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Palaeoecology of Coal-Bearing Eocene Sediments in Central Anatolia (Turkey) Based on Quantitative Palynological Data

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Abstract: In this study, the lignite-bearing Yoncalı formation between Yozgat and Sorgun, in central Anatolia has been palynologically examined. Based on 37 outcrop samples, quantitative palynological studies recognized 64 genera and 136 palynoflora species in the palynological assemblage, which indicated a Middle–?Late Eocene age. This paper also presents a quantitative palaeovegetation and palaeoclimate reconstruction for the Middle–?Upper Eocene coal occurrences of Central Anatolia on the basis of palynomorph assemblages. The diversified floral and ecological characteristics of the pollen taxa indicates that the Middle–?Upper Eocene formations in central Anatolia were characterized by the presence of a complex mangrove swamp with contributions by *Nypa, Pelliciera, Avicennia*, *Diporites iszkaszentgyörgyi* and dinoflagellate cysts which reflect warm climatic conditions. Behind the mangrove zone, pollen of Restionaceae, Ephedraceae, *Mauritia, Proxapertites* (Araceae) and *Longapertites* (Arecaceae) as well as the fern *Acrostichum aureum* occur. Lowland-riparian and montane elements are characterized by the dominance of Myricaceae, Symplocaceae, Icacinaceae, *Quercus*, *Pinus* and *Castanea*. Swamp-freshwater elements are represented by Sparganiaceae, Nymphaceae, Taxodiaceae, Cupressaceae and *Nyssa* as well as fern spores such as Osmundaceae and Gleicheniaceae.

The calculations were performed with the help of the 'Coexistence Approach' method to climatically evaluate palynoflora from the Yozgat–Sorgun area. The obtained results have been compared to data derived from the application of the Coexistence Approach to other, already published Central Anatolian palynofloras of the same age. The results of the climatic inferences suggest that the palaeoclimatic conditions were in the megathermal zone (mean annual temperature of 24.8–25 ºC), megatherm/mesotherm intermediate zone (mean annual temperature of 23.1–24.8 ºC near the coast) whereas mesothermic (mean annual temperature of 16.5–23.1 ºC) conditions prevailed in the montane region. Likewise, the results of mean annual range of temperatures indicate the influence of the Indian ocean, which enabled the development of the mangroves.

Key Words: Middle–Late Eocene, mangrove, palaeoenvironment, palaeoclimate, central Anatolia

Orta Anadolu'daki (Türkiye) Kömürlü Eosen Tortullarının, Sayısal Palinolojik Veriye Dayalı Paleoekolojisi

Özet: Bu çalışmada, Yozgat ve Sorgun alanı arasındaki (Orta Anadolu) linyit içerikli Yoncalı formasyonu palinolojik açıdan incelenmiştir. 37 adet yüzlek örneklerine dayalı olarak, sayısal palinolojik çalışmalar, palinolojik toplulukta tanımlanan 64 cins ve 136 türün varlığına işaret etmektedir. Yozgat-Sorgun alanındaki palinolojik topluluk Orta–?Geç Eosen yaşını belirtmektedir. Ayrıca bu makale, palinomorflara dayalı olarak, Orta Anadolu'nun, Orta–?Üst Eosen kömür oluşumları için, sayısal paleovejetasyon ve paleoikliminin de yeniden kurulmasını sunmaktadır. Polen taksalarının çeşitli floral ve ekolojik karakterleri, Orta Anadolu'daki Orta–?Üst Eosen formasyonları, sıcak iklimsel koşulları yansıtan, *Nypa, Pelliciera, Avicennia*, *Diporites iszkaszentgyörgyi* ve dinoflagellat kistlerin katkıları ile karmaşık bir mangrov bataklığının varlığı ile karakterize edilmektedir. Mangrov zonun gerisinde, Restionaceae, Ephedraceae, *Mauritia, Proxapertites* (Araceae) ve *Longapertites* (Arecaceae) polenleri ve ayrıca eğrelti sporu olan *Acrostichum aureum* mevcuttur. Alçakalan-ırmak kenarı ve dağ elemanları, Myricaceae, Symplocaceae, Icacinaceae, *Quercus*, *Pinus* ve *Castanea*'nın baskınlığı ile karakterize edilmektedir. Bataklık-tatlısu elemanları, Sparganiaceae, Nymphaceae, Taxodiaceae, Cupressaceae ve *Nyssa* polenleri, ayrıca Osmundaceae ve Gleicheniaceae gibi eğrelti sporları ile temsil edilmektedir.

Yozgat–Sorgun alanındaki palinoflorayı iklimsel olarak değerlendirmek için, sayısal hesaplamalar, 'Coexistence Approach' yönteminin yardımıyla gerçekleştirilmiştir. Elde edilen sonuçlar, 'Coexistence Approach' yönteminin önceden yayınlanmış olan Orta Anadolu'daki, aynı yaştaki palinofloralara uygulanmasından elde edilen verilerle karşılaştırılmıştır. İklimsel sonuçlar, paleoiklimsel koşulların megatermal zonda (yıllık ortalama sıcaklık 24.8–25 ºC), megatermal/mezotermal arazonda (yıllık ortalama sıcaklık 23.1–24.8 ºC, kıyı yakınında) ancak mezotermik koşulların (yıllık ortalama sıcaklık 16.5–23.1 ºC) dağ bölgesinde hakim olduğunu göstermektedir. Benzer şekilde, yıllık ortalama sıcaklıkların menzilleri, mangrov gelişimine olanak sağlayan, Hindistan Okyanus'unun etkisini belirtmektedir.

Anahtar Sözcükler: Orta–Geç Eosen, mangrov, paleoortam, paleoiklim, orta Anadolu

Introduction

Central Anatolia consists of several continental fragments, which formed during the Late Cretaceous–Early Tertiary by the closure of the Neotethys Ocean (Şengör & Yılmaz 1981). After the sea retreated during the Paleocene–Early Eocene, coal-bearing Eocene deposits, associated with submarine volcanic rocks, were laid down in central Anatolia. As a consequence, the Çankırı Basin in central Anatolia evolved during the Tertiary as a detrital basin situated between the Rhodope-Pontides and the Kırşehir Block (Erdoğan *et al*. 1996) (Figure 1a, b).

Although numerous geology and coal geology studies have been made in Central Anatolia (e.g., Barutoğlu 1953; Pekmezciler 1953; Ketin 1955; Özdemir & Pekmezciler 1983; Tüysüz 1993; Koçyiğit *et al*. 1995; Erdoğan *et al*. 1996; Poisson *et al*. 1996; Karayiğit *et al*. 1999), palynological studies of Cretaceous and Lower Tertiary formations in central Anatolia are still scarce (Nakoman 1966; Akyol 1980; Akgün 2002; Akgün *et al*. 2002).

A detailed palynological study was made by Nakoman (1966) in the Yozgat-Sorgun area, in the southern part of the Çankırı Basin. The author studied palynological aspects of fifty-three samples in thirteen boreholes, and suggested that the Sorgun lignites are Early Eocene in age according to the sporomorph association and benthic foraminifera.

Later, Akyol (1980) studied the palynology of coal-bearing Eocene sediments around the Emirşah and Karakaya districts in the Bayat (Çorum) region, and asserted that there was no land emergent during the Cretaceous and Paleocene. Characteristic normapolle pollen species of this period are therefore absent from the Bayat lignites. Akyol (1980) also suggested that the sporomorph content is very similar to the sporomorph content of Nakoman (1966) and brings forward the age of the Bayat lignites to Middle–Late Eocene.

Recently, two detailed palynological studies made by Akgün (2002) and Akgün *et al*. (2002) in both the northern part of the Çankırı Basin between Çorum and Amasya (Figure 1c) and in the Yozgat-Çiçekdağ area (near the Arabınköy mahallesi) in the southern part of the Çankırı Basin (Figure 1d).

The palynofloras studied from the Çorum-Amasya area were collected from the Çeltek and Armutlu formations which were deposited between the Sakarya Continent and Kırşehir Massif, and dated based on the pollen (Akgün 2002), foraminifera (Birgili *et al*. 1975) and mammals (Kaya 1995) as Middle–?Late Eocene.

The palynoflora from the Yoncalı formation (near the Arabınköy mahallesi) in the Yozgat-Çiçekdağ area was described by Akgün *et al*. (2002) who assigned a Middle–?Late Eocene age to it on the basis of palynomorphs and foraminifera.

Akgün (2002) and Akgün *et al*. (2002) obtained new palynological data suggesting the presence of mangrove elements. In the present study, new localities of coal-bearing sediments which were not previously palynologically examined were selected in order to check the distribution of mangrove elements in the Yozgat-Sorgun area (Figure 1b).

The main aim of this study is to discuss the age of the Yoncalı coals in the new localities and reconstruct the palaeovegetation and palaeoclimate at the time of peat accumulation by the combination of the data from the current study, Akgün (2002) and Akgün *et al*. (2002).

Stratigraphy

The tectonic development of the Çankırı Basin has been interpreted in two ways either as piggy-back or collisional by Koçyiğit *et al*. (1995) and Erdoğan *et al*. (1996), respectively (Figure 1a). The sedimentary fill between the Yozgat-Sorgun and Yozgat-Çiçekdağ areas (Figure 1b, d), located on the southern margin of the Çankırı Basin, unconformably overlies the Kırşehir Massif, named by Ketin (1955) (Figure 2). The Middle–?Upper Eocene Yoncalı formation dominantly consists of continental and shallow marine sediments containing basal conglomerate and fine-grained sediments at the base (Figure 2). These fine-grained sediments are overlain by flysch-like sediments including fossiliferous reef limestone lenses (Figure 2). The rich foraminifer assemblage indicated in Figure 2 yielded a Middle Eocene age (Erdoğan *et al*. 1996). Coal seams occur in the lowest part of the unit and are intercalated with sandstone and mudstone layers. The Yoncalı formation laterally and vertically interfingers with the red conglomerates, red sandstones and evaporate-bearing red shales of the İncik formation. The İncik formation was deposited as a dominantly continental facies but evaporate-bearing sedimentations show that deposition sometimes occurred in playa lakes. The subaqueous tuff horizons, which were termed the

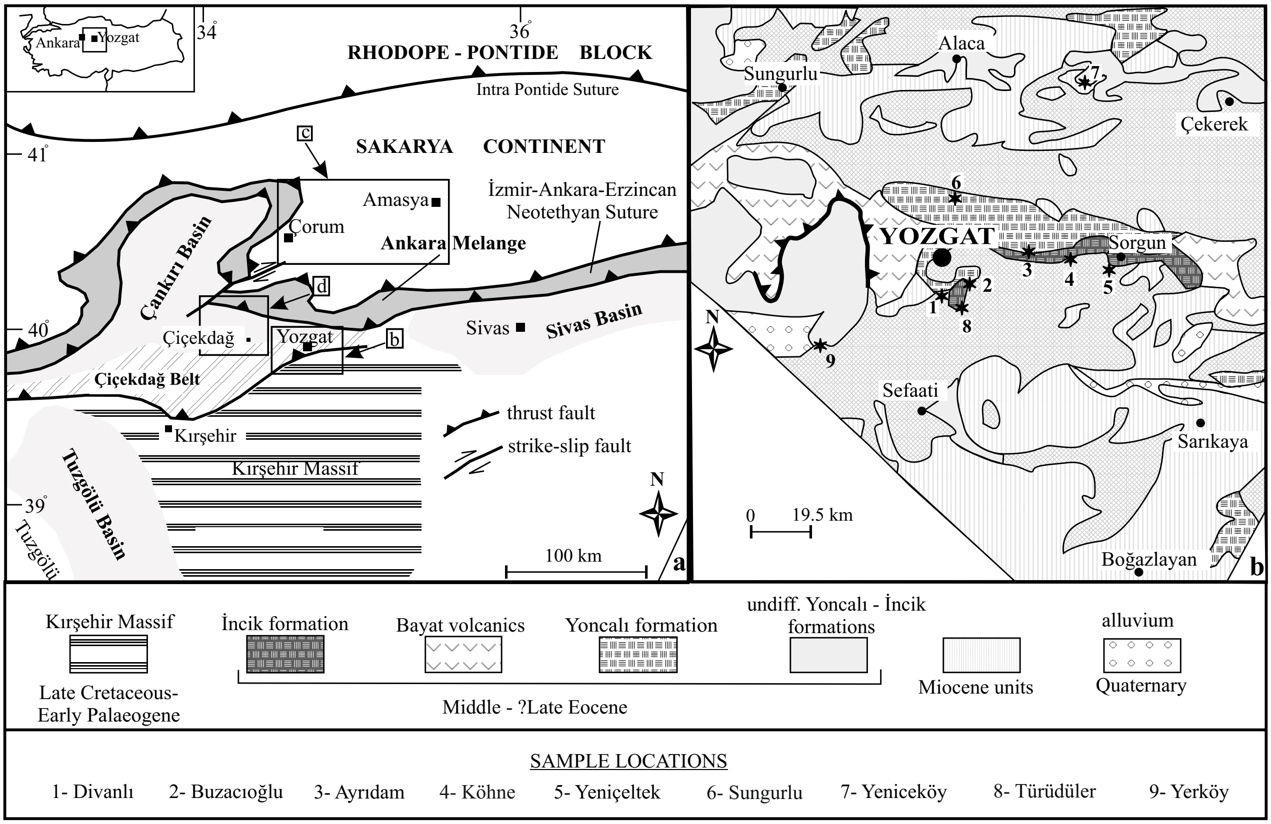

Figure 1. (a) Main tectonic belts of Central Anatolia and the locations of the sedimentary basins developed along the collision zone between these belts (simplified after Tüysüz 1993). (b) The geological map showing the sample locations surrounding the Yozgat–Sorgun area (modified from Tüysüz 1993; Akgün *et al.* 2002). Rectangles in (a) marked by 'c' shows location of Çorum–Amasya area, and 'd', Yozgat–Yerköy area.

Bayat volcanics by Erdoğan *et al.* (1996), interfinger both the Yoncalı and İncik formations (Figure 2). Continental sequences of the Middle Miocene units unconformably overlie the older units (Erdoğan *et al.* 1996; Akgün *et al.* 2002; Kayseri & Akgün 2003).

Material and Methods

In this study, thirty-seven clay, carbonaceous clay and lignite samples were collected from the Yoncalı formation at nine localities in the Yozgat–Sorgun area (Figure 1b). For the recovery of microfossils, the samples were subjected to standard maceration techniques. The final organic residue was screened through an 8 μm mesh screen and 2 and 4 slides per sample of the >8 μm fraction were prepared for transmitted light microscopy. Pollen counts were carried out at 400 X using a microscope. An attempt was made to count at around 200 grains per sample (Appendix 1). All species recorded in this study are illustrated in Plates I–VI. To reconstruct the palaeovegetation of the Çankırı Basin while these coals were being deposited, statistical analysis was done using the MVSP (version 3.1). The unweighted pair-groups method (UPGMA) and Centroid clustering have been used by Kovach (1988, 1989). The similarity indexes used are Pearson Coefficient, Modified Morista and Sørensen's Coefficient. All palynological samples and palaeovegetational types were applied to the Correspondence analysis.

The palynofloras obtained from the Yozgat-Sorgun, Yozgat-Çiçekdağ and Çorum-Amasya areas have also been analyzed quantitatively using the 'Coexistence Approach' method proposed by Mosbrugger & Utescher (1997) for quantitative climatic analysis. This technique is based on the nearest living relative philosophy, i.e. the assumption that climatic requirements of Tertiary plant taxa are similar to those of their nearest living relatives (NLRs). The aim of the Coexistence Approach is to find

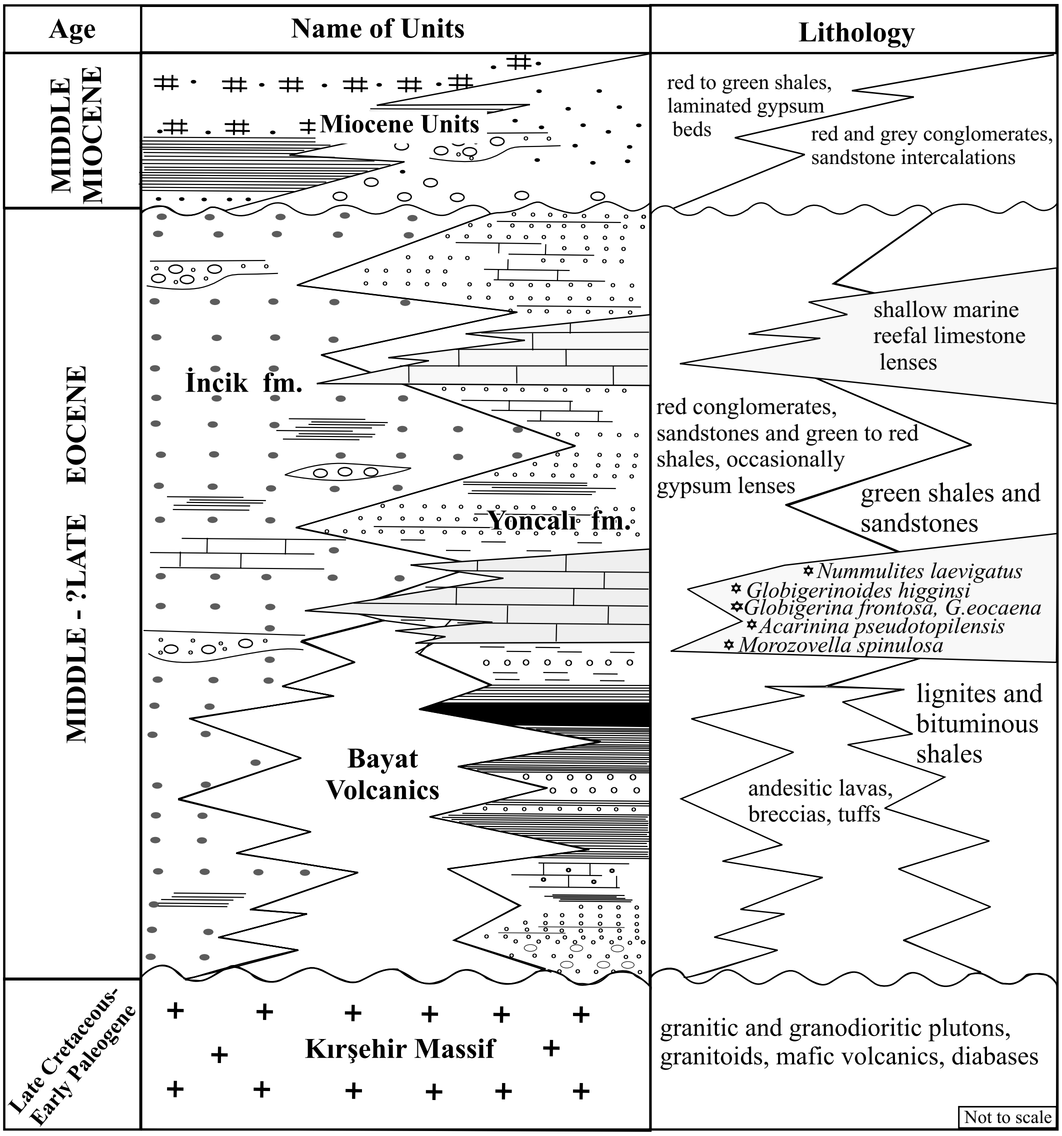

Figure 2. Generalized stratigraphic column of the Çankırı Basin (modified from Erdoğan *et al.* 1996).

the intervals of various climate parameters for a given fossil flora in which maximal number of NLRs of this flora can coexist; these coexistence intervals are taken into account as the best description of the palaeoclimatic situation under which flora had lived. The application of the Coexistence Approach is facilitated by the computer program CLIMSTAT and database palaeoflora that contains NLRs of than 3000 Tertiary plant taxa (see web site www.palaeoflora.de). On the other hand, as indicated by Ivanov *et al.* (2002), the Coexistence Approach involves a number of uncertainties as sources of error: (1) description of fossil taxa may be incorrect; (2) allocation of a nearest living relative to a fossil taxon may be incorrect; (3) the climatic endurance of a nearest living relative may differ from the climatic tolerance of the corresponding fossil taxon. Sometimes, the application of the Coexistence Approach to a fossil flora can also lead to two distinct coexistence intervals (Ivanov *et al.* 2002). This may follow from one or several factors mentioned above, or it may be caused by a mixture of different floras standing for different climate situations.

