



## *Acaciapollenites acaciae* sp. nov., a new mimosoid polyad species from the Neogene of Colorado Basin, Argentina

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**Abstract.** Fossil mimosoid polyads have been recently recovered from Neogene deposits in the Colorado Basin, Argentina, and the new species *Acaciapollenites acaciae* sp. nov. is described, which is closely similar to polyads of species included in *Acacia* Miller subgenus *Acacia* Vassal. It is characterized by colpi apertures on the distal face of the pollen grains, a typical polyad of the subgenus *Acacia* species. The new polyad species is very similar to those of the extant *Acacia curvifructa* Burkart. Comparing the habitat of subgenus *Acacia* extant species, the *Acaciapollenites acaciae* occurrence suggests drier and warmer paleoclimatic conditions than today for the Late Miocene-Early Pliocene in the Colorado Basin. Paleogeographic data of *Acacia* pollen diversity are discussed. A similar early diversification and distribution of *Acacia* genus is recognized for the new and old world.

**Resumen.** ACACIAPOLLENITES ACACIAE SP. NOV., UNA NUEVA POLÍADE DE MIMOSOIDEA DEL NEÓGENO, EN LA CUENCA DEL COLORADO, ARGENTINA. Políades afines a Mimosoideas fueron recuperadas de depósitos del Neógeno de la cuenca del Colorado, Argentina. Por sus detalles morfológicos es reconocida una nueva especie con afinidad botánica a las especies actuales del género *Acacia*, subgénero *Acacia*. *Acaciapollenites acaciae* sp. nov. se distingue por presentar aperturas colporadas sobre la superficie distal de sus granos de polen, políade típica de las especies del subgénero *Acacia*. La nueva especie de políade se compara con las de la especie actual *Acacia curvifructa*. Comparando el hábitat de las actuales especies del subgénero *Acacia*, la presencia de *Acaciapollenites acaciae* en el Neógeno de la cuenca del Colorado, sugiere condiciones paleoclimáticas más áridas y cálidas que las de hoy día. Se discuten los datos paleogeográficos de la diversidad de *Acacia*. Es reconocida tanto para el nuevo como para el viejo mundo, una temprana diversificación y dispersión del género.

**Key words.** *Acacia* polyads. Neogene. Colorado Basin. Argentina.

**Palabras clave.** Políades de *Acacia*. Neógeno. Cuenca del Colorado. Argentina.

### Introduction

Records of fossil pollen having affinity with Mimosoideae (Leguminosae) tetrads or polyads from Neogene sediments started with *Acacia* polyads from Tertiary Australian deposits (Cocks, 1954).

Currently, fossil records of mimosoid polyads representative of different genera are numerous (Sole de Porta, 1961; Graham and Jarzen, 1969; Miltenhall, 1972; Guinet and Salard-Cheboldaëff, 1975; Graham, 1977, 1988, 1991, 1992; Salard-Cheboldaëff, 1978; Anzótegui and Garralla, 1980; Crepet and Taylor, 1985; Guinet and Bessedik, 1984; Lima and Ama-

dor, 1985; Lima *et al.*, 1985; Caccavari and Anzótegui, 1987; Guinet *et al.*, 1987; Guinet and Ferguson, 1989; Barreda and Caccavari, 1992; Cavagnetto and Guinet, 1994; Graham and Dilcher, 1995; Caccavari and Barreda, 2000). Not only do these records demonstrate the diversification of Mimosoideae since the Oligocene, they also contributed to paleoenvironmental and paleobiogeographic interpretations.

Most pollen records from American tropical areas were originally related to the genus *Acacia* Miller. More detailed studies (Caccavari 1996) have, however, indicated botanical affinity with some other genera of recent Mimosoideae and this more recently established New World diversity is comparable to that of the Old World Eocene to Oligocene fossil records.

The present *Acaciapollenites acaciae* sp. nov. describes the distinctive pollen morphology of a new mimosoid pollen fossil species. *Acaciapollenites acaciae* sp. nov. is closely similar to the polyads of living species of *Acacia* Miller subgenus *Acacia* Vassal. Its presence in the Miocene-Pliocene boundary of

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Argentina also has paleoclimatic and paleogeographic significance.

