FEATHER PALM FOLIAGE FROM THE MESSINIAN OF ITALY (CAPO DI FIUME, PALENA AND POLLENZO NEAR ALBA) WITHIN THE FRAMEWORK OF NORTHERN MEDITERRANEAN LATE MIOCENE FLORA

ARTICLE · JANUARY 2015

READS
36

7 AUTHORS, INCLUDING:

Vasilis Teodoridis
Charles University in Prague
49 PUBLICATIONS 351 CITATIONS

S. Agostini
Soprintendenza Archeologia dell'Abruzzo
33 PUBLICATIONS 83 CITATIONS

Edoardo Martinetto
Università degli Studi di Torino
76 PUBLICATIONS 577 CITATIONS

All in-text references underlined in blue are linked to publications on ResearchGate, letting you access and read them immediately.
FEATHER PALM FOLIAGE FROM THE MESSINIAN OF ITALY (CAPO DI FIUME, PALENA AND POLLENZO NEAR ALBA) WITHIN THE FRAMEWORK OF NORTHERN MEDITERRANEAN LATE MIOCENE FLORA

VASILIS TEODORIDIS
Department of Biology and Environmental Studies, Faculty of Education, Charles University in Prague, Magdalény Rettigové 4, 116 39 Prague 1, the Czech Republic; e-mail: vasilis.teodoridis@pedf.cuni.cz

ZLATKO KVAČEK
Institute of Geology and Palaeontology, Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, the Czech Republic; e-mail: kvacek@natur.cuni.cz

SILVANO AGOSTINI
Soprintendenza Archeologia dell’Abruzzo, Via degli Agostiniani 14, I-66100 Chieti, Italy; e-mail: silvano.agostini@beniculturali.it

EDOARDO MARTINETTO
Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, I-10123 Torino, Italy; e-mail: edoardo.martinetto@unito.it

MARIA ADELAIDE ROSSI
Soprintendenza Archeologia dell’Abruzzo, Via degli Agostiniani 14, I-66100 Chieti, Italy; e-mail: mariaadelaide.rossi@beniculturali.it

ORESTE CAVALLO
Museo Civico “Federico Eusebio”, Via Vittorio Emanuele 19, I-12051, Alba (CN), Italy; e-mail: museo@comune.alba.cn.it


Abstract. New records of plant macrofossils of palms and other groups are evaluated within the framework of the Messinian environment at the newly studied site of Capo di Fiume, Palena, central Italy. Similar palm foliage has been also recovered from the Messinian deposits of Pollenzo near Alba, northern Italy. The palm leaves were assigned to Phoenicites sp. based only on the leaf morphology. The floristic composition of the Palena plant assemblage shows a relatively high abundance of woody elements typical of a subhumid environment (Tetraclinis, Cupressus, Leguminosae), but also includes common mesic elements (Pinus, Magnolia, Ilex, Berberis, cf. Trigonobalanopsis, Paliurus, Myrica, Engelhardia), which are known from other Messinian floras of Italy, France and Greece. The affinities of several angiosperm macrofossils including enigmatic inflorescences resembling palms and Butomus, foliage of Dicotylphyllum sp. div. and disseminules of Carpolites sp. div. remain unresolved. The reconstructed vegetation type is interpreted as coastal non-swampy, wet soil (riparian) vegetation with a high abundance of woody elements growing under warm and semi-arid/sub-humid climatic conditions.

Introduction

Fossil palm foliage is relatively common in the Italian Eocene and Oligocene sites (e.g., Bonci et al. 2011, Giusberti et al. 2014), but quite rare in the late Neogene, as it is also elsewhere in Europe. Only a few records of foliage were described by Massalongo and Scarabelli (1859) /it is proved by accurate research e. g., G.B. Vai/ and Gaudin and Strozzi (1859) and Sordelli (1896) commented on its lack in some areas of the Italian Neogene. Recently two specimens of feather (“pinnate”) palm foliage were collected in NW and central Italy, namely at Pollenzo near Alba (Cavallo et al. 2008, Dela Pierre et al. 2011) and Capo di Fiume, Palena (Bertini and Martinetto 2008) respectively – see Text-fig. 1A. At the Pollenzo site, in addition to the palm leaf, only a single leaflet impression of Engelhardia LESCHENAULT ex BLUME was recovered. In contrast several other plant remains were collected at the Capo di Fiume site and require a short treatment in terms of floristic and vegetation reconstruction within the framework of the geological and palaeoecological information so far available for this site.