In this study the Coexistence Approach has been applied to the palynofloras of the Çeltek and Armutlu formations the Yozgat-Sorgun, Yozgat-Çiçekdağ and Çorum-Amasya areas studied by Akgün (2002) and Akgün *et al.* (2002). Consequently, we took the following climatic parameters into account: (i) MAT: mean annual temperature (ºC), (ii) CMT: mean temperature of the coldest month (ºC), (iii) WMT: mean temperature of the warmest month (ºC), (iv) MART: mean annual range of temperature (ºC), and (v) MAP: mean annual precipitation (mm).

To observe the palynofloral variations based on the palaeoclimate, thermal attributions of the pollen and spore grains have also been graded after the classification by Van Steenis (1962) (Appendices 1 and 2).

Palynological Assemblage and Age

In this section, the age of the palynological assemblage of the Yoncalı lignites obtained from the localities indicated in Figure 1b between Yozgat and Sorgun are discussed and correlated with previous studies done by Akgün *et al.* (2002) and Akgün (2002). Counting results of productive samples and also locations are indicated in Appendix 1. Following palynological studies in different localities of central Anatolia (Nakoman 1966; Akyol 1980; Akgün 2002; Akgün *et al.* 2002), a rich species diversification has been obtained in this study.

Nine of the thirty-seven samples investigated for palynological analysis include fairly well-preserved spores, gymnosperm and angiosperm pollen grains (Appendix 1). A rich flora, characterized by 136 taxa, has been recorded (Appendix 1). Quantitative analysis of the Yoncalı palynological assemblage shows that angiosperms (77%) are more abundant than spores (12%) and gymnosperms (11%). Counting results depict that abundant species are not stratigraphically important for palynological assemblage definition. In contrast, some other species have biostratigraphic importance according to the published studies on Tertiary palynomorphs. The stratigraphic ranges of these species are given in Table 1.

The characteristic Normapolles such as *Interpollis, Basopollis* and *Urkutipollenites* are poorly represented in the Early Eocene and totally absent in the Middle Eocene at Hungarian localities (Kedves 1986). Normapolles were not recorded by Nakoman (1966) in Sorgun lignites, by Akyol (1980) in Bayat (Çorum) and by Akgün *et al.* (2002) in the Yoncalı formation in the Yozgat-Çiçekdağ area. Riegel *et al.* (1999) stated that the diversity of the Normapolles is higher in the Early Eocene than the Middle Eocene, and the Normapolle pollen *Interpollis* group was observed as single grains in sample 99/108 (Appendix 1).

The species *Triatriopollenites excelsus*, *Caryapollenites circulus*, *Compositoipollenites minimus*, *Triporopollenites constatus*, *Plicatopollis lunatus*, *Anacolosidites* group, *Diporites iszkaszentgyörgyi* and *Monocolpopollenites crassiexinus* are restricted to the Paleocene and Eocene sediments of Europe and Turkey (Table 1). The presence of *Polypodiaceoisporites lusaticus, Echinatisporis longechinus* and *Leiotriletes maxoides* ssp. *maximus* indicates that the Yoncalı lignites cannot be older than Middle Eocene, as the species *Triporopollenites spackmanii*, *Pentapollenites punctoides, Concavisporites arugulatus* and *Celtipollenites laevigatus* are restricted to the Middle Eocene (Table 1).

In addition to the taxa mentioned above, typical mangrove elements such as: *Spinizonocolpites* group (*Nypa*), *Avicennia alba*-type (Verbenaceae), *Psilatricolporites crassus* (*Pelliciera*) and *Diporites iszkaszentgyörgyi*, which has unknown botanical affinity, were first recorded in this study. The species *Milfordia hungarica* (Restionaceae), *Kopekipollenites transdanubicus* (Monocotyledonopsida), *Mauritiidites franciscoi* (*Mauritia*) and *Diporites iszkaszentgyorgyi* have never been reported before as fossil pollen in the Eocene sediments of central Anatolia. The species *Psilatricolporites crassus* and *Spinizonocolpites echinatus* are abundant in the Middle Eocene of the Venezuelan Maracaibo basin (Rull 1998a, 1999), compared with the Early Eocene and this is consistent with this study. Most European *Nypa* pollen appearances are in the Ypresian–Cuisian deposits of France (Gruas-Cavagnetto 1977), but Spanish occurrences range from Cuisian to Early Lutetian (Haseldonckx 1972). Cavagnetto & Anadón (1996) suggested an intricate mangrove swamp, from elements such as: *Nypa, Avicennia* and *Pelliceria* from the middle Bartonian of the Eastern Ebro basin (Northern Spain). According to Riegel *et al.* (1999), the mangrove association is prevalent and diverse in the Middle Eocene (seam group) compared to the Lower Eocene (seam group) at Helmstedt of Northern Germany. The oldest mangroves on the European sea-shores are of Middle Eocene age (Plaziat *et al.* 2001). Hence, the age of the Yoncalı lignites should be Middle–?Late Eocene in the Yozgat-Sorgun area and can be correlated with the other coal-bearing Turkish Eocene sediments in Central

Table 1. Previous age deteminations of some forms in the Yoncalı formation of Yozgat–Sorgun area.

SPOROMORPHS	Paleocene	EOCENE			Oligocene	REFERENCES
		Early	Middle	Late		
Interpollis group						Von Der Brelie (1988)
						Vinken (1988)
						Allen (1988)
						Fowler (1988); Ollivier-Pierre (1988); Schalke (1988)
Anacolosidites group						Fowler (1988); Ollivier-Pierre (1988)
						Meyer (1988); Kedves (1986)
Milfordia hungaricus						Thomson and Pflug (1953); Krutzsch & Vanhoorne (1977)
						Chateauneuf (1980)
						Stower *et al.* (1966)
Compositoipollenites minimus						Kedves (1970, 1982); Krutzsch & Vanhoorne (1977); Thiele-Pfeifer (1988); Nickel (1996)
Diporites iszkaszentgyörgyi						Roche (1988); Meyer (1988)
						Ollivier-Pierre (1988); Vinken (1988); Kedves (1986)
Triporopollenites constatus						Kedves (1970)
Triatriopollenites excelsus						Thomson & Pflug (1953); Kedves (1969, 1982); Gruas-Cavagnetto (1978); Nickel (1996)
Caryapollenites circulus						Thomson & Pflug (1953); Kedves (1970); Krutzsch & Vanhoorne (1977); Thiele-Pfeiffer (1988); Krutzsch *et al.* (1992); Meyer (1988); Nickel (1996)
						Gruas - Cavagnetto (1968)
Echinatisporis longechinus						Nickel (1996)
						Krutzsch (1959); Kedves (1973)
Polypodiaceoisporites lusaticus						Thiele-Pfeiffer (1988)
						Kaska (1989)
Leiotriletes maxoides ssp. *maximus*						Krutzsch (1959,1962);Kedves (1973); Hochuli (1978)
						Akgün (2002)
Monocolpopollenites crassiexinus						Thomson & Pflug (1953)
						Akyol (1978)
Celtipollenites laevigatus						Thiele-Pfeiffer (1988)
Pentapollenites punctoides						Krutzsch (1962); Thiele-Pfeiffer (1988)
Concavisporites arugulatus						Nakoman (1966); Akyol (1978)
Triporopollenites spackmanii						Kedves (1970)
Spinizonocolpites group						Vinken (1988)
						Elsik (1974); Frederiksen (1973)
Plicatopollis lunatus						Nickel (1996)
						Frederiksen (1980a)
						Thiele-Pfeiffer (1988)
						Akgün (2002)

Anatolia (Akyol 1980; Akgün 2002; Akgün *et al*. 2002). This age is also in accordance with that obtained from benthic and planktic foraminifera from the Yozgat area (Erdoğan *et al*. 1996) (Figure 2).

Reconstruction of Palaeovegetation

This section explains the reconstruction of palaeovegetation in the coal-bearing Middle–?Upper Eocene sediments in the Yozgat-Sorgun, Yozgat-Çiçekdağ and Çorum-Amasya areas (Central Anatolia). Detailed palaeovegetational interpretations based on palynological assemblages using Cluster and Correspondence analyses of the three areas are given below.

The Yozgat–Sorgun Area

Palynological assemblages of the Yoncalı formation in the Yozgat–Sorgun area are diverse and exhibit some differences in the frequency of the same taxa from sample to sample (Appendix 1). To reconstruct the palaeovegetational types during the deposition of the Yoncalı formation in the area, ecological marker taxa have been selected on the basis of published literature (Westgate & Gee 1990; Cavagnetto & Anadón 1995, 1996; Rull 1998a, c; Riegel *et al*. 1999; Lenz & Riegel 2001). The ecological characteristics of the species have been grouped under generic headings (Appendix 1). The dendrogram of Figure 3 can be paired into two groups of samples (X and Y) and into two groups of palaeocommunities (A and B). In the palaeocommunities dendrogram, assemblage A consists of elements dominant in lowland-riparian and montane forest with a low percentage of mangrove and back-mangrove elements (coinciding with sample cluster X). Assemblage B includes a high proportion of swamp-freshwater, back-mangrove and mangrove elements and a low proportion of montane and lowland-riparian forest elements (coinciding with sample cluster Y).

Mangrove elements are abundantly found in samples ZK99/3 and 99/100 and are represented by *Spinizonocolpites* group (*Nypa*), *Psilatricolporites crassus* (*Pelliciera*), *Avicennia alba*-type (Verbenaceae) and *Diporites iszkaszentgyorgyi* (which has unknown botanical affinity) (Assemblage B). Tricolporate and reticulate pollen of *Avicennia* is very similar to that of *Avicennia alba*-type from Southeast Asia figured by Cavagnetto & Anadón (1995). It is restricted to the transition from marine interbeds to lignite seams at Helmstedt where it is always associated with other mangrove elements (Lenz & Riegel 2001). *Avicennia* and *Nypa* are known elements of modern mangrove vegetation, especially in the low diversity communities of the Ganges Delta, India (Blasco 1977; Mai 1995). *Diporites iszkaszentgyörgyi* is rarely observed in sample ZK99/3 but is closely associated with other known mangrove types such as *Nypa* and *Avicennia* (Appendix 1). According to Frederiksen *et al.* (1985), *Diporites iszkaszentgyörgyi* was produced by a coastal plant, probably living in brackish water conditions or at least in an environment which was in contact with normal seawater. Conversely, the association of *Nypa* and *Diporites iszkaszentgyörgyi* is closer to herbaceous marsh taxa such as *Milfordia* (Restionaceae) and *Sparganiaceaepollenites* (Sparganiaceae) than to mangrove elements (Boulter & Hubbard 1982). According to Lenz & Riegel (2001), *Diporites iszkaszentgyörgyi* is a member of the mangrove fringe rather than a member of a brackish marsh community and it grew together with *Avicennia* within the mangrove fringe. Complex mangrove swamp vegetation occurred along the coast with *Avicennia alba*-type and *Pelliciera,* and further inland, a plain with *Nypa* may have covered a large area (Cavagnetto & Anadón 1996). Pollen of *Pelliciera*, which was observed in samples Z99/2 and ZK99/3 as individual grains, grows close to tidal channels north of the Gulf of Nicoya and south of the Esmeraldes River (Horna *et al.* 1980; Jiménez 1981). According to Jiménez (1984), *Pelliciera* is more sensitive to high soil salinities than other more widespread neotropical mangroves. It develops best on wet soils, shallowly flooded only at high tides to a certain extent (Collins *et al.* 1977).

In brief, the Middle–?Late Eocene mangrove communities defined in the Yozgat-Sorgun area were dominated by *Nypa*, *Pelliciera*, *Avicennia alba*-type and *Diporites iszkaszentgyorgyi*.

The back-mangrove elements, indicating brackish water conditions, include *Milfordia hungarica* (Restionaceae), *Mauritiidites franciscoi* (*Mauritia*), *Proxapertites* group (Araceae), *Longapertites* group (Arecaceae), *Monocolpopollenites tranquillus* (Arecaceae), and the pterodophytic spore *Leiotriletes adriennis* (*Acrostichum aureum*). *Mauritia* palm forest associated

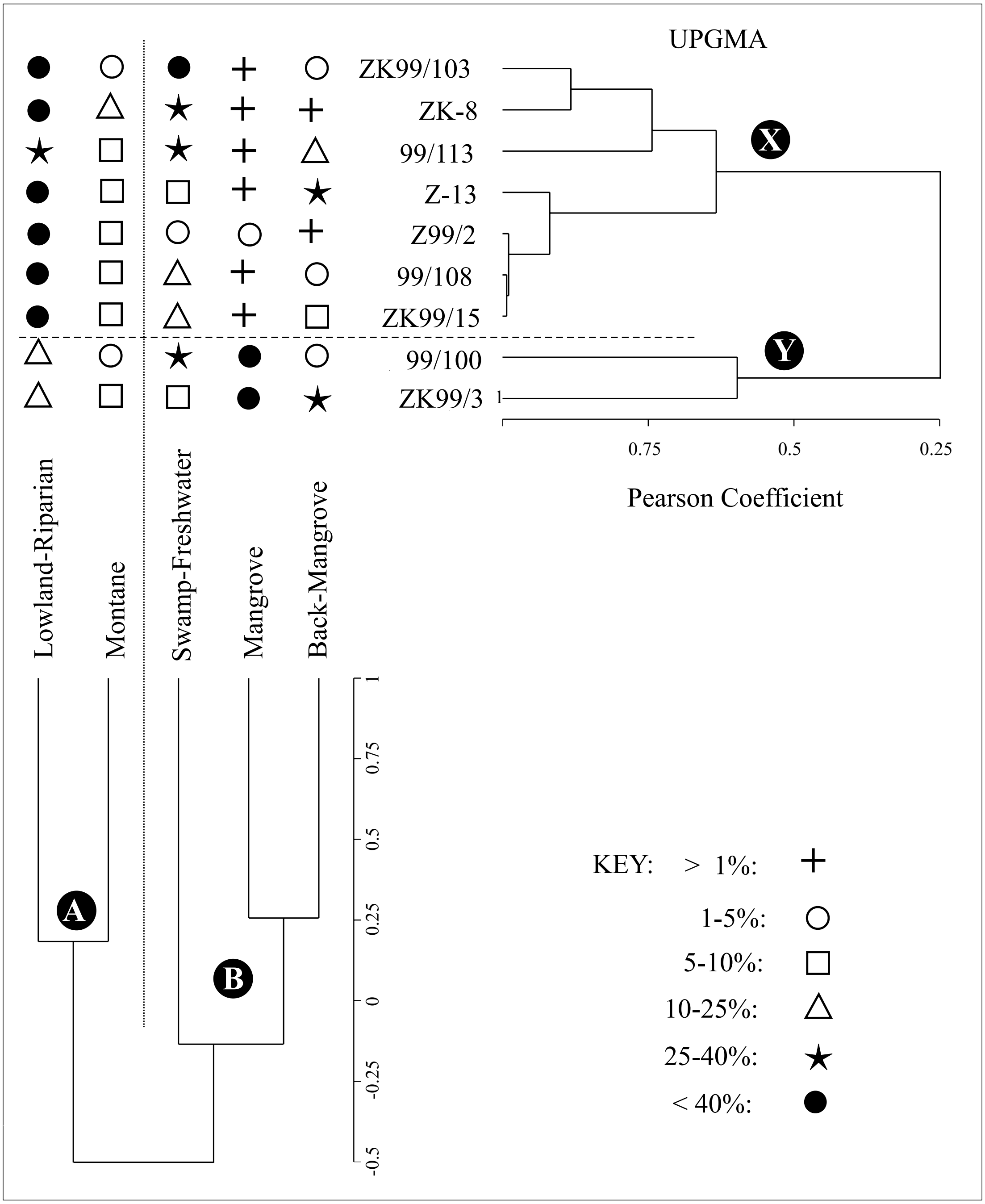

Figure 3. Dendrograms for UPGMA cluster analysis of palaeocommunities (bottom) and samples (side) of Yozgat-Sorgun area, using Pearson Coefficient.

with ferns determines a zone of fresh water (to locally brackish) swamps and marshes in the Eocene of Colombia (González-Guzmán 1967). *Mauritia* grew behind the coastline (van der Hammen & Wijmstra 1964), and the presence of *Mauritia* pollen in the sediments is a reliable indicator of a warm tropical lowland environment flooded by fresh (sometimes oligohaline) waters (Rull 1998b). Palm pollen such as *Proxapertites* (Araceae), *Monocolpopollenites tranquillus* (Arecaceae), *Longapertites* (Arecaceae) present in virtually all samples is attributed to the existence of back-mangroves in brackish water conditions. The presence of *Leiotriletes adriennis* in samples Z-13 and 99/103 has been considered the analogue of *Acrostichum aureum,* which is a typical inner mangrove indicator (Van der Hammen 1963; Ellison 1989; Westgate & Gee 1990; Gee 2001) (Sample cluster X). The presence of Polypodiaceae, Selaginellaceae, Taxodiaceae, Cupressaceae, Sparganiaceae, *Crudia* and *Nyssa* in the samples indicates swamp-freshwater palaeovegetation (Appendix 1). *Striatricolpites catatumbus* has been associated with *Crudia*, a tree that grows on river banks and in freshwater swamps (Germeraad *et al.* 1968; Lorente 1986; Rull 1999). Virtually all samples involve a high percentage of lowland-riparian elements (Assemblage A) such as Juglandaceae, Betulaceae, *Engelhardia*, Fagaceae, Myrtaceae, Anacardiaceae, and Icacinaceae. Montane elements are represented by *Pinus*, *Quercus, Castanea* and Symplocaceae.

The Yozgat-Çiçekdağ Area

In addition to the flora from the Yozgat-Sorgun area mentioned above, we have also evaluated a published flora from the southern margin of the Çankırı Basin (Figure 1d). A detailed palynological study was conducted by Akgün *et al.* (2002) in the Yoncalı formation of the Yozgat-Çiçekdağ area (near the village of Arabınköy) (see Akgün *et al.* 2002 for the sample locations). Samples were taken from several profiles in the southern part of the Çankırı Basin by the authors but only eight samples (pointed out in Appendix 2) were found to be palyniferous. In this study, palynological determinations of the Yozgat-Çiçekdağ area have been grouped under generic headings as montane, lowland-riparian, swamp-freshwater, back-mangrove, mangrove and marine (dinoflagellate cysts) (Appendix 2).

In the palaeocommunites dendrogram (Figure 4), assemblage X includes an abundance of lowland-riparian and montane elements. Assemblage Y can be separated into two subclusters, Y1 and Y2. Subcluster Y1 is dominated by shallow marine palynomorphs (dinoflagellate cysts) and mangrove elements. Subcluster Y2 has abundant swamp-freshwater elements and less abundant back-mangrove elements.

Sample cluster A can be divided into subclusters A1 and A2. Subcluster A1 is dominated by lowland-riparian elements and dinoflagellate cysts (Figure 4). Subcluster A2 has a high percentage of palynomorphs typical of swamp-freshwater environments such as Osmundaceae, Polypodiaceae, Gleicheniaceae, Taxodiaceae, Cupressaceae and *Nyssa* (Figure 4, Appendix 2). Cluster B is dominated by lowland-riparian elements and a low percentage of mangroves and dinoflagellate cysts. The number of dinoflagellate cysts in subcluster A1 is always higher than subcluster A2 and cluster B. Lowland riparian elements include the Juglandaceae, Myricaceae, *Engelhardia*, Cyrillaceae, Corylaceae, *Carya*, Icacinaceae, Simaroubaceae, Sapotaceae, *Sambucus*, *Tilia*, *Ulmus*, *Pterocarya*, Myrtaceae, *Castaneae*, *Rhus* and *Ilex* (Appendix 2). The montane elements are represented by *Pinus*, Fagaceae, *Quercus* and Symplocaceae (Appendix 2).

The mangrove elements are represented by different kinds of *Nypa* species, such as *Spinizonocolopites bulbospinosus*, *S. prominatus* and *S.* cf. *baculatus* (Appendix 2). These elements are regularly but less frequently observed in almost all samples (Appendix 2). Furthermore, the back-mangrove element Ephedraceae occurs in small proportions in the Yozgat-Çiçekdağ samples and its scarcity indicates the presence of distinct dry areas away from the site of deposition (Frederiksen 1985; Rull 2000). Cavagnetto & Anadón (1996), stated that a group of seven taxa characteristic of dry climatic conditions, such as Boraginaceae, Chenopodiaceae, *Combretum, Linum*, Plumbaginaceae Thymelaeaceae and *Ephedra* distinguish the flora of the Priabonian from that of the middle Bartonian. Swamp-freshwater elements Cupressaceae and Taxodiaceae are abundant in samples 8, 13, 14, and 15 (Appendix 2).

