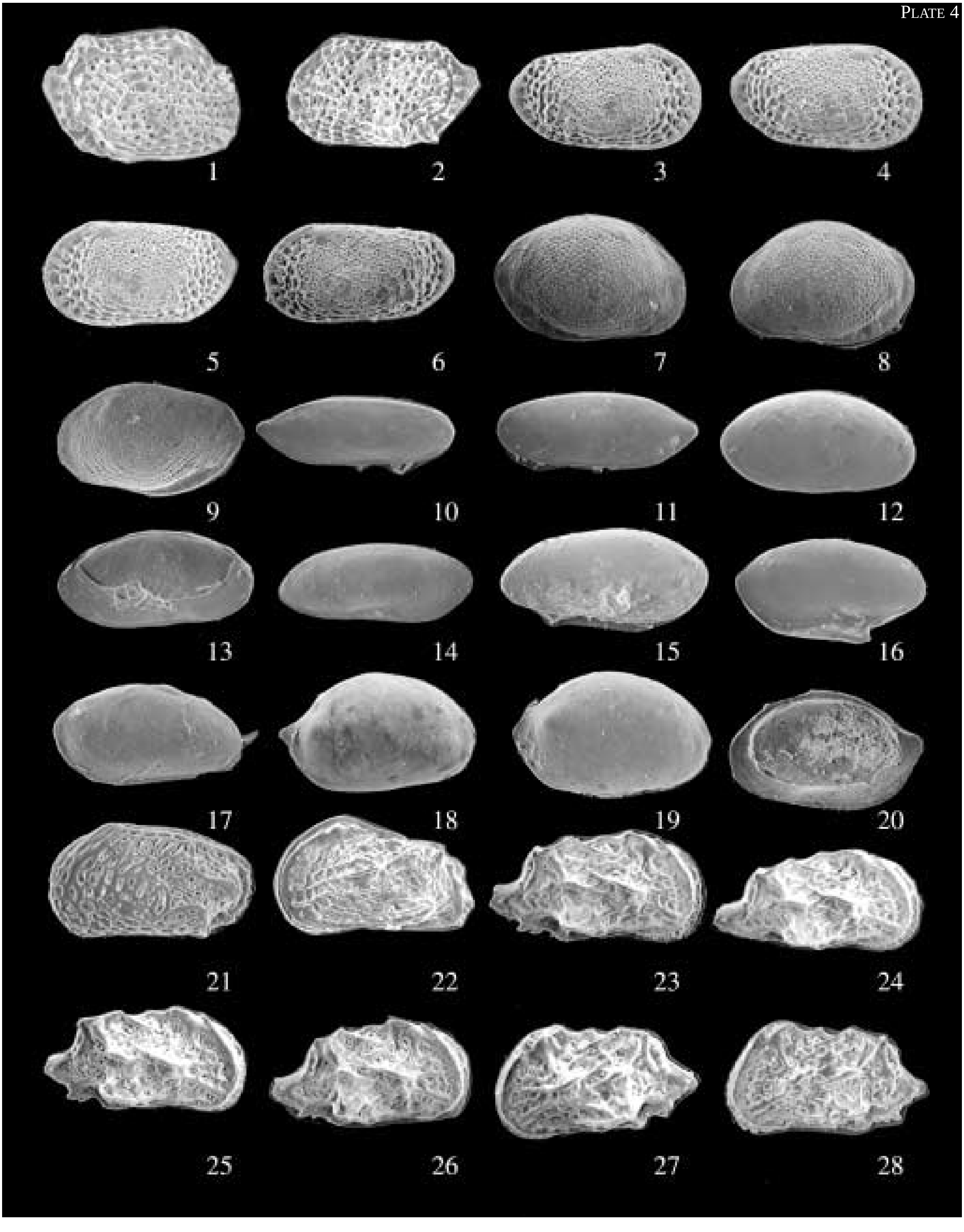
Material.–One specimen.

Diagnosis.–A very small species of *Paradoxostoma*. Elongate subcylindrical in lateral view. Anterior margin rather narrowly rounded. Posterior margin bluntly pointed above mid-height. Dorsal margin very gently and regularly convex. Ventral margin with oral concavity at mid-length and pronounced postero-ventral keel.

→

PLATE 4–(All external lateral views unless otherwise stated). *1, 2. Loxoconcha mayburyae* Whatley *et al.*, 2000. *1,* female RV, PI 88, x 89. *2,* male LV, PI 89, x 89. *3-6, Loxoconcha dictyokloston* sp. nov. *3,* holotype female RV, PI 90, x 61. *4,* paratype male RV, PI 91, x 58. *5,* paratype female LV, PI 92, x 62. *6,* paratype male LV, PI 93, x 63. *7-9, Loxoconcha hendersonislandensis* sp. nov. *7,* holotype female C, PI 94, right lateral view, x 62. *8,* paratype female C, PI 95, left lateral view, x 57. *9,* paratype male C, PI 96, left lateral view, x 55. *10, 11, Paradoxostoma ballistica* Whatley *et al*., 2000. *10,* male C, PI 97, right lateral view, x 57. *11,* female C, PI 98, left lateral view, x 56. *12, 13, Paradoxostoma* sp. 1. *12,* RV, PI 99, x 60. *13,* RV, PI 100, internal view, x 59. *14, Paradoxostoma* sp. 2. LV, PI 101, x 112. *15, Paradoxostoma* sp. 2. C, PI 102, left lateral view, x 72. *16, 17, Paradoxostoma* sp. 4. *16,* C, PI 103, right lateral view, x 114. *17,* C, PI 104, right lateral view, x 114. *18-20, Pellucistoma* sp. *18,* RV, PI 105, x 74. *19,* RV, PI 106, x 80. *20,* RV, PI 107, internal view, x 70. *21, Kotoracythere inconspicua* (Brady, 1880). C, PI 108, left lateral view, x 121. *22, Tenedocythere transoceanica* (Teeter, 1975). A-1 juv. LV, PI 76, x 91. *23-28, Tenedocythere apios* sp. nov. *23,* holotype female right valve, PI 55, x 71. *24,* paratype male RV, PI 56, x 64. *25,* paratype female RV, PI 57, x 69. *26,* paratype female RV, PI 58, x 70. *27,* paratype female LV, PI 59, x 75. *28,* paratype female LV, PI 60, x 72.