The specimens studied were recovered from Neogene marine deposits in the Colorado Basin, Argentina (figure 1). The biostratigraphic control for these Neogene sediments is based mainly on highest occurrences or LADs (last appearance data) of selected dinoflagellate cysts, since the available material is derived from cutting samples (Guerstein and Junciel, 2001; Guerstein *et al.*, 2001; Guler *et al.*, 2001). Based on dinoflagellate cysts and sporomorph assemblages, Guerstein and Junciel, (2001) and Guler *et al.*, (2001) proposed a Late Miocene-Early Pliocene age for the 200-530 m interval. Palynological assemblages, bearing dominant and well-preserved continental palynomorphs, abundant chlorococcalean algal spores, but scarce dinoflagellate cysts, indicate that these deposits accumulated in shallow marine waters near the shoreline (Guler *et al.*, 2001). The pollen assemblages are dominated by angiosperms, mainly represented by Chenopodiaceae associated with Ephedraceae, Anacardiaceae, Asteraceae, Poaceae and Scrophulariaceae, possibly reflecting arid conditions.

## Material and methods

The fossil material was extracted from cutting samples taken from well Cx-1 of the Colorado Basin (figure 1). This is a rift basin formed in the Late Jurassic during the initial opening of the South Atlantic. It is located between 38°S and 41°S and lies primarily offshore. The 200-530 m stratigraphical interval, from which specimens have been recovered, corresponds to the uppermost part of the Barranca Final Formation, which consists of sand and glauconitic sandstone with shale and limestone horizons (Urien *et al.*, 1981).

The fossil specimens from sample n° P34405, are held in the Laboratory of Palynology collection, Universidad Nacional del Sur. The sample was treated according to the technique used by Guler *et al.*, (2001). Pollen reference material from extant species was acetolyzed (Erdtman 1960) and reference slides are held in the Actuopalynothea of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" and prefixed BApa (Buenos Aires, Palynología, Actual).

Microscope coordinates correspond to the Vernier Scale of the Nikon Eclipse 600. Photomicrographs were taken with a Nikon FDX-35 camera. England Finder references are provided for illustrated specimens.

The Glossaries of Punt *et al.* (1994) and Guinet (1990) were used for terminology.

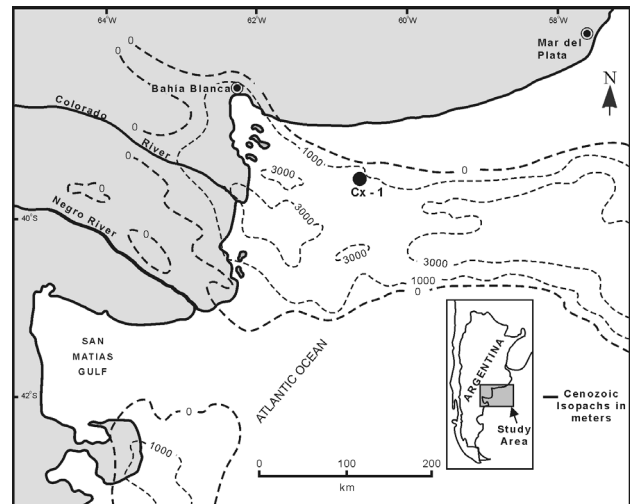


Figure 1. Location map / *mapa de ubicación*.