Different kinds of dinoflagellate species such as *Homotryblium vallum*, *Homotryblium* sp., *Cordospheridium inodes*, *Operculodinium microtrianium*, *Phthanoperidinium amoenum*, *Spiniferites ramosus* and *Wetzeliella lunaris, Wilsonidium echinosuturatum Batiacasphaera* sp. and *Impagidium* sp., were commonly observed in almost all samples except sample 3 (Appendix 2). The presence of *Operculodinium*, *Impletosphaeridum*, *Areosphaeridium*, *Spiniferites*, *Cleistosphaeridium*, *Homotryblium*, *Wetzeliella* and *Cordospheridium* generally characterizes inshore and neritic environments (e.g., Scull *et al.* 1966; Goodman 1979; Islam 1984; Frederiksen 1985; Norris 1986; Wrenn & Kokinos 1986; Zevenboorn *et al.* 1994).

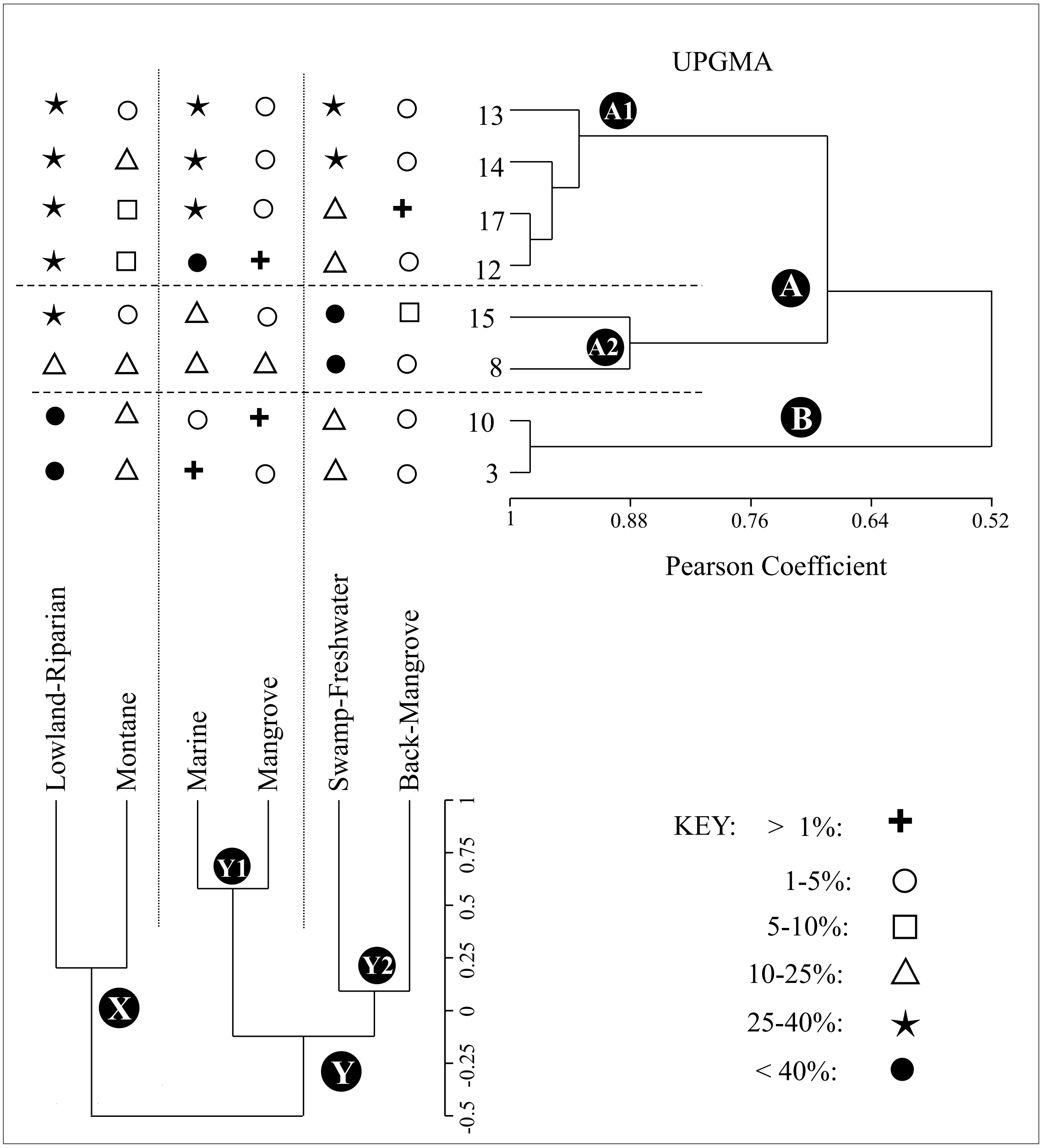

Figure 4. Dendrograms for UPGMA cluster analysis of palaeocommunities (bottom) and samples (side) of Yozgat-Çiçekdağ area, using Pearson Coefficient.

The Çorum-Amasya Area

A detailed palynological study of the Armutlu and Çeltek formations in the Çorum-Amasya area was carried out by Akgün (2002) (Figure 1c). Two different palaeoenvironments were suggested for Middle–?Late Eocene. The quantitative distributions of many stratigraphic and ecologically important palynotaxa and sedimentological features indicate fluviolacustrine conditions for the Çeltek formation (Akgün 2002). The Armutlu formation was deposited in a terrestrial environment but with some marine influence.

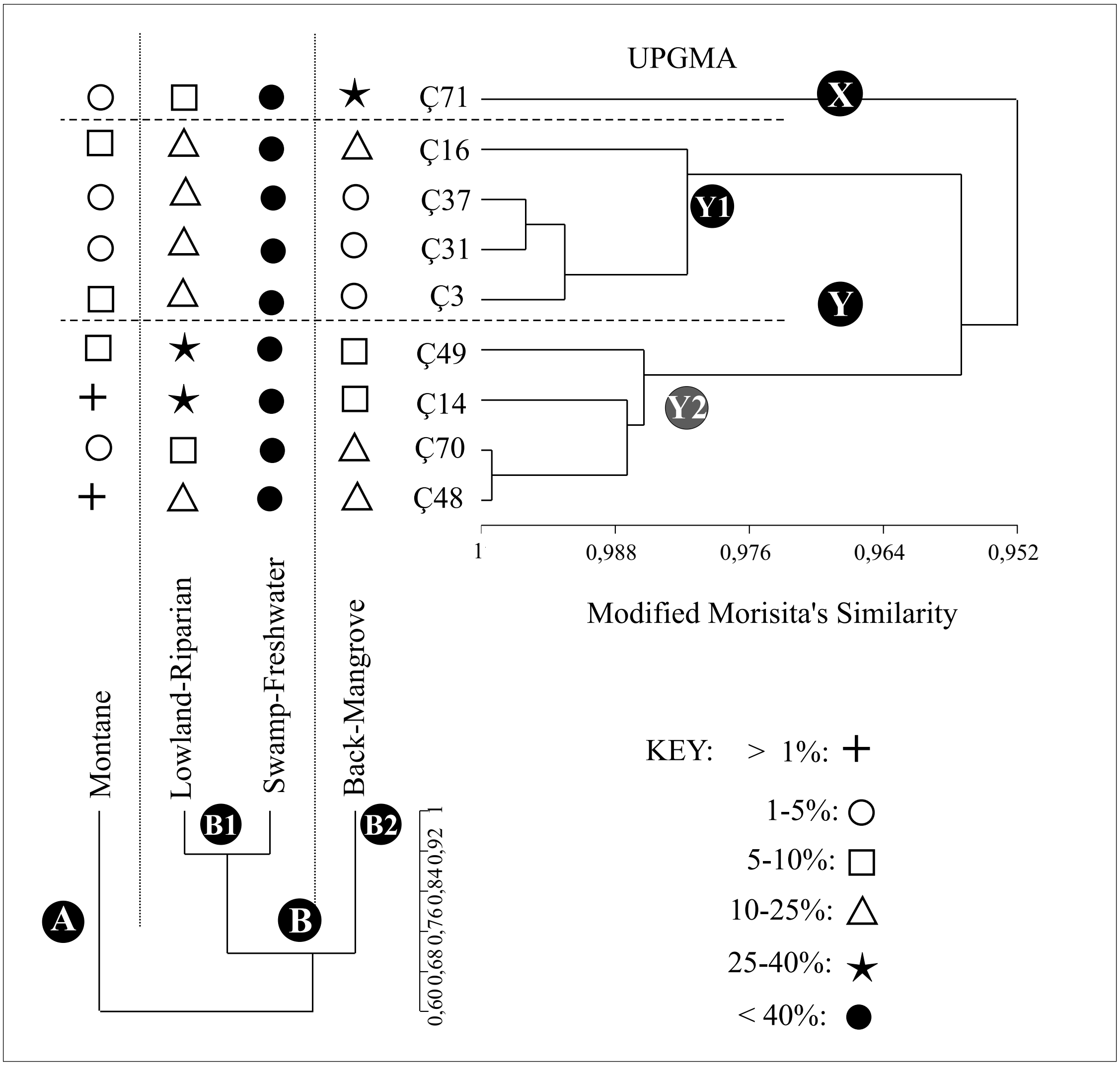

Figure 5. Dendrograms for UPGMA cluster analysis of palaeocommunities (bottom) and samples (side) of Çorum-Amasya area (Çeltek formation), using Modified Morista's Similarity rank order correlation coefficient.

The Çeltek Formation. The palynomorph assemblage of the Çeltek formation in the Çorum-Amasya area has been grouped into four generic headings; the montane, lowland-riparian, swamp-freshwater and back-mangrove (Figure 5). The dendrogram can be paired into two groups of samples (X and Y) and two groups of palaeocommunities (A and B). Sample cluster Y and palaeocommunity cluster B can also be paired into the subclusters as Y1, Y2 and B1, B2, respectively (Figure 5). In the palaeocommunities dendrogram, assemblage A includes a low abundance of the montane elements and corresponds to the sample subcluster Y2. Subcluster B1 has a high percentage of lowland-riparian elements and scarcer back-mangrove elements and coincides with subcluster Y1. Subcluster B2 is characterized by an abundance of back-mangrove elements and corresponds to cluster X. The back-mangrove elements *Longapertites* (Arecaceae), *Proxapertites* (Araceae) and the *Leiotriletes adriennis (Acrostichum aureum)* are rarely observed in all samples (Figure 5, Appendix 2). The swamp-freshwater elements are abundantly observed in all samples and consist of Osmundaceae, Polypodiaceae, Selaginellaceae

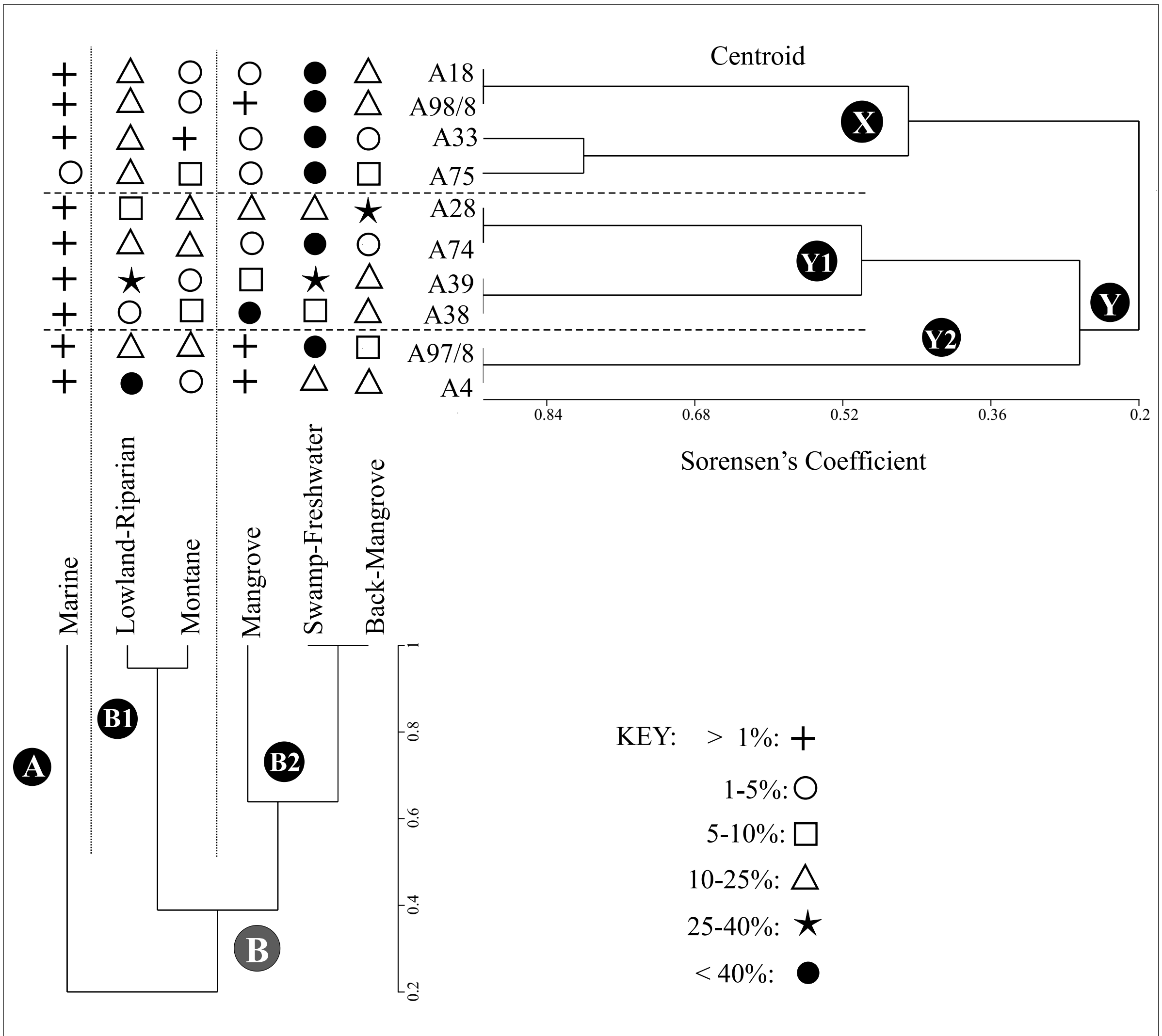

Figure 6. Dendrograms for centroid cluster analysis of palaeocommunities (bottom) and samples (side) of Çorum-Amasya area (Armutlu formation), using Sørensen's coefficient.

and *Nyssa* (Appendix 2). The lowland-riparian forest elements are both rarely and commonly observed in the samples and include Cycadaceae, Juglandaceae, *Pterocarya*, *Alnus*, Corylaceae, *Ulmus*, Cyrillaceae, Simaroubaceae, Araliaceae, *Rhus*, *Castaneae*, *Carya* and *Tilia*. The montane elements are represented by Fagaceae and *Quercus*.

The Armutlu Formation. The dendrogram can be paired into two groups of samples (X and Y) and two groups of palaeocommunities (A and B). Sample cluster B and palaeocommunity cluster Y can be divided into two subclusters as B1, B2 and Y1, Y2. In the palaeocommunities dendrogram, assemblage A includes a high percentage of the lowland-riparian elements and marine palynomorphs (dinoflagellate cysts), mangrove and back-mangrove elements corresponding to cluster X are present (Figure 6). Subcluster B1 contains high percentages of the lowland-riparian and less abundant montane elements and an absence of the mangrove elements. It coincides with subcluster Y2 in the sample dendrogram. Subcluster B2 is characterized by a high percentage of mangrove and back-mangrove elements an absence of marine palynomorphs and corresponds to subcluster Y1 (Figure 6).

Miscellaneous mangrove elements are abundant in the palynomorph assemblage and consist of *Psilatricolporites crassus* (*Pelliciera*), *Avicennia alba* and *Avicennia marina* (Verbenaceae), *Spinizonocolpites* group (*Nypa*). Though the pollen of Verbenaceae and Restionaceae were recorded in the Armutlu formation, these families do not occur in the Yozgat-Çiçekdağ area and in the Çeltek formation of the Çorum-Amasya area (Appendix 2). Swamp-freshwater elements such as Nymphaceae, *Nyssa*, Sparganiaceae, Cupressaceae, Taxodiaceae, Polypodiaceae and Selaginellaceae are abundant in all samples. Lowland-riparian forest elements commonly accompany the montane forest elements and including *Platanus/Salix, Cycadopites*, Juglandaceae, Myricaceae, *Engelhardia*, *Platycarya*, Corylaceae, *Alnus, Celtis, Carya*, Icacinaceae, *Pterocarya*, *Rhus*, *Castanea*, Araliaceae, Vitaceae, *Sambucus*, Rosaceae, Rutaceae, Sapatoceae and Gramineae (Appendix 2). These elements are observed together with the back-mangrove elements which commonly include *Milfordia hungarica* (Restionaceae), *Longapertites* (Arecaceae), *Monocolpopollenites crassiexinus* (Nymphaeaceae), *Proxapertites* (Araceae) and *Leiotriletes adriennis* (*Acrostichum aureum*). The montane elements are generally abundant in the assemblage and contain *Pinus, Abies, Quercus* and Fagaceae (Appendix 2).

Furthermore, all palynological samples and also palaeovegetation types from Yozgat-Çiçekdağ, Yozgat-Sorgun and the Çeltek and Armutlu formations of the Çorum-Amasya areas have also been analysed with the Correspondence Analysis method (Figure 7). Thus, palaeovegetational properties of these areas have been correlated with each other. The Yozgat-Çiçekdağ samples have been grouped into the marine area due to well-preserved dinoflagellate cysts, which indicate close proximity to a marine environment (Group 1) (Figure 7). Even so, sample 3 of the Yozgat-Çiçekdağ area, which lacks dinoflagellate cysts occurs with the samples of the Çeltek formation and also samples A4 and A8 of the Armutlu formation in the Çorum-Amasya area (Group 3). Hence, samples of Group 3 suggest a relatively terrestrial environment. Group 2 generally consists of the samples of the Armutlu formation because of the fact that the samples in the area include a diverse and high percentage of mangrove elements. Also, samples ZK99/3, 99/100 and Z99/2 of the Yozgat-Sorgun area occur in Group 2 as it has rich mangrove and back-mangrove elements. The abundance of mangrove and back-mangrove elements in Group 2 indicates a high sea level.

Overall, palynological assemblages from the Yozgat-Sorgun, Yozgat-Çiçekdağ and Çorum-Amasya areas (Armutlu and Çeltek formations) which include very rare dinoflagellate cysts such as *Operculodinium*, *Impletosphaeridum Areosphaeridium*, *Spiniferites*, *Cleistosphaeridium*, *Homotryblium*, *Wetzeliella* and *Cordospheridium* indicate shallow marine depositional conditions (Figure 8). The pollen of the mangrove elements *Spinizonocolpites* (*Nypa*), *Avicennia* (Verbenaceae) and *Psilatricolporites crassus* (*Pelliciera*) represent deposition near a shoreline. *Diporites iszkaszentgyörgyi* is a part of the mangrove fringe. Behind the mangrove zone, pollen of *Mauritiidites franciscoi* (*Mauritia*), *Milfordia hungarica* (Resitonaceae), Ephedraceae, *Longapertites* (Arecaceae) and *Proxapertites* (Araceae) as well as fern spore *Leiotriletes adriennis* (*Acrostichum aureum*) is present. Ephedraceae is a reliable indicator of dry area. The pollen of Sparganiaceae, Nymphaceae, *Crudia,* Taxodiaceae, Cupressaceae, *Nyssa* and some ferns spores are typical swamp-freshwater elements. The lowland-riparian environment is dominated by the pollen indicated in Figure 8 such as Sapotaceae, Anacardiaceae-*Rhus*, *Platanus/Salix*, Cyrillaceae, Fagaceae, Myricaceae, Juglandaceae, Icacinaceae, *Castanae Ulmus*, and Betulaceae. A montane forest association, including *Pinus*, *Abies* Symplocaceae, Fagaceae and *Quercus* was transported from a well-drained montane environment (Figure 8).

