Review of Palaeobotany and Palynology, 52 (1987): 299–366
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

MIOCENE FLORAS IN THE LOWER RHENISH BASIN AND THEIR ECOLOGICAL INTERPRETATION

J. VAN DER BURGH

Laboratory of Palaeobotany and Palynology, Heidelberglaan 2, 3508 TC Utrecht (The Netherlands)

(Received May 6, 1986; revised and accepted November 10, 1986)

Abstract

Van der Burgh, J., 1987. Miocene floras in the lower Rhenish Basin and their ecological interpretation. Rev. Palaeobot. Palynol., 52: 299–366.

Some 29 samples containing fruits and seeds were collected in three open cast mines in the lower Rhenish Basin. They all originate from Upper Miocene deposits. The samples were analysed for their fruit and seed contents and these are described shortly. Four new species: *Erica palaeoarborea*, *Vaccinium miocenicum*, *Rhynchospora tertiaria* and *Potamogeton extremitatus* are formally described. The floras are interpreted ecologically using the ecological comparison table method and a reconstruction of the landscape is presented.

Introduction

In the course of the years 1978 to 1983 several samples of sediment containing fruits and seeds were collected in the open cast mines of the "Rheinbraun" at Eschweiler, Hambach and Bedburg. They originate from sands, silts, clays and lignite. The samples from the open cast mine "Zukunft West" at Eschweiler contain, besides material from the "Indener Schichten", floras from the fluviatile equivalent of the marine "Neurather Sand". The samples from the open cast mines "Hambach" near Düren and "Fortuna" near Bedburg contain only material from the "Indener Schichten". In this paper the ecology of the known flora of Upper Miocene deposits is presented. Therefore, some samples of autochthonous floras, to be described in another paper (Van der Burgh, in press), are discussed.

Material

The following samples have been used for this study (Table I):

Eschweiler

Two samples, nos.7807 and 7809, were collected in 1974 from a thin lignite seam, mostly very impure, partly developed as no more than a lignitic clay. It lies on top of coarse fluviatile sands and is covered by a series of fine sands and clays, which in turn are covered by the "Garzweiler" seam. The whole series is the counterpart of the marine "Neurather Sand" in other quarries in the same region. Sample 7807 originates from a lignite, sample 7809 from a clay. Samples 7807, 14399, 14400 and 14402 were collected from the "Garzweiler" lignitic seam, which is a thin (maximum thickness 3 m)

0034-6667/87/$03.50

TABLE I

List of samples

Number	Coordinates Eschweiler	Height above sea level (m)	Range of seed size (mm)	Year of collection
7807			1–33	1974
7808	35°84′N 18°42′E	88	1–10	1975
7809			2–35	1975
8297	36°64′N 19°80′E	64	1–11	1979
8300	36°20′N 19°69′E	90	1–11	1979
8334	36°20′N 19°69′E	92	1–8	1979
8335	36°24′N 19°69′E	85	1–7	1979
8336	36°69′N 19°56′E	65	1–25	1979
13285	35°19′N 19°69′E	109	1–21	1981
13286	36°70′N 19°56′E	66	1–15	1979
14399	35°84′N 18°42′E	88	1–15	1975
14400	35°84′N 18°42′E	88	1–15	1975
14401	35°72′N 20°17′E	67	1–80	1981
14402	35°84′N 18°42′E	89	1–33	1975
14403	36°58′N 19°72′E	60	2–6	1979
	Fortuna			
8295	51°84′N 42°36′E	22	1–40	1980
8699	52°29′N 42°61′E	26	2–40	1981
8700	52°29′N 42°61′E	26	1–21	1981
	Hambach			
13349	40°53′N 33°70′E	29	1–15	1982
14139	39°83′N 34°90′E	20	2–70	1983
14140	41°73′N 32°34′E	0	1–80	1983
14141	39°77′N 34°35′E	−8	1–21	1982
14142	41°10′N 34°64′E	5	2–25	1983
14143	41°85′N 32°22′E	−1	1–75	1983
14145	39°38′N 35°02′E	12	1–65	1983
14146	41°71′N 32°26′E	20	1–33	1983
14183	41°91′N 32°17′E	−12	1–21	1983
14428	41°68′N 32°41′E	25	1–14	1983
14429	40°55′N 33°43′E	5	1–15	1983

often impure lignitic seam in this open cast mine. The samples were collected at one locality, with a vertical distance of 30 cm, no.7808 being the lowermost and 14402 the uppermost sample. All the floras extracted from these samples are considered local autochthonous floras in contrast to those from the following samples which are considered as allochthonous extralocal floras: Samples 8297, 8300, 8334, 8335, 8336, 13285, 13286, 14401.

In Upper Miocene times a marine transgression eroded the lignite of the upper lignite seam along the Weisweiler fault. The top layer of the lignitic seam is pitted by teredines and at one place, at a distance of about 50 m from the Weisweiler fault, a cliff-like palaeosurface, also perforated with teredines, could be observed. In places the lignite surface was not pitted and here a pattern of narrow channels was developed on the surface. At these places the lignite was covered by a thin layer of fine grained sand, white in colour and containing many coniferous cones and other organic material. Sample 14401 was collected from this material at about 50 m from the cliff face of the lignite. Overlying the marine-eroded lignite, a coarser sand, creamy in colour was present. Locally, clays with leaf impressions and accumulations of organic matter occur in which the larger parts were perforated by teredines.

Sample 8336 was collected from such a clay, sample 13286 from an accumulation of organic matter.

These sands were incised by a 50–100 m wide river channel, containing alternate layers of coarse and fine white sand. Some of these layers contained organic material. Samples 8300, 8335 and 13285 were collected from these sands, sample 8297 from a sandy clay at the border of the channel and sample 8334 was collected from a clay in a floodplain depression.

Several other samples have been collected, but they contained a fair amount of reworked material and could therefore not be used in this study.

From the lignite of the upper seam one sample was collected that yielded sufficient material for constructing an ecological comparison table: no. 14403. The flora of this sample is considered as autochthonous.

Fortuna

In the open cast mine "Fortuna" near Bedburg, three samples, nos. 8295, 8699 and 8700, have been collected from a river channel in sandy deposits over the "Garzweiler" seam. These sands have been considered of Pliocene age, but the very typical mastixioidean flora found in it is an argument to place them in the Upper Miocene "Indener Schichten". One sample originates from the middle of the channel (no.8295), the other two from a facies near the border of it; no.8699 is from a sand, no.8700 from a silt on top of the sand from which no.8699 was collected. These floras are considered as allochthonous.

Hambach

In the open cast mine "Hambach" near Düren several samples were collected in the uppermost part of the "Indener Schichten", a clay with some intercalated thin lignite seams. Sample 13349 originates from a slight depression in a locally lignitic developed clay layer, forming the top of the main clay. Sample 14429 is from a clay in a river channel just below the main clay. The material showed many monocotyledonous leaf impressions. The floras of these samples are considered as autochthonous local floras in contrast with the floras of the following samples.