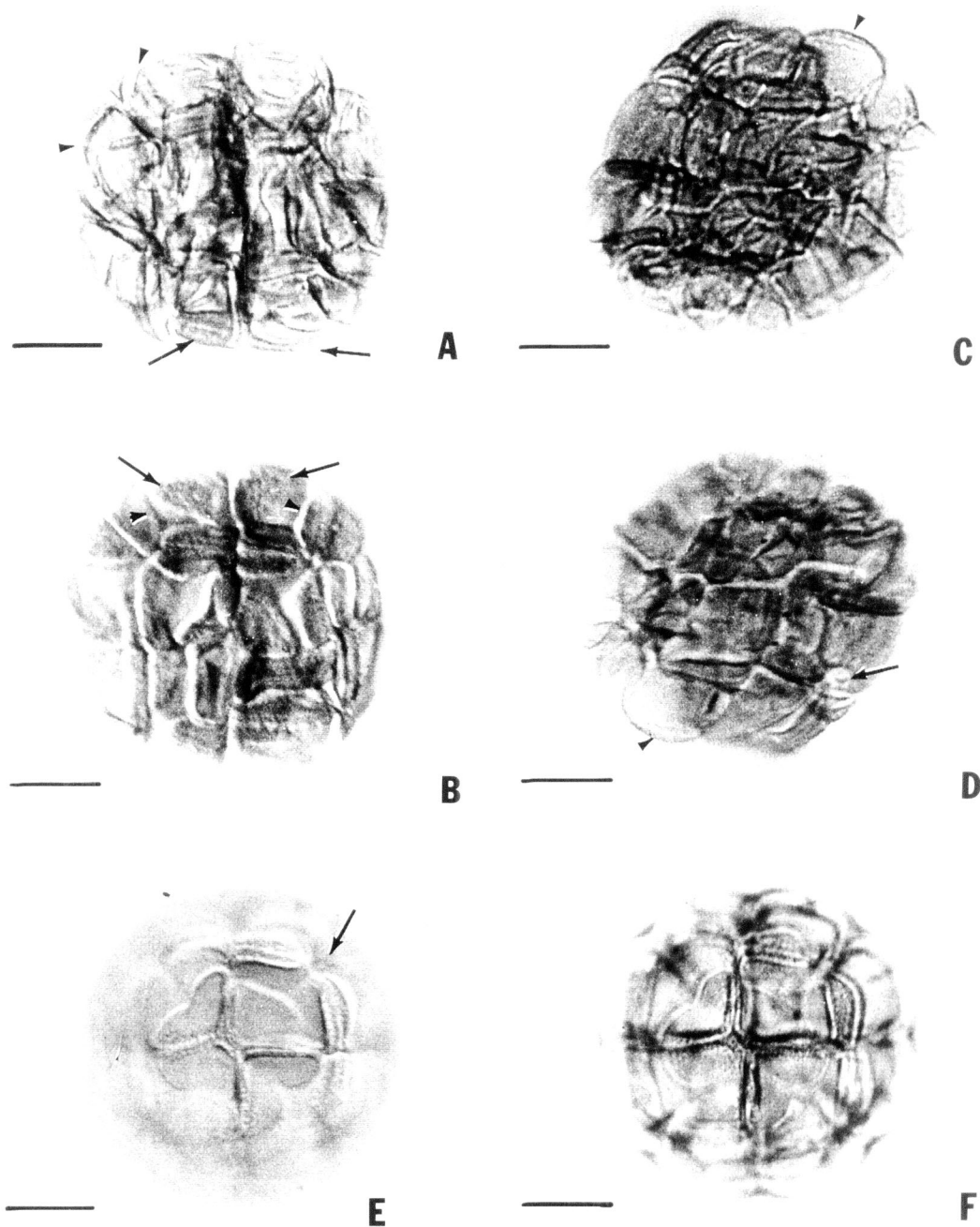
## Results

*Acaciapollenites acaciae* is comparable with the polyads morphology of extant species of *Acacia* subgenus *Acacia* described in Caccavari and Domé (2000), according to the group III of *Acacia* created and illustrated by Guinet (1964). It is characterized by having colporate apertures on the distal faces of the individual pollen grains and a tectate exine with collumellar infratectum (figures 2.A, C and E). The type species, *Acaciapollenites myriosporites* (Mildenhall, 1972), differs from *A. acaciae* in the following characteristics: presence of furrows or pseudocolpi forming a quadrangular syncolpy on distal face of the pollen grains and separately, subdistal pores with angular distribution (group II of *Acacia* polyad created by Guinet (1964); particularly present in many of the extant species of the subgenus *Phyllodineae* Pedley 1978 (Guinet, 1986). The differences between these fossil polyads species have been already marked and illustrated by Caccavari (1996). The morphological features discussed above support *Acaciapollenites acaciae* as a new species.