PLATE 4



Distribution.–Sample 6, Henderson Island.

Dimensions.–

	Length	Height
LV PI 101	0.34	0.14

Remarks.–This very small species is of quite different shape from any of the other species in this study and is also smaller than any others except *Paradoxostoma* sp. 4. It is probably new but left in open nomenclature due to its rarity.

Paradoxostoma sp. 3
(Pl. 4; Fig. 15)

Material.–Five specimens from the Pitcairn group.

Diagnosis.–A medium species of *Paradoxostoma*. Elongate subrhomboidal in lateral view. Anterior margin very narrowly and asymmetrically rounded, with subventral apex. Posterior margin with long, convex postero-ventral slope and much shorter, straight postero-dorsal slope; blunt apex well above mid-height. Dorsal margin almost straight and sloping towards the anterior. Ventral margin with shallow concavity. Smooth apart from some concentric striations which parallel the postero-ventral margin.

Distribution.–Occurring in samples 2, 6 from Henderson and 9 from Pitcairn Islands.

Dimensions.–

	Length	Height
C PI 102	0.58	0.26

Remarks.–Recovered in the present study from two samples of intertidal algae and one from sublittoral sediments at 40’ (12 m) the latter occurrence almost certainly being the product of *post-mortem* transportation. Probably new, but left in open nomenclature due to its paucity.

Paradoxostoma sp. 4
(Pl. 4; Figs. 16, 17)

1995 *Paradoxostoma* sp. 1. Whatley & Roberts, Fig. 1.20.

Material.–Two carapaces.

Diagnosis.-A very small species of *Paradoxostoma*. Subrhomboidal in lateral view. Anterior margin asymmetrically rounded with apex just below mid-height. Posterior margin with long, straight to slightly convex postero-ventral slope and shorter, slightly concave postero-dorsal slope. Apex obtuse and above mid-height. Dorsal margin sloping down on either side of a slight point behind mid-length. Ventral margin almost straight.

Distribution.–From sample 2, Henderson Island.

Dimensions.–

	Length	Height
C PI 103	0.33	0.17
C PI 104	0.33	0.17

Remarks.–Both specimens were live and were from sediments 80’ (24 m) beyond the fringing reef, Henderson Island.

Genus *Pellucistoma* Coryell & Fields, 1937
Pellucistoma sp.
(Pl. 4; Figs. 18-20)

1995 *Pellucistoma* sp. Whatley & Roberts, Fig. 1.23.

Material.–Three specimens.

Diagnosis.–A small to medium, subovate and rather inflated species of *Pellucistoma,* with an upturned caudal process.

Distribution.–Samples 1B and 2, Henderson Island.

Dimensions.–

	Length	Height
RV PI 105	0.52	0.31
RV PI 106	0.49	0.30
LV PI 107	0.54	0.33

Remarks.–Recovered only from sublittoral sediments at depths of 40’ and 120’ (12 and 36.5 m).

Family PECTOCYTHERIDAE Hanai, 1957
Genus *Kotoracythere* Ishizaki, 1966
Kotoracythere inconspicua (Brady, 1880)
(Pl. 4; Fig. 21)

1880 *Cythere inconspicua* Brady, p. 70, Pl. 13, Figs. a-d.

1990 *Morkhovenia kingstoni* (Brady). McKenzie, Reyment & Reyment, p. 11, Pl. 3, Fig. 1.

1990 *Kotoracythere inconspicua* (Brady), Gou, p. 26, Pl. 3, Fig. 7.

1991 *Morkovenia inconspicua* (Brady). Hartmann, p. 171, Pl. 2, Fig. 14b.
1991a *Morkhovenia inconspicua* (Brady). Behrens, p. 33, Pl. 2, Figs. 10, 11.
1991 *Kotoracythere inconspicua* Witte & Van Harten, p. 143, Figs. 3-5. (This gives an exhaustive synonomy of the species to that date, including use of the generic names *Leptocythere* and *Morkhovenia* = *Kotoracythere*).
1992 *Kotoracythere inconspicua* (Brady). Behrens, p. 33, Pl. 6, Figs. k-i.
1993a *Kotoracythere inconspicua* (Brady). Witte, p. 25, Pl. 3, Figs. 19-22.
1993b *Kotoracythere inconspicua* (Brady). Witte, p. 156, Pl. 2, Figs. 17-24.
1993 *Kotoracythere inconspicua* (Brady). Jellinek, p. 121, Pl.7, Figs. 157-165; Pl. 8, Figs. 166-170.
1995 *Kotoracythere inconspicua* (Brady). Yassini & Jones, p. 338, Figs. 287, 288.
1995 *Kotoracythere inconspicua* (Brady). Whatley & Roberts, Fig. 1.24.

Material.–A single specimen from sample 8, Henderson Island.

Dimensions.–

	Length	Height
C PI 108	0.33	0.19

Remarks.–Recovered only from intertidal algae. This species, which various authors have shown to have a very wide circumtropical distribution, is evidently rather rare in the Pitcairn Group. It was not encountered by Whatley *et al*. (2000) at Easter Island.

Family THAEROCYTHERIDAE Hazel, 1967
Genus *Tenedocythere* Sissingh, 1972

Remarks.–We regard *Quadracythere* and *Tenedocythere* as closely related genera differentiated by the presence of strong ribs in the latter and their absence in the former. *Bosasella* Bonaduce, 1985, is considered a junior synonym of *Tenedocythere*, which is where we would also subsume *Neohornibrookella* and *Paraquadracythere*, both Jellinek, 1993. The exact nature of the relationship of *Jugosocythereis* Puri, 1957 to this group remains unknown but this latter genus does not seem to be a true thaerocytherid since two of its adductor scars are divided.

