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Late Oligocene macrofloras from fluviatile siliciclastic facies of the Köln Formation at the south-eastern border of the Lower Rhine Embayment (North Rhine-Westphalia, Germany)

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ABSTRACT. The leaf remains described herein came from the oldest sites of the Cainozoic deposits in the Lower Rhine Embayment, located in the Siebengebirge Volcanic Field at the south-eastern border of this basin, in the area of Siebengebirge and vicinity. These revisited floras are bound to pre-volcanic siliciclastic facies of the Siebengebirge Mts., interpreted as marginal facies of the Köln Formation. Chronostratigraphically they are assigned to the late Oligocene (Chattian). The described leaf remains are partially compressions with preserved epidermal anatomy, and therefore highly useful for systematic determination of leaf impressions recovered from other localities of siliciclastic facies. On account of the epidermal characteristics of leaf compressions varying in gross morphology, the previously determined taxa *Quercus goepperti*, *Laurus phoeboides*, and *Persea speciosa* all fall into the abundantly represented *Eotrigonobalanus furcinervis*. The siliciclastic deposits originated in coastal and flood plain areas within fluviatile environments of variable deposition energy. Remains of *Taxodium dubium*, *Eotrigonobalanus furcinervis*, *Populus germanica*, and *Daphnogene cinnamomifolia* dominate among the recovered fossils. The general aspects of this plant assemblage correspond, together with their sedimentary settings, to riparian forest vegetation with mesophytic elements.

KEYWORDS: macroflora, Lower Rhine Embayment, late Oligocene, Köln Formation

INTRODUCTION

In the Lower Rhine Embayment, fossiliferous levels with plant remains reach from Palaeogene (late Oligocene: Chattian) Köln Formation up to Neogene (late Pliocene) and Quaternary (earliest Pleistocene) strata. The oldest floras, which are of late Oligocene age, occur only at the south-eastern margin of the Lower Rhine Embayment, in the area of Siebengebirge and vicinity. Publications concerning these floras appeared early in the palaeobotanical literature (Göppert 1836, 1850a, 1850b, Weber 1850, 1851, 1851–1852, Wessel & Weber 1855); some of them can be called classics, particularly the flora of the Fossillagerstätte Rott. Weyland (1934, 1937–1948) re-investigated these floras in the 1930s and 1940s. In addition to revising the Rott flora, he also examined the here-revised floras from Altenrath and Stallberg. Both are part of a wider ongoing project of systematic-taxonomical revision of the late Oligocene floras from various localities and different stratigraphic levels of the Siebengebirge Volcanic Field, with the aim of reconstructing the palaeofloristic, environmental, and palaeogeographic setting at the southern part of the Lower Rhine Embayment.

Now, nearly eighty years after the publications by Weyland and in view of the technical

and taxonomic progress in palaeobotanical science, we re-visited the floras of Altenrath and Stallberg as well as the flora of Dürresbach (Winterscheid 2006) once more in order to apply anatomical and cuticular characters in a taxonomical analysis.

MATERIAL AND METHODS

GEOLOGY AND PALAEOGEOGRAPHY

The oldest Cainozoic macrofloras studied are located in the late Oligocene terrestrial border area of the Köln Formation ("Unterflöz-Gruppe") at the south-eastern margin of the Lower Rhine Embayment, in the Siebengebirge region. The Köln Formation in the central basin of the Lower Rhine Embayment to the base of the Ville Formation ("Hauptflöz-Gruppe") is developed as coastal paralic deposits in a cyclic alteration ("Unterflöz-Serien") of marine sands and lacustrine-paralic clay and brown coal horizons at the top of the cycles. The cycles reflect transgressive and regressive phases of the North Sea during the late Oligocene and early Miocene; they have been explained by sea level changes and the variable tempo of taphrogenetic uplift and subsidence (Gliese 1971: 67–72, Schäfer et al. 2005). Toward the north-west the Köln Formation is interfingered by marine sands of the late Oligocene Grafenberg Formation. In the southern and eastern parts of the Köln tectonic block to the margin of the Lower Rhine Embayment the marine sands and lacustrine-paralic clay and brown coal interbeds become thinner and the sediments are interfingered by continental limnic and fluviatile gravel, sand, and clay. These siliciclastic sediments are deposits of rivers which flowed into the Lower Rhine Embayment from the south and east as a meandering braided river system and deltas. Lacustrine-swampy coaly clays and brown coal layers occurring within the fluviatile sediments indicate temporary and local silting-up and the formation of swamps. The stratigraphic sequence of this lithological development was recognised in drillings and outcrops within the Siegburger and Siebengebirge Graben (Gliese 1971, Skupin & Wolff 2011: 24–30, Takahashi & Jux 1986: 32–36, Teichmüller 1974: 273, Von der Brelie et al. 1981).

In the Siebengebirge area and at the south-eastern margin of the Lower Rhine Embayment, in tectonic step faults of the transition zone from the Köln tectonic block to the Rhenish Massif, the lacustrine and fluviatile sediments of the Köln Formation contain macrofloras (Weyland 1934, 1940). The stratigraphical sequence begins with lacustrine and fluviatile floodplain sediments of the "tonige liegende Schichten" (clayey underlying strata), which lie directly on weathering products of the Palaeogene land surface (Udluft 1977a: 20, 21; 1977b: 14, 15). These sediments, consisting of grey and white pelite, represent redeposited products of this weathering. The "tonige liegende Schichten" were deposited by a braided river system

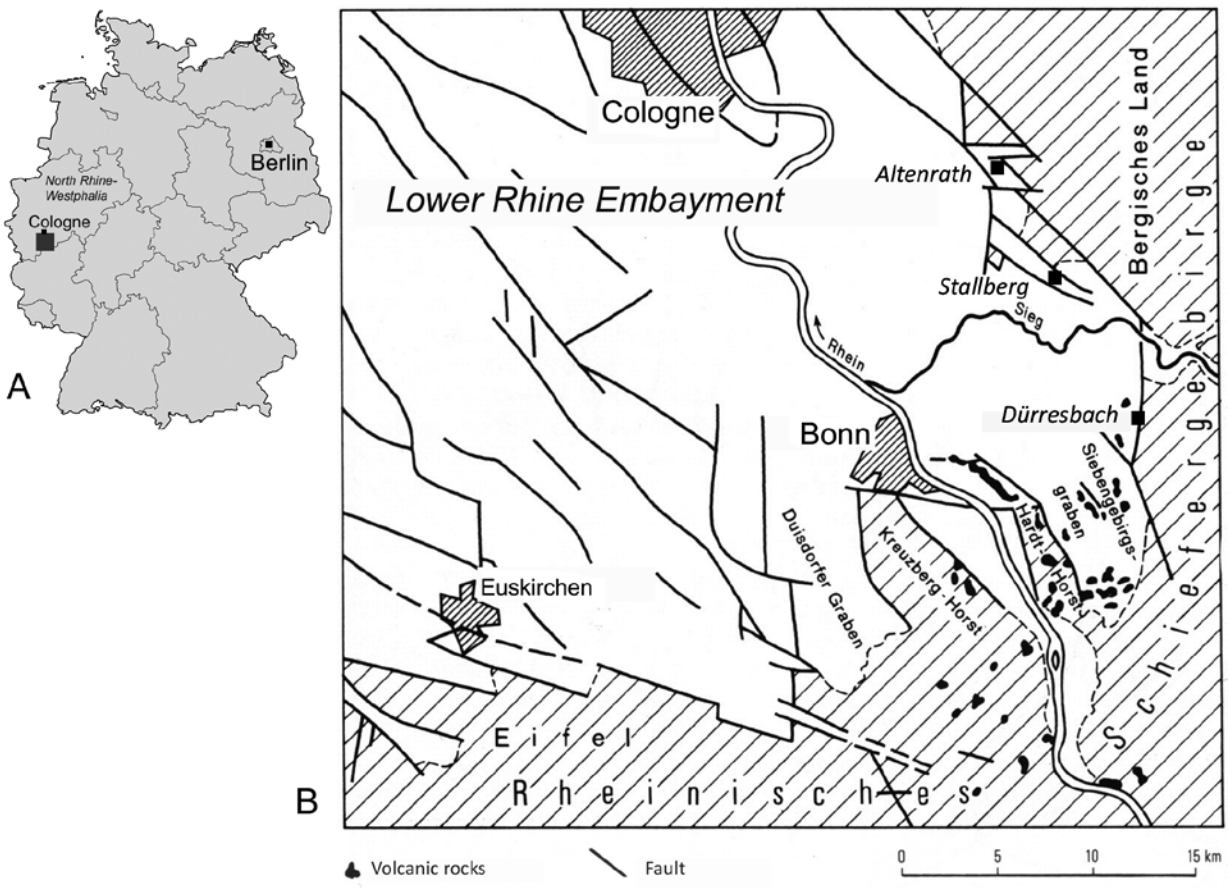


Fig. 1. Location of the investigated area in Germany (**A**), and the sites at the south-eastern border of the Lower Rhine Embayment (**B**, modified after Burghardt 1979)

(see above) in flat lacustrine basins. The clays of these lithologic facies indicate stillwater phases and zones of sluggish water current in a landscape with flatland topography within the late Oligocene North Sea coast in the north-west, and the plateau of the Rhenish Massif in the south and east (Winterscheid 2006: 18, 241).

"Quarzige liegende Schichten" (quartzous underlying strata, siliciclastic facies sensu Winterscheid 2006) continue above the "tonige liegende Schichten". They are built of coarse-grained sediments with silt, sand, and gravel (Udluft 1977a: 21–25; 1977b: 15, 16). The depositional environment of the "tonige liegende Schichten" changed into landscape with a more pronounced topography induced by the beginning taphrogenesis of the Lower Rhine Embayment and the inferred higher current energy of the fluviatile systems. The sands and gravel are locally silicified and hardened in the form of lenses and layers to sandstone, quartzite, and conglomerates (Winterscheid 2006: 18, 19, 241, 242).

LOCALITIES, STRATIGRAPHY, AND MATERIAL

The fluviatile sediments with fossiliferous clay deposits at Troisdorf-Altenrath, Siegburg-Stallberg and Hennef-Söven are located on a NNW–SSE line within a system of faults at the south-east margin of the Lower Rhine Embayment in the transition to the Bergisches Land (Fig. 1). The floras belong lithostratigraphically to the "liegende tonige und quarzige Schichten" of the Siebengebirge Mts. (see Dechen 1852: 468; 1861: 271, 1884: 613, Kaiser 1897: 99–101, 104, 105, Laspeyres 1900: 144, 145, Wilckens 1927: 44, Burre 1930: 30–32, Breddin 1932: 31–40, Weyland 1934: 33, 34; 1940: 104, 105, and Udluft 1939a and 1977a: 19–26; 1939b and 1977b: 15–18). The sediments are composed of an alternating sequence of flat-bedded and cross-bedded quartz gravel and sands with enclosed layers and lens-shaped sandy and coaly clays. Von der Brelie et al. (1981: 53, table 2: outcrops 45 and 46) lithostratigraphically place the sediments of Altenrath and Stallberg in the Köln Formation ("Unterflöz-Serie IV, Ton 06" according to the stratigraphical sequence of Schneider & Thiele 1965). The occurrence of tuffitic layers in the upper part of the sedimentary sequence in the Siegburg-Stallberg area indicates a stratigraphical correlation to Ton 06. In this horizon the first evidence for volcanic eruptions in the Siebengebirge Volcanic Field can be found (Von der Brelie et al. 1981: 46; Skupin & Wolff 2011: 26; pl. 2). Schäfer et al. (2004: 87, fig. 4, 8, table 1) place the layers from sand 05 to sand 4 (Schneider & Thiele-layer) in the late Oligocene (Chattian). The sporomorph *Tricolporopollenites villensis* (Thomson) Thomson & Pflug (synonymous with *Eotrigonobalanus eiszmannii* Walther & Zetter) is connected with the frequently occurring *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček in the siliciclastic facies of the "Liegendschichten" of the Siebengebirge Mts. (Walther & Zetter 1993: 187; Denk et al. 2012: 10–12). This sporomorph is typical for "Unterflöz-Serie IV, Ton 06" of the lower part of the Köln Formation (Von der Brelie et al. 1981: 28, Takakashi & Jux 1982: 81) but it has not yet been proven in the early Oligocene Bergisch Gladbach Formation of the southern Lower Rhine Embayment.

The two localities Troisdorf-Altenrath and Siegburg-Stallberg are the only sites in the siliciclastic facies that provide leaf compressions suitable for anatomical and cuticular analyses. The other localities of the siliciclastic facies (Quegstein, Wintermühlenhof, Remscheid, and Allrott in the central Siebengebirge Mts., Weber 1851–1852: 119, 120, 128, Weyland 1940: 104–108) yielded only impressions as plant remains; therefore the taxa described herein are of particular importance for an examination of the above-mentioned localities of the Siebengebirge Mts. The third locality, Dürresbachtal near Hennef-Söven, provided plant impressions preserved in fossiliferous conglomerates, sandstone, and claystone.

The siliciclastic facies of the "Liegendschichten" of the Siebengebirges Mts. in the southern Lower Rhine Embayment can be interpreted as fluvial sediments deposited by a river system flowing northwards and westwards into the Lower Rhine basin. These sediments represent late Oligocene terrestrial facies of the marginal part of the Köln Formation at the level of "Unterflöz-Serie IV, Ton 06". The sedimentation of the siliciclastic facies abruptly stops with the beginning of volcanic activity in the Siebengebirge Volcanic Field connected with eruptions of mighty pyroclastic flows ("Trachyttuff").