Sample 14141 was collected in a sand from a river channel, also below the top clay of the "Indener Schichten". This is stratigraphically the oldest sample of the series of Hambach. Within the top clay there were shallow sand-filled channels, mainly in the upper part of the clay. From these channels samples 14139, 14140, 14142, 14143, 14145, 14146 and 14428 were collected, the latter from a silt at the border of a channel from which sample 14140 was collected. Normally the coarse sands and gravels of the "Hauptkiesserie" overlie the uppermost clay. At one place a rhythmic succession of fine sands and silts was present between the top clay and the sands of the Hauptkiesserie. Sample 14183 was collected from this deposit.

Methods

All material was dried and sieved with sieves of 5 mm, 2 mm, 1 mm and 0.5 mm mesh apertures. Clays were boiled with sodium carbonate, lignite with sodium lye. After sieving, the residue was dried and floated over CCl_4 and the fruits and seeds handpicked under a preparation microscope. The material was identified and stored in glass tubes and boxes in the collection of the Laboratory of Palaeobotany and Palynology under the above-mentioned sample numbers.

All material has been entered in the annotated taxa list from which a standard list of taxa has been prepared including indications of the floral elements (Arctotertiary and Palaeotropic), see Mai (1967, 1970a,b).

Ecology

In a previous paper (Van der Burgh, 1983), the vegetation of the low-lying plain was divided into nine compound vegetation units,

TABLE II

Standardlist of taxa

Acanthopanax solutus	6*.	P	*Eurya stigmosa*	3*.	P
Acer campestre	4,5.	A	*Fagus decurrens*	6*.	A
Acer sp. cf. *rufinerve*	6*.	A	*Gaylussacia rhenana*	7,9.	A
Acer sp.	4,5,6.	A	*Glyptostrobus europaeus*	3*.	A
Actinidia faveolata	4*.	A	*Halesia crassa*	6*.	A
Aluga antiqua	5*.	A	*Homalanthus costatus*	3*.	P
Alisma plantago-aquatica	2*.	A	*Hypericum holyi*	2,3.	A
Alnus sp.	3*.	A	*Hypericum* sp.		P
Ampelopsis malvaeformis	5*.	P	*Ilex aquifolium*	6*.	A
Aracispermum canaliculatum	2*.	P	*Ilex fortunense*	3,6,7.	P
Arctostaphyloides menzelii	3,9*.	P	*Ilex jonkeri*	3,6,7.	P
Asimina brownii	5*.	A	*Ilex protogaea*	3*.	A
Betula sp.	3,4,5,6,7.	A	*Ilex saxonica*	3,6,7.	P
Brasenia victoriae	1*.	A	*Ilex thuringiaca*	3*.	A
Caldesia cylindrica	2*.	P	*Juniperus oxycedrus*	3*.	A
Carex acuta	2*.	A	*Laurocarpum* sp.		P
Carex acutiformis	2*.	A	*Leucothoe narbonnensis*	3,5,9.	A
Carex flagellata	2*.	A	*Liquidambar magniloculata*	5,6.	A
Carex hostiana	2*.	A	*Liriodendron geminatum*	3,5*.	A
Carex sp.		A	*Lycopus europaeus*	2*.	A
Caricoidea jugata	2*.	P	*Magnolia burseracea*	3*.	P
Carpinus betulus	5*.	A	*Magnolia lignita*	3*.	P
Carya ventricosa	3*.	A	*Magnolia lusatica*	3*.	P
Carya sp. vel *Juglans* sp.		A	*Magnolia* sp.	3*.	P
Ceratophyllum demersus	1*.	A	*Mastixia thomsonii*	3,5*.	P
Ceratophyllum submersum	1*.	A	*Meliosma wetteraviensis*	3*.	P
Chionanthus ruehlii	3*.	P	*Menyanthes carpathica*	2*.	A
Chenopodium album	2*.	A	*Mneme menzelii*	2*.	A
Cladiocarya europaea	2*.	P	*Myrica boveyana*	3,9*	P
Cladiocarya trebovensis	2*.	P	*Myrica ceriferiformis*	3*.	A
Cladium reidiorum	2*.	P	*Myrica minima*	3*.	A
Comptonia costata	8*.	A	*Myrica* sp.	3,9.	
Corema intermedia	8*.	A	*Myrica suppanii*	3,9*.	P
Cornus bugloviana	3*.	A	*Nymphaea alba*	1*.	A
Cornus sp.	4,6.	A	*Nymphaea* sp.	1*.	A
Corylopsis urselensis	3,9*.	A	*Nyssa disseminata*	3*.	A
Corylus avellana	4*.	A	*Nyssa ornithobroma*	3*.	A
Crataegus angusticarpa	4,5,6.	A	*Ostrya carpinifolia*	6*.	A
Crataegus jonkeri	4,5,6.	A	*Ostrya scholzii*	5*.	A
Crataegus nodulosa	4,5,6.	A	*Oxydendrum europaeum*	6,7.	P
Crataegus sp.	4,5,6.	A	*Paliurus sibiricus*	6*.	A
Cupressoconus rhenanus	7*.	A	*Palliopora symplocoides*	4,5,6	P
Cyclocarya nucifera	6*.	A	*Phellodendron lusaticum*	6*.	A
Decodon globosus	2*.	A	*Picea omorikoides*	7*.	A
Distylium uralense	3*.	A	*Picea* sp.	7*.	A
Dulichium spathaceum	2*.	A	Pinaceae	3,7,9.	A
Dulichium vespiforme	2*.	A	*Pinus leitzii*	3,7,9.	A
Empetrum nigrum	3,9*.	A	*Pinus* sp.	3,7,9.	A
Eomastixia persicoides	3*.	P	*Pinus spinosa*	3,7,9.	A
Epacridicarpum mudense	3,9*.	P	*Pinus thomasiana*	3,7,9.	A
Epipremnites ornatus	3*.	P	*Pinus uranii*	3,7,9.	A
Erica palaeoarborea	9*.	A	*Polyspora lignitica*	5*.	P
Ericaceae gen. et sp. indet.	9*.		*Potamogeton extremitatus*	1*.	A
Eriophorum sp.	9*.	A	*Potamogeton* sp.	1*.	A
Eucommia europaea	6*.	A	*Proserpinaca reticulata*	3*.	A
Eurya lusatica	3*.	P	*Pseudoeuryale europaea*	1*.	A

TABLE II (*continued*)

