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On the Tertiary History of the *Theaceae* in Bulgaria

Abstract

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7 fossil taxa of Neogene sediments from the Satovcha Graben in the Western Rhodopes (Southwest Bulgaria), belonging to family *Theaceae* have been analyzed. 4 new species have been established. Genus *Adinandra* has been established for the first time for European Tertiary flora.

Introduction

The representatives of family *Theaceae* play a considerable role in Palaeoholarctic Tertiary flora. They are important phytocoenotic and phytoecological indicators and from that point of view every new finding provokes indisputable interest.

The Tertiary area of the family is disjuncted but, as a whole, it comprises a large part of the Palaeoholarctic floristic kingdom (with the exception of its northernmost regions).

The palaeofloristic data obtained so far testify to the presence of three Tertiary speciation centers: North American (Grote & Dilcher 1989, 1992), Central European (Mai 1960, 1971, Kvaček & Walther 1984a, 1984b, Mai & Walther 1985) and Japanese (Tanai 1970, Tanai & Onoe 1961, Tanai & Suzuki 1972).

The greatest floristic saturation is demonstrated by the North American part of the area. It concentrated representatives of the genera *Camellia*, *Eurya*, *Gordonia* s. str., *Hartia*, *Polyspora*, *Schima*, *Stewartia*, *Ternstroemia*, *Visnea* (Mai & Walther 1985, 1987, Kvaček & Walther 1984a, 1984b).

Bulgarian Tertiary flora, as part of the European area of the family, proves also to be a rich refuge for its representatives. The studies carried out so far have provided data about the composition of the genera *Camellia*, *Eurya*, *Gordonia* s. l. (incl. *Polyspora*), *Stewartia* (Stefanov & Ganchev 1951, Palamarev 1971, 1982, 1993, 1989, Palamarev & Petkova 1987).

The present paper reports the results of the taxonomic study of the floristic materials from family *Theaceae* found in the Neogene sediments from the Satovcha Graben in the Western Rhodopes (Fig. 1). The new data obtained confirm the unique character of that flora from a systematic, phytogeographical and ecological point of view (Palamarev et al. 1991, Palamarev & Bozukov 1992, Bozukov & Palamarev 1992, Bozukov in press).

