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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 colporate apertures on the distal face of the pollen grains, a typical polyad of the subgenus *Acacia*. 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, DE 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 (Cookson, 1954).

Currently, fossil records of mimosoid polyads representative of different genera are numerous (Sole de Porta, 1961; Graham and Jarzen, 1969; Mildenhall, 1972; Guinet and Salard-Cheboldaeff, 1975; Graham, 1977, 1988, 1991, 1992; Salard-Cheboldaeff, 1978; Anzótegui and Garralla, 1980; Crepet and Taylor, 1985; Guinet and Bessedik, 1984; Lima and Amador, 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 work 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 Argentina also has paleoclimatic and paleogeographic significance.

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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 nº 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 Actuopalynotheca of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" and prefixed BApa (Buenos Aires, Palinología, 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.

Results

Acaciapollenites acaciae sp. nov. 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 collumelar infratectum (figures 2.A, C and E). The type species, *Acaciapollenites myriosporites* (Mildenhall, 1972), differs from *A. acaciae* sp. nov. 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 *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.

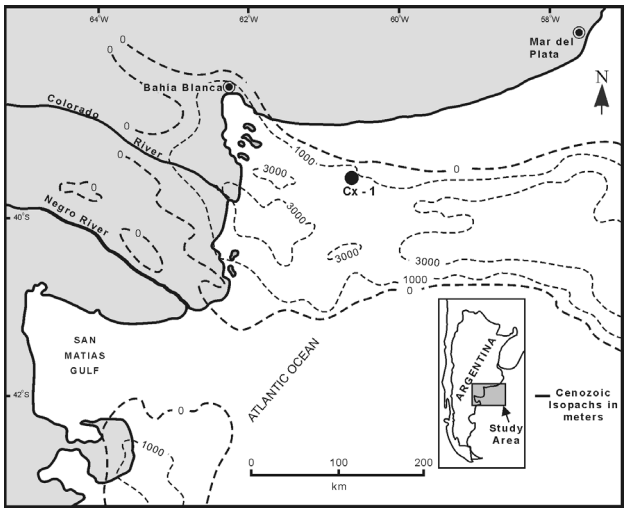

Figure 1. Location map / *mapa de ubicación.*

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 Candole
Tribe Acacieae Bentham 1842