From the palaeoecological point of view, the presence of the mangrove elements is similar to other studies on Eocene palynology from Spain, Germany and United States of America (e.g., Westgate & Gee 1990; Cavagnetto & Anadón 1995, 1996; Rull 1998a, c; Riegel *et al.* 1999; Lenz & Riegel 2001). In Europe the Alpine orogeny concluded as Europe and Africa approached each other in the Palaeocene and Eocene. The ocean currents in the Tethys originated from Indo-Pacific water masses (Hoffmann & Zetter 2001) and should have led to the similar palaeoecological conditions. The Çankırı Basin was an important connecting place between the Tethys and Indo-Pacific oceans during the Middle–?Late Eocene period.

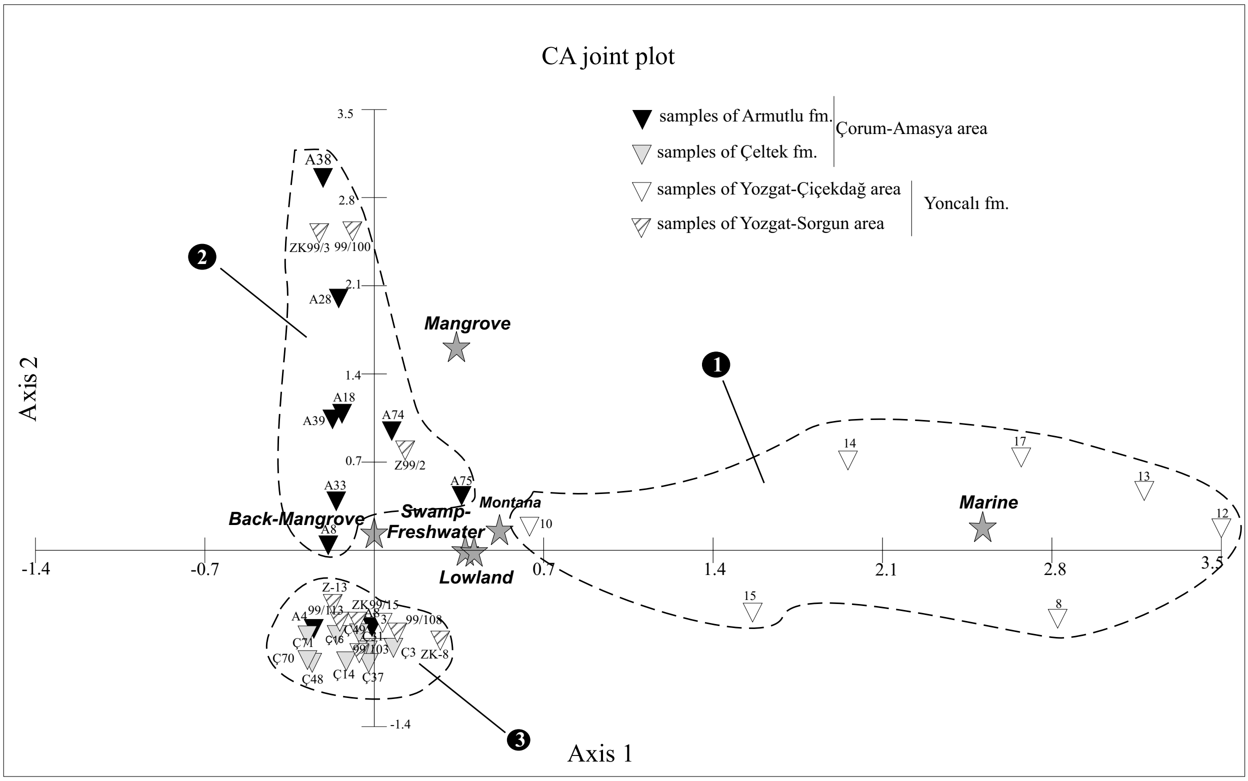

Figure 7. Correspondence Analysis plot of samples and vegetation types representation with respect to axes 1 to 2.

Palaeoclimate

A detailed quantitative palaeoclimatic study of the Turkish Eocene has been neglected until now. The only published Eocene quantitative palaeoclimate reconstruction has been made by Akkiraz *et al.* (2006) on Western Anatolia. To fill this gap, the palynofloras obtained from the Çorum-Amasya (Akgün 2002), Yozgat-Çiçekdağ (Akgün *et al.* 2002) and Yozgat-Sorgun areas (this study) were analysed by the Coexistence Approach method of quantitative palaeoclimatic reconstruction. The percentage of thermal groups (e.g., megathermal, mega-mesothermal) of the spores and pollen has also been calculated and interpreted with the results of the 'Coexistence Approach'.

The Yozgat-Sorgun Area

In the Yoncalı palynoflora of the Yozgat-Sorgun area, 136 taxa have been identified (Appendix 1). Twenty five taxa have NLRs that could be used for calculating the coexistence intervals (Figure 9) and suggested a MAT between 16.5 and 18.8 ºC. A second coexistence interval 24.8–25 ºC may appear. Possibly these two coexistence intervals represent two plant communities that grow under different climatic conditions related to variegated relief. The CMT is between 9.6 and 13.1 ºC but intervals between 22.5–23 ºC also occur. The WMT coexistence interval is constantly 27.3–27.7 ºC. The MAP is determined to be between 1003 and 1520 mm. The MART values are 16.15 and 5.15 ºC. Additionally, the megathermal elements are abundant in the Yoncalı palynoflora of the Yozgat-Sorgun area (~19%), which is characterized by *Nypa*, Theaceae and Sapotaceae (Appendix 1). The mega-mesothermal elements consist of Taxodiaceae, Juglandaceae, *Platycarya*, *Celtis*, *Tilia*, *Quercus*, Fagaceae, Myrtaceae, *Rhus*, Castaneae, Cyrillaceae, *Nyssa* and Verbenaceae which are observed in high percentages (58%) (Table 2). The mesothermal elements include Myricaceae, *Carya*, *Platanus*/*Salix*, *Ilex* and *Salix* and commonly accompany the mega-

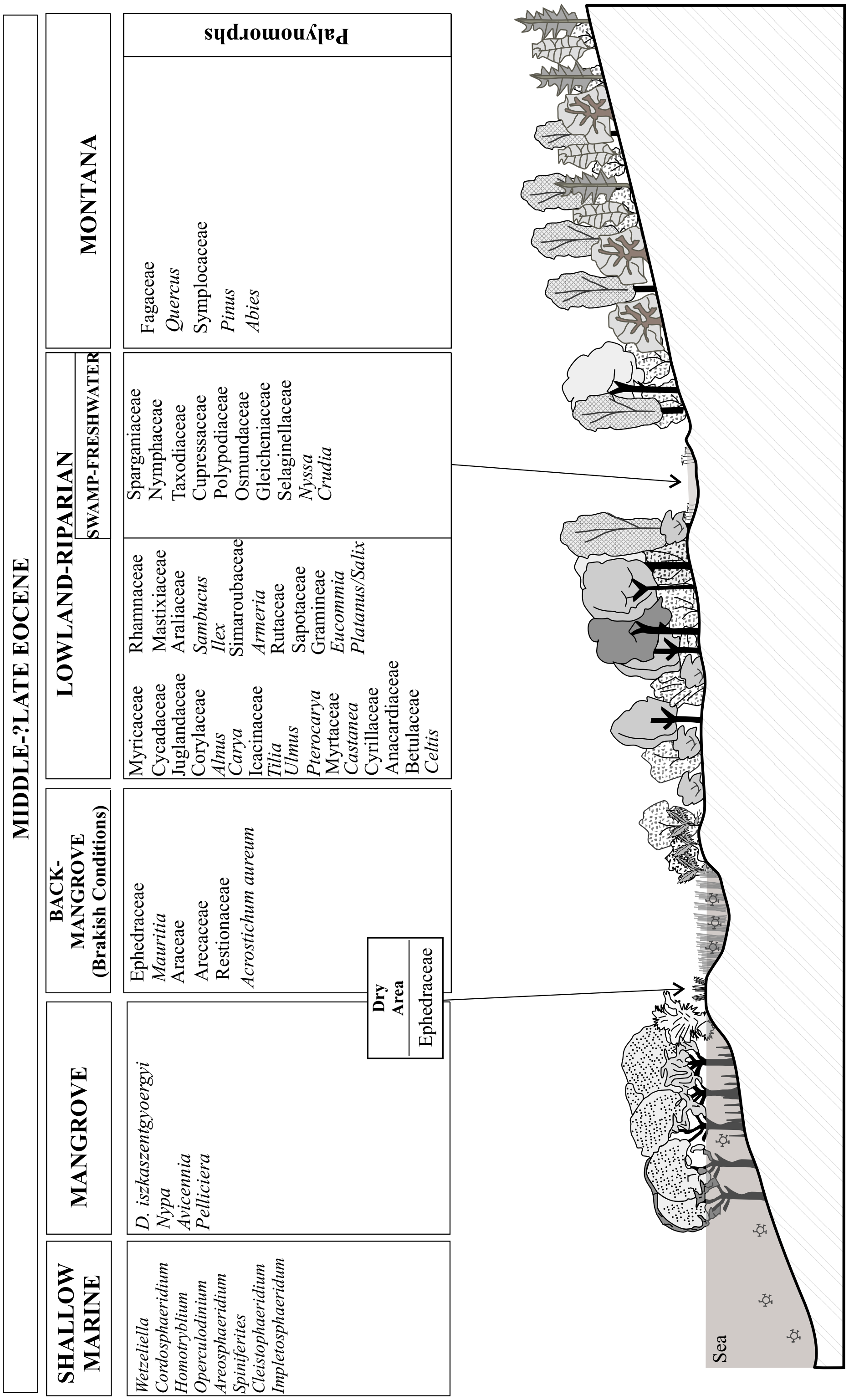

Figure 8. Reconstruction of floral successions in the Yozgat-Sorgun, Yozgat-Çiçeklidağ and Çorum-Amasya areas (modified from Riegel *et al.* 1999).

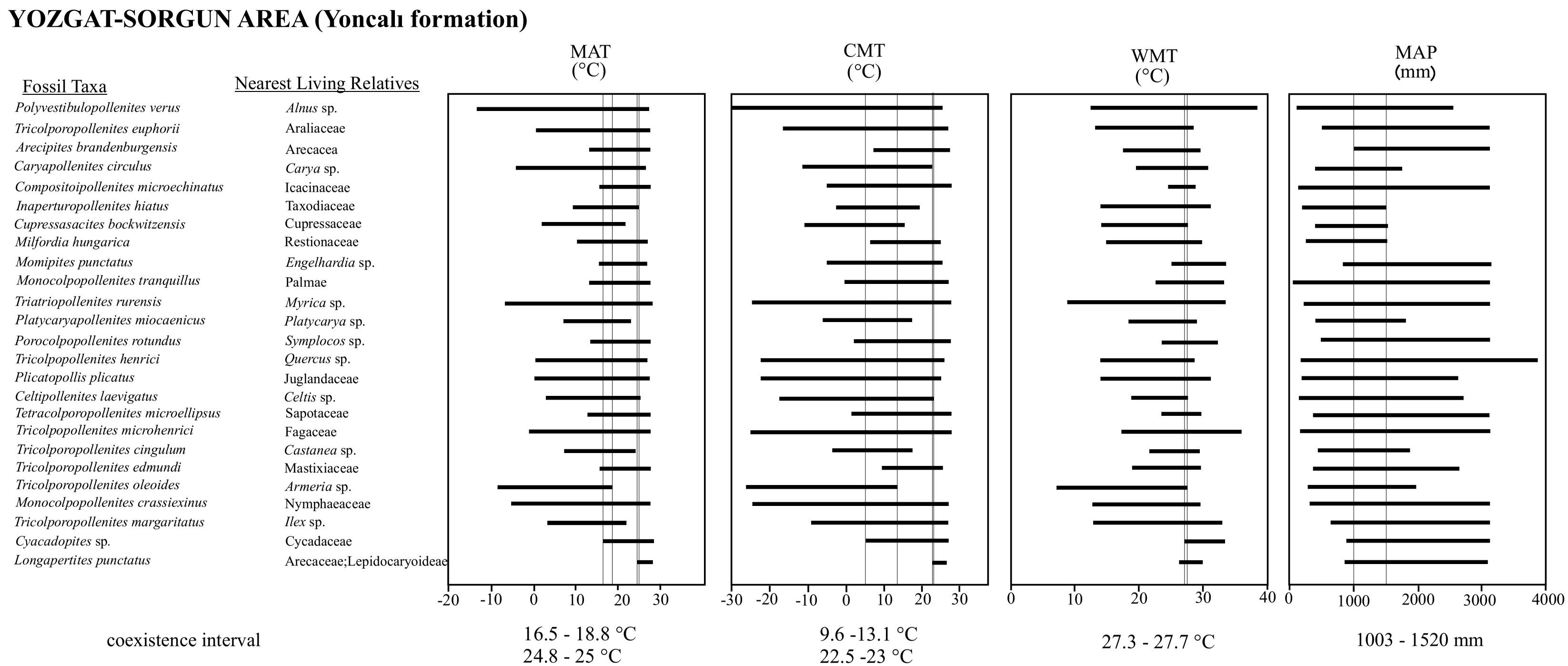

Figure 9. Application of the Coexistence Approach to the Yoncalı palynoflora in the Yozgat-Sorgun area. The shaded boxes mark the climatic requirements of the taxa, the vertical lines delimit the widths of the coexistence intervals (MAT: mean annual temperature, CMT: mean temperature of the coldest month, WMT: mean temperature of warmest month, MAP: mean annual precipitation).

Table 2. Coexistence intervals of the calculated climatic parameters for the evaluated floras and relative percentages of thermal distribution of the floras (MAT: mean annual temperature, CMT: temperature of the coldest month, WMT: temperature of the warmest month, MART: mean annual range of temperature, MAP: mean annual precipitation).

LOCATIONS	No. of taxa	MAT (°C)	CMT (°C)	WMT (°C)	MAP (mm)	MART (°C)	Relative Percentages (%)			
							Megathermal	Mega - Mesothermal	Mesothermal	Mesomic - Microthermal
Yozgat-Sorgun area Yoncalı palynoflora (this study)	25	16.5–18.8 24.8–25	9.6–13.1 22.5–23	27.3–27.7	1003–1520	5.15 16.15	19	58	20	3
Yozgat-Çiçekdağ area Yoncalı palynoflora (Akgün et al. 2002)	16	15.6–20.8	5–13.3	24.7–28.1	823–1520	17.95	11	51	37	1
Çorum-Amasya area Çeltek palynoflora (Akgün 2002)	16	16.5–23.9	7.7–16.8	27.3–27. 9	1003–1520	15.35	7	57	33	3
Çorum-Amasya area Armutlu palynoflora (Akgün 2002)	23	16.5–23.1 24.8–25	9.6–16.4 22.2–24.8	27.3–27. 9	1003–1520	4.1 14.6	14	63	22	1

mesothermal elements (20%) (Table 2). Microthermal (*Alnus*) and meso-microthermal elements such as Betulaceae and *Celtis* are in low percentages (~2–3%).

The Yozgat-Çiçekdağ Area

The palynoflora analyzed from the Yoncalı formation of the Yozgat-Çiçekdağ area includes 99 taxa (Akgün *et al.* 2002), and the palaeoclimatic reconstruction is based on 16 taxa (Figure 10). The resulting coexistence interval for the MAT ranges from 15.6 to 20.8 °C, and CMT and WMT as 5 to 13.3 °C and 24.7 to 28.1 °C, respectively. For the MAP, the coexistence approach yields values from 823 to 1520 mm. The MART value is 17.95 °C (Figure 10). The megathermal elements are characterized by *Nypa* and Sapatoceae and these elements are abundant in the palynoflora (11%) (Table 2). The mega-mesothermal elements consist of *Nyssa*, Anacardiaceae, Cyrillaceae, Castaneae, Myrtaceae, *Quercus*, *Tilia*, *Platycarya*, Symplocaceae, *Engelhardia* and Taxodiaceae and are abundant in the palynoflora (51%) (Table 2). Mesothermal elements such as Myricaceae, *Carya*, *Platanus/Salix* and *Ilex* form a high percentage of this palynoflora (37%). Microthermal elements include only *Ulmus,* which is less abundant in this palynoflora (1%).

The Çorum-Amasya Area

In the palynomorph assemblage of the Armutlu formation from the Çorum-Amasya area, 95 taxa were identified by Akgün (2002). The climatic evaluation is based on 23 taxa (Figure 11). Quantitative results show that the values for the MAT are between 16.5–23.1 °C but an interval between 24.8–25 °C also occurs. The CMT values range from 9.6 to 16.4 °C but an interval between 22.2–24.8 °C is also possible (Figure 11). The WMT values range from 27.3 to 27.9 °C and 1003–1520 mm for the MAP. The MART values are 14.6 and 4.1 °C. Megathermal elements consist of *Nypa*, Sapatoceae and *Pelliciera*, which are abundant in the palynoflora of the Armutlu formation (14%). Mega-mesothermal elements such as Verbenaceae, *Nyssa*, Cyrillaceae, Castaneae, Myrtaceae, *Quercus*, Symplocaceae, *Tilia*, *Platycarya*, *Engelhardia* and Taxodiaceae are abundant in the palynoflora (63%) (Table 2). The mesothermal elements are characterized by the Myricaceae, *Carya* and *Platanus/Salix* which are abundant (22%). The microthermal (*Alnus*) and meso-microtermal (*Celtis*) elements are scarce in the palynoflora (~1%) (Table 2).

The palynoflora of the Çeltek formation from the Çorum-Amasya area comprises 87 taxa (Akgün 2002), 16 of which were used for calculating the coexistence intervals (Figure 12). MAT ranges from 16.5–23.9 °C. The interval for the CMT is broad and ranges from 7.7 to 16.7 °C. Calculations of the WMT yield an interval from 27.3 to 27.9 °C and the MAP is suggested to lie between 1003 and 1520 mm (Figure 12). The MART value of this palynoflora is 15.35 °C. Megathermal elements (Sapotaceae) are scarce (7%) (Table 2). The mega-mesothermal elements are more abundant in this palynoflora, which includes *Nyssa*, Cyrillaceae, Castaneae, *Tilia*, *Quercus*, *Platycarya* and *Engelhardtia* (57%). Mesothermal elements such as Myricaceae, *Carya* and

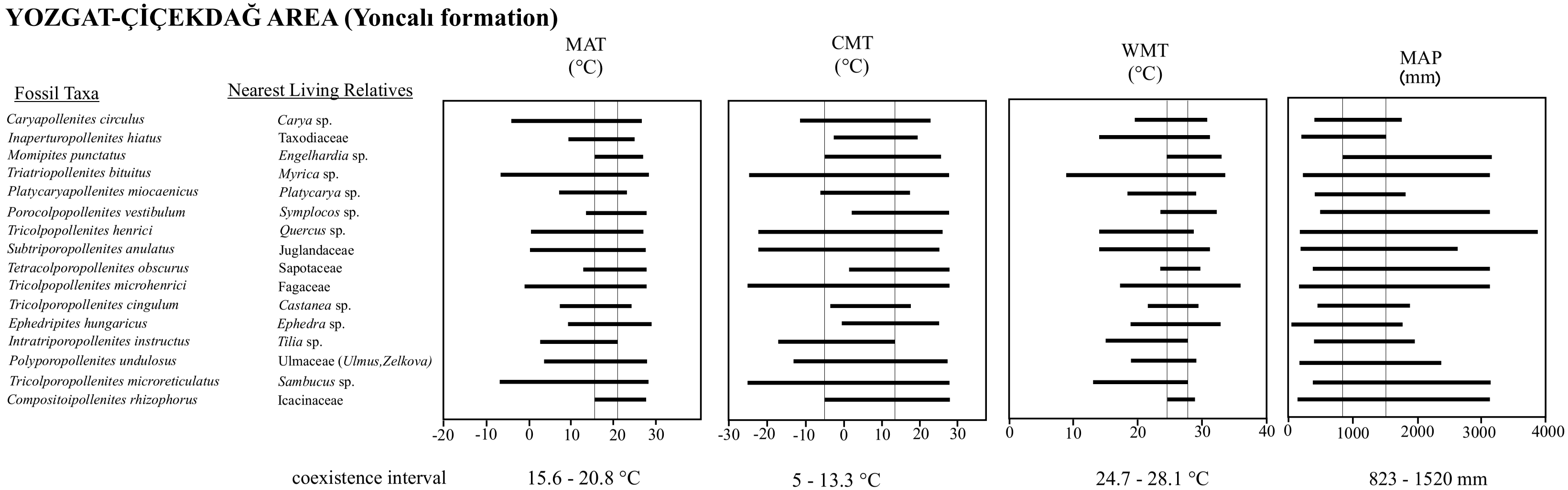

Figure 10. Application of the Coexistence Approach to the Yoncalı palynoflora in the Yozgat-Çiçekdağ area. The shaded boxes mark the climatic requirements of the taxa, the vertical lines delimit the widths of coexistence intervals (MAT: mean annual temperature, CMT: mean temperature of the coldest month, WMT: mean temperature of warmest month, MAP: mean annual precipitation).