Pterocarya limburgensis	3*.	A	*Symplocos germanica*	3*.	P
Punica natans	6*.	P	*Symplocos gothanii*	3*.	P
Quercus robur	5,6,7.	A	*Symplocos lignitarum*	3,5.	P
Rehderodendron ehernbergii	4,5,6.	P	*Symplocos minutula*	3*.	P
Rubus laticostatus	3,4,5,6,7,8.	A	*Symplocos pseudogregaria*	3,5*.	P
Ruppia palaeomaritima	1*	A	*Symplocos salzhausenensis*	3*.	P
Sambucus pulchella	3,4,5.	A	*Symplocos scherero*	5,6.	P
Sapium germanicum	3*.	P	*Taxodium dubium*	3*.	A
Scindapsites crassus	2*.	P	*Tectocarya rhenana*	3,5.	P
Scirpus lacustris	2*.	A	*Tetrastigma lobata*	3,5*.	P
Scirpus melanospermus	2*.	A	*Teucrium* sp.	–	A
Scirpus tabernaemontani	2*.	A	*Toddalia naviculaeformis*	3*.	P
Sequoia langsdorfii	3*.	A	*Toddalia rhenana*	3*.	P
Sinomenium militzeri	4,5.	A	*Trapa heerii*	1*.	A
Sium latifolium	2*.	A	*Trigonobalanus exacantha*	6*.	P
Solanum nigrum	2*.	A	*Typha* sp.	1*.	A
Sorbus aria	6*.	A	*Umbelliferopsis molassicus*	2*.	A
Sorbus herzogenrathensis	3*.	A	*Urospathites cristatus*	2*.	P
Sparganium haentzschelii	2*.	A	*Vaccinium miocenicum*	7,9.	A
Sparganium minimum	2*.	A	*Viola canina*	4*.	A
Sparganium sp.	2*.	A	*Viola rupestris*	7*.	A
Sphenotheca incurva	4,5,6.	P	*Viscum* sp.	3*.	A
Spirematospermum wetzleri	2*.	P	*Vitis lusatica*	3*.	A
Staphylea bessarabica	4,5,6.	A	*Vitis parasylvestris*	3,5.	A
Staphylea sp.	4,5,6.	A	*Vitis* sp.	3,5.	A
Stewartia beckeriana	6*.	A	*Vitis teutonica*	3,5*.	A
Stratiotes tuberculatus	1*.	A	*Zanthoxylum ailanthiforme*	5*.	P
Styrax maximus	6*.	P	*Ziziphus striata*	3*.	–

roughly corresponding to physiognomical entities. These include:
(1) Open water vegetation; (2) Streamside vegetation; (3) Wetland forest (Carr and marsh forest, in Van der Burgh, 1983); (4) Forest border-scrub vegetation; (5) Floodplain forest; (6) Upland forest; (7) Coniferous forest; (8) Heath; (9) Peat bog.

These vegetation units make a rough subdivision of a vegetation which in reality was very complex, as it was influenced by a number of variable edaphic factors. The swamp, dominated by ferns and monocotyledonous plants as described by Mai and Walther (1978) is considered part of the streamside vegetation (Van der Burgh, in press). For definitions see Van der Burgh (1983).

The ecology of the flora is reconstructed using ecological composition tables (see Appendix). Every taxon together with its number of remains has been entered in the column of the unit(s) in which it occurs. A taxon restricted to one unit or occurring predominantly in such a unit is considered characteristic and thus marked with an asterisk. The total of the taxa in a unit has been added and a percentage has been calculated with the total of taxa as 100%. The same has been done with the characteristic taxa and with the remains of the characteristic taxa. These percentages have been added and the figures thus can be used as an expression of the ecological composition of the flora, and to compare the floras with each other.

In an attempt to trace the influence of the Palaeotropic floral elements in these floras all palaeotropical taxa have been underlined in the tables and, besides the general counts,

added up separately and their percentages calculated against the totals of the general counts. By subtracting the figures thus obtained from the figures obtained from the general counts, the relationship palaeotropic - arctotertiary plants can be determined (some plants are indifferent, but their number is very small and they have not been taken into account). The figures are shown in block diagrams to enable easy comparison of the floras.

The samples were poorly sorted with regard to the diameter of the seeds and fruits which ranges from 0.8 to 10 (80) mm (see also Table I). The only sample with relatively well-sorted material, ranging from 1.5–5.0 mm with a maximum of about 3 mm, was no.14403, originating from the upper lignitic seam in "Zukunft West". Although the lignite is considered an autochthonous sediment it is nevertheless possible that parts of it were inundated temporarily or more or less continuously, resulting in some sorting of the fruits and seeds. An argument for this supposition is the observation that the seeds occur in thin layers throughout the locally not very homogeneous lignite, separated by thicker barren layers. Normally the lignite is very amorphous and does not yield recognisable fruits and seeds.

As emphasized by their poor sorting, all other samples reveal a representative reflection of the total of seeds available and can therefore be compared with one another, because sedimentation evidently influenced the seed and fruit content only to a limited extent. Differences in the sedimentological regime have been accounted for in the discussion resulting in slight corrections in the reconstruction of the vegetation.

Annotated list of taxa

In the following section only those taxa are described and illustrated which do not occur in previous papers of the author (Van der Burgh, 1978, 1983, in press). An exception is made for taxa for which additional information was available. The ecology is briefly described and a subsequent grouping within one or more of the nine vegetational units is suggested.

CUPRESSACEAE

Cupressoconus rhenanus Kilpper (Plate I, 1, 5, 6, 8, 9)

Material studied: Cones; coll. no.14401-20: 11; seeds; coll. no.14401-21: 94.
Remarks: The cones are similar to *C. rhenanus* described by Kilpper (1968b). They measure 11–22 mm, are globose and bear more than two seeds per scale. The scales are opposite and there are 4–6 pairs of them. Ridges radiate from a central protuberance on the outer surface of the scale. From one of these cones seeds were extracted which are similar to those found dispersed in the sample.

The seeds are 1.5–3.5 × 1–2 mm and irregular. The surface is black and glossy. Two or three ridges are present and sometimes the surface bears numerous warts. The hilum is irregular, the apex apiculate. The ventral ridge is blunt, the other two ridges wing-like. These seeds are similar to those of *Cupressus benthamii* Endlicher and *C. pygmaea* Sargent from the American continent and to those of *C. duclouxiana* Hickel from the Asiatic continent. They are similar to the seeds extracted from *Cupressoconus rhenanus*.
Ecology: The only occurrence is in an allochthonous flora which had been deposited in proximity of the coast (50–100 m distance). This suggests a dry, well-drained habitat. At the present day *Cupressus* forms woody vegetations under rather dry circumstances, alone or in combination with other conifers. It is therefore assigned to the coniferous forest, unit 7.