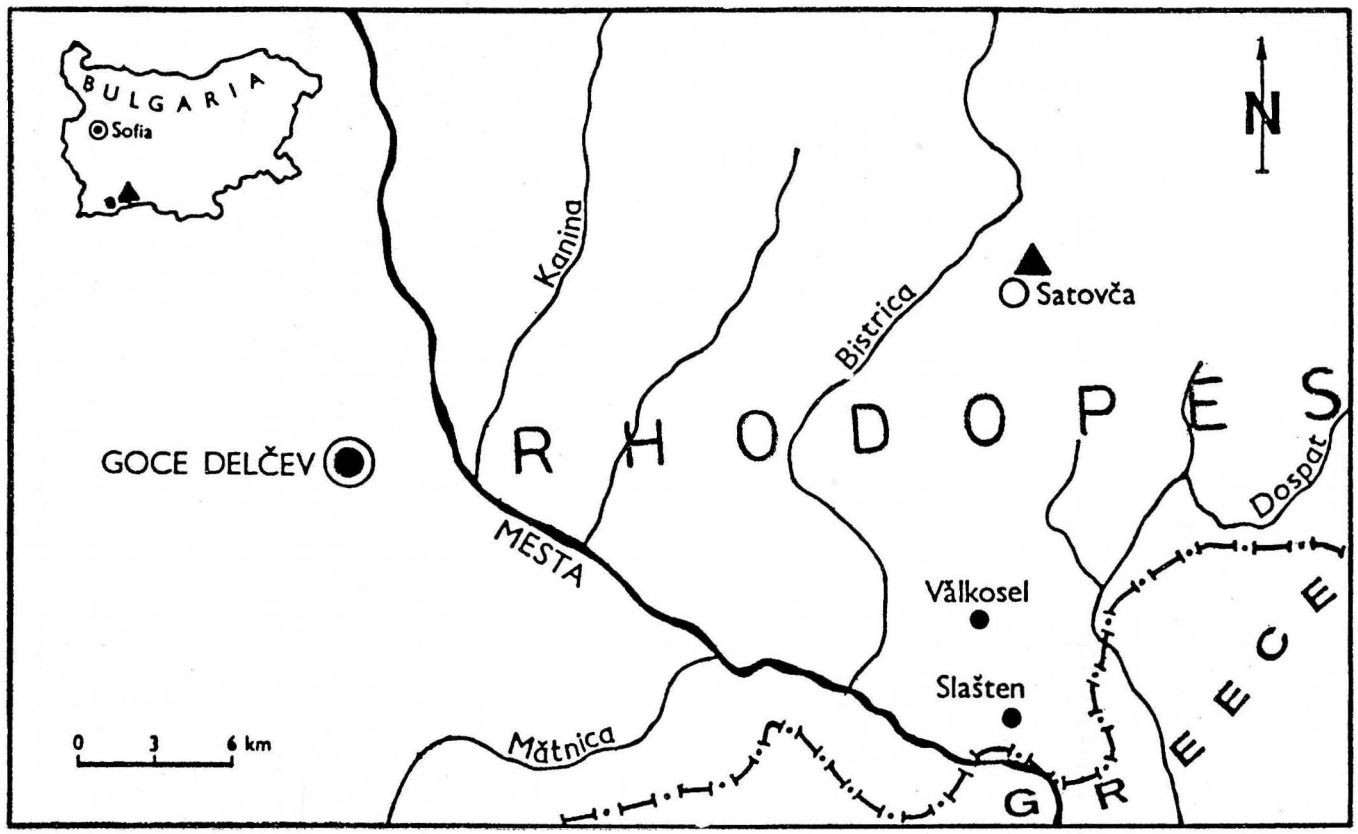


Fig. 1. Map showing locality of flora-bearing sediments near Satovcha village.

The flora-bearing sediments in the graben belong to the so-called Sivik formation and their age is disputable.

According to Vacev & Pirumova (1983) it is Middle - Late Miocene, while Palamarev & Bozukov (1992) determined it as Middle Miocene - a continental equivalent of the Badenian.

Systematic part

The systematics of family *Theaceae* has no scheme which is commonly agreed upon. According to Melchior (1925) and Airy-Shaw (1936) the 25 genera of the family are grouped into two subfamilies: *Ternstroemioideae* and *Camellioideae*. Keng (1962) distinguishes the genus *Ficalchoa* Hiern. as a probable third subfamily. There also exist no uniform opinion on the taxonomical limits of certain genera. Thus, the first of the above-quoted authors consider the genus *Gordonia* Ellis *in sensu lato*, while the third author distinguishes the above-mentioned genus into *Gordonia* Ellis and *Polyspora* Sweet.

Keng (1980) analyzed again the genera *Gordonia* Ellis, *Polyspora* Sweet and *Laplacea* Kunth suggesting a new change in their status, namely combining them as *Gordonia* Ellis. Cronquist (1981) suggest a new classification variant which incorporates 4 subfamilies: *Camellioideae* (vel *Theoideae*), *Terstroemioideae*, *Bonnetioideae* and *Asteropeideae*. He also considered the genus *Gordonia* Ellis *in sensu lato*. Takhtajan (1987) distinguished two subfamilies: *Theoideae* and *Ternstroemioideae*. With respect to the limits of the genus *Gordonia*, he agreed with Cronquist (op. c.). Keng's suggestion was later adopted by Grote & Dilcher (1992) in the taxonomic study of North American fossil representatives from the Eocene. Kvaček & Walther (1984a, 1984b) based their stomatographic analysis of family *Theaceae* on Keng's classification (1962) and acknowledged the separate generic status of *Gordonia* Ellis, *Polyspora* Sweet and *Laplacea* Kunth. The first of these is determined as a North American monotypic genus (*Gordonia lasianthus* (L.) Ellis), the second one - as a Southeast Asian, and the third one - as a Tropical American-Southeast Asian. The present paper has adopted the system of Cronquist (1981) and Takhtajan (1987). With respect to the contemporary distribution of the family, its vast but strongly discontinuous area should be emphasized. As a whole, it can be determined as a pantropical-subtropical one, its separate comprising parts from North and South America, Africa, Southeast Asia, Northeast Australia and Western Melanesia (Fig. 2). In morphological aspect, the leaf impressions studied showed enough differential features on the basis of which five genera and seven species have been distinguished, including four new species. Of special significance is the first establishing of genus *Adinandra* Jack. for the fossil flora of Europe.

Theaceae

Ternstroemioideae

Adinandra Jack

Adinandra palaeorhodopaea Palamarev & Bozukov **sp. n.** (Fig. 3)
— Holotypus: The specimen figured on Fig. 3, CAT-442, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci.; — Isotypus: CAT-3380, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci.; — Locus typicus: Satovcha Graben near Satovcha village, Goce Delchev district, Southwestern Bulgaria; — Stratum typicum: Diatome layers, Middle Miocene (continental equivalent of the Badenian); — Derivatio nominis: The name of the species derives from its ancient origin related to the Rhodopes.