Tenedocythere transoceanica (Teeter, 1975)
(Pl. 4; Fig. 22)

1975 *Hermanites transoceanica* Teeter, p. 450, Pl. 11, Figs. o-q; Pl. 12, Fig. h.
1976 *Jugosocythereis lactea* (Brady). Holden, p. 25, Pl. 3, Figs. 22, 23.
1980 *Quadracythere auricolata* Bonaduce, Masoli, Minichelli & Pugliese, p. 125, Pl. 5, Figs. 1-4.
1980 *Jugosocythereis paralactea* Williams MS, p. 128, Pl. 7, Figs. 12-15.
1981 *Quadracythere insulardaensis* Hartmann, p. 108, text-Fig. 21-25, Pl. 6, Figs. 1, 2.
1981 *Radimella microreticulata* Hu, p. 90, text-fig 8, c-d, Pl. 1, Figs. 4, 9-10.
1982 *Hermanites transoceanica* Teeter. Krutak, p. 267, Pl. 3, Figs. 12, 13.
1984 *Quadracythere insulardaensis* Hartmann. Hartmann, p. 126, Pl. 5, Figs. 1-4 (*non* Pl. 5, Figs. 8, 9).
1984 *Quadracythere insulardaensis* Hartmann. Titterton MS, p. 289, Pl. 9, Figs. 5, 6; Pl. 40, Figs. 9-19.
1986 *Jugosocythereis transoceanica* (Teeter). Gabioch, Anglada & Babinot, p. 27, Pl. 9, Figs. 8, 9.
1988 *Hermanites* sp. Tabuki & Nohara, p. 435, Pl. 1, Figs. 7, 8.
1988 *Hermanites transoceanica* Teeter. Cronin, p. 884, Pl. 2, Figs. 1-8.
1988 *Radimella parviloba* Hu. Zhao & Wang, p. 815, Pl. 5, Fig. 30.
1988 *Quadracythere (Tenedocythere) transoceanica* (Teeter). Watson MS, p. 150, Pl. 29, Figs. 10-18, 20.
1990 *Hermanites transoceanica* Teeter. Gou, p. 28, Pl. 2, Figs. 22, 23.
1992 *Quadracythere transoceanica* (Teeter). Behrens, 51, p. 13, Pl. 13, Figs. c, d.
1993 *Neohornibrookella lactea* (Brady). Jellinek, p. 154, Pl. 28, Figs. 436-443.
1995 *Tenedocythere transoceanica* (Teeter). Whatley & Roberts, p. 362, Pl. 1, Fig. 15.

Material.–Thirteen specimens. Three broken adults, the remainder juvenile.

Distribution.–As Whatley & Roberts (1995, p. 362) and other authors, notably Teeter (1975) have shown, and as reflected in its specific name, this species is widespread throughout the tropics, except the Atlantic. In the present study the species occurs in samples 1A, 1B, 2 and 3 all from Henderson Island.

Dimensions.–

	Length	Height
A-1 juv. LV PI 76	0.43	0.27

Remarks.–Occurring in the present study in a range of samples, from intertidal algae down to sublittoral sediments at 120' (36.5 m). Juveniles of this species tend to resemble adults of *Tenedocythere deltoides* (Brady). Jellinek (1993) considers this species to be conspecific with *Cythere lactea* Brady, 1886. However, *C. lactea* is based on a single specimen (discounting the variety *rudis*) and, neither of these seem in Brady's original illustrations to resemble *T. oceanica* (Teeter) and the same can be said for Brady's (1880) illustration of the species in the *Challenger* material.

Tenedocythere apios sp. nov.

(Pl. 4; Figs. 23-28; Pl. 5, Figs. 1-5)

1995 *Pseudocaudites* sp. nov. Whatley & Roberts, Fig. 1.13.

Derivatio nominis.–Gr. *απιοοσ* far away, distant. Referring to the geographical remoteness of the Pitcairn group, the type locality of this taxon.

Holotype.–Female RV PI 55.

Type locality.–Sample 4, Henderson Island.

Material.–One hundred and fifty seven specimens.

Diagnosis.–A species of *Tenedocythere* with very strong ornament of ribs and irregular reticulation. The ribs are generally oblique, crossing the carapace from postero-dorsal to antero-ventral. Eye tubercle prominent and with a pillar-like rib 'supporting' it. Posterior margin with very pronounced caudal process, especially in male.

Description.–Medium. RV subrectangular in lateral view, especially the male; LV more subquadrate. Sexually dimorphic with male considerably more elongate than female. Anterior margin broadly rounded in RV with apex at mid-height, more asymmetrically so in LV with apex below mid-height; margin with plicated flange, especially antero-ventrally. Posterior margin with pronounced caudal process, particularly in RV and male; postero-ventral slope gently convex from the ventral margin and with two blunt tubercles; apex at about mid height with bluntly oblique termination and concave postero-dorsal slope. Dorsal margin straight but overreached by dorso-lateral ornament. Ventral margin with shallow median concavity. Ornament coarsely reticulo-costate. A smooth rib borders and parallels the anterior margin and extend around most of the venter. There is a prominent postero-dorsal loop that projects beyond and parallels the dorsal margin almost to mid-length. A series of irregular rather parallel ribs, of varying length and strength extend diagonally across the carapace approximately from postero-dorsal to antero-ventral. These ribs cross the central muscle scar area and are separated by strong reticulation. There is a strong sub-alar process. the eye tubercle is prominent and is 'supported' by a short, strong, pillar-like rib. Internal features typical of the genus. The holamphidont hinge is verystrongly developed, with a strongly crenulated postero-median element. Central muscle scars typically thaerocytherine with four undivided adductor and two oval frontal scars.

Distribution.–In all samples from Henderson Island and Oeno Atoll and only absent from Pitcairn Island.

Dimensions.–

		Length	Height
Holotype female RV PI 55	Sample 4	0.59	0.31
Paratype male RV PI 56	Sample 4	0.63	0.31
Paratype female RV PI 57	Sample 1B	0.58	0.30
Paratype female RV PI 58	Sample 1B	0.56	0.29
Paratype female LV PI 59	Sample 1B	0.53	0.29
Paratype female LV PI 60	Sample 1A	0.56	0.31
Paratype female LV PI 61	Sample 2	0.56	0.31
Paratype female LV PI 62	Sample 2	0.54	0.29
Paratype male LV PI 63	Sample 4	0.57	0.30
Paratype female RV PI 64	Sample 4	0.56	0.29

Remarks.–This species differs from all other species of the genus, or of the related genus *Quadracythere* Hornibrook, in its more subrectangular shape and very pronounced caudal process. In shape it is probably closest to *Tenedocythere deltoides* (Brady, 1890), but the present species has much more robust ornament and more pronounced caudal process.