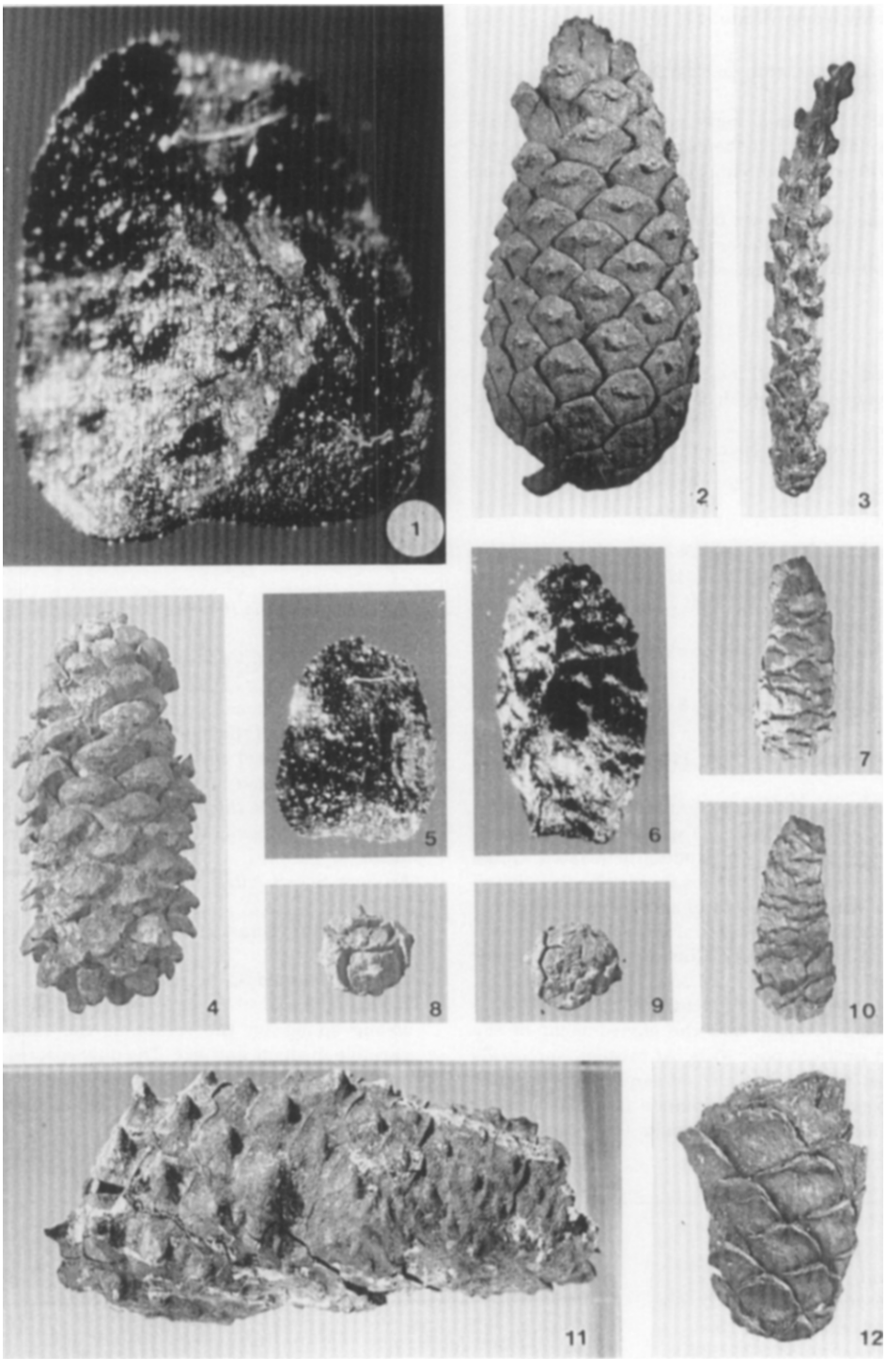
Juniperus oxycedrus L.

Material studied: Seeds; coll. no.7808-22: 2.
Ecology: See Van der Burgh (in press).

PLATE I

1,5,6. *Cupressoconus rhenanus*; seed; no.14401-21; 1: 25 ×; 5,6: 12.5 ×.
2. *Pinus thomasiana*; no.14143-1; 1 ×.
3. *Pinus leitzii*; cone axis; no.14139-30; 1 ×.
4. *Pinus uranii*; no.14401-13; 1 ×.
7,10. *Picea omorikoides*; no.8295-66; 1 ×.
8,9. *Cupressoconus rhenanus*; cone; no.14401-20; 1 ×.
11. *Pinus spinosa*; no.14401-47; 1 ×.
12. *Pinus leitzii*; no.14145-1; 1 ×.

PLATE I



PINACEAE

Picea omorikoides Weber (Plate I, 7, 10)

Material studied: Cones; coll. no.8295-66: 1; 8699-2: 1; 14139-31: 1.
Remarks: 36–38 × 15–19 mm cones with thin wide scales. They are badly damaged but their similarity to *P. omorika* (Pancic) Purkyne is still evident. They have been identified as *P. omorikoides*.
Ecology: This species is known from Miocene and Pliocene sandy deposits. This is in accordance with the ecology of the recent *P. omorika*, a plant of coniferous forest, unit 7.

Picea sp.

Material studied: cones; coll. no.14140-9: 1.
Remarks: A juvenile cone which cannot be assigned to any one species.
Ecology: See the preceding species.

Pinaceae gen. et sp. indet.

Material studied: Seeds; coll. no.7808-24: 1; 8295-40: 9; 8300-4: 2; 8699-17: 2; 13285-27: 1; 14139-6: 17; 14140-18: 2; 14143-7: 4; 14145-13: 12; 14146-21: 1; 14183-4: 13; 14401-6: 16; cones: 14401-6: one immature cone.
Ecology: See Van der Burgh (in press).

Pinus leitzii Kirchheimer (Plate I, 3, 12)

Material studied: Cones: coll. no. 14139-29: 12; 14143-2: 6; 14145-1: 18.
Remarks: Cones up to 100 mm long and 35 mm broad. The axis is narrow (5–8 mm diameter) with slender adhering scale bases. Scales thin and longitudinally striated. Umbo at the apex of the scale. These cones are similar to *P. leitzii* as described by Kirchheimer (1936) and Kilpper (1968a).
Ecology: Pines of several sections of the genus are known from the lignite of the lower Rhenish basin (Van der Burgh, 1964, 1973).

Although it is not possible to identify cones with xylotomous taxa, it is still clear that the environment of the genus included nutrient poor soils. At present, such soils not only consist of peat but also of sand, and pines are known from vegetations which include units 3, 7 and 9. Samples from lignite and sand deposits (Van der Burgh, 1983) suggest that in Neogene times the pines occupied comparable ecological niches.

Pinus sp. (diploxytic sections)

Material studied: Scales; coll. no.13286-14: 2; 14183-4: 4; cones; 14145-2: 7.
Remarks: Very strongly abraded or deformed thick cones or isolated scales, which cannot be identified to the species level. They clearly belong to one or several species of the diploxytic sections with massive lignified cones consisting of thick lignified axes and ditto scales.
Ecology: See *P. leitzii*.

Pinus spinosa Herbst (Plate I, 11)

Material studied: Cones; coll. no.14140-8: 1; 14401-47: 1.
Remarks: Both cones are incomplete: one (14140-8) represents only part of the base of a cone, the other (14401-47) lacks the apex and part of the base. Nevertheless, this elongate cone with its characteristic short spines on the scales on one side of the cone can be compared with *P. spinosa* as redescribed by Mai (1965) and also with the description of Kilpper (1968a) and Schloemer-Jäger (1960).
Ecology: See *P. leitzii*.