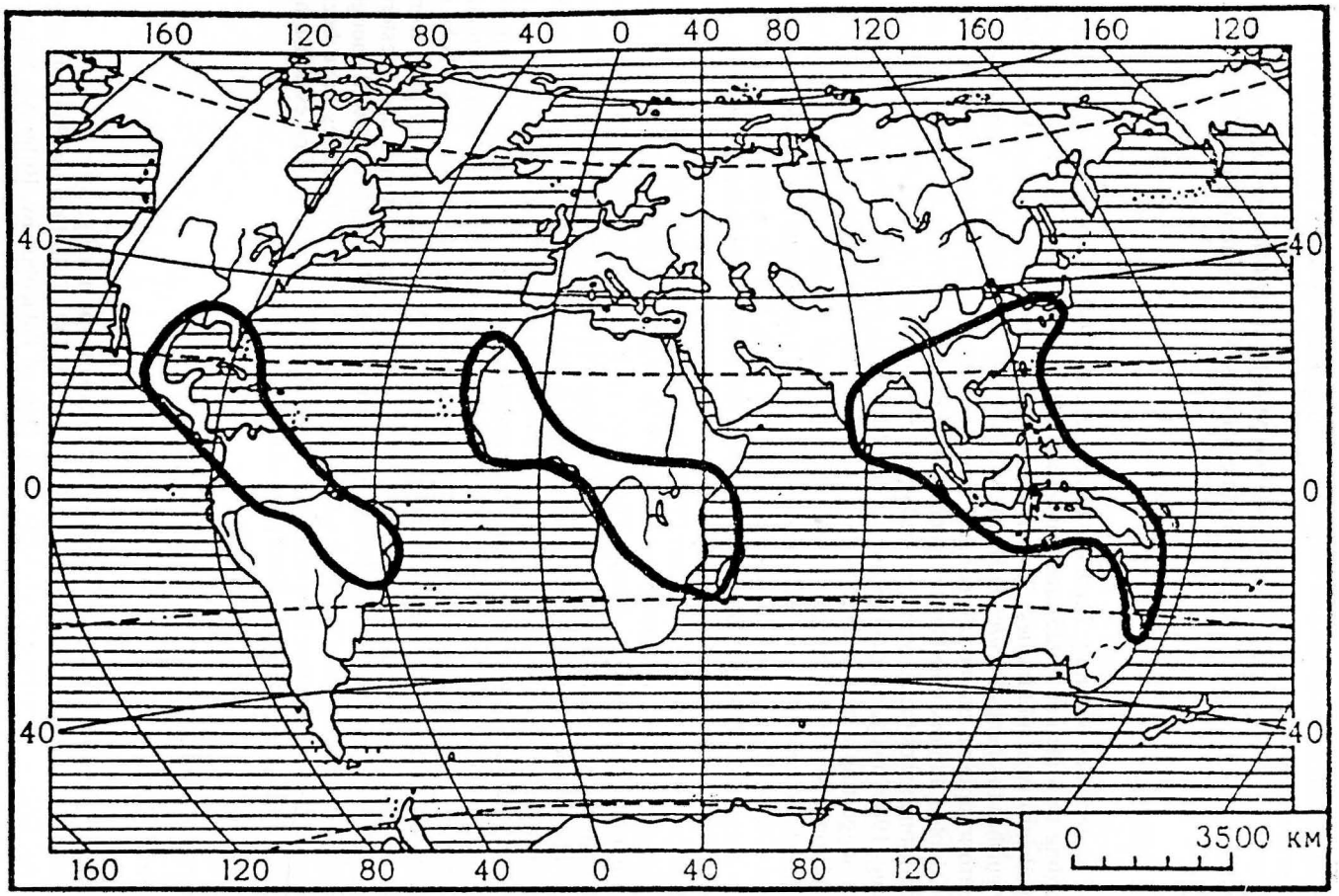


Fig. 2. Distribution of *Theaceae* in the world (after Takhtajan 1981).

Figs. 3-7. **3**, *Adinandra palaeorhodopaea* — holotypus, CAT-442 (x 0.8); **4**, *A. megaphylla* (after Hu & Chun 1937), (x 0.6); **5**, *Eurya aff. acuminatissima*, CAT-2007; **6**, *E. acuminatissima* (after Hu & Chun 1937); **7**, *Gordonia hradekensis*, CAT-2063.

Material. — 2 leaf impression.

Diagnosis: — Shape narrow elliptic; base probably cuneate; apex acuminate, ending with a nose about 2.0 cm long; margin of lamina toothed, teeth strongly inclined towards lamina apex with a gland on their rounded apex. Venation semicraspedodromous; midrib very slightly arch-shaped, 0.3 cm thick at the base, strongly thinned towards the apex; secondary veins about 20 pairs, much thinner than the midrib, consecutive, arch-shaped, taking a quick turn at the upper end forming a wide arch with the next vein; the angle between them and the midrib gradually decreasing towards the apex of the lamina from 90 to 45°; intercalary veins developed between most of the secondary ones, but hardly visible; tertiary veins forming a subtle reticulum of polygonal, almost round areolas. Dimensions: length 19.5 cm, width 3.3 cm.

Comments — Among the fossil representatives of fam. *Theaceae*, the Palaeogene species from NW Bochemia *Ternstroemites sokolovensis* Kvaček & Walther (Kvaček & Walther 1984b) shows certain resemblance with respect to the leaf shape and venation. The dimensions of our specimen were three times bigger, however, which testifies to the different taxonomic belonging of the cited materials. The specimen under study has a big morphological resemblance with the contemporary Chinese representative *Adinandra megaphylla* Hu (Fig. 4) distributed in the province of Yunnan (Hu & Chun 1937). The genus *Adinandra* has been established for the first time for European Tertiary flora.