## Systematic palynology

Division MAGNOLIOPHYTA Cronquist,  
Takhtajan and Zimmerman 1966  
Clase MAGNOLIOPSIDA Cronquist,  
Takhtajan and Zimmerman 1966  
Order ROSALES Cronquist 1968  
Family LEGUMINOSAE Adanson 1763  
Subfamily MIMOSOIDEAE (R. Br.) De Candolle  
Tribe Acacieae Bentham 1842

Genus *Acaciapollenites* Mildenhall 1972



**Figure 2.** A-D, *Acaciapollenites acaciae* sp. nov. A, Holotype, general view in optical section. Note in the distal exine of the peripheral pollen grains, the infratectal columella (arrows) and the interrupted sexine corresponding to the optical section of colpi (arrowheads); slide coordinates P34405, EF: N 48/2 / holotipo, vista general en corte óptico. En la exina distal de los granos de polen periféricos, pueden observarse las columelas infratectales (flechas) y la sexina interrumpida (puntas de flecha), correspondiendo a la sección óptica de un colpo. B, Holotype, general view of polyad in surface focus with Normasky microscope system. Note colpi Y-shaped of the central grains, the colpi H-shaped (arrowheads) in peripheral grains and the irregularly perforate surface of the exine on the distal face of the pollen grains (arrows) / holotipo, vista general de la políade con foco en la superficie con sistema Normasky. Se observa la sincolpía en forma de Y en los granos centrales y en forma de H (puntas de flecha) en los granos periséricos de la políade y la superficie irregularmente perforada de la exina en la cara distal de los granos de polen (flecha). C, Paratype, general view; slide P34408, coordinates EF: Q52/4. Note the columellate exine (arrowhead) / paratipo, vista general. Nótese la exina columelada (punta de flecha). D, Paratype, general view with Normasky microscope system. Note a pore at the end of a colpulus (arrow) and the columellate exine (arrowhead) / paratipo, vista general en sistema Normasky. Se observa un poro al final de un colpo (flecha) y la exina columelada (punta de flecha). E-F, *Acacia curvifructa* Burkart BAPa 269. E, Focus on the distal face of the central grains and syncolpi Y-shaped. A pore (arrow) and the irregular exine surface is observed / foco sobre la cara distal de los granos centrales y la sincolpía en forma de Y. Se observa un poro (flecha) y la superficie irregular de la exina. F, General view of the polyad. Note the distal irregularly perforate exine and columella of the peripheral pollen grains and the interrupted sexine corresponding to the section of colpulus, / vista general de la políade. Se observa la exina distal de los granos de polen periféricos irregularmente perforada, las columelas y la interrupción de la sexina correspondiente a la sección de un colpo. Scale bar in all illustrations, 10  $\mu\text{m}$  / escala gráfica en todas las ilustraciones, 10  $\mu\text{m}$ .

1956. *Polyadites* van der Hammen p. 78 (nomen nudum).

**Type species.** *Acaciapollenites myriosporites* (Cookson 1954) Mildenhall 1972.

*Acaciapollenites acaciae* sp. nov.  
Figures 2.A-D

1985. *Polyadopollenites myriosporites* Cookson; Lima *et al.*, Brazil-Oligocene, pl. 5, fig. 22.

2001. *Acaciapollenites myriosporites* (Cookson) Mildenhall; Guler *et al.*, Argentina, Neogene (Miocene - Pliocene), pl. 2, fig. 13.

**Holotype.** Slide P 34405, 43.5/103, England Finder references N48/2.

**Repository.** Palynological Collection, Departamento de Geología, Laboratorio de Palinología, Universidad Nacional del Sur, Argentina.

**Type locality.** Cx-1 well (39° 11'S, 60° 11'W<sup>o</sup>), offshore Colorado Basin, Argentina.

**Type stratum.** 200 - 530 m depth, Barranca Final Formation, Patagonia, Neogene.

**Derivation of name.** From *Acacia* subgenus *Acacia*, the species, of which have polyads with a closely similar morphology.

**Diagnosis.** Biconvex polyads, circular in outline with 16 anisopolar pollen grains, 8 central and 8 peripheral, syncolporate on the distal face (Y-shaped syncolpy in central and H-shaped in peripheral pollen grains).