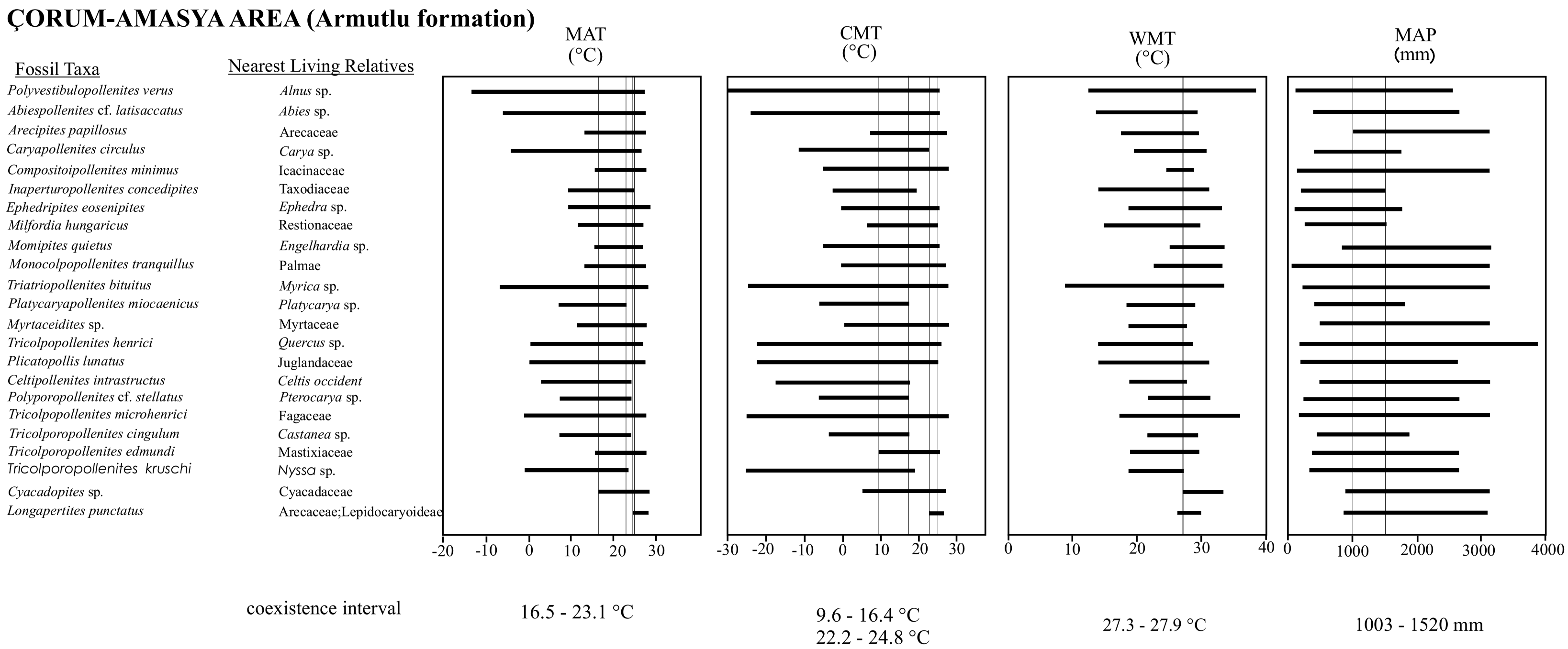

Figure 11. Application of the Coexistence Approach to the Armutlu formation in the Çorum-Amasya area. The shaded boxes mark the climatic requirements of the taxa, the vertical lines delimit the widths of coexistence intervals (MAT: mean annual temperature, CMT: mean temperature of the coldest month, WMT: mean temperature of warmest month, MAP: mean annual precipitation).

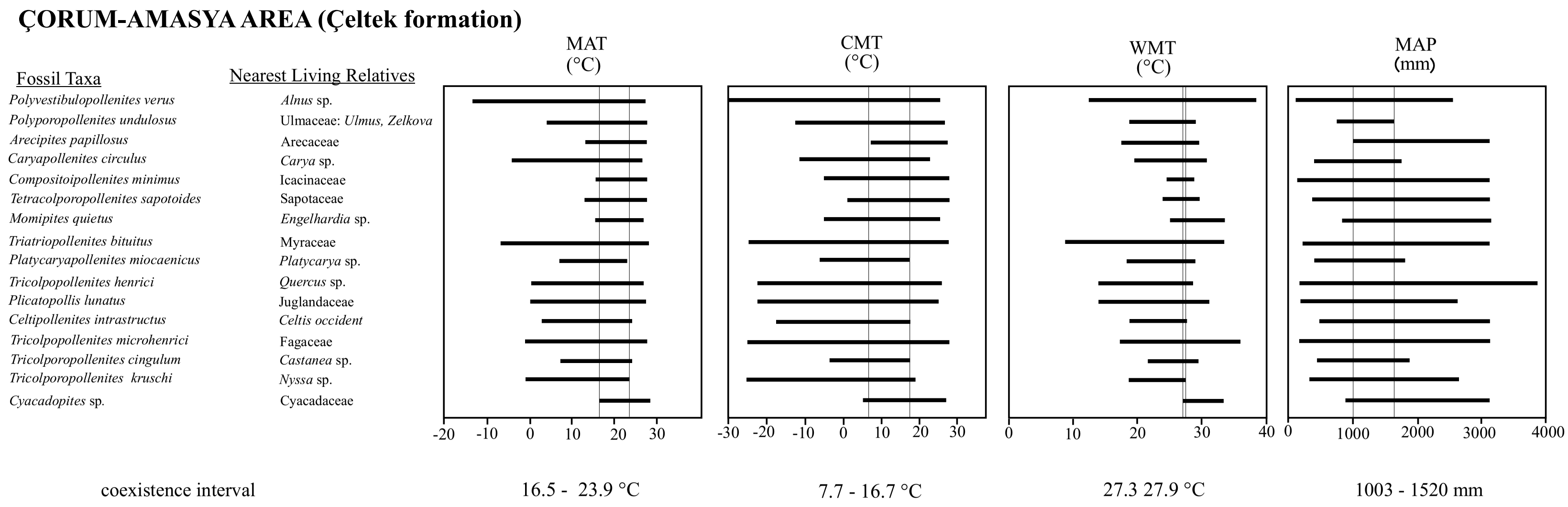

Figure 12. Application of the Coexistence Approach to the Çeltek formation in the Çorum-Amasya area. The shaded boxes mark the climatic requirements of the taxa, the vertical lines delimit the widths of coexistence intervals (MAT: mean annual temperature, CMT: mean temperature of the coldest month, WMT: mean temperature of warmest month, MAP: mean annual precipitation).

Platanus/Salix are abundant (33%). The microthermal (*Alnus* and Ulmaceae) and meso-microthermal (*Celtis*) elements are scarce in the palynoflora of the Çeltek formation (~3%) (Table 2).

Palaeoclimatic Interpretation

In this study, we have obtained two different MATs and CMTs values for the Yozgat-Sorgun area (Figure 9, Table 2). The calculated quantitative climatic values (MATs: 16.5–18.8 ºC and 24.8–25 ºC) and also CMTs values (9.6–13.1 and 22.5–23 ºC) for the Yozgat-Sorgun area indicate both tropical and subtropical conditions with high rainfall. This is also true of the Çorum-Amasya area (Armutlu formation) (Figure 11, Table 2). As opposed to climatic values for the Yozgat-Sorgun and Çorum-Amasya (Armutlu formation) areas, the calculated mean annual temperatures (MATs) for the Yozgat-Çiçekdağ and Çorum-Amasya areas (Çeltek formation) change from 15.6 to 20.8 ºC and 16.5 to 23.9, respectively (Table 2). This indicates warm temperate and/or subtropical palaeoclimatic conditions. The source of error can be misidentification of a fossil taxon or poor modern climatic data.

The following discussion of climate follows the terminology of Nix (1982), who recognized a series of broad plant groups with characteristic temperature response models for Australia and New Guinea. In the context of the Early–Middle Eocene climate history of New Zealand the terms megatherm and mesotherm have been used to distinguish temperature zones (Nix 1982; Pocknall 1990). The megathermal element is dominant, where mean annual air temperature exceeds 24 ºC and corresponds to the environment of the mangrove association. The mesothermal element is dominant, where the mean annual air temperature ranges between 14 ºC and 21 ºC and coincides with the slope and montane forest association. An intermediate zone is indicated for an area, where the mean annual temperature is in between 21–24 ºC. In this study, different climatic values were discovered as a mixture of temperate/tropical taxa from the coast to the montane environments. Nix (1982) used these terms to eliminate the confusion usually associated with the use of the terms tropical, subtropical and temperate, which have both geographic and thermal associations. When we combined the MATs values of the Yozgat-Sorgun and Çorum-Amasya areas (Armutlu formation), the quantitative palaeoclimate has been estimated 24.8–25 ºC in the megatherm zone including high percentage of megathermal elements (Table 2). It should be 23.1–24.8 ºC in the intermediate zone, which generally consists of mega-mesothermal elements. The mesothermic zone is characterized by 16.5–23.1 ºC. The calculated results (15.6–21.7 ºC) for the Yozgat-Çiçekdağ and Çorum-Amasya areas (Çeltek formation) indicate the mesothermal zone of Nix (1982) (Table 2). Possibly, diverse coexistence intervals indicate different plant communities growing under different climatic conditions on variegated relief (Ivanov *et al.* 2002). These two coexistence intervals indicate two plant communities that grow under different climatic conditions. The varied climatic values in CMTs for the Yozgat-Sorgun and Çorum-Amasya areas (Armutlu formation) should also be of interest in palaeogeographic organizations.

According to Wolfe (1979), moist tropical forests have an MAT higher than 25 ºC; the 20–25 ºC isotherms encompass paratropical forest; and broad leaf evergreen forests grow in a subtropical climate (13–20 ºC). Wolfe & Poore (1982) estimated that MAT in the Mississippi Embayment fluctuated between about 20 ºC and 30 ºC during the Middle–Late Eocene period, a result consistent with this study because it lay at similar latitude. Frederiksen (1980a, b) suggested a regime of dry winter tropical climate on lowlands adjacent to the coastline and a marginal humid paratropical climate on the upper coastal plain. According to Fechner (1988), *Nypa* cannot survive in temperatures less than 20 ºC on account of its sensitivitiy to sea temperatures. Shackleton & Kennett (1975) stated that Early Eocene surface water temperatures of 20 ^{o}C for the Campbell Plateau are high enough for the water temperature needs of *Nypa*. Pole & Macphail (1996), who studied the palaeogeography and palaeoecology of Eocene *Nypa* from Regatta Point, Tasmania, claimed that temperature is not only factor restricting the dispersion of *Nypa,* which records monsoonal conditions, or at least seasonal rain, in Tasmania during the Eocene.

Mosbrugger *et al.* (2005) used the Geiseltal flora (Weiselster basin) to show that the warmest climate conditions occurred in the Lutetian. At that time the MAT ranged from 23 to 25 ºC, MAP from 1000 to 1600 mm and CMT from 17 to 21 ºC, indicating virtually tropical climatic conditions. Throughout the Eocene epoch, the climate of the Mediterranean region fluctuated (Aleksandrova *et al.* 1987). The Early Eocene was marked by some decrease in the mean annual temperatures in Belgium, Germany, and the East European platform, and the climate became warm tropical to subtropical (Buchardt 1978; Yasamanov 1982). Paleobotanical determinations of the Middle Eocene (Gray 1960; Dilcher 1973; Wolfe 1978; Upchurch & Wolfe 1987; Greenwood & Wing 1995) and Late Eocene paleoclimate (Frederiksen 1980b; Wolfe 1992) for the northern Gulf Coast indicate a dry winter, tropical to humid paratropical climate on the lowlands, with freezing unlikely. Ediger e*t al.* (1990) studied the palaeopalynology and palaeoecology of the Northern Thrace Basin, Turkey and suggested that the climate was relatively warmer in the Oligocene than in the Eocene due to an increase of thermophilous elements such as *Cycadopites*, *Monocolpopollenites* and *Dicolpopollenites kalewensis*. However, they also suggested that Eocene climate should be considered cautiously, based on previous palaeoclimatic estimates and reconstructions (e.g., Wolfe 1978; Hochuli 1984; Aleksandrova *et al.* 1987). Recently, Akkiraz *et al.* (2006) have studied palynological and palaeoenvironmental properties of coal-bearing Eocene sediments in Western Turkey, predating the Bartonian–Priabonian transgression. They also indicated the presence of a subtropical/paratropical climate, corresponding to a MAT between 17.2 ºC and 25 ºC, from the coast to montane environments and consistent with the results of this study. Palaeoclimatic variation in the terrestrial environment may therefore be caused by tropical Tethys marine surface waters circulating around a complex coastline, which may have produced the range of climatic values in the Eocene terrestrial environment in central Anatolia.

In addition to the MAT and CMT values, MARTs (mean annual range of temperatures) suggest an interpretation of the palaeogeography during the deposition of the coals. MART values obtained from the Yozgat-Çiçeklidağ (17.95 ºC) and Çorum-Amasya areas (16.35 ºC) (Çeltek formation) are comparable (Table 2). The similar values indicate that the palaeotopography was more or less the same during coal deposition. Conversely, two different MATs and CMTs values from the Yozgat-Sorgun and Çorum-Amasya areas (Armutlu formation) produced two different MART values, which are 5.15 ºC and 16.5 ºC for the Yozgat-Sorgun area and 4.1 ºC and 14.6 ºC for the Armutlu formation (Çorum-Amasya area) (Table 2). A high MART value (15 ºC) indicates continental conditions. However, lower MART values (4–5 ºC) suggest that the sedimentation occurred under a strong maritime influence (Sezer 1990). The lower MART values in the Eocene might be an indication of Indian ocean influence (Rögl 1994). In contrast, MART values in the Miocene of Anatolia are between 17 and 23 ºC indicating continental conditions (Kayseri & Akgün 2005). These authors also argued that the high MART values suggested a high palaeotopography. If so, either the palaeotopography in the Eocene was lower than in the Miocene, or an absence of polar ice prevented production of cold air masses in the winter.

Conclusions

The palynological data obtained from the Yoncalı formation in the Yozgat-Sorgun area suggest a Middle–?Late Eocene age.

A rich mangrove pollen association, important for the interpretation of the palaeoenvironment, was found in the Çankırı Basin. Dinoflagellate cysts such as *Wetzeliella*, *Cordospheridium* and *Homotryblium* indicate shallow marine conditions. The pollen of mangrove elements *Spinizonocolpites* (*Nypa*), *Avicennia* (Verbenaceae) and *Psilatricolporites crassus* (*Pelliciera*) represent depositional sites near a shoreline. In the back mangrove zones pollen of *Mauritiidites,* Restionaceae, Ephedraceae, *Proxapertites* and *Longapertites* as well as the fern spore *Acrostichum aureum* are present. Sparganiaceae, Nymphaceae, Taxodiaceae, Cupressaceae, *Crudia Nyssa* and some spores such as Polypodiaceae, Osmundaceae are typical swamp-freshwater elements. The rich lowland-riparian environment was dominated by presence of the Sapotaceae, Anacardiaceae-*Rhus*, Cyrillaceae, *Platanus/Salix*, Fagaceae, Myricaceae, Juglandaceae, Icacinaceae, *Ulmus*, and Betulaceae. Elements of a montane forest association, including *Pinus*, *Abies*, Symplocaceae, *Quercus*, and *Castanea,* were transported from a well-drained montane environment.

The mixture of temperate and tropical taxa from the coast to the montane environments suggests a range of climate. The mean annual temperature has been estimated to be in the order of 24.8–25 ºC in the megathermal zone, 23.1–24.8 °C in the megathermal/mesothermal intermediate zone (near the coast) and 16.5–23.1 °C in mesothermal (slope and montane environments).

A low mean annual range of temperature (MART) suggests Indian ocean influence during the deposition of the Middle–?Late Eocene coals in the Çankırı Basin. In conclusion, Alpine orogeny had concluded when Europe and Africa neared each other. The ocean currents in the Tethys originated from the Indian Ocean should have led to similar paleoecological conditions. The Çankırı Basin is in a significant location at the junction between the Tethys and Indian oceans during Middle–?Late Eocene period.

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PLATE I

All photomicrographs enlarged ×500, unless otherwise stated. Figured specimens are in the collections of the Dokuz Eylül University, Department of Geological engineering, İzmir, Turkey.

1, 2	*Retitiriletes stellarius* Krutzsch, Yozgat (Yerköy); from sample 99/108
3, 4	*Leiotriletes microadriennis* Krutzsch, Yozgat (Divanlı); from sample 99/100
5	*Leiotriletes adriennis* (R. Potonié & Gelletich) Krutzsch, Yozgat (Ayrıdam); from sample Z-13
6, 7	*Baculatisporites primarius* (Wolff) Thomson & Pflug ssp. *major* Raatz, Yozgat (Yerköy); from sample 99/108
8	*Triletes solidus* Krutzsch, Yozgat (Yerköy); from sample 99/108
9, 10	*Triletes asolidus* (Krutzsch) Krutzsch, Yozgat (Yerköy); from sample 99/108
11–13	*Ischyosporites foveosolidus* Krutzsch, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
14	*Leptolepidites* sp., Yozgat (Yerköy); from sample 99/108
15, 16	*Polypodiidites lusaticus* Krutzsch, Yozgat (Divanlı); from sample ZK99/15
17	*Verrucingulatisporites undulatus* Nagy, Yozgat (Yerköy); from sample 99/108
18	*Echinatisporites longechinus* Krutzsch, Yozgat (Yerköy); from sample 99/108
19, 20	*Echinatisporites* cf. *longechinus* Krutzsch, Yozgat (Yerköy); from sample 99/108
21	*Echinatisporites* cf. *faculeatus* Krutzsch, Yozgat (Yerköy); from sample 99/108
22	*Laevigatosporites haardti* (R. Potonié & Venkatachala) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/3
23	*Laevigatosporites discordatus* Pflug, Yozgat (Divanlı); from sample ZK99/15
24	*Verrucatosporites tenellis* (Krutzsch) Krutzsch, Yozgat (Yeniceköy); from sample 99/113
25–28	*Polypodiidites secundus* (R. Potonié) Krutzsch ssp. *secundus* Krutzsch, Yozgat (Ayrıdam); from sample Z-13
29, 30	*Monocolpopollenites tranquillus* (R. Potonié) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108
31, 32	*Pityosporites microalatus* (R. Potonié) Thomson & Pflug, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
33, 34	*Inaperturopollenites dubius* R. Potonié, Yozgat (Yeniceköy); from sample 99/113
35, 36	*Inaperturopollenites concepidites* (Wodehouse) Krutzsch, Yozgat (Yerköy); from sample 99/108
37, 38	*Inaperturopollenites hiatus* (R. Potonié) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/1