Eurya Thunberg

Eurya aff. acuminatissima Merril & Chun (Fig. 5)

Materia. — 2 leaf impressions.

Description. — Shape narrow elliptic or oblanceolate; base cuneate; apex acute; margin of lamina toothed, teeth small, strongly inclined towards lamina apex, better expressed in its upper part, with rounded tips and basal side outlined as an elongated "S". Venation semicraspedodromous; midrib straight, strongly expressed; secondary veins 8-9 pairs, arch-shaped, consecutive, forming an angle of 30-45° with the midrib and much thinner than it; intercalary veins developed between all secondary ones; tertiary veins anastomosing between themselves and forming the subtle polygonal reticulum typical of the family; the angle between them and secondary veins is 80-90°. Dimensions: length 6.0-9.0 cm, width 2.0-3.0 cm. Petiolum up to 0.8 cm long and up to 1.2 mm thick.

Comments. — The material studied shows determinate morphological resemblance with the contemporary Chinese species *Eurya acuminatissima* Merril & Chun (Fig. 6) and less with *E. tetragonoclada* Merril & Chun distributed in the province of Kwangtung (Hu & Chun 1937). The genus has been established for Bulgarian Tertiary flora on seeds (Palamarev & Petkova 1987, Palamarev 1989).

Theoideae

Gordonia Ellis s.l. (incl. ***Polyspora*** Sweet)

Gordonia hradekensis (Kvaček & Walther) Bozukov & Palamarev comb. n. (Fig. 7);

— *Symplociphyllum hradekense* Kvaček & Bůžek (1966), p. 293, Pl. 2, Figs. 5, 6; Pl. 3, Fig. 1; Pl. 4, Fig. 8; — *Polyspora hradekensis* (Kvaèek & Bůžek) Kvaček & Walther (1984b), p. 335, Pl. 57-59.

Material. — 1 impression of a twig with leaves.

Description. — Shape lanceolate or narrow elliptic; base cuneate, strongly narrowed; upper part acute, probably elongated; margin of lamina toothed, teeth small, strongly inclined towards lamina apex, basal side much longer than apical one, gland at tip. Venation semicraspedodromous; midrib straight, comparatively thick at base, strongly thinned towards the apex; secondary veins much thinner than midrib, 5-6 mostly opposite pairs, slightly arch-shaped, turning sharply at the apex and forming an arch with the next vein; the angle between the midrib and secondary veins grows towards the apex of lamina, for the first pair it is about 20°; intercalary veins developed only between the first several secondary veins; tertiary veins from an angle of 80-90° with the secondary ones, undulate, forming irregular areolas. Dimensions: length 6.0-7.0 cm, width 1.5-2.0 cm. Petiolum up to 1.0 cm long and 0.1 cm wide.

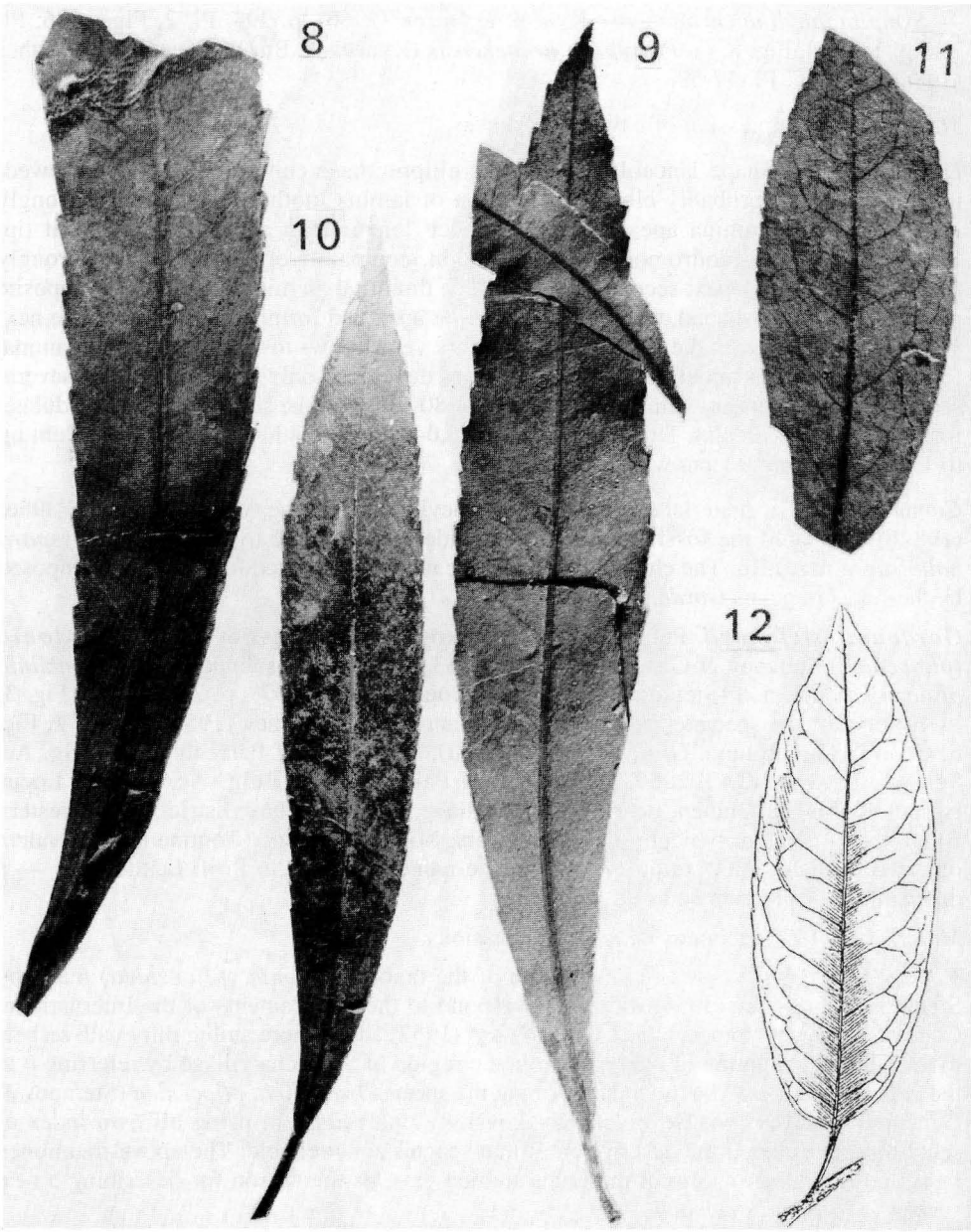
Comments. — The material studied shows no deviation from the type. Kvaček & Walther (1984b) compared the fossil species by its epidermis structure to the recent *Polyspora balansae* (Pitard) Hu. The change in the generic name of the cited fossil taxon is imposed by the status of genus *Gordonia* adopted by us.