**Description.** Polyads with 16 pollen grains syncolporate on quadrangular distal face. Colpi Y-shaped on central and H-shaped on peripheral pollen grains. Ora faintly distinctive, 3 or 4 in number, close to the equatorial ends of colpi, in subdistal, not angular position. Distal exine with irregular surface, tectate, supramicrorreticulate, collumelate, 2 µm or thicker; sexine twice as thick as the nexine.

**Dimensions.** Maximum polyad diameter: 30-33 µm; Maximum diameter of central pollen grains: 12 µm; exine thickness: 1-2 µm (two specimens measured).

**Botanical affinity.** Leguminosae, subfamily Mimosoidae, genus *Acacia*, subgenus *Acacia*. The genus *Acacia* has a pantropical distribution, it is widely represented in America and in Africa where it is an important component of temperate to warm habitats with arid seasonality. Most species of the subgenus cannot resist successive frosts. Currently the north and central provinces of Argentina (32° S) are the southernmost geographical boundary of subgenus *Acacia*. The fossil polyads closely resemble those of modern *A. curvifruca* Burkart (figures 2.E-F), a characteristic constituent of the Paraguayan Chaco region (Burkart 1952). The new pollen species shares some similarities with un-named *Acacia* polyads from Puerto Rico, illustrated but not described by Graham and Jarzen (1969), but it is only about half the size of the Puerto Rican polyads.

## Discussion

*Acacia* is a cosmopolitan genus, with more than 1200 species, it is divided into three subgenera (Vassal, 1972), these subdivisions are supported by pollen characteristics (Guinet 1964, 1990, Caccavari and Domé 2000). The *Acacia* subgeneric differences in the pollen of *Acacia* species are valuable in fossil pollen identification and of significance in paleoenvironmental, paleobiogeographical, phylogenetic and systematic interpretations.

*Acacia myriosporites* from the Miocene of Patagonia (Argentina) was recognized as *Acacia* pollen type II (Guinet 1964) by Barreda and Caccavari (1992), whom have extended the paleogeographical distribution of these species to the southern Argentina and suggested a warmer temperate region than now a days. This polyads type, typical for the recent species of the genus *Phyllodineae* which have grains with false furrows in quadrangular parasyncolpy on distal face and the exine does not have infratectal columella.

Cavagnetto and Guinet (1994) have recognized two different pollen fossil species of *Acacia* for the Lower Oligocene of northern Spain (see table 1), which correspond to the subgenera *Aculeiferum* and *Phyllodineae*. These authors have considered the occurrence of these taxa as indicative of an abrupt drier climatic pulse and suggested their possible migration towards North America through the European continent.

Caccavari (1996) in her re-evaluation of paly-nomorphs assigned to the Mimosoideae, has pointed out an important systematic diversity for South America and proposed that the Subfamily Mimosoideae would have an early diversification in the New World, including the occurrence of two different *Acacia* type.

The identification of the new species *A. acaciae* extends the areal distribution of *Acacia* and support the hypothesis that a considerable diversity and dispersal have occurred since the Oligocene (table 1); this is corroborated by the fossil records of three polyad types, representative of the three extant subgenera: *Aculeiferum* (Cavagnetto and Guinet, 1994), *Phyllodineae* (Cookson, 1954; Mildenhall, 1972; Martin, 1978; Barreda and Caccavari, 1992; Cavagnetto and Guinet, 1994) and *Acaciae* (Graham and Jarzen, 1969; Lima *et al.*, 1985; the present contribution). This diversification since the Oligocene suggests an earlier origin of the genus.

The fossil pollen material from the Brazilian Oligocene (Lima *et al.*, 1985) here re-assigned to the new species, suggest an even earlier occurrence of *Acacia* subgenus *Acacia* during the Eocene of Tropical America, possibly contemporaneous with *Polyadopollenites vancampoi* Salard-Cheboldaeff (Salard-Cheboldaeff 1978) from Africa, especially since it shares

an affinity with *Acacia*, although Caccavari (1996) considers the likeness to *Acacia* doubtful.

The geographic distribution of *Acacia* subgenus *Acacia* during the Oligocene would be similar to the present distribution in Central America (Graham and Jarzen, 1969) to Brazil (Lima *et al.*, 1985), extending to the southernmost latitudes during the Miocene and suggesting warmer and more arid climates during this period.