The fossil content from this Messinian succession consists of abundant leaves, branches, pine cones, fruits and seeds as well as animal remains, such as a nearly complete...
articulated skeleton of the ochotonid *Prolagus cf. apricenicus* MAZZA, 1987 (see Mazza et al. 1995), bird feathers, rare echinoids, decapod crustaceans, bivalves and numerous fishes. The well preserved fish fossil assemblage includes 22 different taxa from 14 families, of which the clupeid *Spratelloides gracilis* TEMMINCK et SCHLEGEL, 1846 is the

most abundant (e.g., Carnevale and Landini 2000, 2001, Carnevale 2011). The Italian Ministry of Cultural Heritage issued a special decree in 1998 aimed at preserving the Capo di Fiume site due to the extraordinary scientific interest.

Geological setting

The Capo di Fiume stratigraphic section is composed of paralic to open marine Messinian deposits that unconformably overlie a “terra rossa” soil formed during prolonged exposure to karst and illuvial processes (see Carboni et al. 1992, Miaceddi and Parotto 1998, Carnevale et al. 2011). The “terra rossa” consists of Fe and Mn hydroxide rich clay, with eolian quartz grains and layers of limestones and cherty pebbles. The “terra rossa” soil overlies uppermost Cretaceous carbonates characterized by medium-grained bioclastic limestones with a pseudo-crystalline texture deposited in an open shelf environment. The lithofacies exposed in the Capo di Fiume stratigraphic section can be described as containing 3 different parts as follows (see Text-fig. 1, Carnevale et al. 2011): (1) Mottled marls, clayey marls and lenticular beds of pebbly conglomerates (indicated as “a” in Text-fig. 1B), that represent a paralic deposit with hydromorphic features in a strongly reducing environment of fresh water marsh and tidal creeks. The fossil content consists of terrestrial pulmonate gastropods (zonitids) and plant remains including wood fragments and cavities created by root activity. (2) Fissile marls, shaly marls (indicated as “b-c” in Text-fig. 1B) characterized by thin lumachella layers of Dreissa BENEDEN, 1835; these are swamp deposits with salinity fluctuating from hypohaline to oligohaline conditions, containing hygrophilous land gastropods, ellobiids, lymneids, hydrobiids, vertiginids and brackish fossil assemblages of ostracods, potamidids and cerithioids belonging to the families Cerithiidae, Diastomidae and Litiopidae. The gastropods are indicative of stagnant freshwater ponds and of a humid densely vegetated land with a progressive increase in salinity. All the facies are referred to as estuarine bay (indicated as “b-c” in Text-fig. 1B). The above mentioned first three parts of the deposits (see Text-fig. 1B/a-c) correspond to coastal transitional marine facies which are related to the Lithotamnium Limestone Fm. The Lithotamnium Limestone Formation is always conformably overlain by hemipelagic deposits with Turborotalia multiloba ROMEO, 1965 whose first occurrence has been astronomically dated at 6.415 Ma (Hilgen and Krijgsman 1999, Sierro et al. 2001). (3) The sequence evolves upwards into open-marine shelf diatom-rich deposits, equivalent to the Messinian Tripoli Formation. They consist of diatom marls, bio-lithoclastic calcarenites, marly limestones and calcareous marls, and a massive muddy deposit produced by a mass-flow mechanism. The thickness of this interval is approximately 30 metres divided into six cycles (indicated as “d-e” in Text-fig. 1B). Each cycle is constituted of dark-grey calcareous marls and finely laminated diatomitic marls. The marls show a decrease in thickness throughout the interval, ranging from about 180 cm in the first cycle to 50 cm in the sixth. The fossil content consists in rare dreissenids, abundant bivalves (primarily Corbula gibba OLIVI, 1792, oysters, cardids, semelids, tellinids) and planktonic foraminifers. The diatomitic marls are constituted by clastic-biogenic couplets made up of siliceous laminar mats, felded diatom frustules, calcisiltite laminae, abundant siliceous sponge spicules and fish remains. The skeleton of the ochotonid Prolagus cf. apricenicus Mazza (see Mazza et al. 1995) occurred at this level, where several plant-bearing horizons have also been found.