Gordonia stefanovii Palamarev & Bozukov sp. n. (Figs. 8-10) — *Gordonia (pliocenica)* Stefanov & Ganchev (1951), p. 163, Fig. 5, nom. subnudum; — *Franklinia pliocenica* auct. non (Stefanov & Ganchev) Kolakovskyi (1957), p. 293, Pl. 20, Fig. 3; — Holotypus: the specimen figured by B. Stefanov & A. Ganchev (1951) on p. 171, Fig. 5, CAT-1538, sub nom. *Gordonia (pliocenica)*, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci; — Isotypus: CAT-2060, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci; — Locus typicus: Satovcha Graben, near Satovcha village, Goce Delchev district, Southwestern Bulgaria; — Stratum typicum: Diatome layers, Middle Miocene (Continental equivalent of the Badenian); — Derivatio nominis: The name is related to Prof. B. Stefanov — a distinguished Bulgarian botanist.

Material. — 107 specimens with leaf impressions.

Nomenclature notes. — The description of the taxon *Gordonia (pliocenica)* made by Stefanov & Ganchev (1951) did not correspond to the requirements of the International Code of Botanical Nomenclature. Kolakovskyi (1957) added more ambiguility with respect to the generic belonging of the taxon from the region of Satovcha village by referring it to the genus *Franklinia* March. and describing the species *Franklinia pliocenica* (Stefanov & Ganchev) Kolakovskyi. However, Kolakovskyi (1973) himself, using his own index of reliability, considered the description of that species as unreliable. The above-mentioned facts and the numerous fossil materials studied gave us the reason for describing a new species - *Gordonia stefanovii*.

Diagnosis. — Shape oblanceolate to narrow oblanceolate or narrow elliptic; base cuneate; margin of lamina toothed, teeth small, with long and strongly inclined basal side and very short apical one, with rounded tips. Venation semicraspedodromous; midrib straight or slightly bent, thick, thinning towards the apex of lamina; secondary veins 17-22 pairs, arch-shaped, consecutive or opposite, forming an angle of about 50° with midrib and much thinner than it; intercalary veins frequent; tertiary veins hardly visible, where preserved forming among themselves a subtle polygonal reticulum.



Figs. 8-12. **8**, *Gordonia stefanovii* — holotypus, CAT-1538; **9**, *G. stefanovii*: CAT-929; **10**, *G. stefanovii* — isotypus, CAT-2060, (x 0.5); **11**, *Hartia palaeorhodopensis* — isotypus, CAT-1934; **12**, *H. micrantha* (after Hu & Chun 1937).

Dimensions. — The lamina is (6.5-)11.5-28.0 cm long and (1.6-)2.0-5.4 cm wide. Petiolus up to 2.7 cm in length and up to 0.3 cm in width.