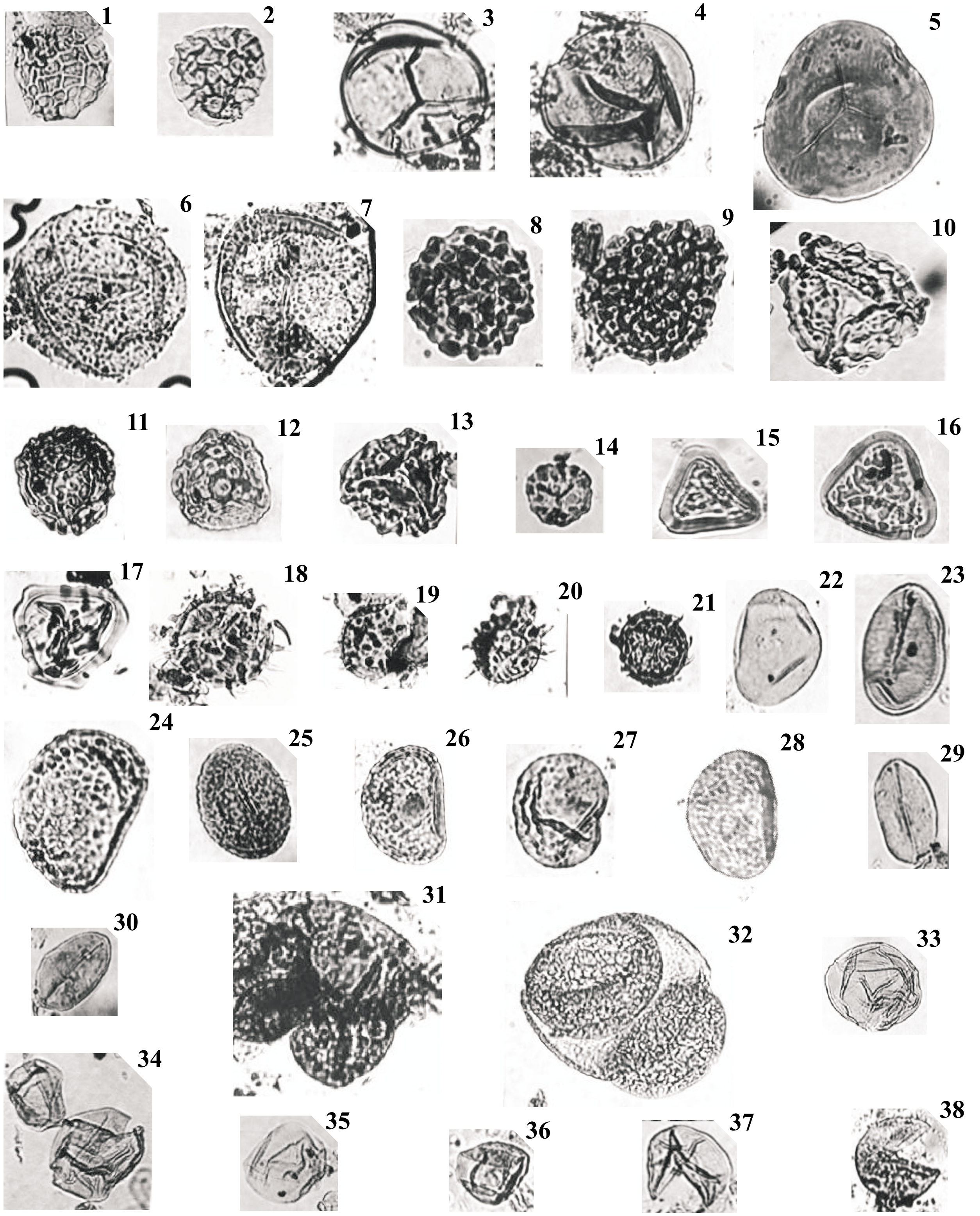
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PLATE II

1	*Arecipites brandenburgensis* Krutzsch, Yozgat (Divanlı); from sample ZK99/3
2	*Arecipites* sp., Yozgat (Divanlı); from sample ZK99/3
3	*Proxapertites granulatus* Singh & Singh, Yozgat (Yeniceköy); from sample 99/113
4	*Proxapertites microreticulatus* (Jain) Kar & Sah, Yozgat (Yeniceköy); from sample 99/113
5	*Proxapertites* sp., Yozgat (Yeniceköy); from sample 99/113
6–9	*Longapertites punctatus* Frederiksen, Yozgat (Divanlı); from sample 99/100
10, 11	*Longapertites retipilatus* Frederiksen, Yozgat (Divanlı); from sample 99/100
12, 13	*Longapertites* cf. *psilatus* Frederiksen, Yozgat (Divanlı); from sample ZK99/3
14	*Milfordia hungarica* (Kedves) Krutzsch & Vanhoorne, Yozgat (Yerköy); from sample 99/108
15	*Diporites iszkaszentgyoergyi* Kedves, Yozgat (Divanlı); from sample ZK99/3
16–20	*Kopekipollenites transdanubicus* Kedves, Yozgat (Divanlı); from sample 99/100
21, 22	*Interpollis microsupplingensis* Krutzsch, Yozgat (Yerköy); from sample 99/108
23	*Interpollis velum* Krutzsch, Yozgat (Yerköy); from sample 99/108
24	*Interpollis* cf. *velum* Krutzsch, Yozgat (Yerköy); from sample 99/108
25–29	*Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch, Yozgat (Ayrıdam); from sample Z-13
30–32	*Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch ssp. *minor* Pflug, Yozgat (Yerköy); from sample 99/108
33	*Plicapollis pseudoexcelsus* (Krutzsch) Krutzsch ssp. *turgitus* Pflug, Yozgat (Yerköy); from sample 99/108
34	*Plicapollis* cf. *conserta* Pflug, Yozgat (Yerköy); from sample 99/108
35–38	*Triatriopollenites rurensis* Thomson & Pflug, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
39	*Triatriopollenites excelsus* (R. Potonié) Thomson & Pflug, Yozgat (Buzacıoğlu); from sample Z99/2
40–44	*Plicatopollis lunatus* Kedves, Yozgat (Divanlı); from sample ZK99/15
45	*Plicatopollis plicatus* (R. Potonié) Krutzsch, Yozgat (Yerköy); from sample 99/108
46–48	*Plicatopollis* spp., Yozgat (Ayrıdam); from sample Z-13
49–53	*Momipites punctatus* (R. Potonié) Nagy, Thomson & Pflug, Yozgat (Buzacıoğlu); from sample Z99/2
54	*Momipites quietus* (R. Potonié) Nichols, Yozgat (Yerköy); from sample 99/108
55	*Anacolosidites ocutullus* Kedves, Yozgat (Yerköy); from sample 99/108
56–59	*Triporopollenites robustus* (Pflug) Thomson & Pflug, Yozgat (Ayrıdam); from sample Z–13
60–62	*Triporopollenites undulatus* Pflug, Yozgat (Divanlı); from sample ZK99/15
63–66	*Triporopollenites spackmanii* (Traverse) Kedves; from sample Z99/2
67–70	*Triporopollenites constatus* Takahashi, Yozgat (Buzacıoğlu); from sample Z99/2
71, 72	*Labrapollis labraferus* (R. Potonié) Krutzsch & Vanhoorne, Yozgat (Yerköy); from sample 99/108
73–79	*Celtipollenites laevigatus* Thiele-Pfeiffer, Yozgat (Buzacıoğlu); from sample 99/103
80, 81	*Subtriporopollenites constans* (Pflug) Thomson & Pflug, Yozgat (Ayrıdam); from sample Z–13

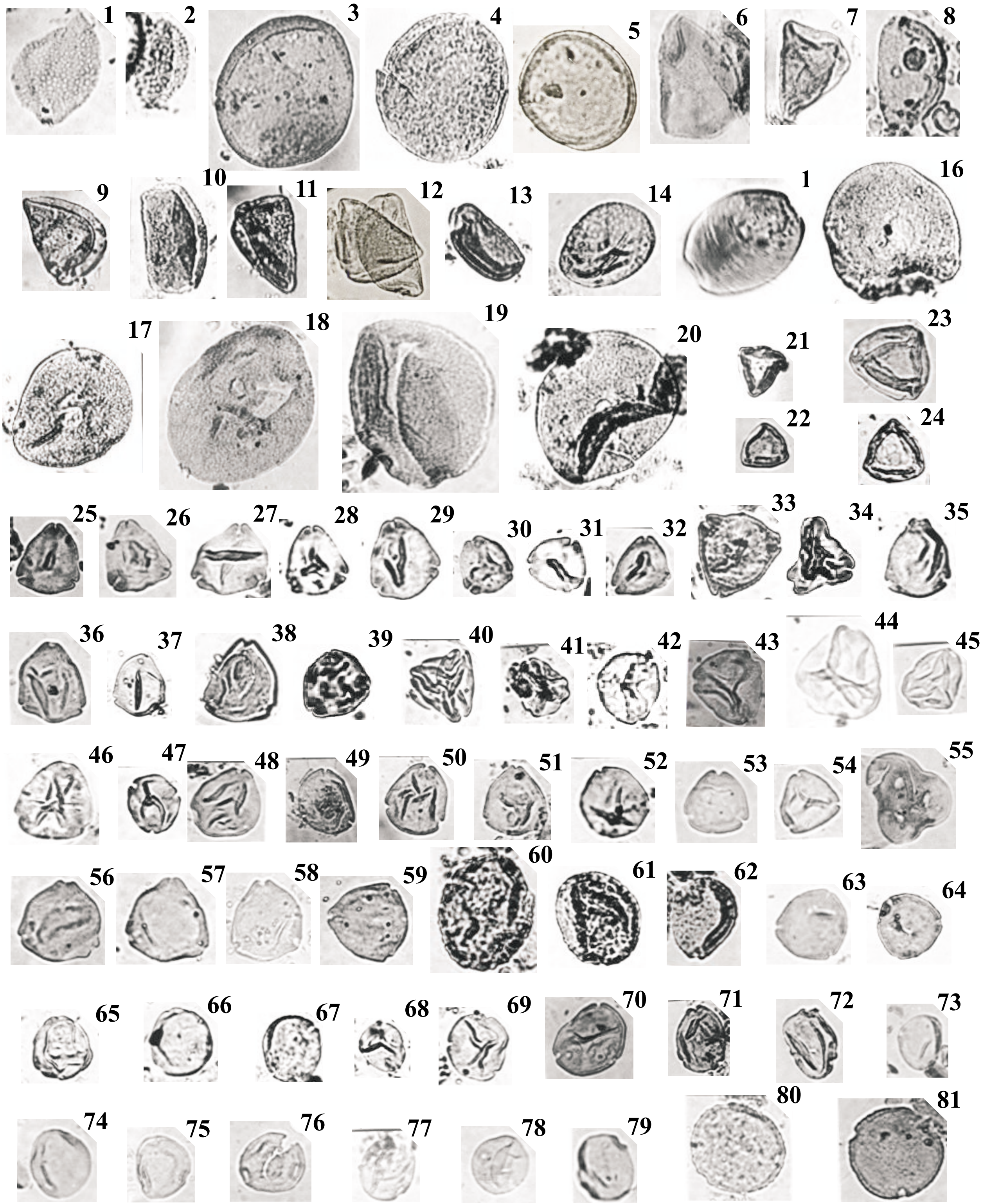
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PLATE III

1–6 *Subtriporopollenites anulatus* (Pflug) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/15
7–11 *Caryapollenites circulus* (Thomson & Pflug) Krutzsch, Yozgat (Divanlı); from samples ZK99/15 and 99/100
12, 13 *Compositoipollenites rizophorus* R.Potonié, Yozgat (Yerköy); from sample 99/108
14, 15 *Compositoipollenites rizophorus* (R. Potonié) R.Potonié ssp. *burghasungensis* R. Potonié, Yozgat (Buzacıoğlu); from sample Z99/2
16 *Compositoipollenites medius* Krutzsch & Vanhoorne, Yozgat (Yerköy); from sample 99/108
17 *Compositoipollenites minimus* Krutzsch & Vanhoorne, Yozgat (Yerköy); from sample 99/108
18 *Compositoipollenites* sp., Yozgat (Yerköy); from sample 99/108
19–22 *Mauritiidites franciscoi* (van der Hammen) van Hoeken-Klinkenberg, Yozgat (Divanlı); from sample ZK99/15
23 *Malvacipollis spinulosa* Frederiksen, Yozgat (Yerköy); from sample 99/108
24 *Polyporopollenites* sp., Yozgat (Yerköy); from sample 99/108
25 *Stephanoporopollenites hexanadiatus* (Thiergart) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108
26, 27 *Myrtaceidites* spp., Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
28, 29 *Pentapollenites punctoides* Krutzsch, Yozgat (Yerköy); from sample 99/108
30, 31 *Rhamnaceaepollenites triquetrius* Theile-Pfeiffer, Yozgat (Ayrıdam); from sample Z-13
32, 33 *Tricolpopollenites henrici* (R. Potonié) Thomson & Pflug, Yozgat (Ayrıdam); from sample Z–13
34, 35 *Tricolpopollenites densus* (Pflug) Thomson & Pflug, Yozgat (Ayrıdam); from sample Z–13
36–38 *Tricolpopollenites retiformis* (Pflug & Thomson) Thomson & Pflug, Yozgat (Yeniceköy); from sample 99/113
39–44 *Tricolpopollenites microhenrici* (R. Potonié) Thomson & Pflug, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
45 *Tricolpopollenites parmularius* (R. Potonié) Thomson & Pflug, Yozgat (Buzacıoğlu); from sample Z99/2
46, 47 *Tricolpopollenites* spp., Yozgat (Divanlı); from sample ZK99/3
48 *Striasyncolpites zwocardi* Germeraad, Yozgat (Yerköy); from sample 99/108
49 *Verrutricolpites* cf. *rotundiporis* Van Der Hammen & Wymstra, Yozgat (Yerköy); from sample 99/108
50 *Verrutricolpites* sp., Yozgat (Sorgun-Yeniçeltek); from sample ZK–8
51, 52 *Striatricolpites catatumbus* Gonzáles, Yozgat (Divanlı); from sample ZK99/3
53–55 *Psilatricolpites crassus* van der Hammen & Wymstra, Yozgat (Divanlı); from sample ZK99/3
56–59 *Polycolpites transdanubicus* Kedves, Yozgat (Yerköy); from sample 99/108
60 *Tricolporopollenites villensis* (Thomson) Thomson & Pflug, Yozgat (Ayrıdam); from sample Z-13
61–67 *Tricolporopollenites cingulum* (R. Potonié) Thomson & Pflug, Yozgat (Buzacıoğlu); from sample Z99/2
68–76 *Tricolporopollenites megaexactus* (R. Potonié) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/15
77 *Tricolporopollenites steinensis* (Pflug) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108

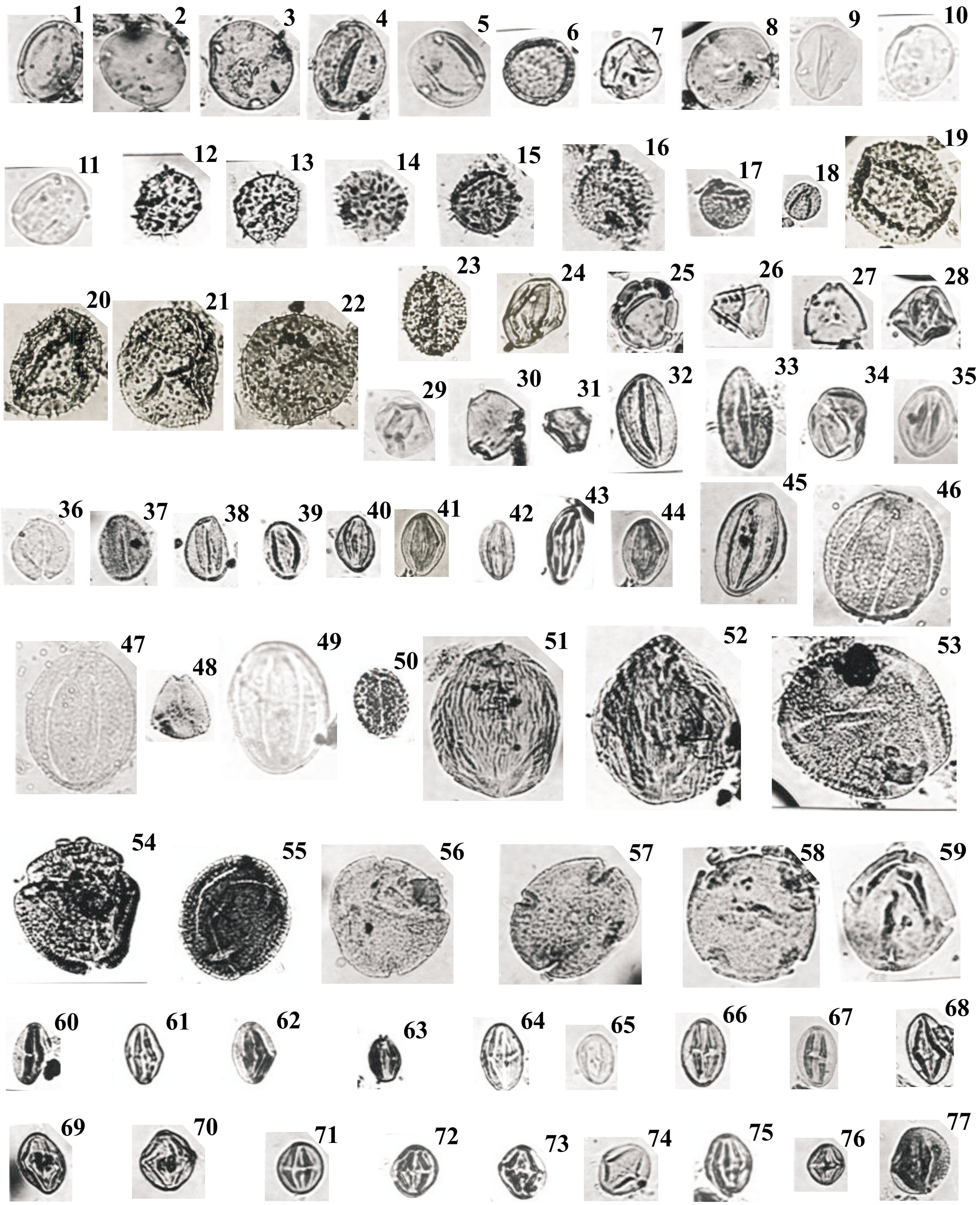
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PLATE IV

1–4	*Tricolporopollenites pseudocingulum* (R. Potonié) Thomson & Pflug, Yozgat (Yeniceköy); from sample 99/113
5–8	*Tricolporopollenites* cf. *pacatus* (Pflug) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/3
9–10	*Tricolporopollenites edmundi* R. Potonié, Yozgat (Yerköy); from sample 99/108
11–16	*Tricolporopollenites euphorii* (R. Potonié) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108
17, 18	*Tricolporopollenites macrodurensis* (Pflug & Thomson) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108
19, 20	*Tricolporopollenites kruschi* (R. Potonié) Thomson & Pflug, Yozgat (Yerköy); from sample 99/108
21–23	*Tricolporopollenites microreticulatus* (Pflug & Thomson) Thomson, Yozgat (Yerköy); from sample 99/108
24, 25	*Tricolporopollenites margaritatus* (R. Potonié) Thomson & Pflug, Yozgat (Divanlı); from sample ZK99/15
26, 27	*Tricolporopollenites oleoides* (Krutzsch & Vanhoorne), Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
28, 29	*Tricolporopollenites striatoides* Krutzsch, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
30–44	*Tricolporopollenites* spp., Yozgat (Divanlı); from sample ZK99/15
45	*Avicennia alba* Blume, Yozgat (Divanlı); from sample ZK99/3
46	*Ilexipollenites propinguis* Thille-Pfeiffer, Yozgat (Buzacıoğlu); from sample 99/103
47	*Salixpollenites major* Ke and Shi, Yozgat (Buzacıoğlu); from sample Z99/2
48	*Retitricolporopollenites retiformis* (Pflug) Thomson & Pflug, Yozgat (Sorgun-Yeniçeltek); from sample ZK-8
49	*Polygalacidites clarus* Sah & Dutta, Yozgat (Yerköy); from sample 99/108
50–56	*Polycolporopollenites* spp., Yozgat (Divanlı); from sample ZK99/15
57	*Polycolporopollenites viesenensis* Krutzsch, Yozgat (Divanlı); from sample ZK99/3