Genus ***Acaciapollenites*** Mildenhall 1972

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

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

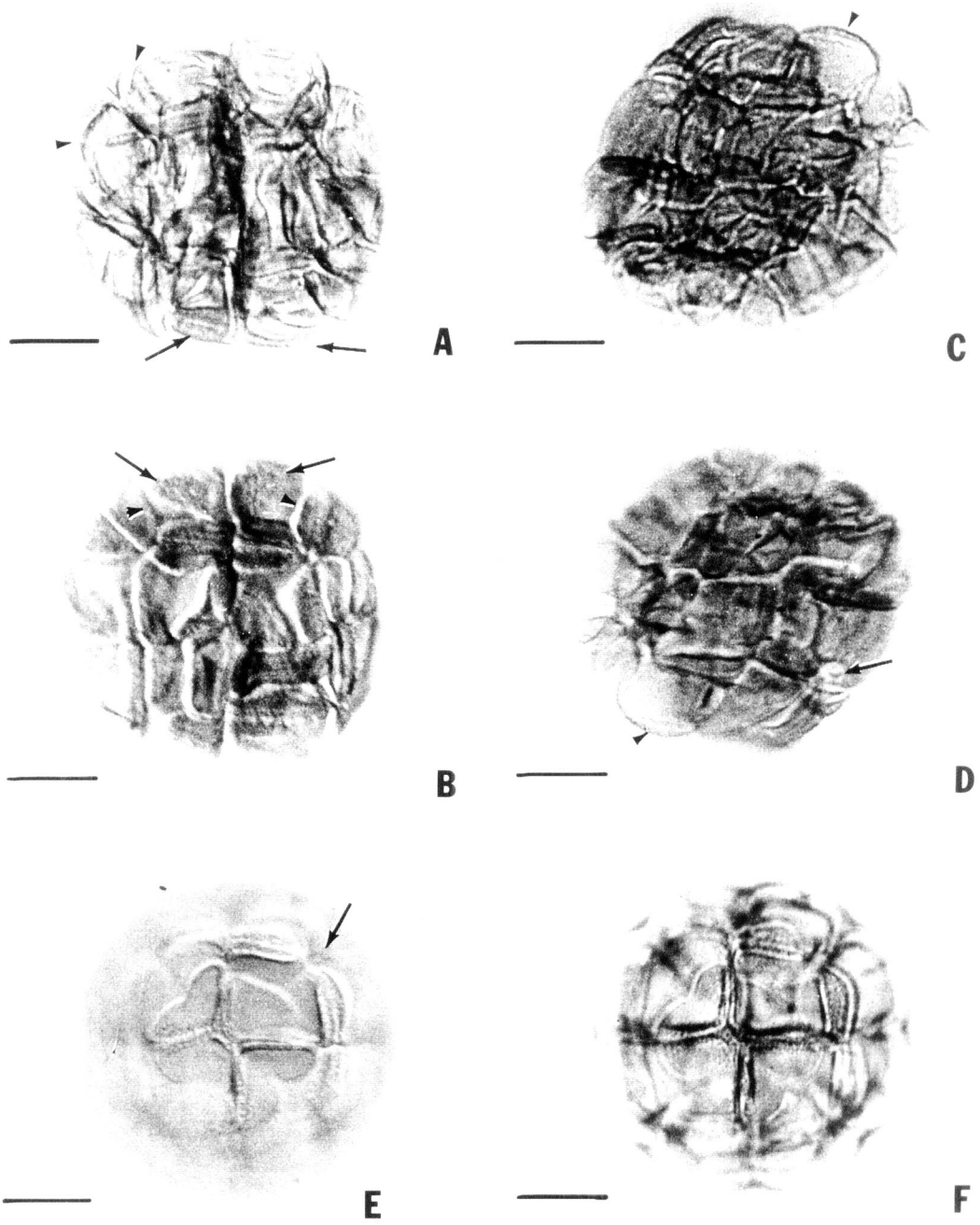

Figure 2. A-D, ***Acaciapollenites acaciae*** sp. nov. **A,** Holotype, general view in optical section. Note in the distal exine of the peripheral pollen grains, the infratectal columella (arrows) and the interrupted sexine corresponding to the optical section of colpi (arrowheads); slide coordinates 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 perispéricos 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 colpus (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 are 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 collumella of the peripheral pollen grains and the interrupted sexine corresponding to the section of colpus, / *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 µm / *escala gráfica en todas las ilustraciones, 10 µm.*

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 (39º11´ S, 60º11´ W), 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 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 (32º S) are the southernmost geographical boundary of subgenus *Acacia*. The fossil polyads closely resemble those of modern *A. curvifructa* 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 and 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), wich 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 palynomorphs 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 A. *acacia*e sp. nov. extends the areal distribution of *Acacia* and supports 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 *Acacia*e (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, suggests 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 paraphylletic or monophyletic origin along with others Mimosoid genera. These conclusions would be supported by the present pollen data study.

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

Fossil taxa	Botanical affinity	Occurrence			Reference
Acacia sp.	Subgenus *Aculeiferum*	AFRICA		Eocene	Guinet and Ferguson, 1989
Acacia sp.		AMÉRICA	Panamá	Miocene	Graham, 1991
Polyadopollenites pflugii Cavagneto *et* Guinet		EUROPE	Spain	Oligocene	Cavagnetto and Guinet, 1993
Acaciapollenites acaciae Caccavari *et* Guler	Subgenus *Acacia*	AMÉRICA	Argentina	Neogene	(this work)
Polyadopollenites myriosporites Cookson			Brazil	Oligocene	Lima *et al.*, 1985
Acacia sp.			Puerto Rico	Oligocene	Graham and Jarzen, 1969
Acacia sp.		AMÉRICA	Colombia	Oligocene	Guinet and Ferguson, 1989
Acaciapollenites myriosporites (Cookson) Mildenhall	Subgenus *Phillodineae*	AUSTRALIA	Argentina	Miocene	Barreda and Caccavari, 1992
Acaciapollenites miocenicus Mildenhall *et* Pocknall			New Zealand	Miocene	Mildenhall and Pocknall, 1989
Polyadopollenites myriosporites Cookson				Oligocene	Cookson, 1954
Polyadopollenites cooksonii Cavagnetto *et* Guinet		EUROPE	Spain	Oligocene	Cavagnetto and Guinet, 1994

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