Pinus thomasiana (Goeppert) Reichenbach (Plate I, 2)

Material studied: Cones; coll. no.14143-1: 3; 14401-48: 3.
Remarks: 65–85 × 38–40 mm slightly oblique cones with rhombic to pentamerous apophyses. The umbo, which is in the upper part of the apophyse, is very short, knoblike and equally developed on all sides of the cone. The cones possess a 7–10 mm long stout stalk. This material can be compared with *P. thomasiana* as described by Kirchheimer (1936) and Schloemer-Jäger (1960) from the lower Rhenish basin.
Ecology: See *P. leitzii*.

Pinus uranii (Unger) Schimper (Plate I, 4; Plate II, 1)

Material studied: Cones; coll. no.14401-13: 14.
Remarks: These 40–85 × 27–50 mm oblique cones with very strong spines on the scales at the long side are very variable in shape and size. The only species which matches our material is *P. uranii* as described by Kilpper (1968a) from the Indener Series in the same quarry.
Ecology: See *P. leitzii*.

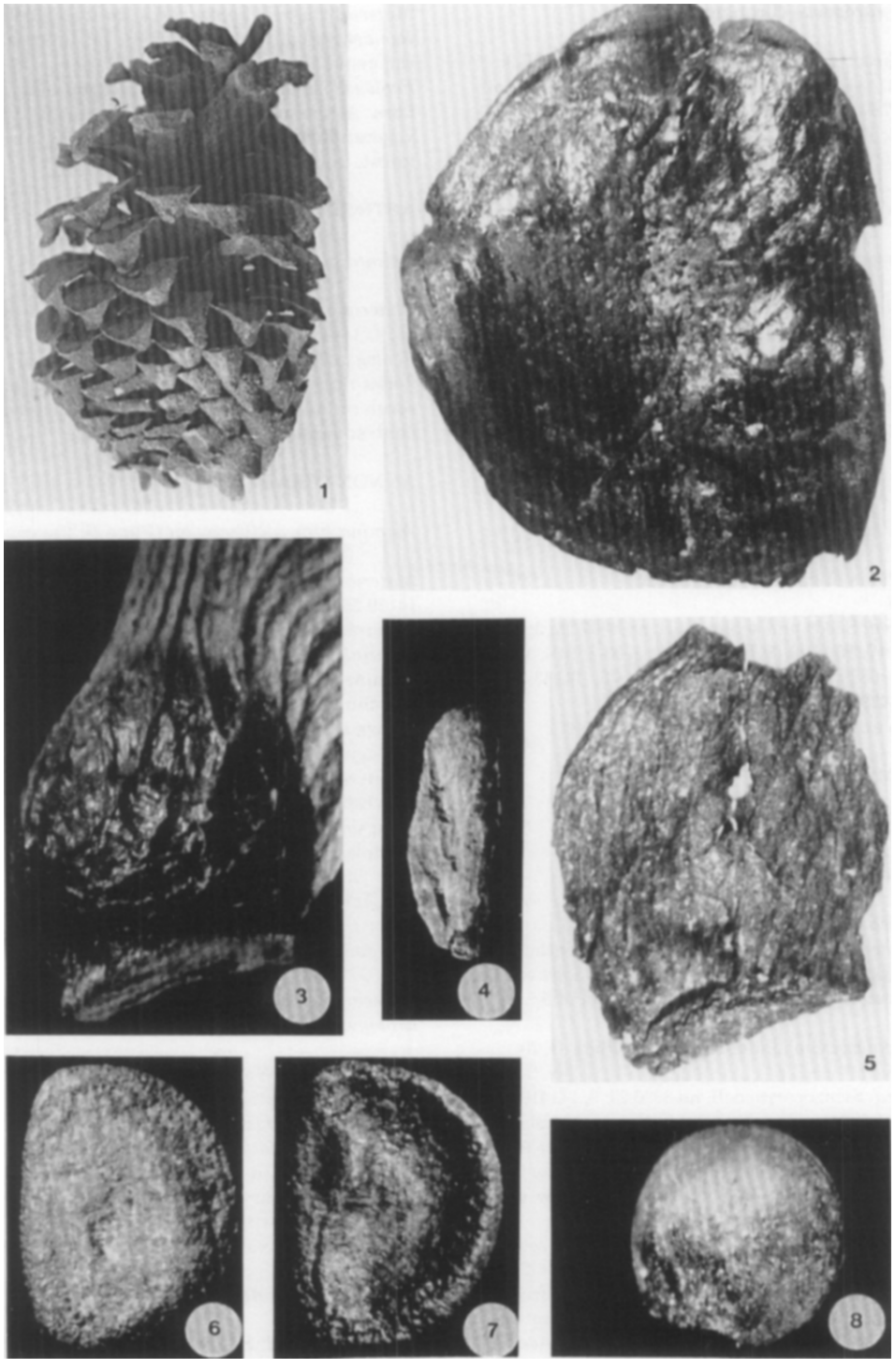
PLATE II

1. *Pinus uranii*; no.14401-13; 1 ×.
2. *Asimina brownii*; no.14145-22; 6 ×.
3. *Acer rufinerve*; Recent; 12.5 ×.
4. *Ilex protogaea*; no.8335-26; 12.5 ×.
5. *Acer* sp. cf. *rufinerve*; no.14141-13; 12.5 ×.

6,7. *Acanthopanax solutus*; no.14146-7; 12.5 ×.

8. *Chenopodium album*; no.8295-76; 25 ×.

PLATE II



TAXODIACEAE

Glyptostrobus europaeus (Brongniart) Unger

Material studied: Cones; coll. no.13286-11: 11; 13349-3: 1; 14140-7: 65; 14143-5: 26; 14146-22: 10; 14429-2: 6; seeds; coll. no.7807-6: 18; 7808-2: 5; 7809-7: 1; 8295-42: 11; 8297-2: 8; 8336-17: 1; 8700-3: 3; 13349-3: 16; 14139-12: 6; 14140-17: 120; 14141-4: 11; 14143-6: 5; 14145-9: 1; 14146-23: 72; 14399-3: 47; 14400-3: 11; 14401-7: 1; 14402-12: 10; 14429-3: 209.
Ecology: See Van der Burgh (in press) (unit 3).

Sequoia langsdorfii (Brongniart) Heer

Material studied: Cones: coll. no.8295-23: 554; 8699-1: 121; 13285-2: 63; 14139-13: 40; 14140-6: 127; 14141-12: 1; 14142-10: 2; 14143-3: 52; 14145-3: 26; 14146-24: 20; 14183-25: 2; 14399-4: 9; 14400-4: 6; 14401-18; 4; 14402-4: 3; seeds: coll. no.7808-13: 17; 8295-23: 3025; 8297-3: 44; 8300-6: 38; 8335-7: 209; 8336-9: 23; 8699-1: 140; 8700-1: 13; 13285-2: 155; 13286-16: 32; 14139-14: 129; 14140-16: 156; 14143-4: 52; 14145-19: 48; 14146-25: 161; 14183-25: 4; 14399-5: 139; 14400-5: 291; 14401-19: 40; 14402-5: 23; 14403-9: 1.
Ecology: See Van der Burgh (in press) (unit 3).