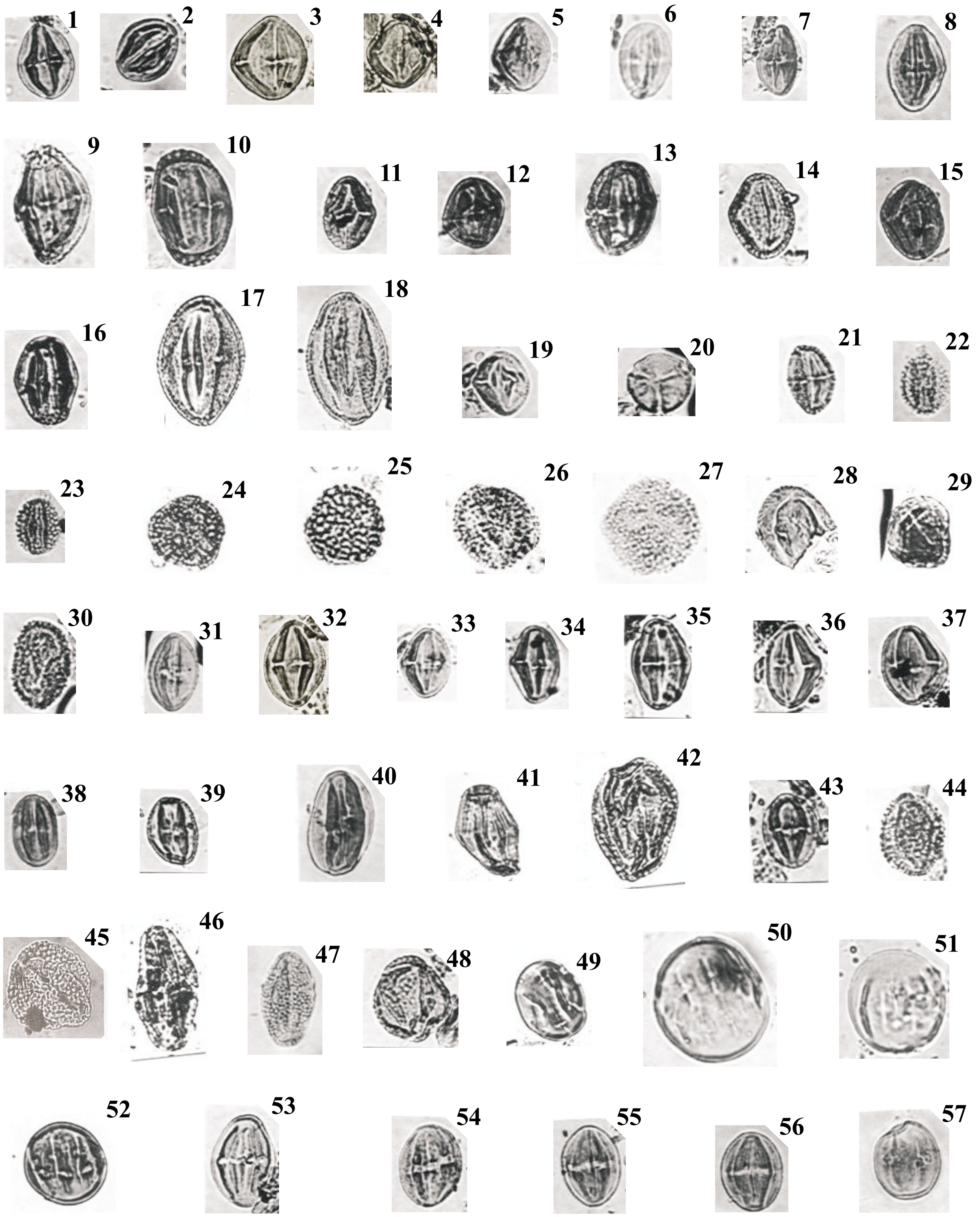
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PLATE V

1–12	*Spinizonocolpites* sp., Yozgat (Divanlı); from sample ZK99/3
13	*Spinizonocolpites* cf. *wodehousei* Singh, Yozgat (Divanlı); from sample ZK99/3
14, 15	*Spinizonocolpites bulbospinosus* Singh, Yozgat (Divanlı); from sample ZK99/3

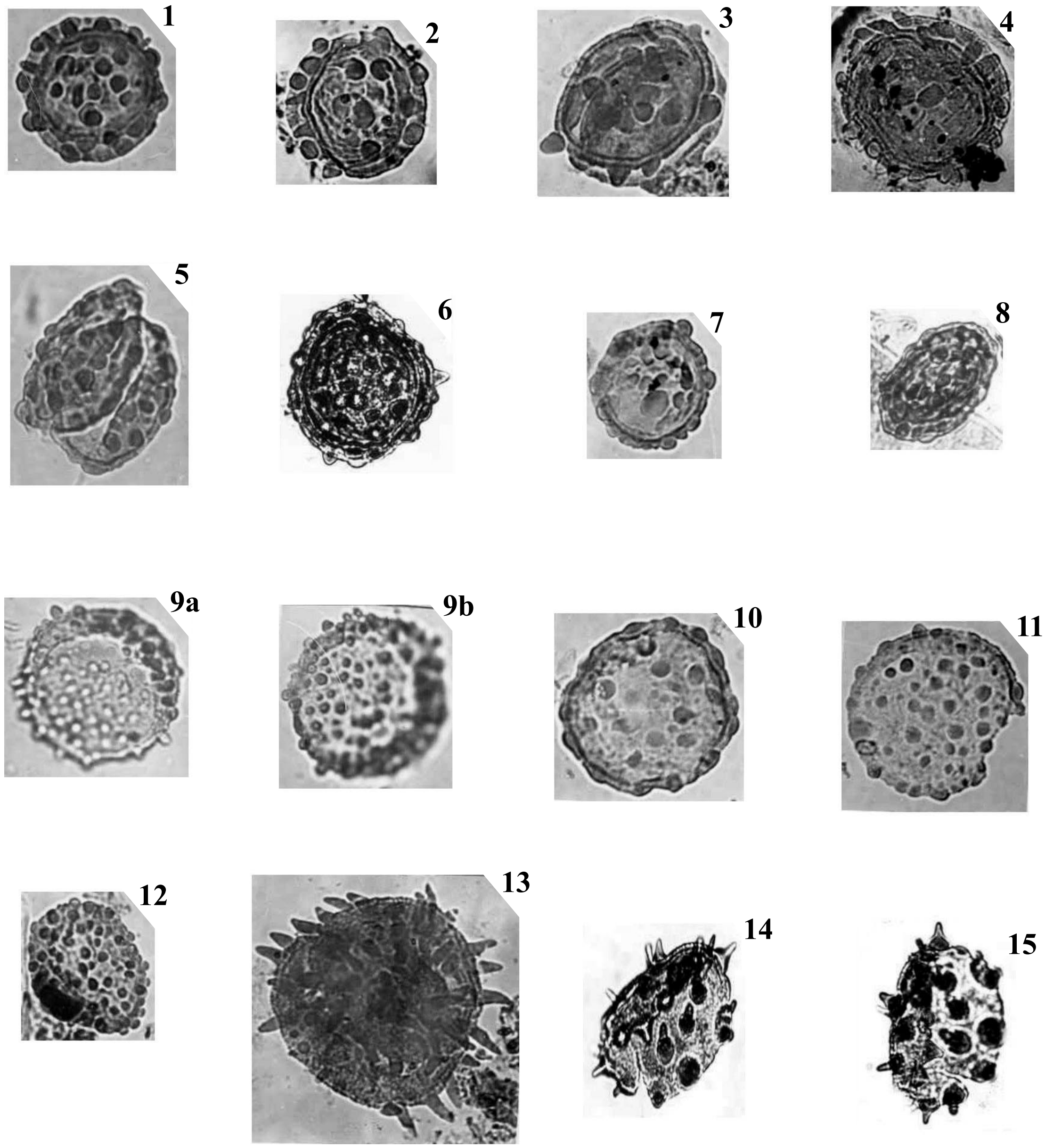
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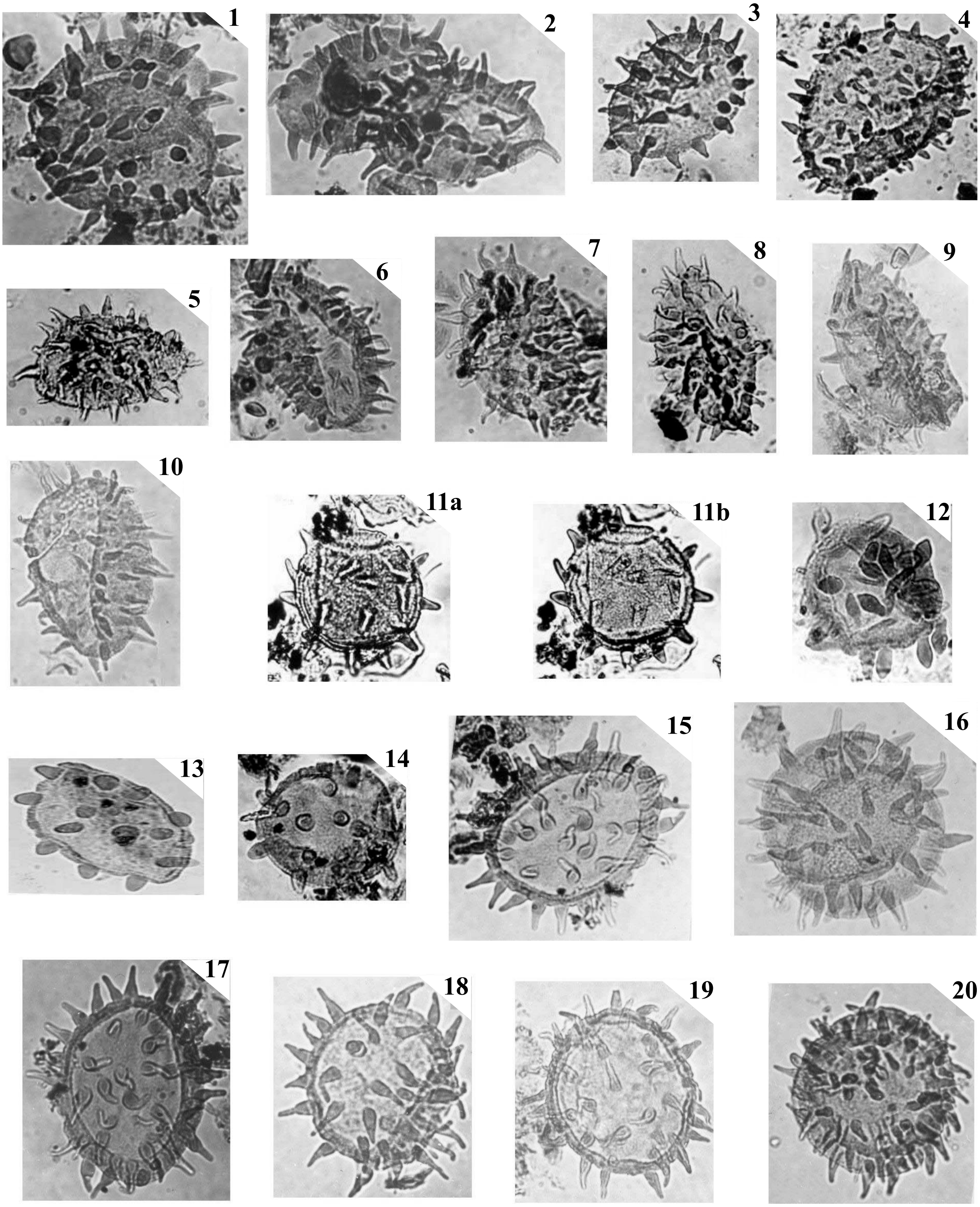
PLATE VI

1–4	*Spinizonocolpites echinatus* Singh, Yozgat (Divanlı); from sample ZK99/3
5–10	*Spinizonocolpites prominatus* Singh, Yozgat (Divanlı); from sample ZK99/3
11a, b	*Spinizonocolpites baculatus* Muller, Yozgat (Divanlı); from sample 99/100
12–14	*Spinizonocolpites* cf. *adamanteus* Frederiksen, Yozgat (Divanlı); from sample 99/100
15–20	*Spinizonocolpites indicus* Singh, Yozgat (Divanlı); from sample 99/100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Appendix 1. Quantitative distribution of the palynomorphs encountered in the Yoncalı formation of Yozgat-Sorgun area.

LOCATIONS		Palaeovegetational Properties	Palaeoclimatic Properties	Yozgat- Divanlı			Yozgat-Yerköy	Yozgat Yeniceköy	Yozgat Ayrıdam	Yozgat Sorgun-Yeniçeltek	Yozgat Buzacıoğlu	
SAMPLE NUMBERS				ZK99/3	ZK99/15	99/100	99/108	99/113	Z-13	ZK-8	99/103	Z99/2
SPORES												
Laevigatosporites haardti ssp. *haardti*				8	4		4	2				
Laevigatosporites discordatus	(Polypodiaceae)			1								
Laevigatosporites ovatus						3						
Laevigatosporites spp.										26		
Polypodiidites secundus ssp. *secundus*	(Polypodiaceae)	Swamp-Freshwater							2			
Polypodiidites lusaticus												
Ischyosporites foveosolidus	(Schizeaceae)											
Verrucatosporites tenellis	(Polypodiaceae)							1				
Verrucatosporites favus			Unknown					2				
Retriletes stellarius	*(Lycopodium)*						1					
Leiotriletes microadriennis	(Schizeaceae)					33	2	22	8	16		8
Leiotriletes maxoides maximus								1				
Leiotriletes adriennis	(*Acrostichum aureum*)	Back-Mangrove				11			40		4	
Concavisporites arugulatus	(? Gleicheniaceae)			10								
Baculatisporites primarius ssp. *major*							1					
Echinatisporites longechinus							1					
Echinatisporites cf. *longechinus*	(Selaginellaceae)	Swamp-Freshwater					1					
Echinatisporites cf. *faculeatus*							1					
Trilites solidus	(Schizeaceae)						1					
Trilites asolidus							1					
Polypodiaceoisporites lusaticus	(Polypodiaceae)						1					
Verrucingulatisporites undulatus	(Adiantaceae)						1					
Leptolepiidites sp.												
POLLEN												
Gymnosperm									1	14		
Pityosporites microalatus	*(Pinus)*	Montane	Unknown				2					
Inaperturopollenites concedipites	(Taxodiaceae:Taxodium, Glyptostrobus)				4		10	20		16	28	
Inaperturopollenites dubius	(Taxodiaceae)	Swamp-Freshwater	Mega-mesothermal		13			30		4	28	
Inaperturopollenites hiatus	(Taxodiaceae)										20	
Cupressacites bockwitzensis	(Cupressaceae)		Unknown									
Angiosperm												
Monocotyledoneae								2				
Sparganiapollenites polygonalis	(Sparganiaceae)	Swamp-Freshwater		6		5		6		26	1	
Cycadopites spp.	*(Cycas-Ginko)*	Lowland-Riparian					1					
Monocolpopollenites tranquillus	*(Palmae)*				8							
Monocolpopollenites zievelensis					4							
Arecipites brandenburgensis	(Arecaceae)			12								
Arecipites spp.			Unknown	2								
Proxapertites granulatus		Back-Mangrove		12								
Proxapertites microreticulatus	(Araceae)							1				
Proxapertites sp.								42			4	
Longapertites punctatus								1				
Longapertites cf. *psilatus*	(Arecaceae; Lepidocaryoideae)			4		4			10			
Longapertites retipilatus				40								2
Milfordia hungarica	(Restionaceae)					3			1			
Diporites iszkaszentgyoergyi	Unknown	Mangrove	Megathermal				2					
Kopekipollenites transdanubicus	(Monocotyledonopsidae)			1								
Interpollis microsupplingensis		Unknown	Unknown	1		8						
Interpollis velum	Unknown						1					
Interpollis cf. *velum*							1					
Spinozonocolpites gemmatus							1					
Spinozonocolpites microgemmatus				1								
Spinozonocolpites cf. *wodehousei*				1		25						
Spinozonocolpites indicus	*(Nypa)*	Mangrove	Megathermal	4		3						
Spinozonocolpites echinatus												4
Spinozonocolpites prominatus				2		4						
Spinozonocolpites baculatus				8		3						
Spinozonocolpites cf. *adamenteus*						7						
Spinozonocolpites spp.				16		52						
Dicotyledoneae												
Plicapollis pseudoexcelsus				18								
Plicapollis cf. *conserta*	(Myricaceae)			34								
Plicapollis pseudoexcelsus ssp. *minor*			Mesothermal		36		14		40	4		8
Plicapollis pseudoexcelsus ssp. *Turguitus*							1					
Triatriopollenites exelsus		Lowland-Riparian					1					
Triatriopollenites intermedius	(Myricaceae)						1					
Triatriopollenites rurensis				2	4	5	2		12			
Plicatopollis plicatus	(Juglandaceae)								24			6
Plicatopollis lunatus						3	2			12		
Plicatopollis spp.			Mega-mesothermal				4					
Momipites punctatus	(Engelhardia)			2	8			38	2		20	
Momipites quietus							4	1	6		4	
Platycaryapollenites miocaenicus	(Juglandaceae: *Platycarya)*											4
Platycaryapollenites platycaryoides							2					
Anacolosidites ocutulus	(Olacaceae)	?							1			
Triporopollenites robustus	(Betulaceae)		Microthermal						1			4
Triporopollenites constatus		Lowland-Riparian					1					
Triporopollenites undulatus			Unknown				1		18	2	2	
Triporopollenites spackmanii	(Corylaceae)											8
Triporopollenites sp.					4							
Labropollis labraferus	Unknown	Unknown	Unknown									2
Polyvestibulapollenites verus	(Betulaceae: *Alnus*)	Lowland-Riparian	Microthermal			4						
Echitriporites sp.	Unknown	Unknown	Unknown				1					
Subtriporopollenites anulatus	(? Juglandaceae)						1					

Appendix 1. (Contunied)

Subtriporopollenites constans		Lowland-Riparian	Mega-mesothermal								30	
Subtriporopollenites intraconstans					9		1				8	
Subtriporopollenites facilis									2		8	6
Caryapollenites circulus	*(Carya)*		Mesothermal		17			8			2	
Subtriporopollenites intrastructurus	(Ulmaceae/*Celtis*)		Meso-microtermal				1					
Subtriporopollenites spp.	Unknown	Unknown	Unknown		4	3	1		1	2		
Intratriporopollenites magnoporatus	(Juglandaceae)	Lowland-Riparian	Mega-mesothermal				1					
Intratriopollenites indubitaibilis	*(Tilia)*			4				2			4	
Compositoipollenites rhizophorus		Lowland-Riparian	Unknown				1					
Compositoipollenites rhizophorus ssp. *burghasungensis*					12	5	2					48
Compositoipollenites medius							1					
Compositoipollenites microechinatus	(Icacinaceae)											44
Compositoipollenites minimus							1					
Compositoipollenites sp.							1					
Mauridiites franciscoi	*(Mauritia)*	Back-Mangrove					1					
Malvacipollis spinulosa	(Malvaceae)	?					1					
Celtipollenites laevigatus	*(Celtis)*	Lowland-Riparian	Meso-microthermal		4		1					
Polyporopollenites sp.	Unknown	Unknown	Unknown				1					
Stephanoporopollenites hexaradiatus	Unknown										4	
Porocolpopollenites rotundus	(Symplocaceae)	Montane					1					
Porocolpopollenites sp.	Unknown	Unknown					1					
Pentapollenites punctoides	Unknown						1					
Rhamnaceaepollenites triquetrius	(Rahamnaceae)	Lowland-Riparian		2			2					
Tricolpopollenites pudicus		Montane	Mega-mesothermal				2					
Tricolpopollenites henrici	*(Quercus)*								6			
Tricolpopollenites asper							1					
Tricolpopollenites densus									6			
Tricolpopollenites parmularius	(Fagaceae, Eucommiaceae:Eucomminia)											4
Tricolpopollenites retiformis	*(Platanus/Salix)*		Mesothermal		4					10		
Tricolpopollenites microhenrici	(Fagaceae/?*Quercus*)		Mega-mesothermal				10					6
Tricolpopollenites liblarensis	(Fagaceae)			2				16				
Tricolpopollenites spp.		Unknown	Unknown		4	3	2		12	14	4	4
Striasyncolpites zworcardi	Unknown									6		4
Verrutricolpites cf. *rotundiporis*				8				2				
Verrutricolpites sp.							1					
Striatricolpites catatumbus	*(Crudia)*	Swamp-Freshwater					1					
Retitricolpites sp.		Unknown								1		
Polycolpites micropunctatus	Unknown			1								
Polycolpites transdanubicus					8		1					
Myrtaceidites sp.	(Myrtaceae)	Lowland-Riparian	Mega-mesothermal				1					
Tricolporopollenites villensis	(Anacardiaceae/*Rhus*)						1					
Tricolporopollenites cingulum	*(Castanea)*									2		
Tricolporopollenites megaexactus	(Cyrillaceae)						4		8	4	6	
Tricolporopollenites undulatus	Unknown	Unknown	Unknown		8		106					24
Tricolporopollenites steinensis					13		1			4	4	2
Tricolporopollenites striatoides										8		
Tricolporopollenites pseudocingulum	(Anacardiaceae)	Lowland-Riparian					1					
Tricolporopollenites cf. *pacatus*	(Simaroubaceae)						2		4	14		
Tricolporopollenites edmundi	(Mastixiaceae)						2	4			1	
Tricolporopollenites euphorii	(Araliaceae)			4	4		1					4
Tricolporopollenites macrodurensis	Unknown	Unknown					2					
Tricolporopollenites kruschi	*(Nyssa)*	Swamp-Freshwater	Mega-mesothermal				1					
Tricolporopollenites microreticulatus	Caprifoliaceae: *Sambucus*	Lowland-Riparian	Unknown				1					
Tricolporopollenites margaritatus	*(Ilex)*		Mesothermal		4							
Tricolporopollenites oleoides	*(Armeria)*		Unknown				1					
Tricolporopollenites messelensis	(Rutaceae)						14			2		
Tricolporopollenites striatoides	Unknown	Unknown		4								
Psilatricolporites crassus	(Theaceae)	Mangrove	Megathermal	1								2
Avicennia alba	(Verbenaceae)		Mega-mesothermal				1					
Ilexipollenites propinguis	*(Ilex)*	Lowland-Riparian	Mesothermal								1	
Salixpollenites major	*(Salix)*	Montane				3						
Retitricolporopollenites retiformis	Unknown	Unknown	Unknown							1		
Tricolporopollenites spp.							1					
Polygalacidites clarus					20	3				12		4
Polycolporopollenites viesenensis							1					
Polycolporopollenites spp.							1					
Tetracolporopollenites obscurus	(Sapotaceae)	Lowland-Riparian	Megathermal		4		1					
Tetracolporopollenites microellipsus							1					
Tetracolporopollenites sapotoides								2				
TOTAL				211	200	190	249	203	205	200	184	198

Appendix 2. Quantitative distribution of the palynomorphs encountered in the Yozgat-Çiçekdağ (Yoncalı formation), Çorum-Amasya (Armutlu and Çeltek formations) areas (data from Akgün 2002 and Akgün *et al.* 2002).