The sparse occurrence of extant species of *A.* subgenus *Acacia* in Africa, Asia and Australia was suggested by Vassal and Guinet (1972) to indicate a probable dispersion from Tropical America prior to the breakup of Gondwana. Nevertheless, we agreed with Macphail and Hill (2001) that the data are still insufficient to suggest dispersal routes for *Acacia*.

The morphological distinction of fossil pollen *Acacia* subgenera is today more significant. This is in accordance with the phylogenetic analysis of the Mimosoideae based on chloroplast DNA sequence data made by Luckow *et al.* (2003), whom have indicated the no monophyly of *Acacia* genus and the necessary abandonment of Bentham tribal classification. *Acacia* subgenus *Acacia* has been also considered as *Acacia* s.s. monophyletic group and has been segregated from others *Acacia* s.l. subgenera: *Aculeiferum* and *Phyllodineae*, which present a paraphyletic or

monophyletic origin along with others Mimosoid genera. These conclusions would be supported by the present pollen data study.

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## References

- Anzotegui, L.M. and Garralla S.S. 1980. Estudio palinológico de la Formación Paraná (Mioceno superior) (Poza Josefina, provincia de Santa Fe, Argentina). *Facena* 6: 101-178.
- Barreda, V.D. and Caccavari, M.A. 1992. Mimosoideae (Leguminosae) occurrences in the Early Miocene of Patagonia (Argentina). *Palaeogeography, Palaeoclimatology and Palaeoecology* 94: 243-252.
- Burkart, A. 1952. *Las Leguminosas Argentinas silvestres y cultivadas*. In: Acme Agency, Buenos Aires 2<sup>a</sup> edición, 569 pp.
- Caccavari, M.A. 1996. Analysis of the South American fossil pollen record of Mimosoideae (Leguminosae). *Review of Palaeobotany and Palynology* 94: 123-135.
- Caccavari, M.A. and Anzotegui, L.M. 1987. Pollen de Mimosoideae (Leguminosae) de la Formación Ituzaingó, Plioceno su-

**Table 1.** World Cenozoic record (oldest citation) of fossil polyads of the *Acacia* subgenera / registro mundial para el Cenozoico (primeras citas) de los géneros de *Acacia*

Fossil taxa	Botanical affinity	Occurrence			Reference
		Continent	Country	Age	
<i>Acacia</i> sp.	Subgenus <i>Aculeiferum</i>	AFRICA		Eocene	Guinet and Ferguson, 1986
<i>Acacia</i> sp.		AMÉRICA	Panamá	Miocene	Graham, 1981
<i>Polyadopollenites pflugii</i> Cavagnetto et Guinet		EUROPE	Spain	Oligocene	Cavagnetto and Guinet, 1993
<i>Acaciapollenites acaciae</i> Caccavari et Guler	Subgenus <i>Acacia</i>	AMÉRICA	Argentina	Neogene	(this work)
<i>Polyadopollenites myriosporites</i> Cookson			Brazil	Oligocene	Lima <i>et al.</i> , 1985
<i>Acacia</i> sp.			Puerto Rico	Oligocene	Graham and Jarzen, 1969
<i>Acacia</i> sp.			Colombia	Oligocene	Guinet and Ferguson, 1986
<i>Acaciapollenites myriosporites</i> (Cookson) Mildenhall	Subgenus <i>Phyllodineae</i>	AUSTRALIA	Argentina	Miocene	Barreda and Caccavari, 1992
<i>Acaciapollenites miocenicus</i> Mildenhall et Pocknall			New Zealand	Miocene	Mildenhall and Pocknall, 1989
<i>Polyadopollenites myriosporites</i> Cookson				Oligocene	Cookson, 1953
<i>Polyadopollenites cooksonii</i> Cavagnetto et Guinet			EUROPE	Spain	Oligocene