Material and methods

The Capo di Fiume site is located in central Italy on the north-eastern slope of the Monte Porrara, along the Aventino River, a few kilometres to the south of the village of Palena (Chieti, Abruzzo, Italy). The Pollenzo site is located near Alba (Cavallo et al. 2008, Dela Pierre et al. 2011), in NW Italy, and its plant fossils were preliminarily introduced in a popular publication (Cavallo et al. 2008). This site yielded, in addition to the palm foliages, only a single leaflet impression assigned to Engelhardia orsbergensis (Wessel et Weber) Jahnichen, Mai et Walther (Bertini and Martinetto 2014).

The studied leaf fossils from the Capo di Fiume and Pollenzo near Alba sites are determined only on the basis of morphological features. Cuticle preparation was attempted on several leaves from the Capo di Fiume site (except the feather palm, which was evidently preserved as an impression), but was always unsuccessful.

The complete palaeontological collection including plants recovered from Capo di Fiume is housed in the “Museo Geopaleontologico Alto Aventino” of Palena (MGPAA), where most of the specimens form a part of the “Di Carlo collection”. The figured material from Pollenzo near Alba is housed in the collection of the Museo Civico F. Eusebio (ALB). A binocular magnifying glass was used for observation of details preserved in leaf material. Currently accepted morphological terminology for angiosperm foliage with the exception of palms follows Ellis et al. (2009). The current terminology for palm foliage is in accordance with the published palm monograph (Dransfield et al. 2008).

Systematic palaeontology

The systematic section follows the classification scheme published by the Angiosperm Phylogeny Group (2009) and authors Revel and Chase (2011).

Subclass Magnoliidae NOVÁK ex Takhtajan (angiosperms)
Superorder Lilianae Takhtajan (monocots)
Order Arecales Bromhead
Family Areaceae Berchtold et J. Presl (palms)

Genus Phoenicites BRONGNIART emend. Read et Hickey

Type: Phoenicites pumila BRONGNIART, 1828, p. 121, diagnosis generico-specifica.

Comments. The type of the fossil genus Phoenicites as emended by Read and Hickey (1972) is a fragmentary palm leaf from the Eocene of France (Chartreuse-de-Brivès, Haute-Loire, France), housed in the Muséum National d’Histoires Naturelles, Paris, No. F. 1934, collection Bertrand-Roux).
**Phoenicitites sp.**

Pl. 1, Fig. 1–4; Pl. 2, Fig. 1–2

2008 cf. Calamus sp.; Bertini and Martinetto, p. 110, pl. 1, fig. 9.

**Material.** An impression and its counterpart of an incomplete palm leaf (Capo di Fiume) and one incomplete palm leaf (Pollenzo near Alba).

**Description.** Leaves pinnately dissected (feather palm), simple. Midrib 179 and 297 mm long, straight, at least 3 and 5 mm wide, not tapering significantly over its last quarter. Segments often fragmentary, reduplicate on axial surface, decurrent, sessile, lanceolate to rarely oblong, up to 175 and 164 mm long, up to 12 mm wide, alternate to (sub)opposite in apical part of the blade, originating at an angle of 40° to 55°, irregularly spaced between 2 to 17 mm. Segment bases asymmetrical and cuneate, apices attenuate to 175 and 164 mm long, up to 12 mm wide, alternate to 1 to 17 mm. The associated flora of Capo di Fiume

We offer a preliminary review of the flora of Capo di Fiume, Palena, to accompany the above treatment of the Phoenicitites sp. specimen.

**Conifers**

**Pinaceae Lindley**

*Pinus Linnaeus* subgen. *Pinus Linnaeus*, is represented by the remains of an incomplete seed cone identified as *P. cf. hampeana* (Unger) Heer, ca. 50 mm long and 15 mm wide (Pl. 3, Fig. 3) with its external mould. The material is not well

**Phoenicitites sp.**

Pl. 1, Fig. 1–4; Pl. 2, Fig. 1–2

2008 cf. Calamus sp.; Bertini and Martinetto, p. 110, pl. 1, fig. 9.