ALTENRATH

LOCATION AND DESCRIPTION

Geographic map TK25: 5109 Lohmar (R ^{25}82800 H ^{56}37000). N 50°51′32.0″ E 7°11′04.0″.

Rhein-Sieg-Kreis, Stadt Troisdorf, Ortsteil Altenrath. An abandoned gravel and clay pit of the Ludwigshütte brickyard near Hohen Schanze hill, north-west of Altenrath.

The Ludwigshütte brickyard near Troisdorf-Altenrath was worked between 1878 and 1914. Fliegel & Stoller (1910: 231, 232) described the quarry and the flora for the first time and gave a profile of the strata:

Profile of the Winter clay-pit near the Ludwigshütte brickyard from 1909, according to Fliegel & Stoller (1910: 231):

overlying stratum: ≥ 1 m yellow and brown sand with thin layers of gravels	
≤ 3 m	white, partly sandy quartz gravel
≤ 3 m	**brown, partly sandy clay with leaf remains, forming a lens**
≤ 4 m	white, partly sandy quartz gravel, lighter sand ("Quarzkies"), intercalated with white quartz sand and layers of gravel
erosional unconformity	
≤ 6 m	clay with some brown coal layers, the lowermost seam 1.20 m thick
1.80 m	light grey quartz sand
underlying stratum: ≤ 7 m white clay	

Elevation of strata c. + 120 m a.s.l.

LITERATURE (CHRONOLOGICALLY)

Fliegel & Stoller (1910: 228–232), Wilckens (1927: 30, 33, 36), Weyland (1934: 33, 34), Udluft (1939a and 1977a: 20–25), Weyland (1940: 104–108), Winterscheid (2006: 26).

MATERIAL

The described plant remains of Troisdorf-Altenrath are housed mainly in the Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, in Berlin (Tab. 1). The material was collected in 1909 by Fliegel and Stoller and was originally kept in the palaeobotanical collection of the Preußische Geologische Landesanstalt (Signum: MfN coll. P.G.L.A. Berlin). More specimens are housed in the palaeobotanical collection of the Institut für Geologie und Mineralogie der Universität zu Köln (palaeobotanical collection of Hermann Weyland, Signum: IGMK coll. Weyland).

STALLBERG

LOCATION AND DESCRIPTION

Geographic map TK25: 5109 Lohmar (R ^{25}86700 H ^{56}30700). N 50°48′16.0″E 7°13′42.0″. Rhein-Sieg-Kreis, Stadt Siegburg, Ortsteil Stallberg. Abandoned Langel gravel-pit on the Zeithstrasse road.

Table 1. Vouchers of types in collections of Altenrath

Author	Figure	Taxon	Collection
Weyland 1934	Textabb. 1	*Quercus goepperti* C.O. Weber	MfN: missing
	Textabb. 2		MfN: missing
	Textabb. 4	*Laurus princeps* Heer	MfN: missing
	Textabb. 5		MfN: missing
	Textabb. 6	*Laurus phoeboides* Ettingsh.	MfN: missing
	Taf. 1 Fig. 2	*Lastraea stiriaca* (Unger) Heer	MfN MB.Pb.2005/0065
	Taf. 1 Fig. 6	*Manicaria formosa* Heer	MfN MB.Pb.2005/0063
	Taf. 6 Fig. 1	*Quercus goepperti* C.O. Weber	MfN MB.Pb.2005/0070
	Taf. 6 Fig. 2		missing
	Taf. 10 Fig. 1	*Menispermites germanicus* Menzel	MfN MB.Pb.2005/0064
	Taf. 11 Fig. 4	*Laurus princeps* Heer	MfN MB.Pb.1984/0020
	Taf. 11 Fig. 6	*Daphnogene lanceolata* Unger	MfN MB.Pb.2005/0068
	Taf. 12 Fig. 6	*Persea speciosa* Heer	MfN MB.Pb.2005/0067
	Taf. 12 Fig. 9		missing
	Taf. 13 Fig. 4	*Laurus princeps* Heer	MfN MB.Pb.1984/0022
	Taf. 13 Fig. 7	*Daphnogene lanceolata* Unger	MfN MB.Pb.2005/0066
	Taf. 14 Fig. 3	*Laurus phoeboides* Ettingsh.	MfN MB.Pb.1984/0021.1
	Taf. 14 Fig. 8	*Daphnogene lanceolata* Unger	MfN MB.Pb.2012/0388
	Taf. 16 Fig. 7	*Laurus grandifolia* Ettingsh.	MfN MB.Pb.2005/0069
Weyland 1940	Textabb. 7	*Quercus goepperti* C.O. Weber	MfN MB.Pb.2005/0070
	Textabb. 8		missing
	Textabb. 9		missing
	Textabb. 10		missing
	Taf. 4 Abb. 6	*Daphnogene septimontana* Weyland	MfN MB.Pb.2012/0388
	Taf. 4 Abb. 7		MfN MB.Pb.2005/0068
Kräusel & Weyland 1950	Taf. 14 Fig. 5	*Daphnogene septimontana* Weyland	MfN MB.Pb.2012/0388
	Taf. 15 Fig. 1	*Laurophyllum phoeboides* (Ettingsh.) Kräusel & Weyland	MfN MB.Pb.1984/0021.1
Kvaček & Walther 1989b	Textabb. 9/1	*Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček	missing
	Textabb. 9/2		MfN MB.Pb.1984/0024
	Textabb. 9/3		MfN MB.Pb.1984/0020.1
	Textabb. 9/4		MfN MB.Pb.1984/0028.1
	Textabb. 9/5		missing
	Textabb. 9/6		MfN MB.Pb.1984/0034
	Textabb. 9/7		MfN MB.Pb.1984/0023
	Textabb. 9/8, Taf. 35 Fig. 6		MfN MB.Pb.1984/0025.2
	Textabb. 9/9, Taf. 35 Fig. 5		MfN MB.Pb.1984/0021.1
	Taf. 35 Fig. 4		MfN MB.Pb.1984/0026

Table 2. Vouchers of types in collections of Stallberg

Author	Figure	Taxon	Collection
Weyland 1940	Textabb. 1	*Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček	SMSU coll. Bauckhorn, Inv.-Nr. 9
	Textabb. 2		SMSU coll. Bauckhorn, Inv.-Nr. 10
	Textabb. 3		SMSU coll. Bauckhorn, Inv.-Nr. 11
	Textabb. 4		SMSU coll. Bauckhorn, Inv.-Nr. 12
	Textabb. 5		SMSU coll. Bauckhorn, Inv.-Nr. 13
	Textabb. 6		SMSU coll. Bauckhorn, Inv.-Nr. 14

In the vicinity of the sand and gravel pits of Siegburg-Stallberg (also in the fossiliferous Langel pit), intercalations of volcanic tuff (trachyte and trachytic tuff pebbles) as lens-shaped layers are noteworthy (Udluft 1977a: 22, 23). This indicates on one hand that the sediments belong to the "Liegendschichten" and that sedimentation continued until the eruptions of the Siebengebirge volcano interrupted it. The tuffitic layers indicate the age of the deposits as late Oligocene, because the volcanic activity of the Siebengebirge Volcanic Field started at ca 26.5 Ma and lasted until 25.0 Ma (Teichmüller 1974, Todt & Lippolt 1980, Winterscheid 2006). The lithostratigraphy indicates that they were deposited within the Köln Formation, "Unterflöz-Serie IV, Ton 06" (Von der Brelie et al. 1981, Takakashi & Jux 1982).

LITERATURE (CHRONOLOGICALLY)

Kaiser (1897: 101), Wilckens (1927: 36), Udluft (1939a, 1977a: 22–25), Weyland (1940: 104–108), Winterscheid (2006: 43).

MATERIAL

Kaiser (1897: 101) mentioned the occurrence of frequent leaf impressions ("in einzelnen Schichten ziemlich häufig Blattabdrücke von tertiären Laubblättern") in the clay and gravel quarries on both sides of Zeithstraße road in Siegburg-Stallberg. Hermann Weyland first published the flora in 1940. The plant remains were collected by Hugo Bauckhorn in the Langel sand quarry and housed in Heimatmuseum Siegburg (Tab. 2), where they remain (Signum: SMSU coll. Bauckhorn). Further material is housed in the Weyland collection in the palaeobotanical collection of the Instituts für Geologie und Mineralogie der Universität zu Köln (Signum: IGMK coll. Weyland).

DÜRRESBACH

LOCATION AND DESCRIPTION

Geographic map TK25: 5209 Siegburg (R ^{25}89700 H ^{56}25300). N 50°45′21.0″E 7°16′18.0″.

Rhein-Sieg-Kreis, Stadt Hennef, Ortsteil Söven.

The Dürresbach locality, south of the Dürresbach riding-ground, is located near the Wolfsbachtal valley, which extends from Hennef-Söven to Hennef-Geistingen. The locality is directly at the intersection of the Söven–Hennef road at the 145.1 m elevation marker and the farm road from Auf der Domkaule. In the immediate vicinity are dumps of brown coal pits of the Fossillagerstätte Rott.

According to Kaiser (1897: 104, 105) the Dürresbach locality was situated at the above mentioned farm road next to the adit entrance of the Romerikenberge brown coal pit of the Rott locality. Trachytic tuff and sandstone, like that from Dürresbach, was noted in the underlying sequence of the oil shale and brown coal layer in the Romerikenberge brown coal pit near Rott. Kaiser (1897: 104) noted: "Der Tuff bildet auch hier das Hangende der quarzigen Schichten". On the streambed of Wolfsbach are rocks of pelitic facies of the "Liegendschichten", and sandstone and conglomerate of the siliciclastic facies in the "Blättersandstein" outcrop above. Dechen (1852: 468; 1861: 271) described this occurrence as follows: "Bei Dürresbach kommt feinkörniger, weissgelblicher und gelbbrauner Sandstein mit sehr vielen Blattabdrücken, in flammig gezeichneten gelbgrauen Hornstein übergehend vor"; and "Kiesel-Konglomerat, abweichend von dem gewöhnlichen Vorkommen in einem lockeren Zusammenhange."

LITERATURE (CHRONOLOGICALLY)

Dechen (1852: 468; 1861: 271; 1884: 613), Kaiser (1897: 104, 105), Wilckens (1927: 44), Burre (1930: 30–32), Udluft (1939b und 1977b: 15–18), Winterscheid (2006: 28, 29).

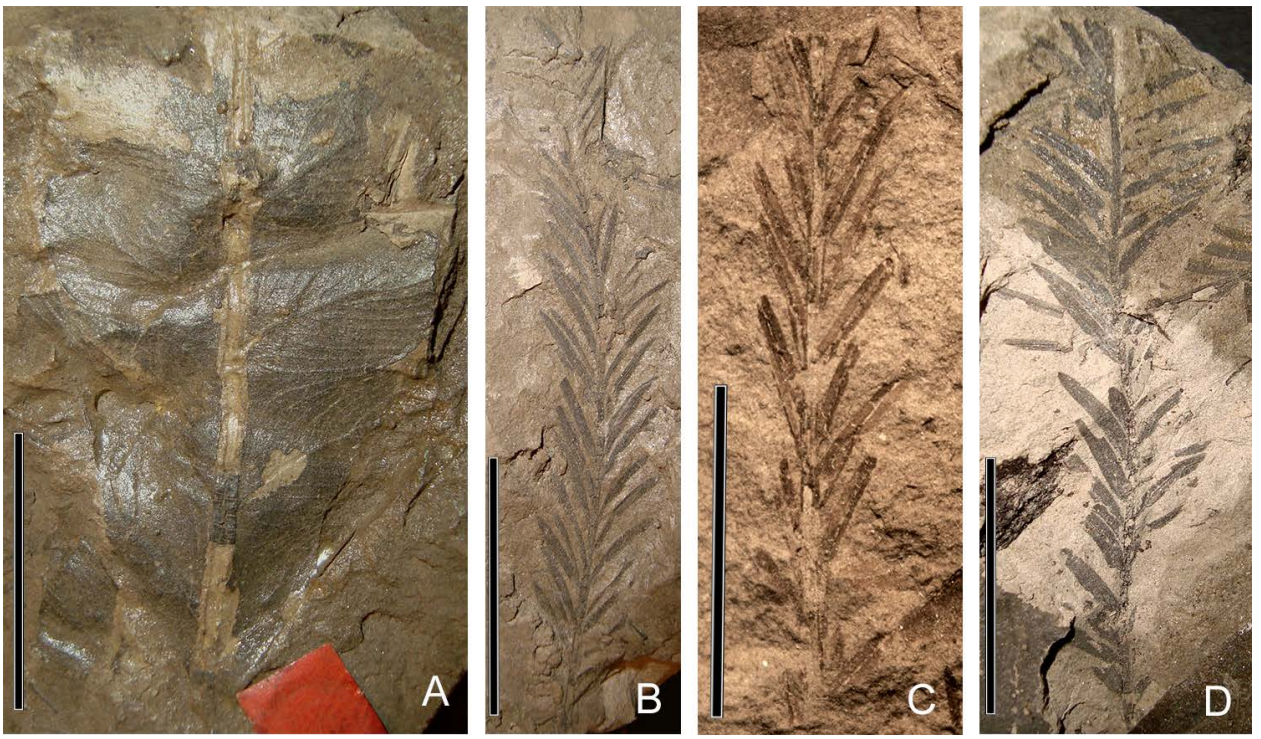


Fig. 2. *Osmunda lignitum* (Giebel 1857) Stur 1870, Altenrath. **A**: Fragmentary sterile pinnule, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0065 = Weyland (1934: Taf. 1, Fig. 2). *Taxodium dubium* (Sternb. 1823) Heer 1853, Altenrath. **B**: Short shoot, MfN coll. P.G.L.A. Berlin: MB1984/0028; C: Short shoot, MfN coll. P.G.L.A. Berlin: B2013/2047; D: Short shoot, IGMK coll. Weyland: 425 (1). Scale bar: 20 mm

MATERIAL

The material described by Winterscheid (2006) and given here in the updated list (Table 4) belongs to the palaeontological collections of the Goldfuß-Museums at the Steinmann-Institute for Geology, Mineralogy and Palaeontology of the University of Bonn (Signum: StIPB coll. Winterscheid). Material gathered by Mr. Hellmund (diploma thesis by Hellmund 1986 from the same collection (leaf remains, etc.) is not in a good state of preservation, lacks diagnostic features, and is not suitable for taxonomic examination.