Comments. — Some of the specimens studied show variations in the shape of the lamina and its dimensions but they comply with the intraspecific variation. The polymorphism observed with the contemporary analog supports that statement. The fossil species has a morphological similarity with the recent North American species *Gordonia lasianthus* Ellis (the southeastern regions of the USA), but it differs from it by the larger dimensions and the greater number of secondary veins.
Stefanov & Ganchev (1951) compare the fossil species with another North American species - *G. alatamaha* Sarg. considered by Krüssmann (1977) a synonym of the species *Franklinia alatamaha* Mach. That comparison is not suitable for the following reasons: the toothing of the leaf margin of *F. alatamaha* is more subtle and with much more teeth; the angle between the secondary veins and the midrib is larger than the of genus *Gordonia*; the shape of lamina of *Franklinia alatamaha* is narrow obovate.

Hartia Dunn

Hartia palaeorhodopensis Bozukov & Palamarev **sp.n.** (Figs. 11, 13-14) — Holotypus: The specimen figured on Fig. 14, CAT-2171, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci.; — Isotypus: The specimen figured on Fig. 11, CAT-1934, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci.; — Locus typicus: Satovcha Graben near Satovcha village, Goce Delchev district, Southwestern Bulgaria; — Stratum typicum: Diatome layers, Middle Miocene (continental equivalent of Badenian); — Derivatio nominis: The name of the species derives from its ancient origin related to the Rhodopes.
Material: 5 leaf impressions.

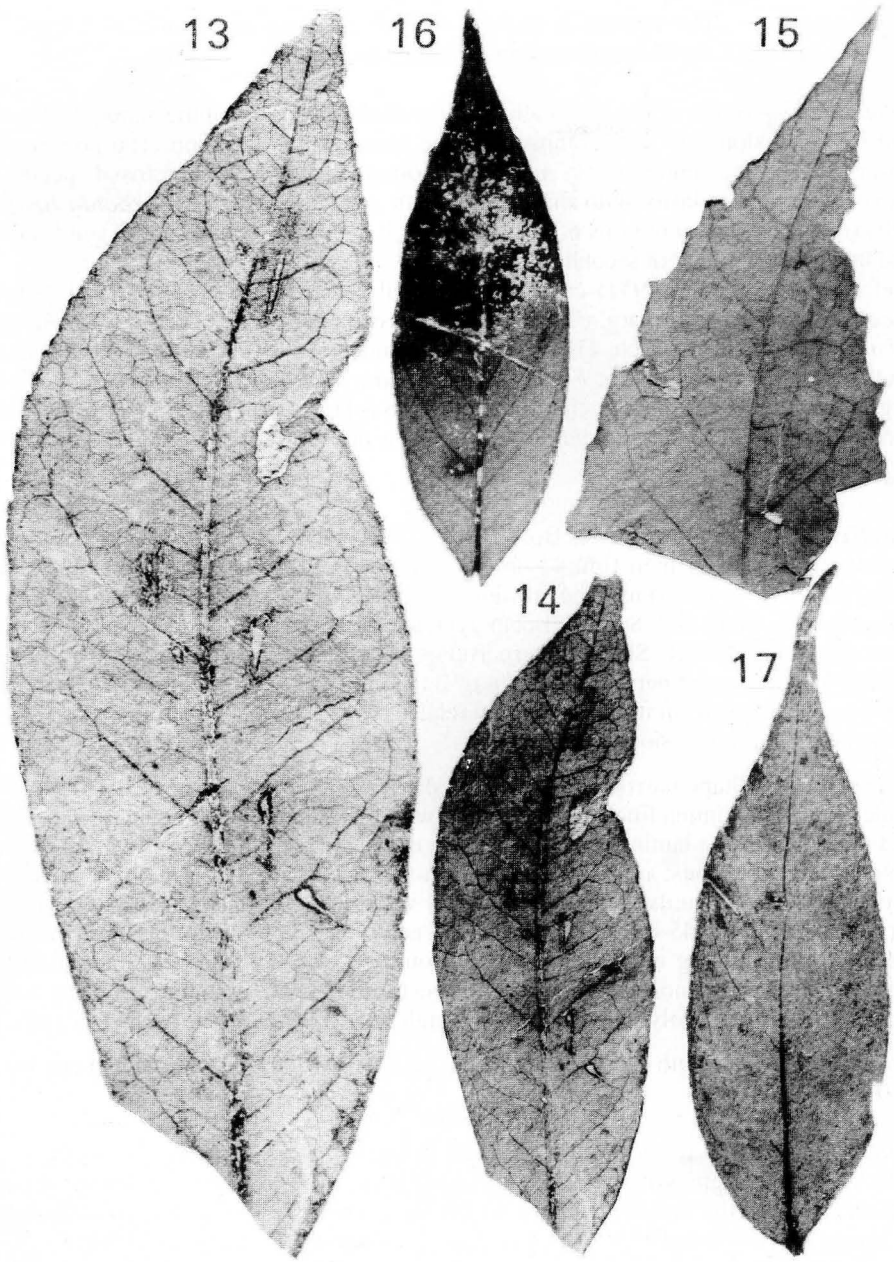
Diagnosis. — Shape narrow elliptic, base slightly asymmetrical, cuneate; apex slightly acute; margin of lamina finely toothed, teeth with glands on their rounded tips are strongly inclined towards the lamina apex, the margin of lamina near the base is whole. Venations semicraspedodromous; midrib slightly arch-shaped, up to 1.0 mm thick at the base, strongly thinned towards the apex; secondary veins 8-10 pairs, consecutive, arch-shaped, forming an angle at 45-80° with midrib, that angle increasing from the first pair towards the leaf apex, joining either directly or through a system of arches; intercalary veins developed between most of secondary ones; tertiary veins undulate, forming between themselves irregular polygons and forming angles of 70-90° with the secondary ones.