**Material.** An impression and its counterpart of an incomplete palm leaf (Capo di Fiume) and one incomplete palm leaf (Pollenzo near Alba).

**Description.** Leaves pinnately dissected (feather palm), simple. Midrib 179 and 297 mm long, straight, at least 3 and 5 mm wide, not tapering significantly over its last quarter. Segments often fragmentary, reduplicate on axial surface, decurrent, sessile, lanceolate to rarely oblong, up to 175 and 164 mm long, up to 12 mm wide, alternate to (sub)opposite in apical part of the blade, originating at an angle of 40° to 55°, irregularly spaced between 2 to 17 mm. Segment bases asymmetrical and cuneate, apices attenuate to 175 and 164 mm long, up to 12 mm wide, alternate to 1 to 17 mm. The associated flora of Capo di Fiume

We offer a preliminary review of the flora of Capo di Fiume, Palena, to accompany the above treatment of the Phoenicitites sp. specimen.

**Conifers**

**Pinaceae Lindley**

*Pinus Linnaeus* subgen. *Pinus Linnaeus*, is represented by the remains of an incomplete seed cone identified as *P. cf. hampeana* (Unger) Heer, ca. 50 mm long and 15 mm wide (Pl. 3, Fig. 3) with its external mould. The material is not well
preserved, quite abraded and without details of the apophyses. It is similar to pine cones of this fossil species widely distributed in the Miocene (see Mai 1986), and also present in the upper Miocene of Greece (Vegora) and in the Pliocene of Italy. The associated needles in fascicles of two (Pl. 3, Fig. 4) are best assigned to a separate fossil-species, *Pinus hepis* (UNGER) HEER, even if possibly produced by the same plant. The foliage of another co-occurring pine species, assigned to *Pinus rigios* (UNGER) ETTINGSHAUSEN (Pl. 3, Fig. 5), differs in its much longer needles found in fascicles of three. This fossil species is also widely distributed in the European Miocene, mainly in the lignite facies.

**Cupressaceae Gray**

*Tetraclinis brachyodon* (BRONGNIART) MAI et WALTHER was recovered as an almost complete foliage shoot with flattened leafy segments (Pl. 3, Fig. 1). It is a xeromorphic species ancestral to the living Mediterranean *Tetraclinis* articulata (Vahl) Masters, which is a relict conifer that has survived since the Eocene (Kvaček et al. 2000). It was rarely recorded in late Miocene floras (Givulescu 1975).

*Cupressus rhenana* (KILPPER) MAI et E. VELITZELOS, (Pl. 3, Fig. 2) was recovered as foliage shoots with decussate, isomorphic scale-like leaves and apically attached pollen cones. This conifer is typically represented in the Miocene flora of Kymi and Vegora (Kvaček et al. 2002) in addition to a few other occurrences in Western Europe (Kilpper 1968, as *Cupressocodon rhenanus* KILPPER).

*Chamaecyparis* sp. is represented by foliage shoots with decussate, scale-like, imbricate, adpressed and persistent leaves (Pl. 3, Fig. 6).

**Angiosperms**

**Magnoliaceae Jussieu**

The morphotype assigned here to *Magnolia cf. liblarensis* (KRAUSEL et WETLAND) KVAČEK (Pl. 3, Fig. 7) is characterized by a simple elliptic entire-margined leaf with cuneate base and relatively dense brochidodromous venation. Its definite identification requires anatomical characteristics, including mesophyllous lens-shaped oil cells and other details of the cuticle structure which are not available in the examined specimen. *Trigonobalanops rharnoides* was well represented in the Neogene of Italy having been previously called *Castanopsis toscana* (BANDULSKA) KRAUSEL et WEYLAND (Kräusel and Weyland 1950, Fischer and Butzmann 2000).