LOCATION	Palynomorphs	Palaeovegetational Properties	Palaeoclimatic Properties	Yozgat-Cicekdağ area								Çorum-Amasya area										Çorum-Amasya area								
FORMATION				YONCALI								ARMUTLU										ÇELTEK								
SAMPLE NUMBERS				3	8	10	12	13	14	15	17	A4	A8	A38	A39	A74	A75	A28	A8	A33	A18	Ç48	Ç49	Ç3	Ç70	Ç71	Ç14	Ç16	Ç31	Ç37
Pteridophytes																														
Leiotriletes microadriennis	Schizaeacea: ? *Lygodium*	Swamp-Freshwater	Unknown		3	3			*				19	2	26	30	43	14	24	3	35	3	22		44	60	53	66	39	31
Leiotriletes adriennis	*Acrostichum aureum*	Back-Mangrove											6	5	7		2	21	2		13		1		1	5	1	3		
Leiotriletes maxiodes ssp. *maximus*		Swamp-Freshwater												2	1	4		5	*			6				5				
Leiotriletes wolffi ssp. *wolffi*	Polypodiaceae: *Microlepia*												*												4			1	1	
Leiotriletes wolffi ssp. *brevis*	Polypodiaceae: *Microlepia*																											*		
Leiotriletes neddenioides	?Schizaeceae																									*				
Leiotriletes seidewitzensis															3		1													
Leiotriletes microsinuosoides															2								1							
Deltoidisporites cf. *rotundus*														*																
Punctatisporites tanndorfensis	Fernspore; ?Schizaeaceae													*																
Divisisporites sp.													*																	
Toroisporites neddeni													*																	
Neogenisporis sp.	?Gleicheniaceae												*																	
Concavisporites pseudopartitus	?Gleicheniaceae														*															
Concavisporites arugulatus											*																			
Concavisporites cf. *undulatus*																														
Lusatisporites sp.																				1					1					
Echinatisporis hungaricus	Selaginellaceae											1											1							
Echinatisporis erinaceus																*														
Echinatisporis cf. *aculeatus*																					*									
Echinatisporis cf. *spiculum*																														*
Baculatisporites quintus ssp. *quintus*	Osmundaceae:Osmunda																					1								
Baculatisporites quintus ssp. *pseudoprimarius*																											1			
Baculatisporites quintus ssp. *rugulatoides*																						8	1							
Baculatisporites primarius ssp. *primarius*																						14	8							
Baculatisporites primarius ssp. *major*						1	4	1		4	*											2	1							
Baculatisporites primarius ssp. *oligocaenicus*																						2	1							
Baculatisporites gemmatus																														
Trilites solidus	?Lycodiaceae						1		*			1											2							
Trilites multivallatus	Schizaeaceae, Lygodiaceae: *Lygodium*												*																1	
Trilites (*Ischyosporites*) *tertiarius*													1							13	3	1		28						
Trilites cf. *menatensis*													*																	
Ischyosporites asolidus	?*Aremeria* , *Kygodium* , ?*Cibotium*																					6							2	
Ischyosporites foveosolidus	Schizaeaceae																					1								
Cicatricosisporites paradorogensis	Schizaeaceae: *Ruffordia* , Subcretacea								*															*					*	*
Cicatricosisporites regularis																														
Retitriletes sp.																	1									*				
Polypodiaceoisporites gracillimus ssp. *semiverrucatus*												*									3	1	1		1				1	
Polypodiaceoisporites saxonicus	Polypodiaceae: *Pteris* ;Cyatheacea					*									1							*	*						3	
Polypodiaceoisporites marxheimensis	? *Lycopodium*									1	4																			
Polypodiaceoisporites lusaticus	Polypodiaceae: *Pteris*																						*						4	
Polypodiaceoisporites cf. *cyclocingulatus*																										1				
Polypodiaceoisporites sp.																													1	
Gleicheniidites simplex	?Gleicheniaceae								1																					
Cingulatisporites levispeciosus														*									*					*		
Leavigatosporites gracilis	Polypodiaceae												3									1								
Leavigatosporites haardti ssp. *haardti*				3	7		2	8				7	25		3	5	11	2	32	55	22	18	15	36	2		6	3	5	35
Leavigatosporites cf. *haardti*													*																	
Laevigatosporites ovatus																														5
Leavigatosporites discordatus													3			*	4													
Polypodiidites secundus ssp. *secundus*													*			5	1		2			12	6		3		2		10	*
Microfoveolatosporis pseudodentatus	?Schizaeceae: *Schizaea*												*												1					
Echinosporis cf. *echinatus*	Polypodiaceae:*Dryopteri,Cystoptens*												*																	
Verrocosisporites cf. *rariverrucatus*	?Polypodiaceae								*																					
Verrucatosporites favus ssp. *favus*	Polypodiaceae: *Polypodium*												*			*		2	1			1	*	4						
Verrucatosporites favus ssp. *gracilis*												*																	4	*
Verrucatosporites tenellis	Polypodiaceae																					1								
Verrucatosporites favus ssp. *magnus*				3				1	*							*														
Verrucatosporites favus ssp. *pseudosecundus*														*																
Verrucatosporites cf. *alenius*	Polypodiaceae: *Polypodium*						2				*																			
GYMNOSPERM																														
Pityosporites microalatus	Pinaceae: *Pinus*	Montane	Unknown	2		2	2	3	9	4	6			*		*														
Abiespollenites cf. *latisaccatus*	Pinaceae:*Abies*													*																
Inaperturopollenites magnus	*Psuedotsuga/Larix*	Swamp-Freshwater				1	1			*	*																			
Inaperturopollenites hiatus	Taxodiaceae		Mega-mesothermal	1		1		*																						
Inaperturopollenites emmaensis	Cupressaeae		Unknown	1	15	3	4	5	5	13																				
Inaperturopollenites concedipites	Taxodiaceae:*Taxodium,Glyptostrobus*		Mega-mesothermal	1	25	1	5	18	20	23	10		1	6																
Cupressacites cuspidataeformis	Cupressaeae:*Taxus*		Unknown													20							1		5					
Ephedripites claricristatatus	Ephedraceae	Back-Mangrove		3			2			7	*																			
Ephedripites hungaricus							*			*																				
Ephedripite eosenipites				1																										
Ephedripites sp.									3					*																

Appendix 2. (Contunied)

LOCATION	Palynomorphs	Palaeovegetational Properties	Palaeoclimatic Properties	Yozgat-Çiçekdağ area								Çorum-Amasya area										Çorum-Amasya area								
FORMATION				YONCALI								ARMUTLU										ÇELTEK								
SAMPLE NUMBERS				3	8	10	12	13	14	15	17	A4	A8	A38	A39	A74	A75	A28	A8	A33	A18	Ç48	Ç49	Ç3	Ç70	Ç71	Ç14	Ç16	Ç31	Ç37
ANGIOSPERM																														
Monocotyledon																														
Graminidites subtiliglobosus	Gramineae	Lowland-Riparian	Unknown													1										*				
Graminidites laevigatus																					1									
Milfordia minima	Restionaceae:*Lyginia*	Mangrove												51	4	2														
Milfordia hungaricus	Restionaceae													29		1														
Sparganiaceaepollenites polygonalis	Sparganiaceae	Swamp-Freshwater														5	2										6	7		
Sparganiaceaepollenites neogenicus																	6											1		
Sparganiaceaepollenites magnoides																	1									*				
Aglaoreidia cyclops		Lowland-Riparian												*																
Cycadopites intrastructus	*Cycas-Ginko*												*																	
Cycadopites cf. *intrastructus*													*	*																
Cycadopites cf. *gracilis*													*						5											
Cycadopites tulipiferus														*																
Cycadopites kyushuensis																1														
Cycadopites spp.												4	3		2				1						3	4	1			3
Monocolpopollenites tranquillus	Palmae	Back-Mangrove													3	*														
Monocolpopollenites crassiexinus	Nymphaeaceae, ?*Nymphaea*												1						1				6				1	*	1	1
Arecipites wiesaensis	Arecaceae														1															
Arecipites papillosus																										6				
Arecipites cf.*eopapillosus*														*												5				
Arecipites sp.														*													1	5		1
Proxapertites microreticulatus	Araceae, *Astrocaryum*											12													*	6				
Proxapertites granulatus																						1								
Longapertites triangulatus	Arecaceae: Lepidocaryoidae: probably *Eugeissona*											2		2	2															
Longapertites punctatus												2		1	7	1	2		11	3					9	7			1	
Longapertites indicus												1			2				2											
Longapertites cf. *psilatus*												1							2											
Longapertites hammenii														3	2															
Longapertites discordis														*																
Spinizonocolpites prominatus	*Nypa* ,Typically Mangrove	Mangrove	Megathermal				1		1		2				*	*														
Spinizonocolpites cf. *baculatus*								2	1		1																			
Spinizonocolpites bulbospinosus																														
Spinizonocolpites spp.						*			*																					
Monogemmites pseudosetarius	Arecaceae: *Palmae*	Unknown	Unknown	1			1				1																			
Monogemmites ovalis																											1			
Dicotyledon																														
Plicapollis pseudoexcelsus	Juglandaceae:Myricaceae	Lowland-Riparian	Unknown			1			2			2	*		4				2			3	5	6	12			1	7	3
Triatriopollenites excelsus	Myricaceae:*Myrica*		Mesothermal	7	5	11	7	4	2	5	3		1					2	1		10	5	4				7			*
Triatriopollenites rurensis				3	2	4	2	2	1		3		*								1	1								
Triatriopollenites rurobituitus											1																			
Triatriopollenites bituitus						4			*														1							
Triatriopollenites spp.				*					1								1													
Plicatopollis plicatus	Juglandaceae		Mega-mesothermal									7	4	1	5	5	2			5						2	3	1		
Plicatopollis lunatus												1								*										
Plicatopollis sp.												1																		
Momipites punctatus	Juglandaceae:*Engelhardia*			1	2	1						3	2			1	1		1	3		*	*		1				2	
Momipites quietus	Juglandaceae:*Engelhardia*						*						1										*				4	1		
Platycaryapollenites cf. *platycaryoides*	Junglandaceae, Platycarya								*			2																		
Platycaryapollenites miocaenicus						2							*	*	2												3			
Triporopollenites constatus	Corylaceae		Unknown												3	1	2			1			1			1				1
Triporopollenites spackmanii					*	3			4		*				2					1										
Triporopollenites robustus												1																		
Triporopollenites megagranifer																				1										
Labrapollis globosus	?Juglandaceae											1	1		3	3	1					1	2			1	1	1		
Polyvestibulopollenites verus	Betulaceae:*Alnus*		Microthermal																1							*				
Celtipollenites intrastructus	Ulmaceae: *Celtis*	Lowland-Riparian	Meso-microthermal												*					2			*		1					
Celtipollenites laevigatus																													2	
Subtriporopollenites constans	?Juglandaceae		Mesothermal	2		1	1		1							1	1							2		1	1	*		
Subtriporopollenites palaeogenicus						3			1																					
Subtriporopollenites intraconstans				1		4					*		1																	
Subtriporopollenites instructus						*		1			*																			
Subtripollenites anulatus ssp. *nanus*	Juglandaceae: cf. *Carya*			1		2	4	4		4	*	3	1	*		3	4		2						1		1	7		
Subtriporopollenites magnoporatus	Juglandaceae															*														
Caryapollenites circulus	Juglandaceae: *Carya*				1	1					4				*						*			3						
Caryapollenites triangulus	Juglandaceae: *Carya*																		*											
Compositoipollenites rizophorus ssp. *burghasungensis*	Icacinaceae:? *Iodes, Polyporandra*		Unknown		*	*					*		4											2						
Compositoipollenites minimus																*														
Intratriporollenites indubitabilis	*Tilia*		Mega-mesothermal	*						*				*											*					
Intratriporollenites magnoporatus										1																				
Intratriporollenites instructus				1		*																								
Polyporopollenites undulosus	Ulmaceae: *Ulmus, Zelkova*		Microthermal	3						2	1													2						
Polyporopollenites cf. *stellatus*	*Pterocarya*		Unknown									1							1											
Polyporopollenites sp.																														
Porocolpopollenites rotundus	Symplocaceae	Montane	Mega-mesothermal	*		1	1		1																					
Porocolpopollenites cf. *rotundus*							1																							
Porocolpopollenites stereofomis						2			1																					
Porocolpopollenites vestibulum						2																								
Porocolpopollenites sp.									1	1																				

Appendix 2. (Contunied)

LOCATION	Palynomorphs	Palaeovegetational Properties	Palaeoclimatic Properties	Yozgat-Çiçekdağ area								Çorum-Amasya area										Çorum-Amasya area								
FORMATION				YONCALI								ARMUTLU										ÇELTEK								
SAMPLE NUMBERS				3	8	10	12	13	14	15	17	A4	A8	A38	A39	A74	A75	A28	A8	A33	A18	Ç48	Ç49	Ç3	Ç70	Ç71	Ç14	Ç16	Ç31	Ç37
Pentapollenites cf. *punctoides*		Unknown	Unknown									5													10			*		
Pentapollenites sp.																			1	1			4					*		*
Tricolpopollenites henrici	Fagaceae : *Quercus*	Montane	Mega-mesothermal			1						1		*		*														
Tricolpopollenites pudicus						*																								
Tricolpopollenites asper											1			*																
Tricolpopollenites microhenrici				3		1	2		1		1			*	2	1	1		*		5		*					1	2	
Tricolpopollenites densus				4	12	4	3					1	3		1	7	6	24						7				1	2	2
Tricolpopollenites retiformis	Salicaceae:*Salix/Platanus*		Mesothermal		1	1		1			1		13		1	3			1				5			2	1	*		
Tricolpopollenites liblarensis	Fagaceae				1	2								*		1												1		
Tricolpopollenites parmularius	Eucommiaceae:*Eucommia*	Lowland-Riparian														*										*				
Tricolpopollenites spp.		Unknown	Unknown		1	*	2						1																	
Tricolpites longicolpus													2																	
Myrtaceidites sp.	Myrtaceae	Lowland-Riparian	Mega-mesothermal	*									*	*																
Pistilipollenites mcgregorii	Gentianaceae	Unknown	Unknown					1		1																				
Tricolporopollenites villensis	?Anacardiaceae:*Rhus*	Lowland-Riparian	Mega-mesothermal			*		1							*							1	1							
Tricolporopollenites cf. *villensis*													*																	
Tricolporopollenites cingulum	Fagaceae:*Castanea*		Mega-mesothermal	19		6		*	*	1		2	2				2	2	4	2		4	3	6					3	2
Tricolporopollenites megaexactus	Cyrillaceae			6	2	6	2	7	3	2	7		4		2	*	1					1	3	2			3			11
Tricoporopollenites steinensis	Un known	Unknown	Unknown					1					1															*		
Tricolporopollenites dolium	Anacardiaceae:*Rhus*	Lowland-Riparian	Mega-mesothermal										*																	
Tricolporopollenites pseudocingulum	Anacardiaceae			*		*			1																					
Tricolporopollenites pacatus	Simaraubaceae		Unknown	*		6			1		1		*										1	1			1	1		
Tricolporopollenites edmundi	?Mastixiaceae, ?Cornaceae											1	*																	
Tricolporopollenites euphorii	Araliaceae											3	*		2		1			1			1							
Tricolporopollenites marcodurensis	Vitaceae												*		*															
Tricolporopollenites kruschi	Nyssaceae:Nyssa	Swamp-Freshwater	Mega-mesothermal	1		3							*		*	*					2			2		*	1	*		
Tricolporopollenites baculaferus	Un known	Unknown	Unknown			*			1																	*				
Psilatricolporites crassus	Theaceae. Pelliciera	Mangrove	Megathermal															24	*	1	5									
Tricolporopollenites cf. *porasper*	?Fagaceae	Lowland-Riparian	Unknown								1							2												
Tricolporopollenites microreticulatus	Caprifoliaceae: *Sambucus*			4		5		2	1		5	2		*	1				1				1		1				2	
Tricolporopollenites margaritatus	Aquifoliaceae/Ilex		Mesothermal	27	4	3	4	3	6	10	4																			
Tricolporopollenites striatoides	Un known	Unknown	Unknown												3			2												
Tricolporopollenites striatopunctatus	Un known												1																	
Tricolporopollenites sole-de-portai	?Anacardiaceae,?Rosaceae	Lowland-Riparian										1	1		*								*							
Avicennia type *alba*	Verbenaceae	Mangrove	Mega-mesothermal												*															
Avicennia type *marina*														*			2			1										
Tricolporopollenites messelensis	Rutaceae	Lowland-Riparian	Unknown											1		*														
Tricolporopollenites spp	Un known	Unknown		1		1		1	1	1							1		1											
Tetracolporopollenites obscurus	Sapotaceae	Lowland-Riparian	Megathermal			1			1														1						1	*
Tetracolporopollenites abditus						2	6	1	3	2	1				*							1	1							
Tetracolporopollenites microelipsus						2			1																					
Tetracolporopollenites sapatoides						*																								
Tetracolporopollenites manifestus						2			1						1							1					1			
Tetracolporopollenites folliformis																											*			
Tetracalporopollenites spp.				21							*	2															*			1
Areosphaerdium arcuatum	Dinofgellate cycsts	Marine	Unknown					2																						
Batiacasphaera sp.							1	2		1																				
Cleistosphaeridium sp.							2		*		2																			
Cordosphaeridium inodes							2		*		*																			
Cordosphaeridium sp.									*																					
Homotryblium sp.							2				1																			
Impagidinium sp.											5																			
Impletosphaeridium sp.							7	21	*	1	10																			
Melitasphaeridium sp.							2		8	7																				
Operculodinium microtriainum						*	3				2																			
Pentadinium sp.							1		2																					
Phthanoperidinium amoenum							1				3																			
Polysphaeridium sp.							2	1			3																			
Samlandia sp.									1																					
Spiniferites ramosus							5	3		1																				
Spiniferites sp.							7	1	2	5	8																			
Wetzeliella lunaris						*			3																					
Wilsonidium echinosuturatum								*																						
Wilsonidium cf. *tabulatum*								1																						
Wilsonidium sp.								2	1	1																				
Dinoflagellate spp.					19		5		7	2	1						*													