SYSTEMATIC PALAEOBOTANY

The systematic organisation and data for authors and publication dates of higher taxonomic ranks follow the classifications of Chase & Reveal (2009) and Reveal (2012). For listed synonyms the abbreviations and symbols follow Granzow (2000). The lists of synonyms include the first description and protologue of a taxon, then systematic and taxonomic citations, and detailed descriptions of the taxon; citations based on the Altenrath locality are added. In the lists of examined specimens, the inscriptions and determinations written on old labels by Hermann Weyland and recovered in the collections are given in brackets […]. The results of the present study of the Altenrath and Stallberg floras are shown in Table 3.

THE ALTENRATH AND STALLBERG FLORA

Class EQUISETOPSIDA C. Agardh 1825
sensu M.W. Chase et Reveal 2009

Subclass POLYPODIIDAE
Cronquist, Takht. et Zimmerm. 1966

Order OSMUNDALES Link 1833

Family OSMUNDACEAE Martinov 1820

Osmunda L. 1753

Subg. *Plenasium* (C. Presl 1836) C. Presl 1845

Osmunda lignitum (Giebel 1857) Stur 1870

Fig. 2A

***1857** *Pecopteris lignitum* Giebel: 303; pl. 2, fig. 2a [Rhunthal near Weißenfels].

1870 *Osmunda lignitum* (Giebel) Stur: 5 [Socka].

* The asterisk marks the first publication of the species (name, basionym) in synonymy-lists (= protologue of the species). See Granzow (2000: 357).

1934 *Lastraea stiriaca* (Unger) Heer – Weyland: 37, 38; pl. 1, fig. 2 [Altenrath].

1940 *Lastraea stiriaca* Unger – Weyland: 105 (list) [Altenrath].

1950 *Osmunda lignitum* (Giebel) Stur – Kräusel & Weyland: 25–30; pl. 2, figs 1–4; text-fig. 3.

1976 *Osmunda lignitum* (Giebel 1857) Stur 1870 – Barthel: 440–443; pls 72, 73; text-fig. 1 [Mücheln and Kayna-Süd mines near Halle].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0065 = Weyland (1934: pl. 1, fig. 2).

Description. Fragmentary pinna with ca 1 mm thick rachis, pinnules sterile, sessile, halfway fused, apically bent and slightly wavy, with distinct straight midrib reaching the rounded tip, veinlets dense, subparallel, running from pinnule base towards notch between pinnules and looping along margin.

Discussion. The single fragment of a pinna was at first assigned by Weyland (1934, 1940) to *Lastraea stiriaca* Unger, but later recognised by Kräusel & Weyland (1950: 26) – based on the venation – as representing a fragment of *Osmunda lignitum* (Giebel) Stur. Differences between the two ferns are well recognisable morphologically. In *Osmunda lignitum* (Giebel) Stur the veinlets start immediately at the base of the pinnule and end in the notch between two neighbouring pinnules; higher ones loop along the margin. Differences in venation pattern and leaf anatomy were described in detail by Kräusel & Weyland (1950: 26) and Barthel (1976: 442, 456).

Subclass PINIDAE
Cronquist, Takht. et Zimmerm. 1966

Order CUPRESSALES Link 1829

Family CUPRESSACEAE
Gray 1822 nom. cons.

Taxodium Rich. 1810

Taxodium dubium (Sternb. 1823) Heer 1853

Fig. 2B–D; Fig. 3A, B

***1823** *Phyllites dubius* Sternb.: 37, tent. 39; pl. 36, fig. 3 (= Kvaček, 1976: fig. 5) [Bílina].

1853 *Taxodium dubium* (Sternb.) Heer: 136 [Hoher Rhonen].

1934 *Taxodium distichum miocenicum* Heer – Weyland: 39 [Altenrath].

1940 *Taxodium distich. mioc*. Heer – Weyland: 105 (list) [Altenrath, Stallberg].

1976 "*Taxodium distichum miocenicum* Heer versus *Taxodium dubium* (Sternb.) Heer" – Kvaček: 290–294; figs 5–7 (figs 6b–6c = Neotypus of *Phyllites dubius* Sternb. 1823) [Bílina].

2006 *Taxodium dubium* (Sternb. 1823) Heer 1853 – Winterscheid: 72, 73; pl. 4, fig. 10 [Altenrath, Stallberg, Quegstein, Telegraphenberg].

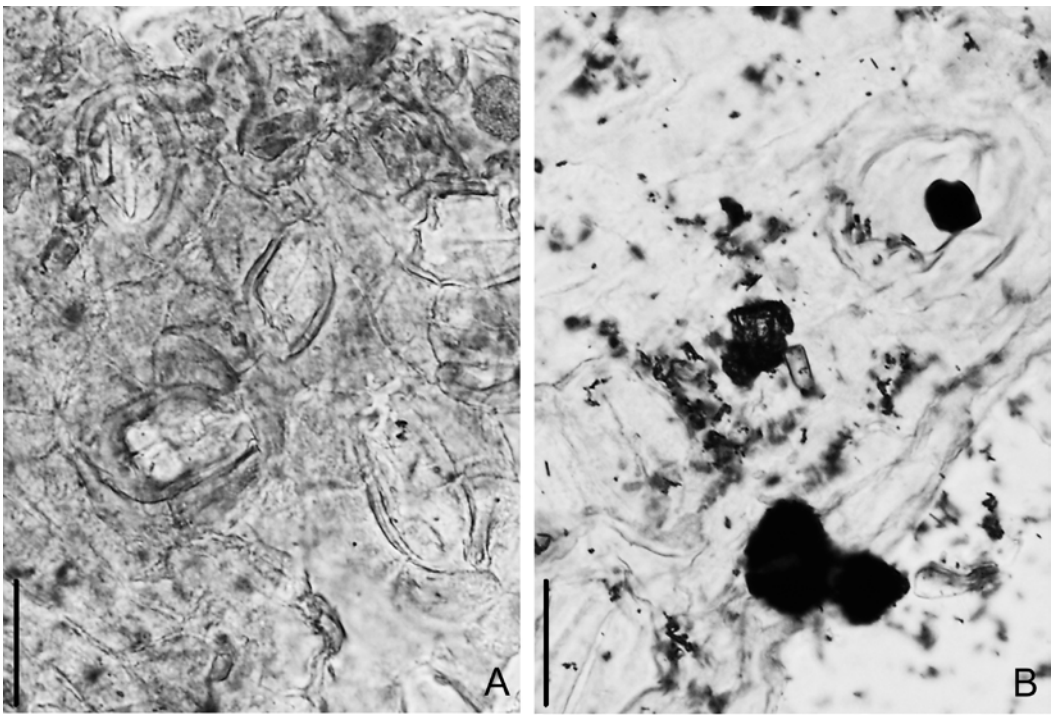


Fig. 3. *Taxodium dubium* (Sternb. 1823) Heer 1853, Altenrath. **A**: Irregularly oriented stomata, IGMK coll. Weyland: 4151b; **B**: Two transversally oriented stomata, MfN coll. P.G.L.A. Berlin: MB.Pb.2012/0388.2. Scale bar: 25 µm

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0020.2, MB.Pb.1984/0021.2, MB.Pb.1984/0025.3, MB.Pb.1984/0027.2, MB.Pb.1984/0028.2, MB.Pb.1998/0394.2, MB.Pb.2012/0388.2, MB.Pb.2013/2008, MB.Pb.2013/2011, MB.Pb.2013/2021, MB.Pb.2013/2025.3, MB.Pb.2013/2028, MB.Pb.2013/2047, MB.Pb.2013/2050, MB.Pb.2013/2056, MB.Pb.2013/2062, MB.Pb.2013/2064, MB.Pb.2013/2066, MB.Pb.2013/2069, MB.Pb.2013/2077, MB.Pb.2013/2092, MB.Pb.2013/2095. IGMK coll. Weyland: 425(1), 425(2), 4144b(1), 4151b(1).

Description. See the detailed morphological description by Kunzmann et al. (2009). Epidermal anatomy of MB.Pb.2012/0388.2 and IGMK 4151b (1) – needles hypostomatic, cuticles thin; non-stomatal zone reflecting quadrangular straight-walled cells 25–60 µm long and 15–25 µm wide, slightly pitted longitudinally; abaxial side showing two stomatal zones with amphicyclic, irregularly or perpendicularly oriented stomata; subsidiary cells mostly five, 12 µm wide and 17 µm long, in a simple circle around a widely elliptic pit 15 µm wide and 40 µm long formed by only slightly thickened outer edges of guard cells; stomata densely disposed but only exceptionally sharing encircling cells.

Discussion. The co-occurrence of *Osmunda lignitum* (Giebel) Stur and *Taxodium dubium* (Sternb.) Heer suggests a wetland forest environment.

Subclass MAGNOLIIDAE Novák ex Takht. 1967

Superorder MAGNOLIANAE Takht. 1967

Order LAURALES Juss. ex Bercht. et J. Presl 1820

Family LAURACEAE Juss. 1789 nom. cons.

Laurophyllum Göpp. 1854

Laurophyllum pseudoprinceps Weyland et Kilpper 1963

Fig. 4A; Fig. 5C, D

1934 *Laurus grandifolia* Ettingsh. – Weyland: 75; pl. 13, figs 3, 6; pl. 16, fig. 7 [Altenrath].

1940 *Laurus grandifolia* Ettingsh. – Weyland: 105 (list) [Altenrath].

1950 *Laurophyllum princeps* (Heer) Kräusel & Weyland: 58–61; pl. 13, figs 1–9; pl. 14, figs 1–4; text-figs 20–21 [Oberlausitz, Wiesa at Kamenz – early Miocene].

***1963** *Laurophyllum pseudoprinceps* Weyland & Kilpper: 100–101; pl. 23, figs 14–19; text-fig. 6 [Frimmersdorf– middle Miocene].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0069 = Weyland (1934: pl. 16, fig. 7 – *Laurus grandifolia* Ett.), MB.Pb.2013/2033 [*Persea speciosa* Heer].

Description. Entire-margined elongate leaf compressions from which epidermal structures were obtained upon maceration, vaguely showing gross morphological characters which are not satisfactorily preserved. Epidermal anatomy of MB.Pb.2005/0069 (= Weyland 1937: pl. 16, fig. 7) and MB.Pb.2013/2033 – adaxial epidermis medium-cutinised, smooth, composed of polygonal cells with coarsely slightly undulate anticlinal walls showing lens-shaped and only less distinct thickenings; adaxial epidermis thinly cutinised, smooth but well showing cell structure; outlines of ordinary cells polygonal, ca 35 µm in diameter; anticlinal walls shallowly undulate, with only slight thickenings; stomata amphibrachyparacytic, ca 20 µm long and up to 45 µm wide; guard cells deeply sunken, with broad ledges; inner subsidiary cells quite narrow, parallel to guard cells, outer subsidiary cells not uniform, asymmetrically developed; trichome bases simple, rare on veins.

Discussion. The identification is based on epidermal cell structure, which corresponds in the coarsely undulate anticlinal walls with the thickenings and stomata to *Laurophyllum undulatum* Weyland & Kilpper sensu stricto, interpreted here as a shade form of *Laurophyllum pseudoprinceps* Weyland & Kilpper.

Laurophyllum acutimontanum Mai 1963

Fig. 4B; Fig. 5E, F

***1963** *Laurophyllum* (*Tetradenia*) *acutimontanum* Mai: 72–75; pl. 8, figs 7–9, 12 (non figs 10–11); pl. 9, figs 1–4; text-figs 11 f–h [Seifhennersdorf].

2007 *Laurophyllum acutimontanum* Mai – Walther & Kvaček: 95; pl. 3, fig. 7; pl. 4, figs 1–5; pl. 22, fig. 11 [Seifhennersdorf].