**Rhamnaceae Jussieu**

A single leaf impression is attributable to *Paliurus tiliaefolius* (UNGER) BŮŽEK, although this ovate leaf with widely cuneate base and blunt apex differs in its entire margin from most records occurring in the European Miocene (see Bůžek 1971). The type population from the middle Miocene of Parschlug (Kovar-Eder et al. 2004) confirms the foliage variation of this plant. It is a mesophytic Miocene element contrary to the extant Mediterranean *Paliurus spin-christi* Miller that adapted as a relict to the present summer dry climate in southern Europe.

**Myricaceae Richard ex Kunth**

The morphotype assigned here to *Myrica cf. lignium* (UNGER) SAPORTA (Pl. 3, Fig. 11) represents a simple, petiolate elliptic leaf with entire margin and regular eucaptodromous secondaries. The genetic affinity is somewhat doubtful, not supported by epidermal traits characteristic of this species, namely biseriate stalks of glandular trichomes (Kovar 1982).

**Juglandaceae de Candolle ex Perleb**

A leaflet fragment is attributable to *Engelhardia orsbergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER on account of its finely serrate margin and sessile asymmetrical base. This extinct mesophytic element accompanies late Palaeogene and Neogene floras of Europe (Jänhichen et al. 1977) mostly comprised of thermophilous aspects (mastixioid assemblages). It is rare in the late Miocene and Pliocene deposits of Europe (e.g., Kvaček et al. 1995).

**Berberidaceae Jussieu**

*Berberis* sp. is a small simple sub-sessile and spatulate leaf with fine venation. In this aspect it is similar to the much larger foliage of *Berberis berberidifolia* (HEER) PALMAROV et PETKOVA known from the European Miocene (LI et al. 2010).

**Aquifoliaceae Berchtold et J. Presl**

An almost complete leaf with coarsely simple dentate margin is assigned to *Ilex* sp. and comparable with *Ilex geissertii* KVAČEK, TEODORIDIS et WANG (Kvaček et al. 2009) and morphologically similar fossil species known from the Pliocene of Europe.
Leguminosae Jussieu

Several morphotypes of legume leaflets were recognized here: Leguminosites sp. 1 (Pl. 3, Fig. 16, relatively large obovate leaflet, very shortly petiolulate, emarginate at apex and slightly cordate at base), Leguminosites sp. 2, (Pl. 3, Figs 17, 18, complete, shortly petiolulate oval leaflets), Leguminosites sp. 3 (Pl. 4, Fig. 1, complete, shortly petiolulate oval leaflet with asymmetric widely cuneate base and shortly attenuate apex), Leguminosites sp. 4, (Pl. 4, Fig. 2, complete, shortly petiolulate oval leaflet with cuneate base and blunt apex), and Leguminosites sp. 5 (Pl. 4, Figs 3, 4 incomplete, widely oval to obovate leaflets with brachidodromous venation). The exact affinities within the Leguminosae remain open.

Angiosperms incertae sedis

A monopodially branched inflorescence/infructescence (Pl. 4, Figs 5, 6) with densely, regularly disposed alternate sessile bodies on its branches, each supported by a small bract. At first sight it resembles a fragmentary palm inflorescence but the presence of bracts supporting each flower is an uncommon feature in palms. Another umbel-like inflorescence (Pl. 4, Figs 7–8) resembles Butomus Linnaeus. It differs from a similar “Butomus” heerii Ettingshausen (Kvaček and Teodoridis 2011, Eocene of North Bohemia) by flower-like terminations of the branches. In both cases the affinity to the Butomaceae Mirbel is improbable but can not be ruled out.

Some morphotypes of foliage assigned to Dicotylodendron saporta obviously belong to eudicots but their affinities can not be more exactly identified: Dicotylodendron sp. 1 (Pl. 4, Fig. 9, complete longly petiolate widely elliptic leaf with brachidodromous venation and entire margin resembling “Celastrus” persei Unger), Dicotylodendron sp. 2 (Pl. 4, Fig. 10, complete petiolate/petiolulate obovate leaf/leaflet with rounded apex, narrowed base and entire margin) and Dicotylodendron sp. 3 (Pl. 4, Fig. 11, complete long petiolate oblong entire-margined leaf, rounded at apex and cuneate at base).

Two disseminules were assigned to Carpolites sp. 1 (Pl. 4, Fig. 12, impression of a flattened oval seed) and Carpolites sp. 2 (Pl. 4, Fig. 13, an incomplete elliptic fruit with indistinct central axis and eight pairs of oval seeds oppositely attached).