- perior de Corrientes, Argentina. 4<sup>o</sup> Congreso Latinoamericano de Paleontología, Bolivia, *Actas* 1: 443-458.
- Caccavari, M.A. and Barreda, V.D. 2000. A new calymmate mimosoid polyad from the Miocene of Argentina. *Review of Palaeobotany and Palynology* 109: 197-203.
- Caccavari, M.A. and Domé, E.A. 2000. An account of morphological and structural characterization of American Mimosoideae pollen. Part I: Tribe Acacieae. *Palynology* 24: 231-248.
- Cavagnetto, C. and Guinet, Ph. 1994. Pollen fossile de Leguminosae-Mimosoideae dans l'Oligocene inferieur du bassin de l'Ebre (Espagne)- implications paleoclimatiques et paleogeographiques. *Review of Palaeobotany and Palynology* 81: 327-335.
- Cookson, I.C. 1954. The Cainozoic occurrence of *Acacia* in Australia. *Australian Journal of Botany* 2: 52-59.
- Crepet, W.L. and Taylor, D.W. 1985. The diversification of the Leguminosae: first fossil evidence of the Mimosoideae and Papilionoideae. *Science* 228: 1087-1089.
- Erdtman, G. 1960. The acetolysis method, a revised description. *Svensk Botanisk Tidskrift* 54: 561-564.
- Graham, A. 1977. Studies in neotropical paleobotany. II. The Miocene communities of Veracruz, Mexico. *Annals of the Missouri Botanical Garden* 63: 781-842.
- Graham, A. 1988. Studies in neotropical paleobotany. V. The lower Miocene communities of Panama- the Culebra Formation. *Annals of the Missouri Botanical Garden* 75: 1440-1466.
- Graham, A. 1991. Studies in neotropical paleobotany. IX. The Pliocene communities of Panama- Angiosperms (Dicots). *Annals of the Missouri Botanical Garden* 78: 201-223.
- Graham, A. 1992. The current status of the Legume fossil record in the Caribbean Region. In: Herendeen P.S., Dilcher D.L. (eds.) *Advances in Legume Systematics: Part 4. The Fossil Record*, Kew: 161-167 pp.
- Graham, A. and Dilcher, D. 1995. The Cenozoic record of tropical dry forest in northern Latin America and the southern United States. In: S.H. Bullock, H.A. Mooney, A. Medina (eds.), *Seasonally dry tropical forests* 6: 124-145.
- Graham, A. and Jarzen, D.M. 1969. Studies in neotropical paleobotany. I. The Oligocene communities of Puerto Rico. *Annals of the Missouri Botanical Garden* 56: 308-357.
- Guerstein, G.R. and Junciel, G.L. 2001. Quistes de dinoflagelados del Cenozoico de la Cuenca del Colorado, Argentina. *Ameghiniana* 38: 299-316.
- Guerstein, G.R., Williams, G.L. and Fensome, R.A. 2001. *Cannosphaeropsis quattrocchia*, a new species of dinoflagellate cyst from the mid cenozoic of the Colorado Basin, Argentina. *Micropaleontology* 47: 155-167.
- Guinet, Ph. 1964. Données nouvelles sur le rôle de la morphologie du pollen dans la classification du genre *Acacia*. *Compté Rendu de la Academie de Sciences de Paris* 258: 4823-4825
- Guinet, Ph. 1986. Geographic patterns of the main pollen characters in genus *Acacia* (Leguminosae), with particular reference to subgenus *Phyllodineae*. In: S. Blackmore, I.K. Ferguson (eds.), *Pollen and Spores, Form and Function. Linnean Society Symposium Series* 12: 297-311.
- Guinet, Ph. 1990. The genus *Acacia* (Leguminosae, Mimosoideae): its affinities as borne out by its pollen characters. *Plant Systematics and Evolution*, Suppl. 5: 81-90.
- Guinet, Ph. and Bessedik, M. 1984. Présence de genre *Prosopis* (Leguminosae-Mimosoideae) à l'Aquitainien Basal dans l'aude (Languedoc-France) *Pollen et Spores* 26: 101-108.
- Guinet, Ph. and Ferguson, I.K. 1989. Structure, evolution and biology of pollen in Leguminosae. In: C.H. Stirton, J.L. Zarucchi (eds.), *Advances in Legume Biology. Monographs in Systematic Botany from the Missouri Botanical Garden*, St. Louis 29: 77-103.