Taxodium dubium (Von Sternberg) Heer

Material studied: Seeds and scales; coll. no.7807-25: 3; 8295-25: 97; 8297-1: 17; 8336-23: 2; 8699-3: 223; 8700-2: 918; 13286-13: 3; 13349-4: 688; 14141-46: 1407; 14142-4: 6; 14183-3: 42; 14428-4: 12; 14429-4: 176.
Ecology: See Van der Burgh (1983, in press) (unit 3).

ANGIOSPERMAE

ACERACEAE

Acer campestre L.

Material studied: Schizocarps; coll. no.14183-11: 1.
Ecology: The material has been found in an allochthonous flora. Nowadays, *Acer campestre* forms part of moist to dry forest and forest border communities, units 4 and 5.

Acer sp. cf. *rufinerve* Siebold et Zuccarini (Plate II, 5)

Material studied: Schizocarps: coll. no.8336-24: 9; 14141-13: 9.
Remarks: These 5 × 4 mm schizocarps without wing show a very distinct venation. The longest axis of the fruit forms an angle of about 90° with the dehiscence plane, the wing is given off at an angle of 45°. These fruits show some similarity to *A. rufinerve* from Japan (Plate II, 3).

According to Mai (1983, 1984) the fruits of the section *Platanoidea* also show a distinct venation pattern. These are flattened in contrast with the almost globular fruit of *A. rufinerve*, and they are also larger than the material described here. Therefore this material belongs to *Acer* sp. cf. *rufinerve*.
Ecology: This species has been found in allochthonous floras only; recent *A. rufinerve* is a tree of upland forest, unit 6.

Acer sp.

Material studied: Schizocarps: coll. no.8335-11: 1; 8700-7: 1.
Remarks: Small schizocarps as yet unidentifiable beyond the genus level.
Ecology: The material has been found in an allochthonous flora. At the present day *Acer* is a shrub or tree in various vegetations, ranging from floodplain forest to upland forest, unit 4, 5 and 6.

ACTINIDIACEAE

Actinidia faveolata Reid et Reid

Material studied: Seeds; coll. no.8295-41: 1; 8300-22: 1; 8699-35: 4; 14141-2: 15; 14183-30: 2.
Ecology: This species has been found in allochthonous floras only. Recent *Actinidia* is a plant of thickets and scrub on rather fertile soil, unit 4; our records are not in contradiction with these conditions.

ANNONACEAE

Asimina brownii Thomson (Plate II, 2)

Material studied: Seeds; coll. no.8699-31: 2; 13285-25: 1; 14139-28: 2; 14145-22: 4.
Remarks: Large, 15–22 × 11–14 mm seeds with a long hilum on the narrow side. The surface is glossy with a fine cellular pattern. Most seeds are deformed or broken, due to the thin testa. They resemble *A. triloba* Dunal and are known in the literature under *A. brownii* (Thomson, 1954).
Ecology: Recent *A. triloba* is a plant of floodplains and rich damp woods. The occurrence of seeds of *A. brownii* in allochthonous floras only would also suggest a habitat alongside rivers. It is therefore assumed to have grown in floodplain forest, unit 5.

AQUIFOLIACEAE

Ilex aquifolium L.

Material studied: Endocarps; coll. no.14145-28: 1.
Ecology: Dry upland forest in a moist climate, unit 6.

Ilex fortunensis Van der Burgh

Material studied: Endocarps; coll. no.8300-20: 1.
Ecology: As *I. fortunensis* is not yet matched with any recent species, it is impossible to specify its ecology. According to Mai (1970c) *Ilex* is predominantly a genus of moist climate, with a preference for moist to wet, often peaty soils or forest with much raw humus, units 3, 6 and 7.

Ilex jonkeri Van der Burgh

Material studied: Endocarps; coll. no.7808-27: 1.
Ecology: See Van der Burgh (in press) (units 3, 6 and 7).

Ilex protogaea Mai (Plate II, 4)

Material studied: Endocarps; coll. no.8335-26: 1; 14146-3: 1; 14401-10: 1.
Remarks: These three endocarps, 3.0–3.5 × 1.0–1.4 mm, bear ridges on the outer side as well as on the lateral faces. These lateral faces form an acute angle with each other. The ridges on the outer side anastomose, forming a more or less reticulate pattern; the ridges on the lateral planes divide and become thinner towards the apex. This material clearly belongs to the genus *Ilex* and is similar to *I. protogaea*, described by Mai (1970a,b,c).
Ecology: This species shows similarities with *I. cassine* L. from swamps in Virginia and Florida in the USA. Our allochthonous finds are not in contradiction with these conditions, so it is considered a plant of wetland forest, unit 3.

Ilex saxonica Mai

Material studied: Endocarps; coll. no.7808-14: 2; 8295-39: 1; 13286-27: 1; 14140-25: 3; 14399-6: 2; 14429-7: 13.
Ecology: See Van der Burgh (in press) (unit 3, 6 and 7).

Ilex thuringiaca Mai

Material studied: Endocarps; coll. no.7807-21: 1.
Ecology: See Van der Burgh (in press) (unit 3).

ARALIACEAE

Acanthopanax solutus Gregor (Plate II, 6, 7)

Material studied: Endocarps; coll. no.8295-77: 1; 8300-15: 2; 8336-38: 2; 14139-10: 1; 14146-7: 1.
Remarks: Flattened endocarps with a straight and a semicircular outline. They measure 4.0–4.6 × 2.4–3.2 mm. The surface is smooth with a fine cellular pattern and sometimes a thin cross striation. These endocarps are similar to the material described by Gregor (1977).
Ecology: The material has been found in allochthonous floras only. Gregor (1978a, 1980) reported the species from allochthonous floras or from autochthonous floras with allochthonous influences. The present-day ecological conditions of the genus constitutes forests and thickets on rather fertile well-drained soil, unit 6. The fossil finds are in accordance with this ecology.

BETULACEAE

Alnus sp.

Material described: Cones; coll. no.7807-26: 3; 8700-11: 4; 13349-2: 49; 14428-1: 5; 14429-8: 20; nuts; coll. no.8295-13: 6; 8297-6: 1; 8300-3: 1; 8335-6: 11; 8336-13: 7; 8699-37: 1; 8700-11: 4; 13285-30: 1; 13286-21: 4; 14141-20: 48; 14183-26: 5; 14429-9: 76.
Ecology: *Alnus* is generally a plant of wetland forest, unit 3 (Van der Burgh, 1983).

Betula sp.