The leaf assemblage from the locality Capo di Fiume, Palena is characterized by the absence of deciduous broad-leaved elements (e.g., Fagus Linnaeus, deciduous Quercus Linnaeus, Alnus Miller) as well as lauraceous elements (e.g., Laurophyllum Goepfert, Daphnogene Unger) and swampy conifers (e.g., Taxodium Richard, Glyptostrobus Endlicher and Sequoia Endlicher). It typically shows a predominant occurrence of sclerophyllous to mesophytic elements including conifers, such as Tetroclis brachyodon (Brongniart) Mai et Walther, Cupressus Linnaeus, Chamaeyparis Schischkin, Pinus sp. div., five morphotypes of Leguminosae sp. div., five morphotypes of Leguminosae sp. div., Ilex sp., cf. Berberis Linnaeus, Palisurus. A few other elements, such as Magnolia Linnaeus, cf. Trigonobalanopsis Kvaček et Walther, cf. Sapindas and Engelhardia as well as Dicotylodendron sp. div. can be interpreted as mesophytic elements. Myrica Linnaeus, Salix Linnaeus and Typha Linnaeus represent azonal wet soil (riparian) to swamp elements. Also one inflorescence and one infructescence of unknown angiosperms, respectively showing some morphological affinity to Butomaceae (Pl. 4, Figs 7–8) and to an unknown palm (Pl. 4, Figs 5–6). As we mentioned above, the floristic composition of Capo di Fiume shows a higher abundance of elements characteristic of sub-humid vegetation. However, it also includes common mesophytic elements which are also known from the other Messinian floras from Italy (Bertini and Martinetto 2008, 2011, Sami et al. 2014), France (Roiron 1991) and Greece (Kvaček et al. 2002).

Palaeoenvironmental signals

According to the composition of the associated flora and sedimentological signals it is possible to interpret the general vegetational character of the Capo di Fiume plant assemblage as coastal non-swampy, wet soil (riparian) vegetation with high abundance of woody elements growing under semi-arid to sub-humid climatic conditions. The closest palaeoecological affinity of the Capo di Fiume vegetation may be found in the early Miocene plant assemblage of Kymi (Evia, Greece) originally described by Unger (1867) and partly revised by Velitzelos et al. (2002, 2014).

Acknowledgements

Our special thanks go to Zdeňka Hroudová (Institute of Botany, the Czech Academy of Science) for her fruitful discussion on morphology of unspecified inflorescence/infructescence and to Edmondo Bonelli for the careful preparation of the Pollenzo palm which he discovered. Greatly appreciated were also the suggestions and comments made on the first version of the manuscript by Jakub Sakala and Guido Roghi. The study was financially supported by the Ministry of Education, Youth and Sports of the Czech Republic and Charles University in Prague (projects Nos J 13/98: 113100006, MSM 002162085 and PRVOUK P 15 and 44) and GAČR (project 14-23108S).

References


Bůžek, Č. (1977): Date-palm seeds from the Lower Miocene of Central Europe. – Věstník Ústředního ústavu geologického, 52: 159–168.


http://dx.doi.org/10.1002/fdr.19770880503


http://dx.doi.org/10.1007/BF03043465


http://dx.doi.org/10.1086/314245


http://dx.doi.org/10.1016/j.revpalbo.2009.04.011


http://dx.doi.org/10.1016/j.revpalbo.2010.01.001


http://dx.doi.org/10.1080/03036758.1993.10721227


http://dx.doi.org/10.2307/1219237


Explanations to the plates

PLATE 1

*Phoenicites* sp., Capo di Fiume, Palena, MGPAA, no. PalB7
1. Impression of incomplete pinnate leaf, scale bar 30 mm.
2. Counterpart of the leaf, scale bar 30 mm.
3. Detail of the pinnate venation with distinct midribs and almost indistinct parallel venation network, scale bar 10 mm.
4. Detail of the leaf basal part with thick rachis and decurrent, alternate attachment of reduplicate pinnate with asymmetric cuneate base and distinct midrib, scale bar 10 mm. Photo M. A. Rossi.