- Guinet, Ph. and Salard-Cheboldaeff, M. 1975. Grains de pollen du Tertiaire du Cameroun pouvant être rapportés aux Mimosacées. *Boissiera* 24: 21-28.
- Guinet, Ph., El Sabrouy, N., Soliman, H.A. and Omran, A.M., 1987. Étude des caracteres du pollen des Legumineuses-Mimosoideae des sediments Tertiaires du Nord-Ouest de l'Egypte. *Mémoires Travaux E.P.H.E.*, Institute de Montpellier 17: 159-171.
- Guler, M.V., Guerstein, G.R. and Quattrocchio, M. 2001. Palinología del Neógeno de la perforación Cx-1, Cuenca del Colorado, Argentina. *Revista Española de Micropaleontología* 33: 183-204.
- Lima, M.R. and Amador, E.S. 1985. Análise palinológica de sedimentos da Formação Resende. Terciário do Estado de Rio de Janeiro, Brasil. *VIII Congresso Brasileiro de Paleontologia* 1983. MME-DNPM. *Seção Paleontologia e Estratigrafia* 2: 371-378
- Lima, M.R., Salard-Cheboldaeff, M. and Suguio, K. 1985. Étude palynologique de la Formation Tremembé, Tertiaire du Bassin de Taubaté, (état de Sao Paulo, Bresil) d'après les échantillons du sondage N° 42 du CNP. *VIII Congresso Brasileiro de Paleontologia* 1983. MME-DNFM *Seção Paleontologia e Estratigrafia* 2: 379-393.
- Luckow, M., Miller, J.T., Murphy, D.J. and Livshultz, T. 2003. A phylogenetic analysis of the Mimosoideae (Leguminosae) based on chloroplast DNA sequence data. In: B.B. Klitgaard and A. Bruneau (eds.), *Advances in Legume Systematics*, part 10, Higher Level Systematics, *Royal Botanic Gardens*, Kew, pp. 197-220.
- Macphail, M.K. and Hill, R.S. 2001. Fossil record of *Acacia* in Australia: Eocene to Recent. In: A.E. Orchard (ed.), *Flora of Australia*. Vol. 11. Mimosaceae, *Acacia* part 1. *Australian Biological Resources Study*, Canberra, pp. 13-29.
- Martin, H.A. 1978. Evolution of the Australian flora and vegetation through the Tertiary: evidence from pollen. *Alcheringa* 2: 181-202.
- Mildenhall, D.C. 1972. Fossil Pollen of *Acacia* Type from New Zealand. *Journal of Botany* 10: 485-94.
- Pedley, L. 1978. Revision of *Acacia* Mill. in Queensland. part I. *Austrobaileya* 1: 75-234.
- Punt, W., Blackmore, S., Nilsson, S. and Le Thomas, A. 1994. *Glossary of Pollen and Spore Terminology*. LPP Contribution Series 1. LPP Foundation, Utrecht, 71 pp.
- Salard-Cheboldaeff, M. 1978. Sur la palynoflore Maestrichtienne et Tertiaire du bassin sédimentaire littoral du Cameroun. *Pollen et Spores* 20: 215-260.
- Sole de Porta, N. 1961. Contribución al estudio palinológico del Terciario de Colombia. *Boletín Geológico de la Universidad Industrial de Santander* 7: 55-81.
- Urien, C. M., Zambrano, J. J. and Martins, L. R. 1981. The basins of southeastern South America (southern Brazil, Uruguay and eastern Argentina) including the Malvinas Plateau and Southern South Atlantic paleogeographic evolution. In: W. Volkheimer, E.A. Musacchio (eds.), *Cuencas sedimentarias del Jurásico y Cretácico de América del Sur*; Comité Sudamericano del Jurásico y Cretácico 1: 45-125.
- Van Der Hammen, Th. 1956. Nomenclatura palinológica sistemática. *Boletín Geológico del Instituto Geológico Nacional de Colombia* 4: 23-62.
- Vassal, J. 1972. Apport des recherches ontogeniques et semi-ontologiques à l'étude morphologique, taxonomique et phylogénique du genre *Acacia*. *Bulletin de la Société. d'Histoire naturelle*. Toulouse 108: 125-247.
- Vassal, J. and Guinet, Ph. 1972. Une *Acacia* Americaine pétiole diaphylloidinisé *A. willardiana* Rose. *Adansonia* 12: 421-428.

**Recibido:**  
**Aceptado:**