Tenedocythere stasiotes sp. nov.
(Pl. 5; Figs. 6-17)

1995 *Ambostracon* sp. nov. Whatley & Roberts, Fig. 1.12.

Derivatio nominis.–Gr. *στασιωτησ* mutineers. With reference to the original colonists of Pitcairn Island who came here after the mutiny on H. M. S. *Bounty.*

Holotype.–Male LV PI 65.

Type locality.–Sample 4, 40’ (36.5 m) deep off East Beach, Henderson Island.

Material.–Thirty-five specimens.

Diagnosis.–A subrectangular species of *Tenedocythere* with very broadly but assymetrically rounded anterior margin, posterior margin sloping strongly posteriorly and posterior margin that is truncate in LV but subcaudate in RV, especially in male. Ornament reticulo-punctate with numerous horizontal ribs separated by rows of very cribrose puncta.

Description.–Medium. Well calcified. Subrectangular in lateral view. Sexually dimorphic; males more elongate than females. Anterior margin broadly rounded in RV but more asymmetrically rounded in LV, with straight to gently convex antero-dorsal slope; apex at mid-height. Posterior margin subtruncate in LV, more caudate in RV, especially in male; apex somewhat below mid-height; bearing 5 small marginal denticles postero-ventrally. Dorsal margin straight, sloping gently towards the posterior and with characteristic small, looped overhang just behind mid-length. Ventral margin straight in LV, but with distinct median concavity in RV. Greatest length just below mid-height; greatest height at the anterior cardinal angle; greatest width in posterior $^1/_4$. Ornament reticulo-punctate. There is a strong rib which extends parallel to and a little distance from the anterior margin, which then extends parallel to the ventral margin, defining the border between the lateral and the ventral surfaces. This rib then extends onto the posterior margin where it forms a marginal rim and then extends peripherally along the dorsal margin, where it forms the small looped overhang just behind mid-length. Also arising on the posterior margin is a less peripheral rib which forms the dorsal loop, one ramus of which extends a little distance onto the postero-lateral surface, while another extends ventrally to its prominent tubercular union with the posterior part of the ventro-lateral rib. Some 6 parallel oblique ribs, each separated by a single row of very cribrose reticulae cover the lateral surface. Several of these ribs cross the prominent subcentral tubercle. A narrow peripheral rib enhances the anterior margin. Between this and the subperipheral rib are a series of some 7 scalloped fossae. The eye tubercle is small but prominent and situated on the anterior slope of the main rib. Hinge holamphidont with a crenulated median element. The anterior terminal element is a single boss-like tooth which arises from an elevated base; the postero-terminal tooth is distinctly bifid. The two most ventral adductor scars are rather elongate but not subdivided.

Distribution.–Occurring in all samples except 8 and 9 and confined to Henderson Island.

Dimensions.–

	Length	Height
Holotype male LV P1 65	0.53	0.31
Paratype female LV PI 66	0.54	0.32
Paratype female LV PI 67, sample 4	0.50	0.30
Paratype male RV PI 68, sample 4	0.53	0.31
Paratype female LV PI 69. sample 4	0.51	0.31
Paratype male RV PI 70, sample 2	0.52	0.30
Paratype female LV PI 71, sample 6	0.51	0.32
Paratype female RV PI 72, sample 6	0.55	0.34
Paratype female LV PI 73, sample 2	0.52	0.33
Paratype male LV PI 74, sample 7	0.53	0. 31
Paratype A-1 juv. LV PI 75, sample 7	0.47	0.29

Remarks.–The species was recovered from a wide range of environments including algae and sediment in the intertidal zone down and sediments down to 120’ (36.5 m). This species differs from *T. apios* sp. nov. in its much more truncated posterior margin, more reduced costation and in the cribrose nature of its intercostal reticulation. It differs from most other members of the genus in that the lateral ribs are rather subdued. The species is rather similar to *Quadracythere alloios* and *Tenedocythere titanikos* both Whatley *et al.*, 2000 from Easter Island. Both the former of these and the present species are borderline species between the reticulate non costate to rather feebly costate

Quadracythere Hornibrook and the strongly reticulo-costate *Tenedocythere* Sissingh. *Q. alloios* has more subdued ornament than the present species; it also lacks the strong sub peripheral marginal rib anteriorly and ventro-laterally and has a pronounced smooth area in the antero-ventral lateral area. *T. titanikos* has much more strongly developed and more chaotic ornament, lacks the looped dorsal overhang and is substantially larger (0.58-0.70 long).

Tenedocythere sp. 1
(Pl. 5; Figs 18-22)

1995 *Australimoosella* sp. Whatley & Roberts, p. 362, Fig. 1, 25.

Material.–4 specimens, all juvenile.

Diagnosis.–A species of *Tenedocythere* represented only by juveniles, which are of medium length. The ornament of the juveniles, which may not be the same as the adults, is reticulo-costate with rather regular reticulation anteriorly and numerous weak diagonal ribs elsewhere. There is a pronounced secondary micropunctation. Internal features typically juvenile, with a very narrow calcified inner lamella and weak merodont dentition.

Distribution.–Occurring in samples 1 and 4, Henderson island.

Dimensions.–

	Length	Height
A-1 juv. RV, PI 77	0.58	0.31
A-1 juv. LV, PI 78	0.64	0.38
A-1 juv. LV, PI 79	0.63	0.38

Remarks.–This material, although all juvenile, is too large to represent juveniles any of the three other species of *Tenedocythere* encountered in this study. It probably represents juveniles of an as yet undescribed species, but is left in open nomenclature due to its paucity and immaturity.

Tenedocythere sp. 2
(Pl. 5; Fig. 23)

Material.–One specimen.

Diagnosis.–A medium, subrectangular species of *Tenedocythere* with broadly but not well-rounded anterior margin enhanced by a weak marginal rim. Posterior margin produced postero-ventrally and bearing three marginal denticles. Posterior margin straight, sloping gently posteriorly. Ventral margin with shallow oral concavity and overhung by valve tumidity. Ornament a series of horizontal and oblique ribs which cross the carapace, with distinct somewhat isolated intercostal reticulae. Postero-dorsal loop distinct. All the surface, except the crests of the ribs is densely micropunctate. Eye tubercle rather small. Internal features as for genus.

Distribution.–Sample 4, Henderson Island.