2014 *Laurophyllum acutimontanum* Mai – Winterscheid & Kvaček: 11; pl. 1, fig. 13; pl. 9, fig. 8 [Orsberg].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0031 [*Laurus*

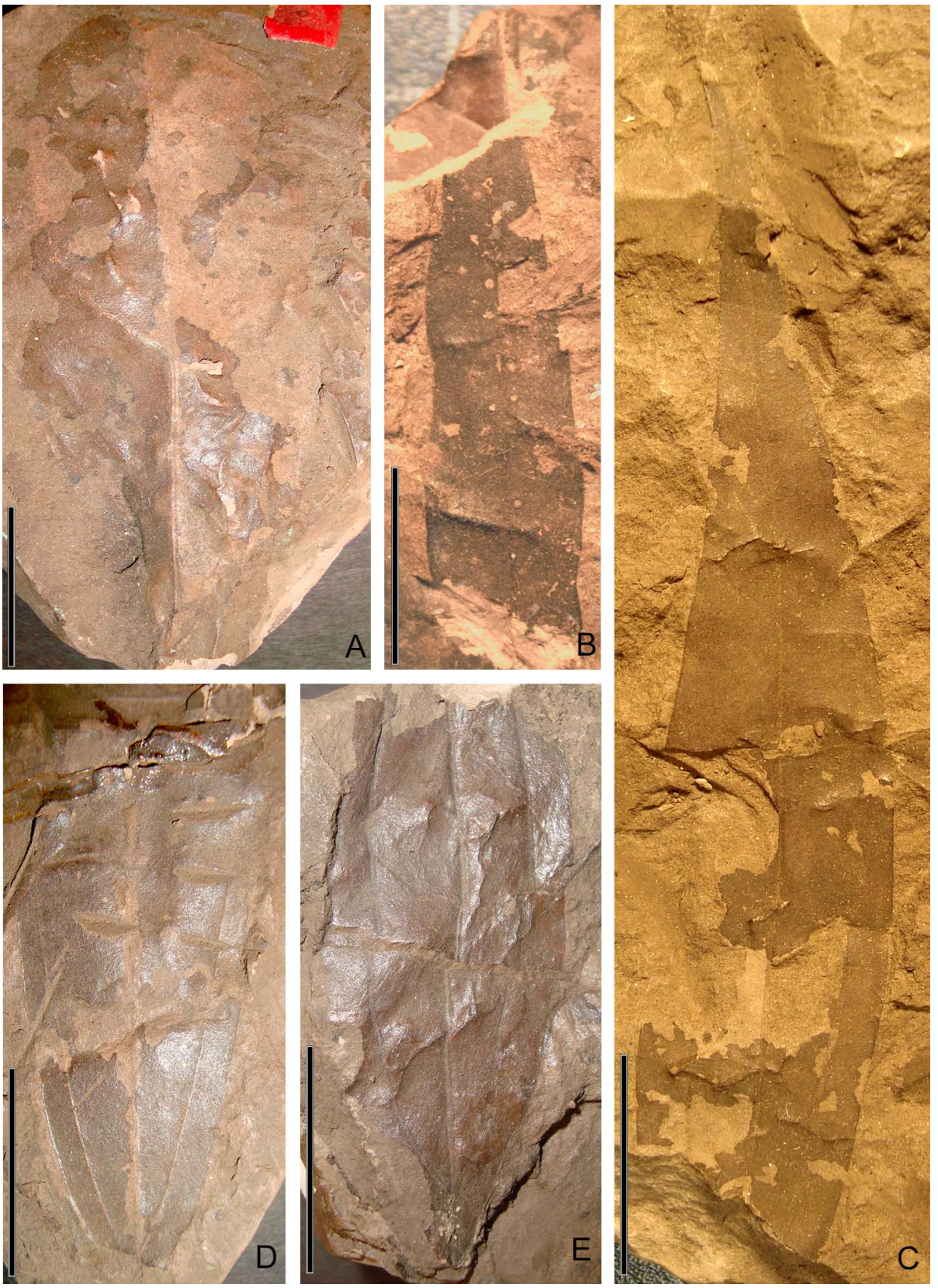


Fig. 4. *Laurophyllum pseudoprinceps* Weyland et Kilpper 1963, Altenrath. **A**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0069 = Weyland (1934: Taf. 16, Fig. 7). *Laurophyllum acutimontanum* Mai 1963, Altenrath. **B**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0031. *Daphnogene cinnamomifolia* (Brongn. in Cuv. 1822) Unger 1850, Altenrath. **C**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2012/0388 – Holotype of *Daphnogene septimontana* Weyland (designated by Weyland 1948: 155) = Weyland (1934: Taf. 14, Fig. 8), Weyland (1940: Taf. 4, Abb. 6) und Kräusel & Weyland (1950: Taf. 14, Fig. 5); **D**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0068 – Syntype of *Daphnogene septimontana* Weyland (designated by Weyland 1948: 155) = Weyland (1934: Taf. 11, Fig. 6) and Weyland (1940: Taf. 4, Abb. 7); **E**: Leaf remain, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0066 = Weyland (1934: Taf. 13, Fig. 7). Scale bar: 20 mm

princeps Heer], MB.Pb.2013/2017 [*Laurus grandifolia* Ett.].

Description. See the detailed morphological descriptions by Walther & Kvaček (2007: 95) and Winterscheid & Kvaček (2014: 11). Adaxial epidermis medium-cutinised, outlines of cells isodiametric-quadrangular to polygonal, 10–25 µm in diameter, anticlinal cell walls almost straight, with slight thickenings, simple trichome bases solitary, indistinct remains of hypodermis partly visible; abaxial epidermis more strongly cutinised; outlines of ordinary cells triangular to mostly polygonal, 20–25(–40) µm in diameter, anticlinal walls pitted, straight to slightly curved and finely undulate, stomata amphicyclobrachyparacytic, guard cells deeply sunken, with two parallel narrow and thickened inner subsidiary cells 17–25 µm long and 10–12 µm wide and a circle of (4–)5–6(–7) outer subsidiary (encircling) small modified cells with smooth anticlinal walls; simple thickened trichome bases 5-8 µm in diameter, solitary, particularly on veins.

Discussion. *Laurophyllum acutimontanum* Mai was widely distributed in the European Oligocene and already began to appear in the late Eocene Staré Sedlo (Altsattel) Formation in North Bohemia (Knobloch et al. 1996). The originally assumed higher variation in gross morphology of leaves from brochidodromous to triveined venation (Mai 1963) has not been confirmed since then (Kvaček 1971, 2004, Knobloch et al. 1996, Walther & Kvaček 2007). This fossil species differs from most other fossil Lauraceae in its complex stomata. The assumed relationship to *Neolitsea* (Bentham et J.D. Hooker) Merrill 1906 nom. cons. [in Mai 1963 originally to *Tetradenia* Nees (non Benth.)] has not been confirmed.

Daphnogene Unger 1850

Daphnogene cinnamomifolia (Brongn. in Cuv. 1822) Unger 1850

Fig. 4C–E; Fig. 5A, B

***1822a** *Phyllites cinnamomeifolia* Brongn. in Cuv. 1822a: 617; pl. 11, fig. 12 [Habichtswald bei Kassel] (only figured).

1822b *Phyllites cinnamomeifolia* Brongn. in Cuv. 1822b: 359–360 [Habichtswald bei Kassel] (diagnosis).

1822 *Phyllites cinnamomeifolia* Brongn. – Brongn. in Cuv. & Brongn.: 361, 362, 402; pl. 11, fig. 12 [Habichtswald at Kassel].

1850b *Daphnogene lanceolata* Unger: 167; pl. 37, fig. 1–7 [Socka].

1850b *Daphnogene cinnamomeifolia* (Brongn. in Cuv.) Unger: 168; pl. 39, figs 7–9 [Socka].

1934 *Cinnamomum scheuchzeri* (Heer) Fr. – Weyland: 81 [Altenrath].

1934 *Daphnogene lanceolata* Ung. – Weyland: 83–84; pl. 11, fig. 6; pl. 13, fig. 7; pl. 14, fig. 8 [Altenrath].

1940 *Cinnamomum scheuchzeri* (Heer) Fr. – Weyland: 105 (list) [Altenrath, Stallberg].

1940 *Daphnogene septimontana* Weyland: 105 (list), 110–111; pl. 4, figs 3–7 [Altenrath, Stallberg].

1950 *Daphnogene septimontana* Weyland – Kräusel & Weyland: 62–64; pl. 14, figs 5–8; text-fig. 24 [Altenrath, Stallberg, Remscheid, Wintermühlenhof].

1999 *Daphnogene cinnamomifolia* (Brongniart) Unger forma *cinnamomifolia* sensu Kvaček & Walther 1995 – Walther: 86, 87; pl. 4, fig. 5; text-fig. 16/3 [Oberlausitz, Kleinsaubernitz near Bautzen].

1999 *Daphnogene cinnamomifolia* (Brongniart) Unger forma *lanceolata* sensu Kvaček & Walther 1995 – Walther: 87; pl. 4, figs 6–9 [Oberlausitz, Kleinsaubernitz near Bautzen].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2012/0388 – [**Holotype** of *Daphnogene septimontana* Weyland (designated by Weyland 1948: 155)] = Weyland (1934: pl. 14, fig. 8), Weyland (1940: pl. 4, fig. 6), Kräusel & Weyland (1950: pl. 14, fig. 5). MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0068 – [**Paratype** of *Daphnogene septimontana* Weyland (designated by Weyland 1948: 155)] = Weyland (1934: pl. 11, fig. 6), Weyland (1940: pl. 4, fig. 7). MB.Pb.2005/0066 = Weyland (1934: pl. 13, fig. 7). MfN coll. P.G.L.A. Berlin: MB.Pb. 2012/0388.1, MB.Pb.2013/2007, MB.Pb.2013/2014, MB.Pb.2013/2016, MB.Pb.2013/2019, MB.Pb.2013/2027, MB.Pb.2013/2029, MB.Pb.2013/2032, MB.Pb.2013/2038, MB.Pb.2013/2041, MB.Pb.2013/2044, MB.Pb.2013/2045, MB.Pb.2013/2049, MB.Pb.2013/2054, MB.Pb.2013/2055, MB.Pb.2013/2057, MB.Pb.2013/2059, MB.Pb.2013/2068, MB.Pb.2013/2073, MB.Pb.2013/2080, MB.Pb.2013/2084, MB.Pb.2013/2090 [*Daphnogene lanceolata* Unger], MB.Pb.2013/2082 [*Cinnamomum scheuchzeri* (Heer) Frtz.] + [*Daphnogene bilinica* (Ung.)]. MB.Pb.2013/2089 [? *Daphnogene*]. IGMK coll. Weyland: 4145 (1) [*Daphnogene lanceolata* Ung.], 4154 (1) [*Daphnogene septimontana* Wld.].

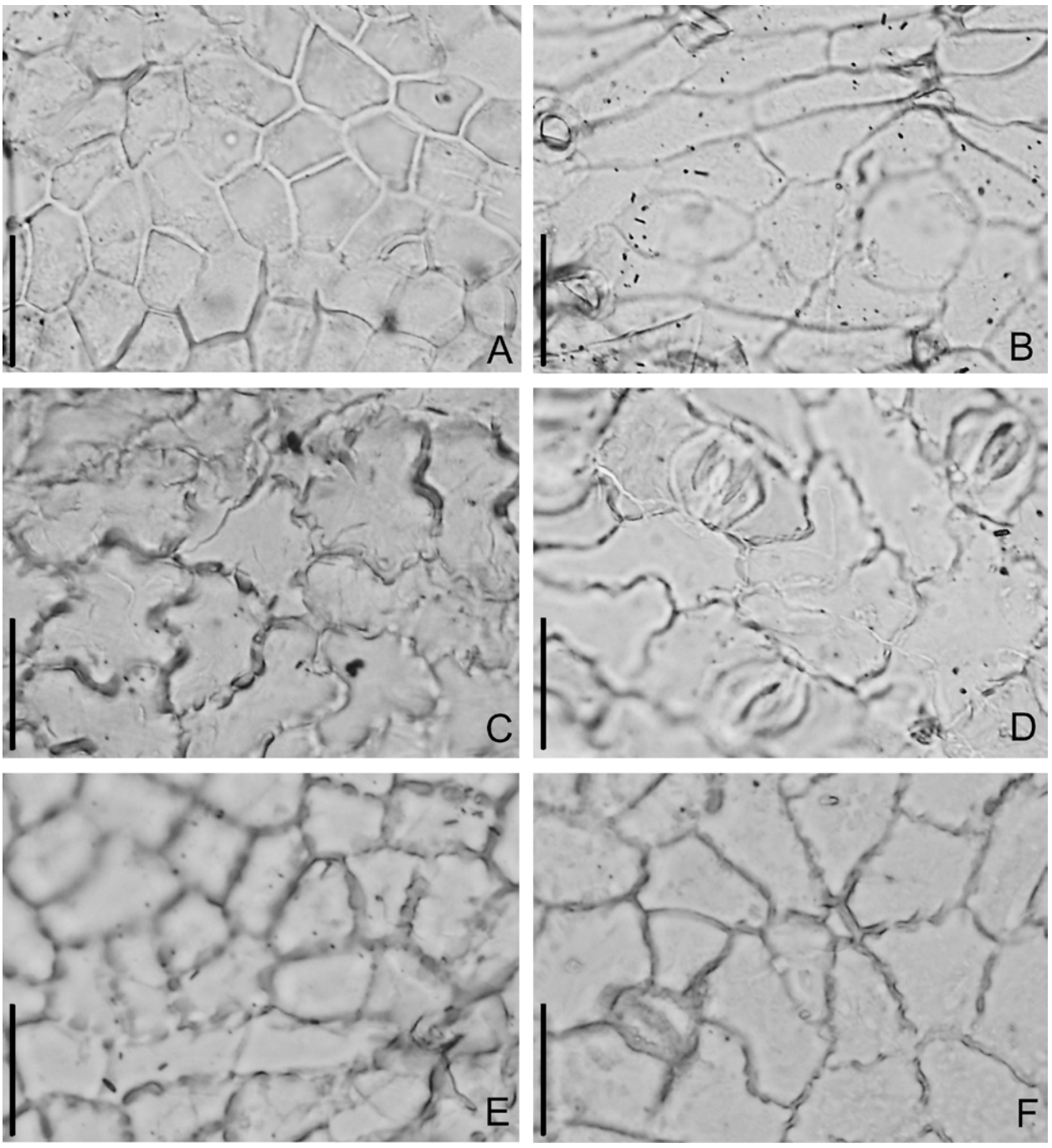


Fig. 5. *Daphnogene cinnamomifolia (*Brongn. in Cuv. 1822) Unger 1850, Altenrath. **A**: Cuticle of the adaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2012/0388.1. **B**: Cuticle of abaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/0029.1. *Laurophyllum pseudoprinceps* Weyland et Kilpper 1963, Altenrath. **C**: Cuticle of adaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2033. **D**: Cuticle of abaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2033. *Laurophyllum acutimontanum* Mai 1963, Altenrath. **E**: Cuticle of adaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0031. **F**: Cuticle of abaxial side of leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0031. Scale bar: 25 µm