Material studied: Nuts; coll. no.14183-21: 7.
Ecology: The present-day ecology of the genus comprises all types of forest, units 3, 4, 5, 6 and 7.

Carpinus betulus L.

Material studied: Nuts; coll. no.8295-12: 5; 14428-6: 1.
Ecology: This species has been found in allochthonous floras. Recent hornbeam forms part of moist forest vegetation, especially floodplain forest. The fossil finds are not in contradiction with this ecology, unit 5.

Corylus avellana L.

Material studied: Nuts; coll. no.8295-21: 1.
Ecology: See Van der Burgh (1983) (unit 4).

Ostrya carpinifolia Scopoli

Material studied: Nuts; coll. no.8297-29: 3; 8335-4: 2.
Ecology: At the present day this species is a plant of dry upland forest. Our material has been found in allochthonous floras only, which agrees with these conditions, unit 6.

Ostrya scholzii Gregor

Material studied: Nuts; coll. no.8295-64: 27; 8297-7: 32; 8300-19: 2; 8335-3: 34; 8336-27: 65; 8699-6: 418; 8700-6: 247; 13286-10: 27; 14141-15: 52; 14142-11: 1; 14183-10: 34; 14399-25: 1.
Ecology: The majority of our material has been found in allochthonous floras, especially in those of fine grained sand and clay deposits. Although Gregor (1982) reports the species from autochthonous floras in Bavaria our findings indicate a species of the floodplain forest, unit 5, (Van der Burgh, in press).

CAPRIFOLIACEAE

Sambucus pulchella Reid et Reid

Material studied: Endocarps; coll. no.7807-12: 1; 8336-4: 1; 14141-6: 1; 14183-31: 9; 14401-3: 1.
Ecology: See Van der Burgh (in press) (units 3, 5 and 5).

CARYOPHYLLACEAE

Stellaria media (L.) Villars (Plate III, 4)

Material studied: Seeds; coll. no.8295-65: 1.
Remarks: a small circular campylotropous seed, diameter 1.1 mm, damaged on the flat sides, but on the circular narrow side sufficiently complete to allow comparison with recent *Stellaria media* (Plate III, 7).
Ecology: Recent *S. media* is a pioneerplant, occurring in any open environment. It has been assigned to unit 2.

CERATOPHYLLACEAE

Ceratophyllum demersum L.

Material studied: Fruits; coll. no.8295-53: 3.

Ecology: This plant, typical of open water, has been found once in a river deposit. Gregor (1982) reported it from lignitic clay and clay in S. Germany. It is considered a plant of open water communities in rather quiet circumstances, unit 1.

Ceratophyllum submersum L.

Material studied: Fruits; coll. no.8300-24: 2; 13349-17: 70; 14141-40: 1; 14428-11: 2.
Ecology: See Van der Burgh (in press) (unit 1).

CHENOPODIACEAE

Chenopodium album L. (Plate II, 8)

Material studied: Seeds; coll. no.8295-76: 7.
Remarks: These 1.0–1.2 mm diameter round shiny black campylotropous seeds have a width of about 0.8 mm. They are identical to seeds of recent *C. album*, except for the lustre, which is not so pronounced in the fossil material.
Ecology: Recent *Chenopodium album* is a plant of disrupted vegetation, especially when bare soil is exposed. The find in an allochthonous flora in a river channel is in accordance with this ecosystem, unit 2.

CORNACEAE

Cornus bugloviana (Negru) Van der Burgh

Material studied: Endocarps; coll. no.7807-14: 3; 7808-23: 1; 14141-44: 3.
Ecology: See Van der Burgh (in press) (unit 3).

Cornus sp.

Material studied: Endocarps; coll. no.8700-43: 6.
Remarks: These fragments of bilocular endocarps frequently bear ridges and grooves from veins on the outer side. The material bears some similarities with endocarps from *C. controversa* but it is too fragmentary for specific identification.
Ecology: As no comparable species have been determined and the material has been found only in an allochthonous flora, the ecology of the present-day representatives of the genus has to be considered. This is rather variable, ranging from forest to scrub and forest border (Van der Burgh, 1983), (unit 4 and 6).

EMPETRACEAE

Corema intermedia Reid et Reid (Plate III, 1, 2, 3)

Material studied: Fruits and endocarps; coll. no.14401-30: 25.
Remarks: The fruits contain two to three endocarps. The endocarps bear three to four ribs on the outer dorsal surface. The ventral side bears a median groove between two low rounded ridges. The endocarps measure 1.2–2.1 × 0.9–1.4 mm. This material is similar to that described by Reid and Reid (1914) as *C. intermedia* from Britain and the Netherlands.
Ecology: Recent *Corema* is a plant of coastal heath formations in Western Spain and Portugal and in eastern North America. It is therefore considered a plant of heathland, unit 8.

Empetrum nigrum L.

Material studied: Seeds; coll. no.8300-17: 1; 8335-27: 1; 8700-9: 7; 14146-4: 1; 14399-34: 1; 14400-14: 2; 14401-27: 2; 14402-24; 3.

ERICACEAE

Arctostaphyloides menzelii Kirchheimer

Material studied: Fruits; coll. no.8295-20: 4; 13285-12: 5; 14401-12: 30.
Ecology: This plant has been collected mainly from "Zukunft West" at Eschweiler. The highest percentage was found in a deposit in which the influence of lignite moors could be expected. Therefore, it is considered a plant of wetlands and especially of peat bog, units 3 and 9.