Dimensions. — Length 5.8-7.2 cm, width 2.0-2.7 cm. Petiolum about 1.0 cm long, up to 0.2 cm thick.

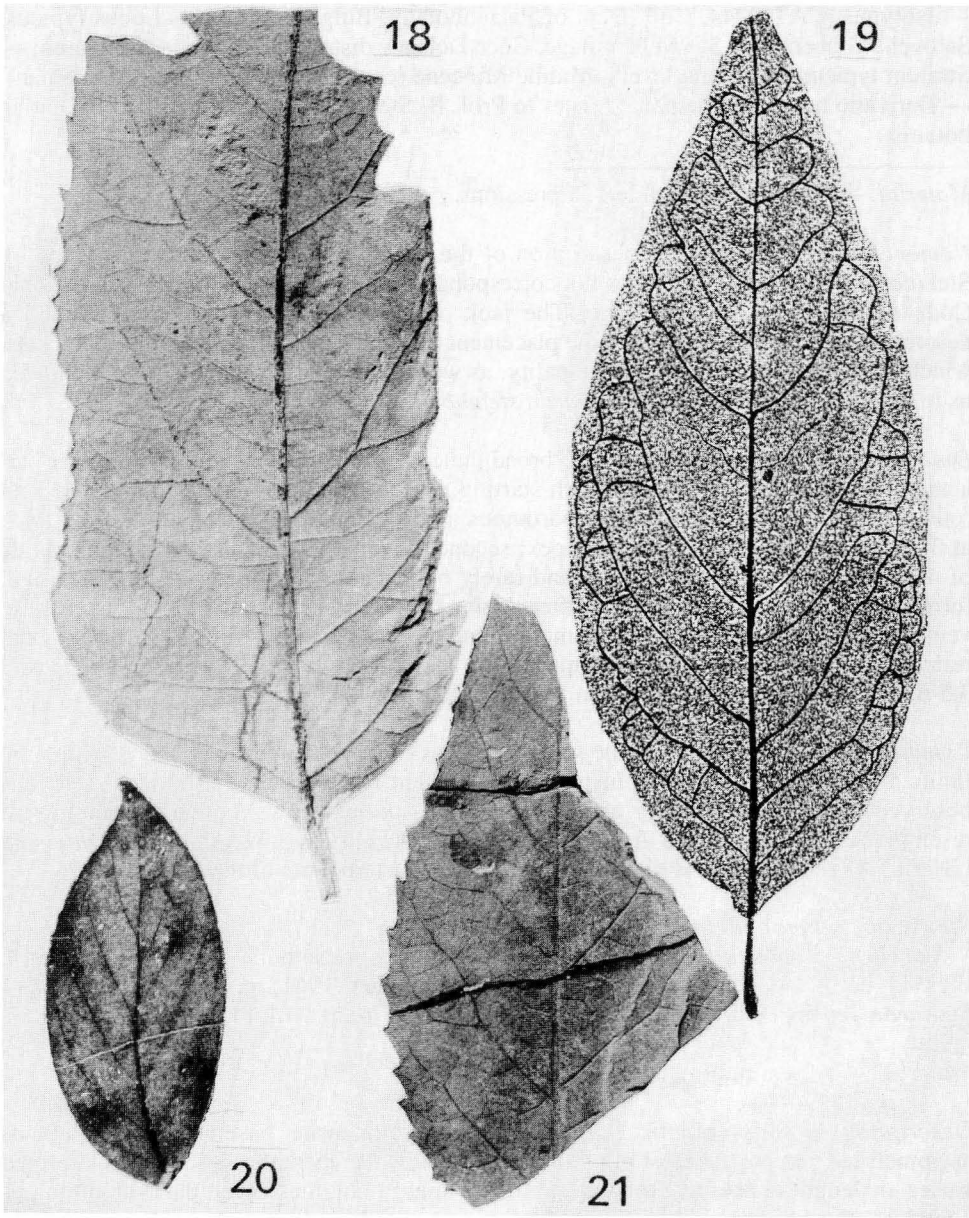
Comments. — The fossil material studied possesses great morphological resemblance with the Chinese representatives from genus *Hartia* - *H. micrantha* Chun (Fig. 12) and *H. yunnanensis* Hu, the first being distributed in the province of Kwangtung, and the second - in Yunan (Hu & Chun 1937). The cited genus is new for Bulgarian fossil flora.