Description. Leaves entire-margined, widely oval to oval (forma "*cinnamomifolia*" sensu Kvaček & Walther) or narrow-lanceolate to oval-lanceolate (forma "*lanceolata*" sensu Kvaček & Walther), with transitions between the two forms: apex acute, trigonal, partly long-acuminate with drip tip, base cuneate, primary vein thick, with two acrodromous secondaries starting ca 5–10 mm above the lamina base (imperfect-suprabasal); higher secondaries pinnate, alternate to subopposite, camptodromous; several tertiaries below basal secondaries looping as anastomoses, tertiaries oriented towards margin and apex camptodromous; higher secondaries in forma "*lanceolata*" only indistinctly developed.

Epidermal structure of MB.Pb.2012/0388.1 and MB.Pb.2013/2027 – adaxial epidermis

strongly cutinised, hairless, composed of straight-walled polygonal cells 10–20 µm in diameter; venation not well seen; abaxial epidermis medium-cutinised, densely hairy, particularly on veins; ordinary cells polygonal, ca 15–22 µm in diameter, with slightly wavy anticlinal walls, stomata brachyparacytic, widely elliptic, 15 µm long and 15–25 µm wide, guard cells widely elliptic, only indistinctly demarcated from two parallel subsidiary cells, stomatal ledges thin, forming short elliptic pore, polar thickenings not developed, trichome bases strongly cutinised, 10–15 µm in diameter, with strong foot and occasionally with narrow distal part preserved, densely distributed over the whole abaxial leaf surface.

Discussion. *Daphnogene cinnamomifolia* (Brongn. in Cuv.) Unger is a common and characteristic species occurring in various facies (fluvial: basinal assemblages; limnic: volcanic assemblages) and habitats (mesophytic forests as well as riparian vegetation) of the Palaeogene.

Superorder LILIANAE Takht. 1967

cf. Arecaceae inc. sed.

cf. ***Palmacites*** [Schloth. 1820] Brongn. 1822

"*Palmacites*" *canaliculatus* Heer 1855

Fig. 6A, B; Fig. 7A–D

***1855** *Palmacites canaliculatus* Heer: 95, 96, pl. 40, figs 2, 3 [Monod].

1934 *Manicaria formosa* Heer – Weyland: 40; pl. 1, fig. 6 [Altenrath].

1940 *Manicaria formosa* Heer – Weyland: 105 (list) [Altenrath].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063 = Weyland (1934: pl. 1, fig. 6).

Description. On the surface of this stem fragment appear regular parallel furrows, densely spaced, (3–)4–5(–6.5) mm apart, between simple flat and fine striated ribs 0.7–1.0 mm thick, forked in one place; carbonised tissue between ribs sclerenchymate, composed of thick-walled polyedric (mostly pentaedric) cells 12–30 µm in diameter (cell walls up to 4 µm thick). Cells of ribs thin-walled, in outline polygonal, rarely quadrangular, 20–30 µm in diameter or 25–30 µm wide and 20–30 µm long, with slightly curved walls, oriented irregularly or in lines.

Discussion. The cell pattern of the studied fossil does not correspond with any of the studied palm leaf samples lacking stomata (e.g. adaxial epidermis of *Caryota rumphiana* Mart. 1838, *Kentia microcarpa* Warb. ex K. Schum. & Lauterb. 1900 (coll. SM.B), or of *Dypsis lutescens* (H. Wendl. 1878) Beentje & J. Dransf. 1995 and *Juania australis* Drude ex Hook. f. 1884 according to Horn et al. (2009). Its sclerenchymate furrows do not support the assumption that the fossil represents a palm leaf. An entire-margined monocot leaf fragment showing midrib and parallel secondaries from the late Oligocene site Enspel in Westerwald (Köhler & Uhl 2014: 43, 44; pl. 14, figs 6, 7) and identified as cf. *Zingiberoideophyllum* sp. is not comparable, showing a clear venation pattern. The type of *Manicaria formosa* Heer (1855: 92, 93; pl. 38) may also represent a leaf, although its affinity to the genus *Manicaria* Gärtner itself

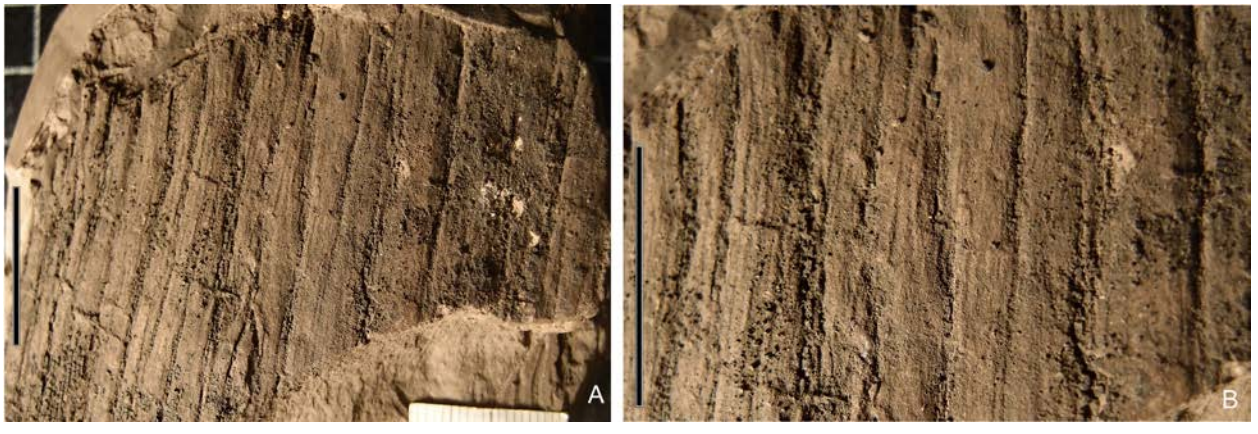
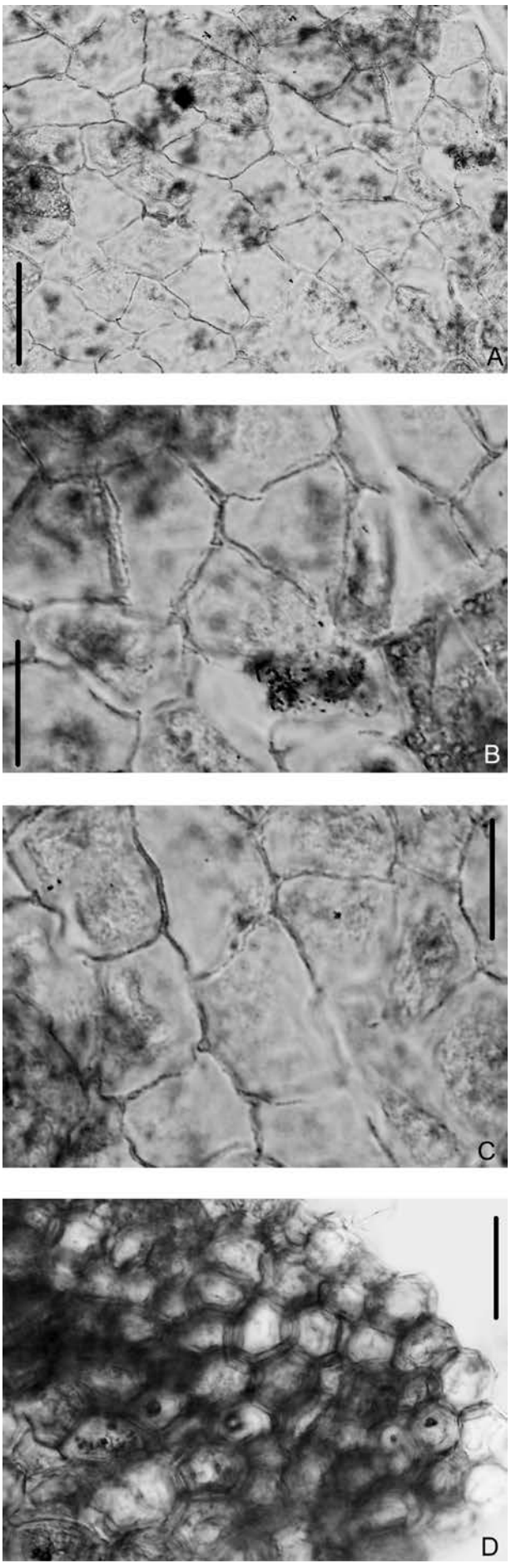


Fig. 6. "*Palmacites*" *canaliculatus* Heer 1855 (= "Manicaria formosa Heer 1855" sensu Weyland 1934), Altenrath. **A**: Trunk surface, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063 = Weyland (1934: Taf. 1, Fig. 6). **B**: Detail from A. Scale bar: 20 mm



is doubtful in our opinion. Plant fossils similar to the specimen studied from Altenrath are best considered as fragments of stems or bark of monocots, which may belong to palms. Similar fossils were described by Heer (1855: 95, 96, pl. 40, figs 2, 3) as *Palmacites canaliculatus* Heer from the late Oligocene deposits of Monod, and by Knobloch (in Knobloch et al. 1996: 140; pl. 50, figs 1, 2) as *Palmacites* (?) aff. *canaliculatus* Heer from the late Eocene Staré Sedlo (Altsattel) Formation of North Bohemia. More extensive comparative anatomical studies are required to determine such fossils. Similar impressions are also known from the sandstone of Dürresbach.

Superorder ROSANAE Takht. 1967

Order FAGALES Engl. 1892

Family FAGACEAE Dumort. 1829 nom. cons.

Eotrigonobalanus Walther et Kvaček in Kvaček et Walther 1989

Eotrigonobalanus furcinervis (Rossm. 1840) Walther & Kvaček 1989

Fig. 8A–D; Fig. 9A–C; Fig. 10A–F

***1840** *Phyllites furcinervis* Rossm.: 33–35; pl. 6, fig. 25; pl. 7, figs 32–36 [Staré Sedlo (Altsattel)].

1851 *Quercus grandidentata* Unger – Weber: 168, 169; pl. 18, fig. 12 [Quegstein, Allrott].

1851 *Quercus undulata* C.O. Weber, 170; pl. 19, fig. 1 [Quegstein].

1852 *Quercus goepperti* C.O. Weber, 171, 172; pl. 19, fig. 2 [Quegstein, Allrott].

1934 *Quercus goepperti* C.O. Weber – Weyland: 59, 60; text-figs 1, 2; pl. 6, figs 1, 2 [Altenrath].

1934 *Laurus princeps* Heer – Weyland: 72, 73; text-figs 4, 5; pl. 11, fig. 4; pl. 13, fig. 4 [Altenrath].

1934 *Laurus phoeboides* Ettingsh. – Weyland: 74; text-fig. 6; pl. 14, fig. 3 [Altenrath].

1934 *Persea speciosa* Heer – Weyland: 78–80; pl. 12, figs 6–9 [Altenrath].

1940 *Persea speciosa* Heer – Weyland: 105 (list) [Altenrath, Stallberg].

1940 *Laurus princeps* Heer – Weyland: 105 (list) [Altenrath, Stallberg].

Fig. 7. *"Palmacites" canaliculatus* Heer 1855 (= "Manicaria formosa Heer 1855" sensu Weyland 1934), Altenrath. **A**: Overview of epidermal structure in intercostal area, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063. **B**: Detail of epidermal structure in intercostal area, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063. **C**: Detail of epidermal structure in intercostal area, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063. **D**: Tissue of rib, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0063. Scale bar: 25 µm.