Dimensions.–

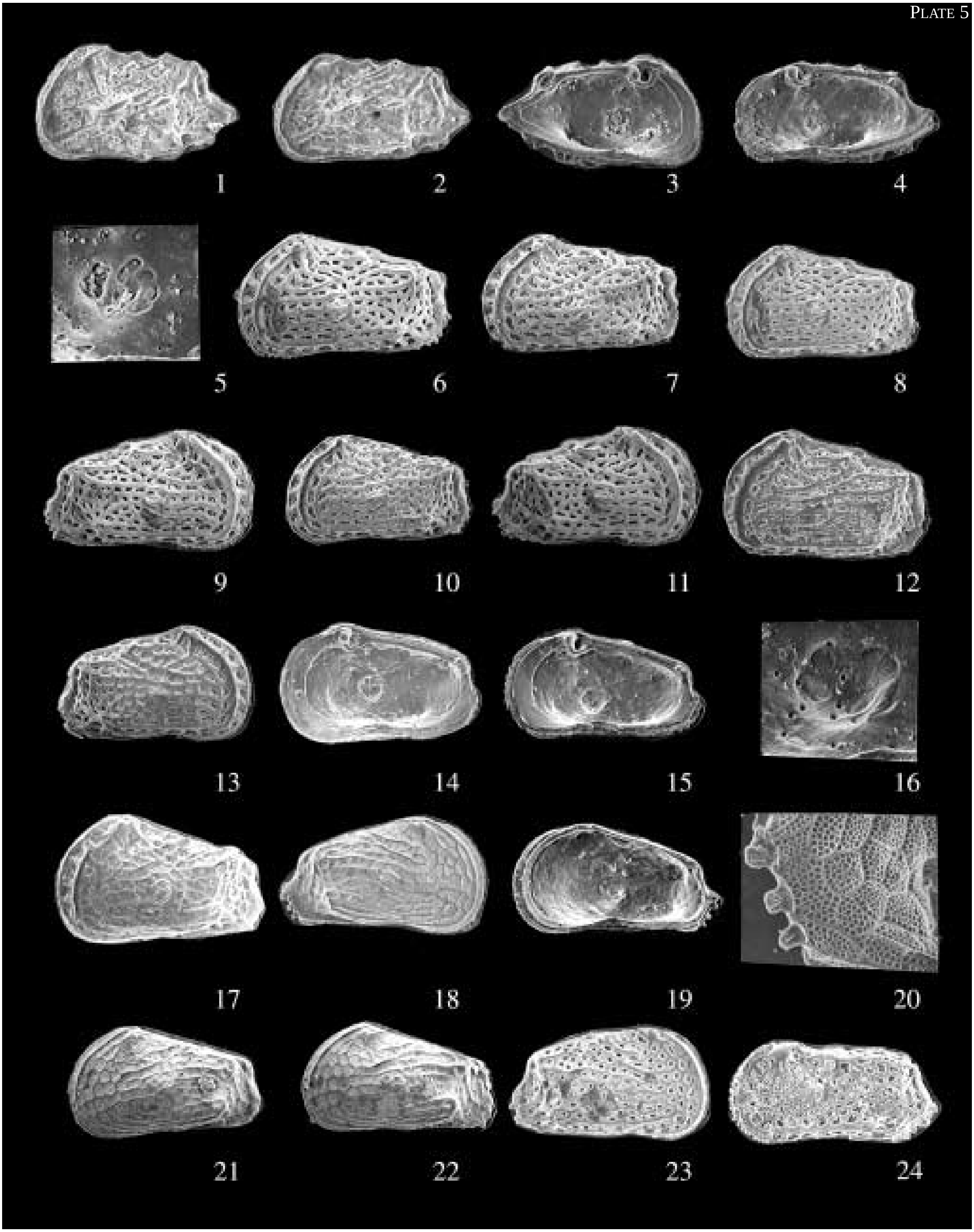
	Length	Height
RV PI 109	0.62	0.34

Remarks.–It is not certain that this specimen is fully adult, as its inner lamella is rather narrow and the amphidont hinge is rather feebly developed. However, it is too large to be the juvenile of any of the other species of the genus in this study. It differs markedly in shape and ornament from *Tenedocythere* sp. 1, although both are of a similar size. It is probably new as it resembles no taxon known to the authors.

→

PLATE 5–(All external lateral views unless otherwise stated). *1-5*, *Tenedocythere apios* sp. nov. *1,* paratype LV, PI 61, x 70. *2,* paratype female LV, PI 62, x 70. *3,* paratype male LV, PI 63, internal view, x 69. *4,* paratype female RV, PI 64, internal view, x 71. *5,* same specimen, detail of muscle scars, x 213. *6-17*, *Tenedocythere stasiotes* sp. nov. *6,* holotype male LV, PI 65, x 77. *7,* paratype female LV, PI 66, x 71. *8,* paratype female LV, PI 67, x 71. *9,* paratype male RV, PI 68, x 75. *10,* paratype female LV, PI 69, x 75. *11,* paratype male RV, PI 70, x 73. *12,* paratype female LV, PI 71, x 77. *13,* paratype female RV, PI 72, x 77. *14,* paratype female RV, PI 73, internal view, x 75. *15,* paratype male RV, PI 74, internal view, x 75. *16,* same specimen, detail of muscle scars, x 275. *17,* paratype A-1 juv. LV, PI 75, x 85. 18-22, *Tenedocythere* sp. 1. *18,* A-1 juv. RV, PI 77, x 70. *19,* same specimen, internal view, x 70. *20,* same specimen, detail of posterior ornament, x 475. *21,* A-1 juv. LV, PI 78, x 60. *22,* A-1 juv. LV, PI 79, x 58. *23,* *Tenedocythere* sp. 2. RV, PI 109, x 64. *24,* *Cletocythereis watsonae* Jellineck, 1993. Male LV, PI 110, x 69.

PLATE 5



Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Genus *Cletocythereis* Swain, 1963
Cletocythereis watsonae Jellineck, 1993
(Pl. 5; Fig. 24; Pl. 6, Fig. 1)

1988 *Cletocythereis rastromarginata* (Brady). Watson MS, p. 23, Pl. 44. Figs. 1-6.
1990 *Cletocythereis* sp. Tabuki & Nohara, Pl. 2, Fig. 5.
1992 *Cletocythereis rastromarginata* (Brady). Behrens, p. 50, Pl. 12, Figs. l-m.
1993 *Cletocythereis watsonae* Jellinek, p. 123, Pl. 18, Figs. 324-328.
1995 *Cletocythereis rastromarginata* (Brady). Whatley & Roberts, p. 362, Pl. 1, Fig. 26.