Stewartia L'Heritier

Stewartia stefanovii Palamarev & Bozukov **sp. n.** (Figs. 15, 18, 21)
— *Stewartia (pliocenica)* Stefanov & Ganchev (1951), p. 163, Fig. 3., nom. subnudum;
— Holotypus: The specimen figured by Stefanov & Ganchev (1951) on p. 167, Fig 3, CAT-1538, sub nom. *Stewartia (pliocenica)*, Col. Dep. of Palaeobotany, Bulg. Ac. Sci..



Figs. 13-17. **13**, *Hartia palaeorhodopensis*, CAT-2171 (x 2); **14**, *H. palaeorhodopensis* — holotypus, CAT-2171; **15**, *Stewartia stefanovii*, CAT- 3178; **16**, *S. submonadelpha*, CAT-2236; **17**, *S. submonadelpha*, CAT-2008.



Figs. 18-21. **18**, *Stewartia stefanovii* — isotypus, CAT-2044; **19**, *S. ovata* (after Stefanov & Ganchev 1951); **20**, *S. submonadelpha*, CAT-1987; **21**, *S. stefanovii* — holotypus, CAT-1538.

— Isotypus: CAT-2044, Coll. Dep. of Palaeobotany, Bulg. Ac. Sci.; — Locus typicus: Satovcha Graben, near Satovcha village, Goce Delchev district, Southwestern Bulgaria; — Stratum typicum: Diatome layers, Middle Miocene (continental equivalent of Badenian); — Derivatio nominis: The name relates to Prof. B. Stefanov — a distinguished Bulgarian botanist.

Material. — 3 specimens with leaf impressions.

Nomenclature notes. — The description of the taxon *Stewartia (pliocenica)* made by Stefanov & Ganchev (1951) does not correspond to the requirements of the International Code of Botanical Nomenclature. The lack of specified type of the species and a description according to the rules, the placement of the species' denomination in brackets, which testifies to a certain conventionality, as well as the new specimens found, allowed us to describe the new species - *Stewartia stefanovii.*

Diagnosis. — Shape lanceolate; base broad cuneate and slightly asymmetric; upper part acute; margin of lamina toothed, teeth starting near the base, strongly inclined and with rounded tips. Venations semicraspedodromous; midrib slightly arch-shaped, 1.5 mm thick at the base and strongly thinning at apex; secondary veins 10-12 pairs, forming an angle of 45-50° with midrib, consecutive and rarely opposite, arch-shaped, slightly distorted, forming 3-4 arches on the basal part after joining the preceding secondary vein; intercalary veins frequent; tertiary veins with numerous and their anastomoses forming the polygonal reticulum typical of the family. Dimensions: The lamina is 9.0-19.0 cm in length and 3.5-6.5 cm in width; petiolus 1.2 cm long and 0.2 cm wide.

Comments. — The variation in the size of laminas of the specimens studied is within the limits of the species' polymorphism. That statement is supported by the leaf variations observed on the contemporary analog. The fossil species shows a great morphological resemblance with the North American species *S. ovata* (Cav.) Weath. (= *S. pentagyna* L'Herit.) (Fig. 19), which is distributed in the southeastern parts of the USA.

Stewartia submonadelpha Tanai & Onoe (Figs. 16-17, 20)
— *Stewartia monadelpha* Siebold & Zuccarini fossilis in Nathorst (1983), p. 66, Pl. 14, Figs. 11-12; — *Stevartia submonadelpha* Tanai & Onoe (1961), p. 53, Pl. 18, Fig. 6; — *Stewartia submonadelpha* Tanai & Onoe in Tanai (1976), p. 314, Pl. 6, Fig. 6.

Material. — 61 leaf impressions.

Description. — Shape elliptic, rarely narrow elliptic or ovate; base cuneate, sometimes asymmetrical; upper part most often thinning towards the apex, the nose which is formed varies in length reaching up to 2.0 cm; the margin of the lower part of lamina is complete, the margin of the upper part has more or less developed rare, small teeth. Venation semicraspedodromous; midrib slightly undulate, strongly thinning towards the apex; secondary veins 7-8 pairs, slightly arch-shaped, consecutive or opposing, forming an angle of 25-35° with the midrib and joining among themselves almost to the leaf margin; no intercalary veins are developed; tertiary veins hardly visible, arch-shaped or undulate, parallel, forming an angle of 70-90° with the secondary ones. Dimensions: length 3.5-9.8 cm, width 1.0-3.1 cm.

Comments. — According to Tanai & Onoe (1961) the fossil species *Stewartia submonadelpha* has been known from the Late Tertiary flora of Mogi, Nagasaki Peninsula, SW Japan. Some of our materials showed great morphological resemblance with the Japanese ones. They, however, possess certain polymorphism which falls within the limits of the recent Japanese species *S. monadelpha* Sieb. & Zucc., which is, in fact, related to the fossil one. That fact allows us to determine the specimens studied by us as belonging to the cited species. The finding of *S. submonadelpha* in Satovcha palaeoflora is of special interest, since that species has been established for the first time in Europe. Its finding offers new data about the relationship between Bulgarian Neogene flora and modern East Asian flora.

Acknowlegments

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