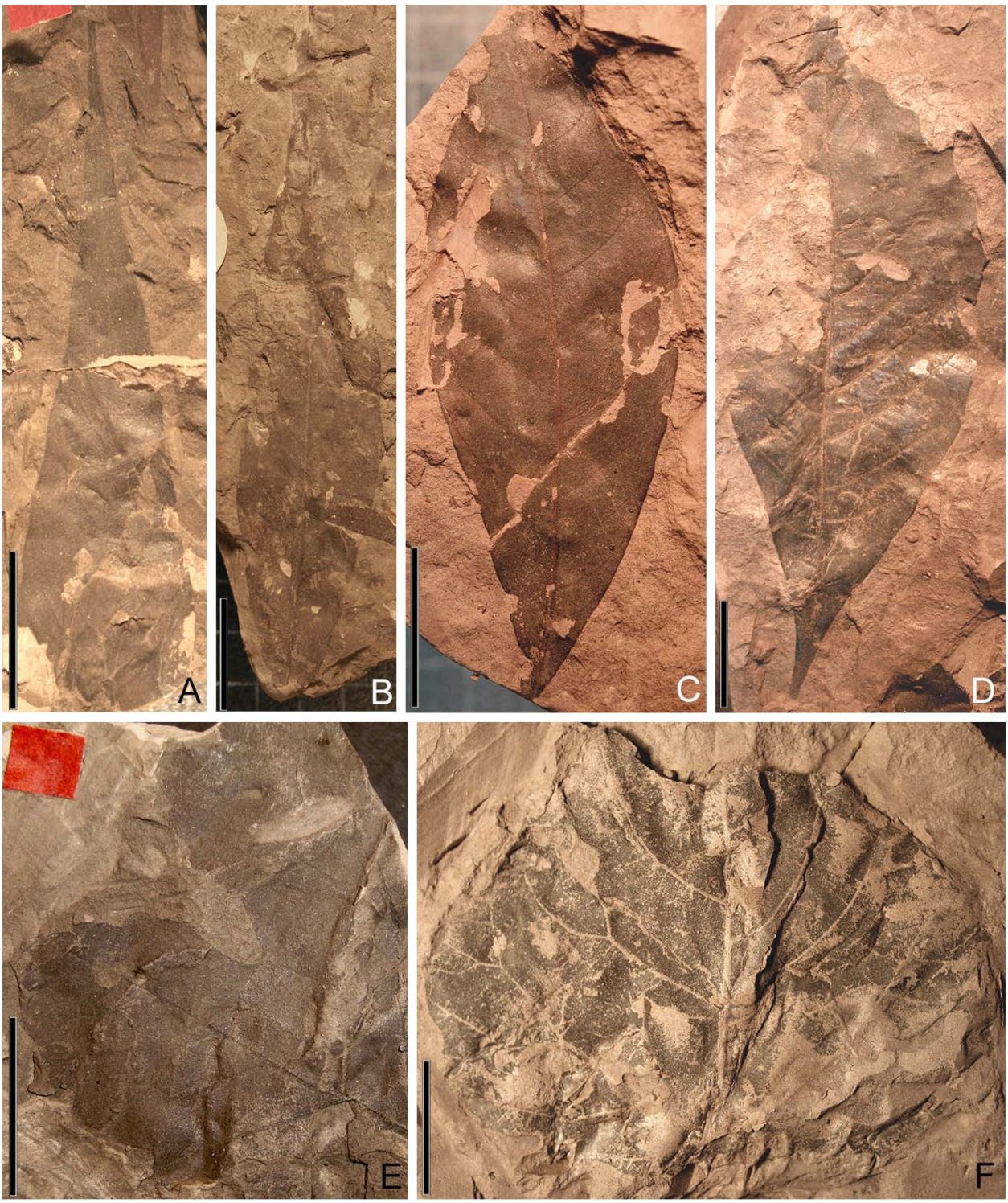


Fig. 8. *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989, Altenrath. **A**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0022 = Weyland (1934: Taf. 13, Fig. 4 – *Laurus princeps* Heer). **B**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0020.1 = Weyland (1934: Taf. 11, Fig. 4 – *Laurus princeps* Heer) = Kvaček & Walther (1989b: Textabb. 9/3) Walther & Kvaček). **C**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2075 [*Persea speciosa* Heer]. **D**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2034 [*Quercus goepperti* C.O. Weber]. *Populus germanica* (Menzel 1926) Walther in Mai & Walther 1991, Altenrath. **E**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0064 = Weyland (1934: Taf. 10, Fig. 1). **F**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2088. Scale bar: 20 mm

1940 *Laurus phoeboides* Ettingsh. – Weyland: 105 (list) [Altenrath, Stallberg].

1940 *Quercus goepperti* C.O. Weber – Weyland: 105 (list), 109, 110; text-figs 1–14 [Altenrath, Stallberg, Allrott, Quegstein].

1950 *Laurophyllum phoeboides* (Ettingsh.) Kräusel & Weyland: 61, 62; text-figs 22, 23; pl. 15, figs 1–8 [Altenrath, Stallberg].

1989a *Dryophyllum furcinerve* (Rossm.) Schmalhausen forma *haselbachense* Kvaček & Walther:

Fig. 9. *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989, Altenrath. **A**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0067 = Weyland (1934: pl. 12, fig. 6 – *Persea speciosa* Heer). **B**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0070 = Weyland (1934: pl. 6, fig. 1 – *Quercus goepperti* C.O. Weber) = Weyland (1940: text-fig. 7). **C**: Leaf, MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0021.1 = Weyland (1934: pl. 14, fig. 3 – *Laurus phoeboides* Ettingsh.) = Kräusel & Weyland (1950: pl. 15, fig. 1) = Kvaček & Walther (1989b: text-fig. 9/9; pl. 35, fig. 5). Scale bar: 20 mm

220; figs 2d, 3a, c [Altenrath, Haselbach, Kleinsaubernitz, Witznitz etc.].

1989a *Dryophyllum furcinerve* (Rossm.) Schmalhausen forma *furcinerve* Kvaček & Walther: 220; figs 3b [Profen].

1989b *Eotrigonobalanus furcinervis* (Rossm.) Kvaček & Walther: 581–593; pls 33–36; pl. 38, fig. 3; pls 39–46; pl. 47, figs 1–3.

1989b *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther: 584; text-figs 7, 8, 10; pl. 34, figs 1–6; pl. 35, figs 1–3, 7; pl. 36, figs 1–4;. pl. 39, figs 2–4; pl. 44, figs 1–4; pl. 45, figs 1–4; pl. 46, figs 1–4 [Altenrath etc.].

1996 *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček ssp. *furcinervis* – Knobloch et al.: 58–66; pl. 19, figs 3, 4; pl. 21, fig. 7; pl. 24, figs 2, 3, 5; pl. 25 figs 1–8; pl. 26, figs 1–6; pl. 27, figs 2–9; pl. 37, fig. 8; pl. 42, figs 3, 6, 7, text-figs 16a–d, 17a–f, 18a–f, 19a–f, 20a, b, 21a, 22a, b, 27e, 28b [various localities of the Staré Sedlo Formation].

1996 *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček ssp. *flagellinervis* (Rossm.) Knobloch & Kvaček in Knobloch et al.: 66–76; pl. 26, fig. 7; pl. 28, figs 5, 6; pl. 29, figs 1–3; pl. 30, figs 1–5; pl. 31, figs 1–6; pl. 32, figs 1–4, text-figs 16e–h, 21, 22c, 25a–f, 24a–c, 25a, b, 25 a–f, 27a–d, 28a, 29a–g [various localities of the Staré Sedlo Formation].

2006 *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 cf. forma *haselbachensis* Kvaček & Walther 1989 – Winterscheid: 122–124; pl. 2, fig. 4; pl. 3, figs 1–3; pl. 5, fig. 1 [Altenrath, Stallberg, Allrott, Quegstein].

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0067 = Weyland (1934: pl. 12, fig. 6 – *Persea speciosa* Heer), MB.Pb.2005/0070 = Weyland (1934: pl. 6, fig. 1) = Weyland (1940: text-fig. 7 – *Quercus goepperti* Web.), MB.Pb.1984/0020.1 = Weyland (1934: pl. 11, fig. 4 – *Laurus princeps* Heer) = Kvaček & Walther (1989b: text-fig. 9/3 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0022 = Weyland (1934: pl. 13, fig. 4 – *Laurus princeps* Heer), MB.Pb.1984/0021.1 = Weyland (1934: pl. 14, fig. 3 – *Laurus phoeboides* Ett.) = Kräusel & Weyland (1950: pl. 15, fig. 1 – *Laurophyllum phoeboides* (Ettingsh.) nov. comb.) = Kvaček & Walther (1989b: text-fig. 9/9; pl. 35, fig. 5 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0023.2 [*Laurus phoeboides* Ett.] = Kvaček & Walther (1989b: text-fig. 9/7 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0024 [*Quercus goepperti* Weber] = Kvaček & Walther (1989b: text-fig. 9/2 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther) und [*Laurus phoeboides* Ett.], MB.Pb.1984/0025.2 [“*Laurus phoeboides* Ett.”] = Kvaček & Walther (1989b: text-fig. 9/8; pl. 35, fig. 6 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0026 [*Laurus phoeboides* Ett.] = Kvaček & Walther (1989b: pl. 35, fig. 4 – *Eotrigonobalanus furcinervis* (Rossm.)

Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0028 [“*Laurus phoeboides* Ett.”] = Kvaček & Walther (1989b: text-fig. 9/4 – *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther), MB.Pb.1984/0034 [“*Laurus princeps* Heer”] = Kvaček & Walther (1989b: text-fig. 9/6 – *Eotrigonobalanus furcinervis* (Rossm.) Walther

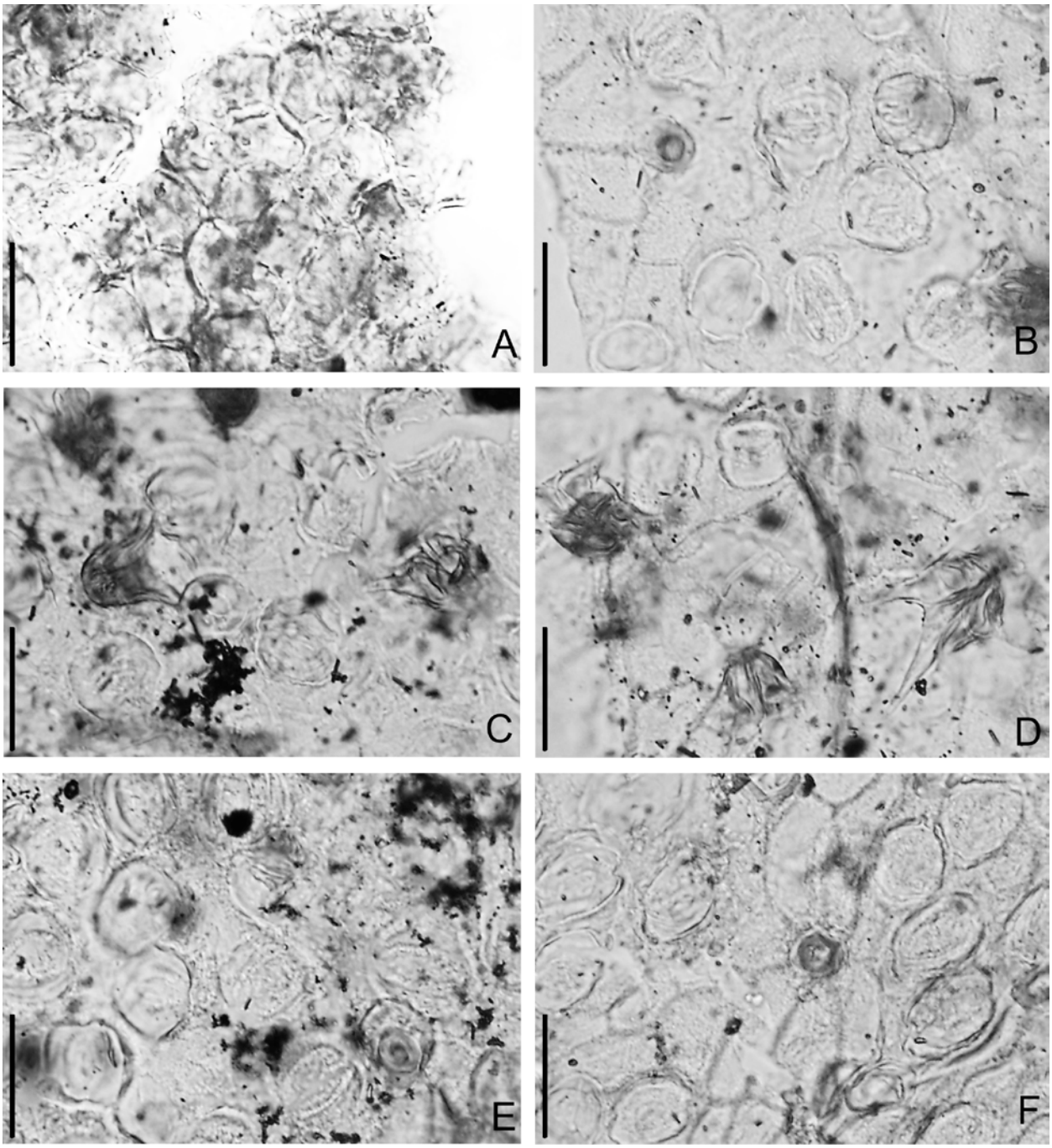


Fig. 10. *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989. **A**: Cuticle of adaxial side of leaf, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *haselbachensis* Walther & Kvaček 1989, Stallberg, SMSU Bauckhorn coll., coll. no. 9 = Weyland (1940: text-fig. 1 – *Quercus goepperti* C.O. Weber). **B**: Cuticle of abaxial side of leaf with trichome base, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *haselbachensis* Walther & Kvaček 1989, Stallberg, SMSU coll. Bauckhorn, coll. no. 13 = Weyland (1940: text-fig. 5 – *Quercus goepperti* C.O. Weber). **C**: Cuticle of abaxial side of leaf with stomata and stellate trichomes, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *furcinervis*, Altenrath, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2018. **D**: 2- to 4 radiate trichomes, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *furcinervis*, Altenrath, MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2024A. **E**: Stomata and base of glandular trichome on cuticle of abaxial side of leaf, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *haselbachensis* Walther & Kvaček 1989, Altenrath, MfN coll. P.G.L.A. Berlin: MB.Pb.2005/2067. **F**: Stomata and base of glandular trichome on cuticle of abaxial side of leaf, *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček 1989 forma *haselbachensis* Walther & Kvaček 1989, Stallberg, IGMK coll. Weyland: 1038. Scale bar: 25 µm

& Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther). MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0025.2, MB.Pb.1984/0027.1, MB.Pb.1984/0032, MB.Pb.1984/0033, MB.Pb.1984/0035, MB.Pb.2013/2010, MB.Pb.2013/2063, MB.Pb.2013/2087 [*Laurus phoeboides*]. MB.Pb.1984/0029, MB.Pb.1984/0030, MB.Pb.1984/0031, MB.Pb.2013/2046 [*Laurus princeps* Heer]. MB.Pb.2013/2018, MB.Pb.2013/2040, MB.Pb.2013/2074, MB.Pb.2013/2079, MB.Pb.2013/2094, MB.Pb.2013/2013, MB.Pb.2013/2043, MB.Pb.2013/2051, MB.Pb.2013/2052, MB.Pb.2013/2075, MB.Pb.2013/2076, MB.Pb.2013/2083, MB.Pb.2013/2091 [*Persea speciosa* Heer]. MB.Pb.2013/2071 [Lauraceenblatt. ? *Persea speciosa* Heer]. MB.Pb.1998/0393, MB.Pb.1998/0394.1, MB.Pb.1998/0406, MB.Pb.1998/0407, MB.Pb.2013/2009, MB.Pb.2013/2012, MB.Pb.2013/2015, MB.Pb.2013/2020, MB.Pb.2013/2037, MB.Pb.2013/2039, MB.Pb.2013/2042, MB.Pb.2013/2058, MB.Pb.2013/2086, MB.Pb.2013/2022, MB.Pb.2013/2023.1, MB.Pb.2013/2024, MB.Pb.1984/0025.1, MB.Pb.2013/2030, MB.Pb.2013/2031, MB.Pb.2013/2034, MB.Pb.2013/2035, MB.Pb.2013/2053, MB.Pb.2013/2060, MB.Pb.2013/2061, MB.Pb.2013/2065, MB.Pb.2013/2081, MB.Pb.2013/2085 [*Quercus goepperti* C.O. Weber]. IGMK coll. Weyland: 4144a (1), 4147 (1), 4148 (1) [*Quercus goepperti* Web.]. 4148 (2), 4149 (1), 4151a (1) [*Laurus phoeboides* Ett.]. 1036 (1), 1036 (2), 4143 (1), 4146 (1), 4148 (3), 4150 (1), 4153 (1-2) [*Persea speciosa* Heer]. Stallberg – SMSU Bauckhorn coll., coll. no. 9 = Weyland (1940: text-fig. 1 – *Quercus goepperti* C.O. Weber), SMSU Bauckhorn coll., coll. no. 10 = Weyland (1940: text-fig.. 2 – *Quercus goepperti* C.O. Weber), SMSU Bauckhorn coll., coll. no. 11 = Weyland (1940: text-fig. 3 – *Quercus goepperti* C.O. Weber), SMSU Bauckhorn coll., coll. no. 12 = Weyland (1940: Textabb. 4 – *Quercus goepperti* C.O. Weber), SMSU Bauckhorn coll., coll. no. 13 = Weyland (1940: text-fig. 5 – *Quercus goepperti* C.O. Weber), SMSU Bauckhorn coll., coll. no. 14 = Weyland (1940: text-fig. 6 – *Quercus goepperti* C.O. Weber). IGMK coll. Weyland: 1038 [? *Quercus goeppertii* Web.], 1048 (1) [*Laurus phoeboides* Ett.]. SM 6332/2 = Kräusel & Weyland (1950: text-fig. 22).

Description. Leaves petiolate, lamina thick and morphologically very variable: elliptic to widely elliptic, ovate to widely ovate, obovate to widely obovate to oblong; base gradually narrowed, acute-cuneate, in wider forms decurrent, apex never preserved, leaf margin in oblong-lanceolate forms entire ("*phoeboides*" form), partly slightly wavy ("*speciosa*" form) to dentate, in wider forms coarsely dentate ("*goepperti*" form); venation pinnate; midrib strong and straight, secondaries eucamptodromous in entire-margined forms, semicraspedodromous in forms with wavy to wavy-dentate forms and craspedodromous in dentate forms; secondaries slightly alternate to subopposite, forked towards margin, with the basally oriented branch entering the tooth and the apically oriented branch passing along the notch, in wavy forms the basal branch entering the arch and the apical one running parallel with the margin and looping with the next above the secondary vein, intersecondaries present; tertiary venation orthogonally oriented to the secondaries.

Cuticle structure variously preserved:

[1] "*goepperti*" form: typical in MB.Pb.2013/2034 and MB.Pb.2005/0070 [synonym: *Quercus goepperti* C.O. Weber] – cuticle of adaxial epidermis not preserved, abaxial epidermis medium-cutinised, slightly pitted, on veins strongly striate, ordinary cells straight-walled, ca 15–20 µm in diameter, stomata anomocytic to cyclocytic, in groups, with slightly darker periphery, densely disposed, almost the same size, widely oval to rounded, 15–18 µm in diameter, ledges slightly thickened and pitted, pore narrow-elliptic, almost fully stretching between stomatal poles; bases of glandular trichomes scattered among stomata, with solid foot; stellate trichomes with 2 to mostly 4 rays ca 20 µm long, rarely scattered among stomata, more often along thicker veins.

[2] "*phoeboides*" form: typical in MB.Pb.1984/0033 and MB.Pb.2013/2063 [synonym: *Laurus phoeboides* Ettingsh.] – adaxial epidermis thinly cutinised, smooth, composed of polygonal straight-walled cells 20–25 µm in diameter; abaxial epidermis more strongly cutinised, densely covered with trichome bases; stomata dense in groups, widely oval to rounded, anomocytic, guard cells very uniform, ca 25 µm long and 20–25 µm wide, on periphery slightly thickened; stomatal ledges short, not thickened. Bases of glandular trichomes

thickened and rounded, ca 20 µm in diameter, very dense over the whole abaxial leaf side. Cuticle over veins striate.

[3] "*speciosa*" form: typical in MB.Pb.2005/0067 and MB.Pb.2013/2051 [synonym: *Persea speciosa* Heer] – cuticle of adaxial epidermis fragmentarily preserved, smooth, showing straight-walled polygonal cells, abaxial epidermis moderately cutinised, slightly pitted, composed of ordinary straight-walled polygonal cells, 15–30 µm in diameter; stomata in groups rounded to widely oval, anomocytic to cyclocytic with slightly darker periphery 15–22 µm long and 18 µm wide, varying in form from widely oval to rounded to transversely oval; ledges thickened, stretching between stomatal poles, pore wide; trichome bases rounded, strongly cutinised, 10–15 µm in diameter, sparse among stomata.

Discussion. Because of "der sehr zahlreich vorliegenden Blätter" at the Ludwigshütte site at Altenrath, Weyland (1934: 59, 60; pl. 6, figs 1, 2, text-figs 1, 2) assumed that both fossil *Quercus goepperti* C.O. Weber (Weber 1852: 171, 172; pl. 19, fig. 2) and *Quercus undulata* C.O. Weber (Weber 1851: 170; pl. 19, fig. 1) belong to the same taxon: "Ihre Variationsbreite übersteigt nicht das bei Eichen übliche Maß und eine Trennung der beiden Formen ist ganz unmöglich." Later, Weyland noted (1938: 136, 137, text-figs 1, 2) under *Quercus goepperti* C.O. Weber two specimens (one entire-margined and one dentate) from the coal facies of Rott, which he considered extreme forms of the same species ("extreme Blattformen dieser Art"). In the same paper Weyland wrote that the form of *Quercus grandidentata* Unger probably is confined to older sites ("offenbar nur auf die etwas älteren Fundorte beschränkt") (e.g. Quegstein, Allrott, Remscheid). Based on the material of Stallberg, *Quercus grandidentata* Unger (Weber 1851: 168, 169; pl. 18, fig. 12) typical of quarzites from the underlying strata, also was included in *Quercus goepperti* Weber by Weyland (1940: 109, 110, text-figs 1–14). According to the emended diagnosis of *Quercus goepperti* C.O. Weber based on the leaf morphology (Weyland 1940: 110) and three taxa following the descriptions in Weber (1852: 54–57) and Weyland (1934: 59, 60, 1938: 136, 137, 1940: 109, 110), these "*Quercus*" species may also fall within the variation of *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček.

Cuticular studies of specimens identified as *Quercus goepperti* C.O. Weber confirmed their affinity to *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček. Besides the "*goepperti*" form, the laurophyllous "*phoeboides*" form (*Laurus phoeboides* Ettingsh.) and the "*speciosa*" form (*Persea speciosa* Heer) are also assignable to this taxon on evidence of cuticle structure. According to the type of pubescence, two intraspecific taxa are recognisable independent of leaf morphology:

[1] *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *furcinervis* [MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0027.1, MB.Pb.1984/0033, MB.Pb.2005/0070, MB.Pb.2013/2016, MB.Pb.2013/2018, MB.Pb.2013/2034B, MB.Pb.2013/2040, MB.Pb.2013/51, MB.Pb.2013/2063, MB.Pb.2013/2071, MB.Pb.2013/2075, MB.Pb.2013/83; SMSU Bauckhorn coll., coll. no. 12 = Weyland (1940: text-fig. 4); IGMK coll. Weyland: 4144(1)]. In most samples from Altenrath, exceptionally also from Stallberg, small stellate trichomes with (2–)4 rays occur on the abaxial leaf side. Hence the data from Walther in Kvaček & Walther (1989b: 590, 592) concerning *Eotrigonobalanus furcinervis* from Altenrath should be corrected. The leaf anatomy varies here to the same extent in dentate as well as in entire-margined forms. Therefore we do not recognise such subspecies (e.g. Knobloch et al. 1996: ssp. *furcinervis* and ssp. *flagellinervis*) and hold them to be a mere taxonomically insignificant variation.

[2] *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček forma *haselbachensis* (Kvaček & Walther) Kvaček & Walther [MfN coll. P.G.L.A. Berlin: MB.Pb.1984/0022, 1984/0031, MB.Pb.2005/0067, MB.Pb.2013/2083; SMSU coll. Bauckhorn, coll. no. 9 = Weyland (1940: text-fig. 1), coll. no. 10 = Weyland (1940: text-fig. 2), coll. no. 11 = Weyland (1940: text-fig. 3), coll. no. 13 = Weyland (1940: text-fig. 5); SM 6332/2 from Stallberg = Kräusel & Weyland 1950: text-fig. 22)]. In the leaf assemblage from Altenrath, this form without stellate trichomes is intermixed with hairy f. *furcinervis* and supports the original concept introduced by Kvaček & Walther (1989a, b) by which this type of variation within *E. furcinervis* does not indicate differentiation of subspecies. In Stallberg the *haselbachensis* form strongly prevails.

Eotrigonobalanus furcinervis (Rossm.) Walther & Kvaček is accessory to the dominant

laurophyllous thermophilous element of the middle to late Eocene coal-forming swamp and riparian forests as well as the Oligocene mixed mesophytic forests in Europe. This taxon was considered by several authors (Kvaček & Walther 1989a, b) to be a very important forest element of the Paleogene, with a broader ecological amplitude. According to all the records so far reported, this taxon occurred in the Lower Rhine Embayment only in the pre-volcanic late Oligocene siliciclastic facies of the Siebengebirge, here as a common element of riparian forests.

Order VIOLALES Vent. ex Berch. et J. Presl 1820

Family SALICACEAE Mirbel 1815 nom. cons.

Populus L. 1753

Populus germanica (Menzel 1926) Walther in Mai et Walther 1991

Fig. 8E, F

***1926** *Menispermites germanica* Menzel: 32; pl. 1–3 [Thüringen, Waltersdorf].
1934 *Populus latior* A. Br. – Weyland: 43 [Altenrath].
1934 *Menispermites germanicus* Menz. – Weyland: 66; pl. 10, fig. 1 [Altenrath].
1940 *Menispermites germanic.* Menz. – Weyland: 105 (list) [Altenrath].
1978 *Populus germanica* (Menzel) Walther in Mai & Walther, 90–92; pl. 3, fig. 16; pl. 8, figs 1–9; pl. 9, figs 1, 2; pl. 36, figs 1–8; pl. 37, figs 1–5 [Weißelster Basin].
1991 *Populus germanica* (Menzel) Walther emend. Walther in Mai & Walther: 80, 81; pl. 43, figs 1–6; pl. 44, figs 5–7.
2006 *Populus germanica* (Menzel) Walther emend. Reuschel & Walther, 6–9; pl. 1, fig. 1; pl. 2, figs 1–4; pl. 3, figs 1–3; pl. 4, figs 1–3; pl. 5, figs 1–4; pl. 6, fig. 1–3; pl. 9, figs 1–5; pl. 10, figs 1, 2.