Material.–Two specimens.

Distribution.–In the present study, confined to sample 7, Henderson Island. The species is known from the coast of Kenya (Jellinek, 1993), the Java Sea (Watson, 1988), the Great Barrier Reef (Behrens, 1992) and the Ryukus Islands, Japan (Tabuki & Nohara, 1990). Whatley & Roberts (1995) misidentified the present material from the Pitcairn Group.

Dimensions.–

	Length	Height
Male LV PI 110	0.59	0.29
Female RV PI 111	0.52	0.27

Remarks.–In the present study, found only in intertidal sediments. The present material is similar in size to that from the Java Sea and the coast of Kenya. This species does not occur at Easter Island where Whatley *et al.* (2000) described the somewhat similar but much larger *Cletocythereis nautes* (L=0.70-0.75).

Family XESTOLEBERIDAE Sars, 1928
Genus *Xestoleberis* Sars, 1866
Xestoleberis entrichos Whatley, Jones & Wouters, 2000
(Pl. 6; Figs. 2, 3)

1999 *Xestoleberis* sp. 3. Whatley & Jones, Pl. 2, Figs. 18, 19.
2000 *Xestoleberis entrichos* sp. nov. Whatley, Jones & Wouters, p. 101, Pl. 7, Figs. 1-8.

Material.–Twenty-three specimens.

Distribution.–Samples 1B, 2, 3, 4, 5, and 6 from Henderson Island and sample 9 from Pitcairn Island.

Dimensions.–

	Length	Height
Female LV PI 142	0.39	0.21
Female LV PI 143	0.44	0.23

The size range as the type material from Easter Island was: Female length 0.45-0.47, height 0.22-0.25; male length 0.38-0.43; height 0.20-0.21.

Remarks.–This species was not encountered in their original survey of the Ostracoda of the Pitcairn group by Whatley & Roberts (1995). It is very abundant at Easter Island where 1540 specimens were recovered and where it occurred in virtually all the samples. In the present study it occurs in algal and sediment samples from both the eulittoral and the sublittoral.

Xestoleberis insulanos Whatley, Jones and Wouters, 2000
(Pl. 6; Figs. 4, 5)

1999 *Xestoleberis* sp. 4. Whatley & Jones, Pl. 2, Figs. 20, 21.
2000 *Xestoleberis insulanos* Whatley, Jones & Wouters, p. 102, Pl. 7, Figs. 9-11.

Material.–Five specimens, all juveniles.

Distribution.–In the present study, confined to sample 1A, Henderson Island.

Dimensions.–

	Length	Height
A-1 juv LV PI 121	0.33	0.18
A-1 juv LV PI 122	0.37	0.20

Remarks.–This species was previously thought to be confined to Easter Island, where it is a fairly common species. It was not encountered by Whatley & Roberts in their original study of the Pitcairn group. The present material is exclusively from the sublittoral at a depth of 120’ (36.5 m).

Xestoleberis kyrtonos Whatley, Jones and Wouters, 2000.
(Pl. 6; Figs. 6-11)

1999 *Xestoleberis* sp. Whatley & Jones, Pl. 2, Fig. 24.

2000 *Xestoleberis kyrtonos* Whatley, Jones & Wouters, p. 104, Pl. 7, Figs. 20-24.

Material.–Twenty-eight specimens.

Distribution.–Found only at Easter Island and in samples 3, 6, and 7 from Henderson Island and sample 9 from Pitcairn Island in the present study.

Dimensions.–

	Length	Height
C PI 128	0.40	0.22
C PI 129	0.43	0.22
C PI 130	0.40	0.23
RV PI 146	0.39	0.22
A-1 juv. C PI 144	0.32	0.17
A-1 juv. C PI 145	0.35	0.19

Remarks.–The present species differs in its shape and outline (which more closely resembles certain species of *Paradoxostoma*), from all other xestoleberids known to the authors. Recovered only from intertidal algae. The present material is within the size range of the type material from Easter Island.

*Xestoleberis macrocicatricos*a
Whatley & Roberts, 1995
(Pl. 6; Figs. 12-16)

1984 *Xestoleberis macrocicatricosa* Titterton MS, p. 506, Pl. 16, Figs. 16, 17; Pl. 58, Figs. 8-12.

1995 *Xestoleberis macrocicatricosa* Whatley & Roberts, p. 362, Fig. 1. 27.

Derivatio nominis.–L. Large scars. With reference to the abnormally large central muscle scars which occupy an unusually large area of the inner surface of the ostracod.

Holotype.–LV RV PI 133.

Type locality.–Sample 4, Henderson Island.

Material.–Eight specimens from the present study and 14 from the Solomon Islands.

Diagnosis.–A very small, rotund species of *Xestoleberis* with strongly arched dorsal margin, broadly rounded posterior, a rather beak-like anterior margin and proportionally abnormally large adductors and frontal scar.

Description.–Very small, thin-shelled, translucent. Sexually dimorphic with male conspicuously smaller than female. Subovate to subtriangular in lateral view; subovate in dorsal view. Anterior margin asymmetrically and narrowly rounded with subventral beak-like structure. Posterior margin bluntly and broadly rounded with extremity at mid-height. Dorsal margin convex with rounded cardinal angles. Ventral margin with shallow oral concavity with strong, sharp convexity antero-ventrally anterior of which in the RV is a concavity just behind the beak-like structure. LV>RV with overlap around entire margin. Valve surface smooth. Npc proportionally large, rather few, regularly distributed, simple externally but with internal sieve plate. Eye spot very small. *Xestoleberis* spot small and inconspicuous. Inner lamella of moderate width, inner margin and line of concrescence divergent except orally; anterior vestibulum triangular, posterior narrow and crescentic. Hinge hemimerodont, with some 6 oval teeth in each terminal element in RV. Central muscle scars and frontal scar proportionally very large, especially the dorsal adductor.