PLATE 2

*Phoenicites* sp., Polleno near Alba, ALB, no. P01110
1. Impression of incomplete pinnate leaf, scale bar 50 mm.
2. Detail of the leaf basal part with thick rachis and decurrent, alternate to subopposite attachment of reduplicate pinnate with asymmetric cuneate base, distinct midrib and parallel venation, scale bar 10 mm. Photo O. Cavallo.

PLATE 3

Associated flora of Capo di Fiume, Palena, MGPAA
1. *Tetraclinis brachyodon* (BRONGNIART) MAI et WALTHER, almost complete foliage shoots with flattened leafy segments, no. PalB30, scale bar 10 mm.
2. *Cupressus rhenana* (KILPPER) MAI et VELITZELOS, foliage shoots with decussate, scalelike leaves and apically attached pollen cones, no. PalB202, scale bar 10 mm.
5. *Pinus rigios* (UNGER) ETTINGSHAUSEN, incomplete needles in fascicles of three, no. PalB10, scale bar 10 mm.
6. *Chamaecyparis* sp., foliage shoots with decussate, scale-like, imbricate, adpressed and persistent leaves, no. PalB46, scale bar 10 mm.
10. *Paliurus tilaeofolius* (UNGER) BÚZEK, ovate leaf with widely cuneate base blunt apex and parallelodromous venation, no. PalB192, scale bar 10 mm.
12. *Engelhardia orbisergensis* (WESSEL et WEBER) JÄHNICHEN, MAI et WALTHER, incomplete ovate leaflet with coarsely serrate teeth, no. PalB134/c, scale bar 10 mm.
13. *Berberis* sp., small simple subsessile and spathulate leaf, no. PalB12/b, scale bar 5 mm.
14. *Ilex* sp., almost complete leaf with coarsely simple dentate margin, no. PalB181, scale bar 10 mm.
16. *Leguminosites* sp. 1, relatively big petiolulate obovate leaflet with emarginate apex and slightly cordate base, no. PalB2, scale bar 10 mm.
17. *Leguminosites* sp. 2, complete shortly petiolulate oval leaflet, no. PalB220, scale bar 3 mm.
18. *Leguminosites* sp. 2, complete petiolulate oval leaflet, no. PalB196, scale bar 3 mm.

PLATE 4

Associated flora of Capo di Fiume, Palena, MGPAA
1. *Leguminosites* sp. 3, complete shortly petiolulate oval leaflet with asymmetric widely cuneate base and shortly attenuate apex, no. PalB6, scale bar 10 mm.
2. *Leguminosites* sp. 4, complete shortly petiolulate oval leaflet with cuneate base and blunt apex, no. PalB152, scale bar 10 mm.
3. *Leguminosites* sp. 5, incomplete widely oval leaflet with brochidodromous venation, no. PalB136, scale bar 10 mm.
4. *Leguminosites* sp. 5, incomplete obovate leaflet with blunt apex, no. PalB200, scale bar 10 mm.
5. Unspecified inflorescence resembling palms, no. PalB4, scale bar 10 mm.
6. Detail of Fig. 5, scale bar 3 mm.
7. Umbel-like inflorescence, no. PalB3, scale bar 10 mm.
8. Detail of Fig. 7, scale bar 5 mm.
9. *Dicotylophyllum* sp. 1, complete, longly petiolate widely elliptic leaf with brochidodromous venation and entire margin resembling *Celastrus persei* UNGER, no. PalB32, scale bar 10 mm.
10. *Dicotylophyllum* sp. 2, complete, petiolate/petirolulate obovate leaf/leaflet with rounded apex, narrowed base and entire margin, no. PalB221, scale bar 5 mm.
11. *Dicotylophyllum* sp. 3, complete, longly petiolate oblong leaf with rounded apex, cuneate base and entire margin, no. PalB43, scale bar 10 mm.
12. *Carpolites* sp. 1, impression of flattened oval seed, no. PalB151, scale bar 5 mm.
13. *Carpolites* sp. 2, incomplete elliptic fruit with indistinct central axis with 8 pairs of oval seeds oppositely attached, no. PalB8, scale bar 10 mm.