Material examined. Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2005/0064 = Weyland (1934: pl. 10, fig. 1 – *Menispermites germanicus* Menz.). MB.Pb.2013/2026, MB.Pb.2013/2088 [*Populus latior* A. Br.]. IGMK coll. Weyland: 4152 (1) [*Menispermites germanica* Menz.]. Stallberg – IGMK coll. Weyland: 1041 [without data], 4181 (1) [*Populus latior* A. Braun].

Description. This morphologically variable foliage has lamina of rounded-oval, rounded-cordate or trilobate form, and a lobed to regularly or irregularly dentate margin – see detailed descriptions by Mai & Walther (1991: 80–81) and Reuschel & Walther (2006: 6–9).

Discussion. *Populus germanica* (Menzel) Walther in Mai & Walther belongs, besides *Taxodium dubium* (Sternb.) Heer, *Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček and *Daphnogene cinnamomifolia* (Brongn. in Cuv.) Unger, to the characteristic elements of riparian azonal vegetation of the siliciclastic facies.

Specimens incertae sedis

Specimens present in collections but indeterminable:

The following listed material comprises leaf remains that cannot be determined systematically and taxonomically because of their poor state of preservation (indistinct venation, fragmentary specimens with missing leaf bases, apices, margins) or their present state of conservation (superficial abrasion and obliteration); thus the previous determinations and notes on labels in collections cannot be verified.

Altenrath – MfN coll. P.G.L.A. Berlin: MB.Pb.2013/2036, MB.Pb.2013/2048, MB.Pb.2013/2067, MB.Pb.2013/2070, MB.Pb.2013/2072, MB.Pb.2013/2078, MB.Pb.2013/2093.

Altenrath and Stallberg – ca 100 specimens in the coll. Bauckhorn in Stadtmuseum Siegburg, available and described by Weyland (1940: 104, 105), cannot be attributed to a locality, and the labels with Weyland's handwriting are not assignable to the collection items. Furthermore, the poor state of preservation and the absence of morphological characters of these specimens prevent a proper description and determination.

THE DÜRRESBACH FLORA

The plant remains of the Dürresbach locality were taxonomically studied by Winterscheid (2006). Here we refrain from describing the taxa in a "fossilium catalogus" again. The results of the present study and revision are shown in Table 4.

DISCUSSION

A proper and thorough vegetation analysis cannot be made at present, because too few taxa are represented in the material from

Table 3. Revision of taxonomic identifications by Weyland (1934, 1940), Kräusel & Weyland (1950), Kvaček & Walther (1989b) and on labels in collections of Troisdorf-Altenrath and Siegburg-Stallberg

Determinations by Weyland (1934, 1940) and labels in collection	Revised determinations	Altenrath	Stallberg
Subclass POLYPODIIDAE Cronquist, Takht. & Zimmerm. 1966 Family OSMUNDACEAE Martinov 1820			
MB.Pb.2005/0065 = Weyland (1934: Taf. 1, Fig. 2 – "*Lastraea stiriaca* (Unger) Heer").	*Osmunda lignitum* (Giebel) Stur	•	–
Subclass PINIDAE Cronquist, Takht. & Zimmerm. 1966 Family CUPRESSACEAE Gray 1822 nom. cons.			
Weyland (1934: 39 – "*Taxodium distichum miocenicum* Heer").	*Taxodium dubium* (Sternb.) Heer	•	•
Subclass MAGNOLIIDAE Novák ex Takht. 1967 Family LAURACEAE Juss. 1789 nom. cons.			
MB.Pb.2005/0069 = Weyland (1934: Taf. 16, Fig. 7 – "*Laurus grandifolia* Ett."). Weyland (1934: Taf. 16, Fig. 7 – "*Laurus grandifolia* Ettingsh."). MB.Pb.2013/2033 ["*Persea speciosa* Heer"].	*Laurophyllum pseudoprinceps* Weyland & Kilpper	•	–
MB.Pb.1984/0031 ["*Laurus princeps* Heer"] und MB.Pb.2013/2017 ["*Laurus grandifolia* Ett."].	*Laurophyllum acutimontanum* Mai	•	–
MB.Pb.2005/0068 = Weyland (1934: Taf. 11, Fig. 6 – "*Daphnogene lanceolata* Ung.") und Weyland (1940: Taf. 4, Abb. 7 – "*Daphnogene septimontana* Weyland"). MB.Pb.2005/0066 = Weyland (1934: Taf. 13, Fig. 7 – "*Daphnogene lanceolata* Ung."). MB.Pb.2012/0388 = Weyland (1934: Taf. 14, Fig. 8 – "*Daphnogene lanceolata* Ung."), Weyland (1940: Taf. 4 Abb. 6 – "*Daphnogene septimontana* Weyland" – Holotypus) und Kräusel & Weyland (1950: Taf. 14, Fig. 5 – "*Daphnogene septimontana* Weyland").	*Daphnogene cinnamomifolia* (Brongn.) Unger	•	•
Family ARECACEAE Bercht. & J. Presl 1820 nom. cons., incertae sedis			
MB.Pb.2005/0063 = Weyland (1934: Taf. 1, Fig. 6 – "*Manicaria formosa* Heer").	"*Palmacites*" *canaliculatus* Heer	•	–
Family FAGACEAE Dumort. 1829 nom. cons.			
MB.Pb.2005/0070 = Weyland (1934: Abb. 1, 2, Taf. 6, Figs 1, 2 – "*Quercus goepperti* Weber"). MB.Pb.1984/0020.1, MB.Pb.1984/0022 = Weyland (1934: Abb. 4, 5; Taf. 11, Fig. 4; Taf. 13, Fig. 4 – "*Laurus princeps* Heer"). MB.Pb.2005/0067= Weyland (1934: Taf. 12, Fig. 6 – "*Persea speciosa* Heer". MB.Pb.1984/0021.1 = Weyland (1934: Abb. 6; Taf. 14, Fig. 3 – "*Laurus phoeboides* Ettingsh.").	*Eotrigonobalanus furcinervis* (Rossm.) Walther & Kvaček	•	•
Family SALICACEAE Mirbel 1815 nom. cons.			
MB.Pb.2005/0064 = Weyland (1934: Taf. 10, Fig. 1 – "*Menispermites germanicus* Menzel").	*Populus germanica* (Menzel) Walther ex Mai & Walther	•	–

Altenrath, Stallberg, and Dürresbach. Such an analysis will be given in detail when the entire flora of the siliciclastic facies, including that from the central Siebengebirge Mts. (e.g. Quegstein, Allrott etc.), is completed.

Plant remains from the Altenrath and Stallberg localities were found in coaly, light to grey-brown, sandy and silty clays, which were deposited in a quietly flowing fluviatile environment or in abandoned channels. The leaf remains were oriented parallel to the bedding and are preserved as compressions.

Higher flow energy is assumed for the fluviatile sedimentation environment of the coarsely clastic sediments of Dürresbach, composed of conglomerates and sands. Here, besides leaf and fruit impressions, wood remains up to 30 cm in diameter were also found. The leaf remains were not arranged parallel to the bedding planes but sometimes embedded in sandstone and thus fossilised. Occasionally the plant remains appear to have been accumulated and deposited in nests along drift lines and by point-bar deposition: for example, the impressions of endocarps of *Mastixia amygdalaeformis* (Schloth.) Kirchh.

All described taxa are elements of riverside and riparian vegetation of azonal habitats (cf. Table 5). The quantitatively most frequent taxa represent typical elements of

Table 4. Taxonomic identifications of the plant remains from Dürresbach near Hennef-Söven

Determinations by Winterscheid (2006)	Revised determinations
Subclass PINIDAE Cronquist, Takht. et Zimmerm. 1966 Family CUPRESSACEAE Gray 1822 nom. cons.	
StIPB Dbt-4.1–2 = Winterscheid (2006: 69, 70; Taf. 5, Figs 3, 4).	*Sequoia abietina* (Brongn. in Cuv.) Knobloch
StIPB Dbt-3 = Winterscheid (2006: 74–76 – "cf. *Glyptostrobus europaeus*").	*Taxodium dubium* (Sternb.) Heer
Subclass MAGNOLIIDAE Novák ex Takht. 1967 Family LAURACEAE Juss. 1789 nom. cons.	
StIPB Dbt-6 = Winterscheid (2006: 94–96).	*Daphnogene cinnamomifolia* (Brongn.) Unger
StIPB Dbt-5 = Winterscheid (2006: 84, 85).	*Laurocarpum* sp.
Family ARECACEAE Bercht. & J. Presl 1820 nom. cons., incertae sedis	
StIPB Dbt-11 = Winterscheid (2006: 239 – Holzreste "inc. sed.").	Arecaceae, gen. et spec. indet., cf. "*Palmacites*" *canaliculatus* Heer
Family HAMAMELIDACEAE R. Br. in C. Abel 1818 nom. cons.	
StIPB Dbt-2 = Winterscheid (2006: 117 – "*Liquidambar* sp. 2").	*Liquidambar europaea* A. Braun
Family FAGACEAE Dumort. 1829 nom. cons.	
StIPB Dbt-13 = Winterscheid (2006: 122–124). StIPB Dbt-7 = Winterscheid (2006: 126, 127; Taf. 1, Fig. 1; Taf. 1, Fig. 2 – *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček et Walther).	*Eotrigonobalanus furcinervis* (Rossm.) Walther et Kvaček
Family CORNACEAE Bercht. & J. Presl 1825 nom. cons.	
StIPB Dbt-9 = Winterscheid (2006: 167–169; Taf. 24, Fig. 7).	*Mastixia amygdalaeformis* (Schloth.) Kirchh.
Family SALICACEAE Mirbel 1815 nom. cons.	
StIPB Dbt-1 = Winterscheid (2006: 188, 189; Taf. 1, Fig. 3).	*Populus germanica* (Menzel) Walther ex Mai & Walther
MAGNOLIIDAE inc. sed.	
StIPB Dbt-8 = Winterscheid (2006: 236, 237; Taf. 5, Fig. 2; Taf. 5, Fig. 5).	*Carpolithus sophiae* (C.O. Weber) Weyland
StIPB Dbt-12 = Winterscheid (2006: 217, 218).	"*Echitonium*" *sophiae* C.O. Weber
StIPB Dbt-10 = Winterscheid (2006: 214; Taf. 1, Fig. 1; Taf. 2, Fig. 1).	*Majanthemophyllum petiolatum* C.O. Weber

Table 5. Taxa of the azonal plant communities

Azonal plant community	Altenrath and Stallberg	Dürresbach
Swamp	*Taxodium dubium*, Arecaceae	
	Osmunda lignitum	*Carpolithus sophiae* (fructus)
Riparian forest	*Eotrigonobalanus furcinervis*, *Populus germanica*	
		Liquidambar europaea (fructus) *Majanthemophyllum petiolatum* "*Echitonium*" *sophiae*
Mesophytic forest	*Daphnogene cinnamomifolia*, *Laurophyllum* spp.	
	Laurophyllum pseudoprinceps	*Sequoia abietina*, *Laurocarpum* sp. *Mastixia amygdalaeformis* (fructus)

different vegetation types in all three floras: *Taxodium dubium* (Sternb.) Heer and ?Arecaceae, gen. et sp. indet. (swamp and wetland forests), *Eotrigonobalanus furcinervis* (Rossm.) Walther et Kvaček and *Populus germanica* (Menzel) Walther ex Mai et Walther (riparian and floodplain forests), and Lauraceae, especially *Daphnogene cinnamomifolia* (Brongn. in Cuv.) Unger (mesophytic forests).

In the flora of Altenrath, another element of the wetland forests occurs, the fern *Osmunda lignitum* (Giebel) Stur, which is also present in the flora of Niederpleis (Köln Formation, *Ton* 01) (Winterscheid 2006: 61, as *Pronephrium stiriacum*) and in the basal part of the main seam ("Hauptbraunkohlenflöz") of Ville (Ville Formation, Morken seam) (Kempf 1971: 50, 51, as *Lastraea stiriaca*).

Fruits of *Carpolithus sophiae* (C.O. Weber) Weyland from Dürresbach are locally frequent in the siliciclastic facies and may belong to the Iridaceae. The habitat of this plant was marsh

landscape (streamside vegetation). Analyses of the systematic position of this taxon have not yet been completed by the first author.

More plants of the riparian forest are known from Dürresbach: *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček et Walther (Fagaceae), *Liquidambar europaea* A. Braun (Hamamelidaceae), *Majanthemophyllum petiolatum* C.O. Weber (?Dioscoreaceae), and "*Echitonium*" *sophiae* C.O. Weber (Magnoliidae incertae sedis).

Besides *Daphnogene cinnamomifolia* (Brongn. in Cuv.) Unger, more Lauraceae (*Laurophyllum pseudoprinceps* Weyland et Kilpper, *Laurophyllum* spp., *Laurocarpum* sp.) and Cornaceae (*Mastixia amygdalaeformis* (Schloth.) Kirchh.) inhabited mesophytic forests.

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