Distribution.–Occurring in samples 1B, 2 and 4 from Henderson Island and in sample 9 from Pitcairn Island. In the Solomon Islands, the species was encountered only from Guadalcanal, occurring in samples 1, 2, 13, 14, 16, 17, 19, 32 53, all from Honiara Bay in offshore sandy and biogenic sediments.

Dimensions.–

	Length	Height
Holotype RV PI 133	0.27	0.16
Paratype LV PI 131	0.24	0.18
Paratype LV PI 132	0.27	0.21
Paratype RV PI 134	0.28	0.18
Paratype RV PI 135	0.24	0.18
Paratype LV RT/SIR/731	0.28	0.21
Paratype RV T/SIR/732	0.28	0.20
Paratype RV RT/SIR/733	0.27	0.19
Paratype LV RT/SIR/734	0.28	0.21

The holotype and the first four paratypes are from Henderson Island and the last four paratypes are from the Titterton collection, also housed in the Department of Palaeontology, Natural History Museum, London, subsequent paratypes are from Henderson Island.

Remarks.–This species was originally described as *X. macrocicatricosa* in manuscript by Titterton (1984) in her unpublished doctoral dissertation on the Ostracoda of the Solomon Islands. It was inadvertently included under this name by Whatley & Roberts (1995) in their original survey of the Ostracoda of the Pitcairn group, although their intention had been to refer to the species under open nomenclature. To validate the species, it is herein formally described, using material from the present study and from the Solomon

Islands and types are erected. In the present study, the species was recovered both from intertidal algae and from subtidal sediments to depths of 120’ (36.5 m). *X. macrocicatricosa* differs from all other species of the genus known to the authors in its combination of very small size, subtriangular shape, anterior beak and abnormally large central muscle scars. The only other species with a somewhat similar beak is *X. arotron* Whatley *et al*. (2000) from Easter Island, but this differs from the present species in shape, its larger size and in lacking enlarged muscle scars.

Xestoleberis macrorrhinos sp. nov.
(Pl. 6; Figs. 17-21)

Derivatio nominis.–Gr. *μακρορρινος* long-nosed. With reference to the extended anterior margin of the LV of this species.

Holotype.–LV PI 123.

Type locality.–Sample 1B, 120’ (36.5 m) below the reef, North Beach, Henderson Island.

Material.–10 specimens.

Diagnosis.–A species of *Xestoleberis* characterised by its equally rounded end margins in the RV, and the extended anterior margin of the LV.

Description.–Very small. Subelliptical in lateral view. Anterior and posterior margins equally narrowly rounded in RV. In the LV, the posterior margin is similarly narrowly rounded, while the anterior margin is narrower, more extended and bluntly pointed with a subventral apex. Dorsal margin regularly convex about mid-height. Ventral margin convex in LV, biconvex about a shallow oral concavity in RV. LV strongly overlapping LV dorsally and anteriorly. Smooth. Internal features as for genus. *Xestoleberis* spot not strongly curved.

Distribution.–Samples 1B, 3 and 4, Henderson Island.

Dimensions.–

	Length	Height	Width
Holotype LV PI 123	0.36	0.19	
Paratype RV PI 124	0.35	0.19	
Paratype RV PI 125	0.34	0.18	
Paratype LV PI 126	0.35	0.18	
Paratype A-1 C PI 127	0.26		0.14

Remarks.–Whatley and Roberts (1995) did not encounter this species in their original study of the Pitcairn group. This species differs from all other species of the genus known to the authors in its very extended anterior margin.

Xestoleberis polys Whatley, Jones & Wouters, 2000
(Pl. 6; Figs. 22-27)

1995 *Xestoleberis* sp. 2. Whatley & Roberts, Fig. 29.
1999 *Xestoleberis* sp. 5. Whatley & Jones, Pl. 2, Figs. 22, 23.
2000 *Xestoleberis polys* sp. nov. Whatley, Jones & Wouters, p 104, Pl. 7, Figs. 12-19.

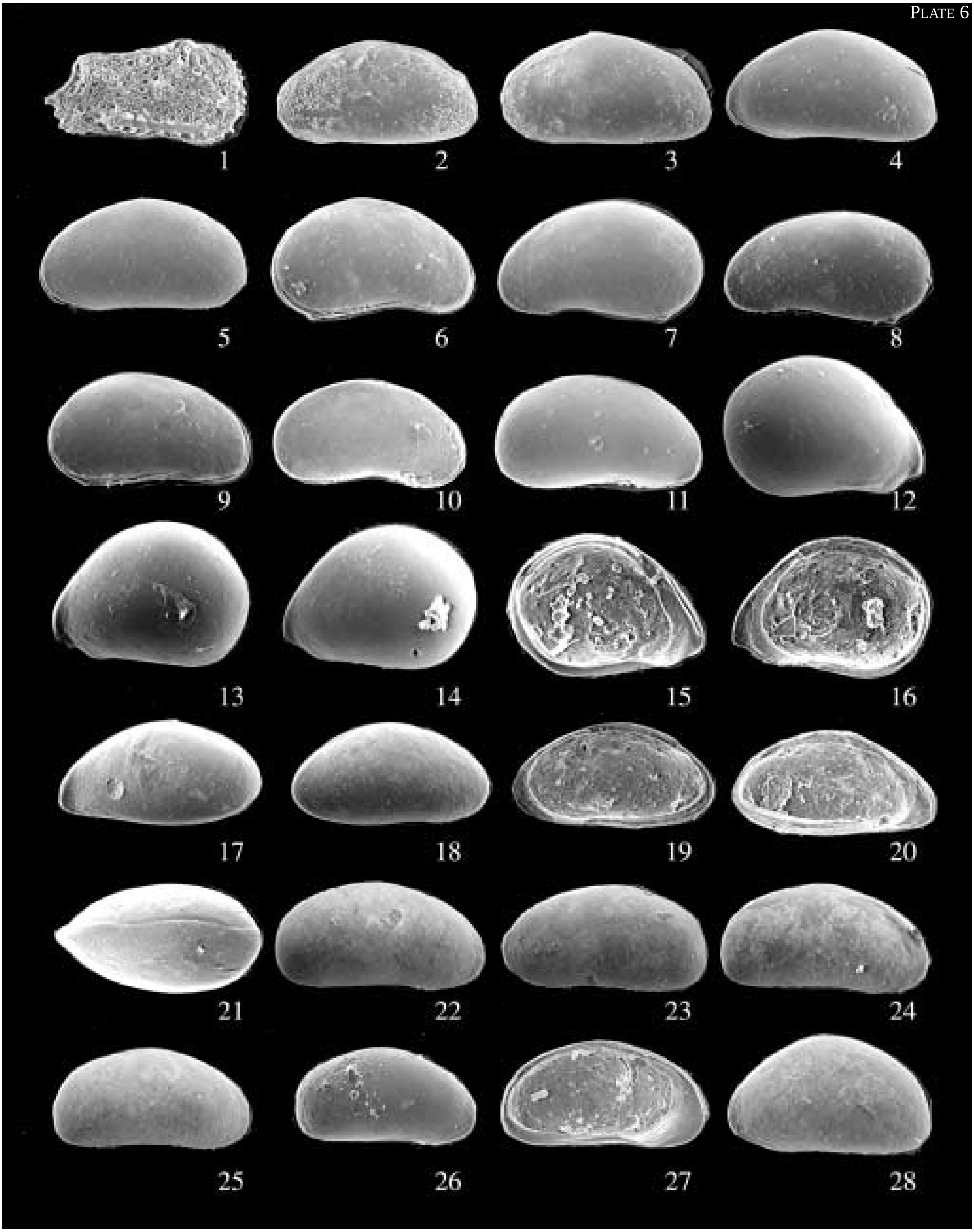
Material.–Twenty-three specimens.

Distribution.–Found only at Easter Island and in the present study where it occurred in samples 1B, 2, 3, 5 and 6, Henderson Island.

→

PLATE 6–(All external lateral views unless otherwise stated). *1, Cletocythereis watsonae* Jellineck, 1993. Female RV, PI 111, x 78. *2, 3. Xestoleberis entrichos* Whatley *et al.,* 2000. *2,* female LV, PI 142, x 100. *3,* female LV, PI 143, x 92. *4, 5. Xestoleberis insulanos* Whatley *et al*., 2000. *4,* A-1 juv. LV, PI 121, x 124. *5,* A-1 juv. LV, PI 12, x 109. *6-11, Xestoleberis kyrtonos* Whatley *et al*., 2000. *6,* C, PI 128, right lateral view, x 100. *7,* C, PI 129, left lateral view, x 94. *8,* C, PI 130, left lateral view, x 100. *9,* A-1 juv. C, PI 144, right lateral view, x 117. *10,* A-1 juv. C, PI 145, right lateral view, x 111. *11,* RV, PI 146, x 106. *12-16, Xestoleberis macrocicatricosa* sp. nov. *12,* holotype, RV PI 13, x 148. *13,* paratype LV, PI 131, x 144. *14,* paratype LV, PI 132, x 144. *15,* paratype LV, PI 134, internal view, x 56. *16,* paratype RV, PI 135, internal view, x 160. *17-21, Xestoleberis macrorrhinus* sp. nov. *17,* holotype LV, PI 123, x 110. *18,* paratype RV, PI 124, x 111. *19,* paratype RV, PI 125, internal view, x 115. *20,* paratype LV, internal view, PI 126, x 114. *21,* paratype A-1 juv. C, PI 127, dorsal view, x 156. *22-27, Xestoleberis polys* Whatley *et al*., 2000. *22,* male RV, PI 136, x 99. *23,* female LV, PI 137, x 107. *24,* female RV, PI 138, x 105. *25,* female RV, PI 139, x 100. *26,* female RV, PI 140, x 88. *27,* male LV, internal view PI 141, x 100. *28, Xestoleberis* sp. LV, PI 147, x 127.

PLATE 6



Dimensions.–

	Length	Height
Male RV PI 136	0.41	0.21
Female LV PI 137	0.38	0.20
Female RV PI 138	0.39	0.20
Female RV PI 139	0.38	0.20
Female RV PI 140	0.41	0.22
Male LV PI 141	0.38	0.19

Remarks.–In the present study, the species was recovered from the sublittoral and the eulittoral and from both sediment and algae. This species was not encountered by Whatley & Roberts (1995) in their initial survey of the Ostracoda of the Pitcairn group.

Xestoleberis sp.
(Pl. 6; Fig. 28)

Material.–One specimen.

Diagnosis.–A very small, strongly dorsally convex species of *Xestoleberis* with somewhat truncated posterior margin.

Distribution.–Sample 1B. Henderson Island, 120’ (36.5 m) below the reef, North Beach.

Dimensions.–

	Length	Height
LV PI 147	0.31	0.19

Remarks.–This species is most similar to *X. insulanos* Whatley *et al*. (2000) in shape and outline but differs in being much smaller and in its more umbonate dorsal margin. This species was not encountered by Whatley & Roberts (1995) in their original survey of the fauna of the islands.

CONCLUSIONS

The ostracod fauna of the Pitcairn Group is unusual in the context of tropical Pacific Island faunas in a number of ways. Firstly, with 43 species, it is of rather low diversity, since the normal diversity of islands to the north and west is between 50 and 60 species for similar sized areas. Also, although it a very remote group, it is the south-western extremity of a large complex of islands, the Tuamotu, Tahiti and Society Islands groups and one would expect it to share much more of its fauna with those islands. However, since 60.5% of the Pitcairn Group fauna is endemic, while 21% occurs only in the Pitcairn Group and in Easter Island, no less than 81% of the fauna does not occur in the islands to the Northwest. No doubt these statistics would change to some extent with more research in the Tuamotu, Tahiti and Society Islands, but notwithstanding this, the Pitcairn Group fauna is quite distinct in its composition from those known faunas to the NW. Easter Island is more remote, and given this, it is surprising that 21% of the Pitcairn Group fauna also occurs there. Whatley (2000) and Whatley & Jones (1999) concluded that the Easter Island ostracod fauna, made up of typically shallow water taxa, had arrived at the island mainly from the Pitcairn Group by a sweepstakes route, taking advantage of numerous emergent islands now submerged as seamounts (Bonatti *et al.*, 1977). This migration was only part of a much greater migration event that took place during the Neogene across the Pacific from West to East (Titterton & Whatley, 1988b). The problem of lack of communality with the island groups immediately to the NW can only be resolved by further research there.

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