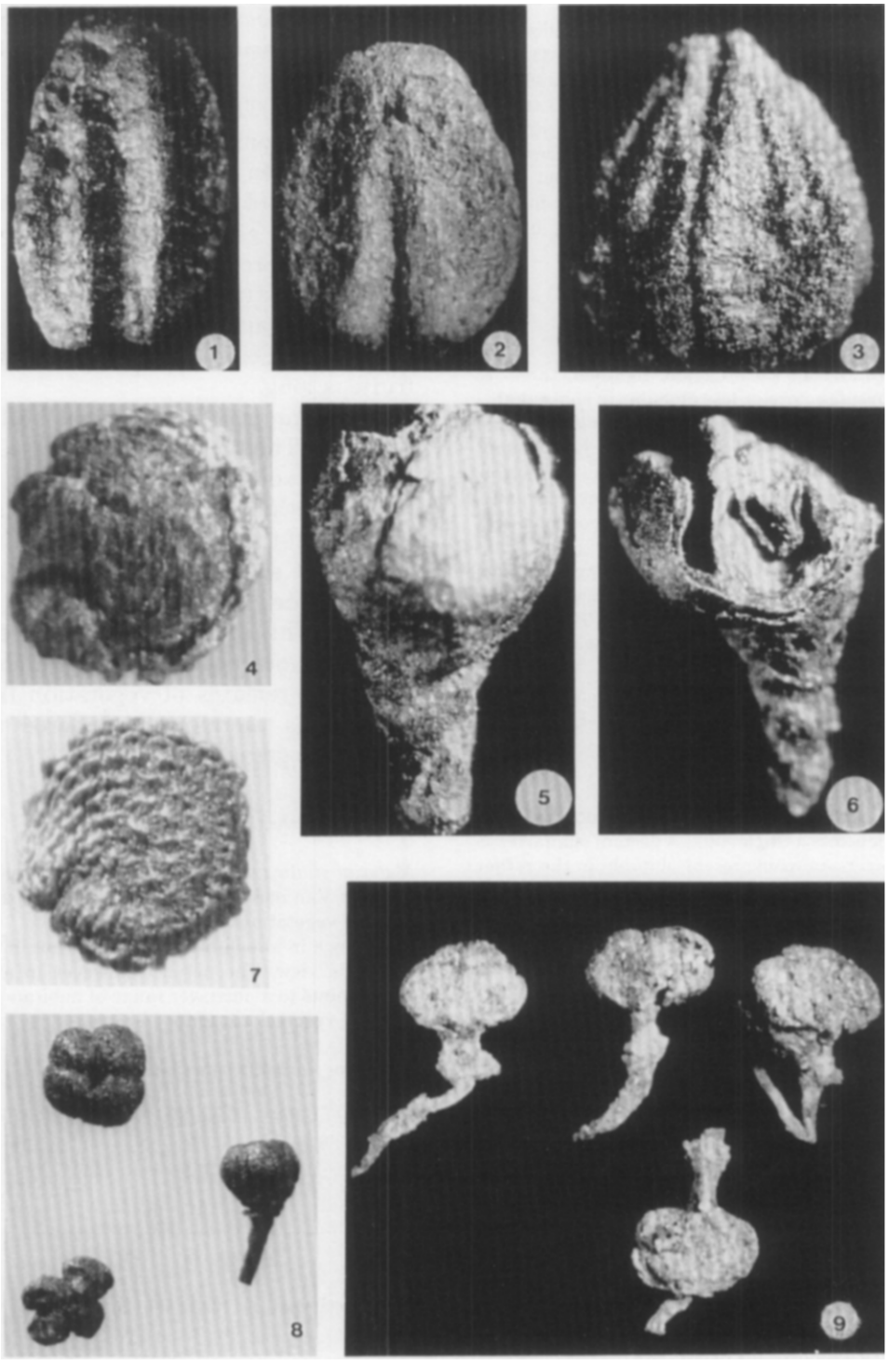
Epacridicarpum mudense Chandler (Plate III, 9; Plate V, 1, 2)

Material studied: Capsules; coll. no.8295-51: 2; 8300-2: 340; 8335-10: 167; 8336-14: 75; 13285-11: 37; 13286-12: 8; 14401-39: 60; 14403-6: 20.
Remarks: This fruit, identified as *Epacridicarpum mudense*, described by Chandler (1960), can be compared with the capsule of *Gaultheria* (Plate V, 7). However, the capsule of this genus is leathery and not woody. Also in *Gaultheria* there is a woody stalk-like or gynophore-like structure between the base of the fruit and the capsule, caused by the development of the corolla after fertilisation. In addition

PLATE III

1,2,3. *Corema intermedia*; no.14401-30; 25 ×.
4. *Stellaria media*; no.8295-65; 25 ×.
5,6. Ericaceae, gen. et sp. indet. 1; no.14401-41; 25 ×.
7. *Stellaria media*; Recent; 25 ×.
8. Ericaceae, gen. et sp. indet. 2; no.14401-43; 12.5 ×.
9. *Epacridicarpum mudense*; no.8335-10; 12.5 ×.

PLATE III



to these structures the material of sample 8335 contains fruit stalks of up to three mm length and a lobed apex of the style.
Ecology: This species has been found mainly in allochthonous floras. The material of sample nos. 8300, 8335, 8336, 13285, 13286 and 14401 originates from river channels in a rather thin sandy deposit over the lignite and contains numerous remains derived from it. Sample 14403 originates from the lignite itself (the upper seam) which is very pure, reflecting an oligotrophic peatbog environment. This species is therefore considered to be a plant of peat-forming and more particularly oligotrophic vegetations, units 3 and especially 9.

ERICACEAE gen. et sp. indet. 1 (Plate III, 5, 6)

Material studied: Capsules; coll. no.14401-42: 309.
Remarks: Small, 1.1–1.9 × 0.9–1.2 mm, lignified, three- to four locular capsules more or less globular in shape with a rather coarse cellular pattern, mostly preserved together with remains of the perianth. Some of them bear a stout style, 0.3–0.5 mm long, with a circular stigma at the top. The massive stalks are covered by crowded opposite scales. These capsules have many characteristics in common with the Ericaceae, but cannot be ascribed to any genus.
Ecology: This material has only been found in an allochthonous flora, characterised by numerous traces of the vegetation from the underlying lignite seam. Therefore, it is considered to have originated from a peatbog vegetation, unit 9.

ERICACEAE gen. et sp. indet. 2 (Plate III, 8; Plate IV, 9, 10)

Material studied: Capsules; coll. no.14401-43: 14.
Remarks: Small globular to four-lobed, four-locular fruits, sometimes attached to a thick stalk. A certain similarity to other ericaceous remains is present, notably in the rather coarse cellular structure. However, it is not possible to match the material with any recent genus.
Ecology: See the preceding species.

Erica palaeoarborea nov. spec. (Plate IV, 1, 2, 4, 5, 6)

Holotype: Coll. no.14401-40a (Plate IV, 1).
Paratypes: Coll. no.14401-40b (Plate IV, 2, 4, 5, 6).

Locus typicus: Quarry "Zukunft West" at Eschweiler.
Stratum typicum: Indener Schichten.
Derivatio nominis: From its similarity with *E. arborea*.
Description: Three to four locular capsules, 0.8–1.0 mm long and wide, slightly elongate to globular, open loculicide and often enclosed in the remains of the perianth. Perianth ca 1 mm in diameter, globular in outline, sympetalous with four more or less triangular petal apexes. Calyx consisting of four scale-like triangular sepals. The capsule bears a stout style, ca 1 mm long, with a circular stigma. The stalk of the fruits is long.
Material studied: Capsules; coll. no.14401-40: 99.
Remarks: These capsules are comparable with those of some species of *Erica*, especially *E. arborea* and to a lesser degree *E. scoparia*, except that the fossil material is half the size of the recent species. Therefore it is considered here as a new species.
Ecology: This material has only been found in allochthonous floras, both of which contained numerous remains of vegetation from lignite bogs. It is therefore considered a plant of peatbog vegetation, unit 9.

Gaylussacia rhenana Van der Burgh

Material studied: Seeds; coll. no.8300-16: 2; 8336-37: 1.
Ecology: Van der Burgh (1983) considered this a genus of upland vegetations and peat, units 3, 7 and 9. The occurrence in allochthonous floras is not in contradiction with this view. The absence however in autochthonous floras points to a narrower range of habitats excluding the wetland vegetations; units 7 and 9.

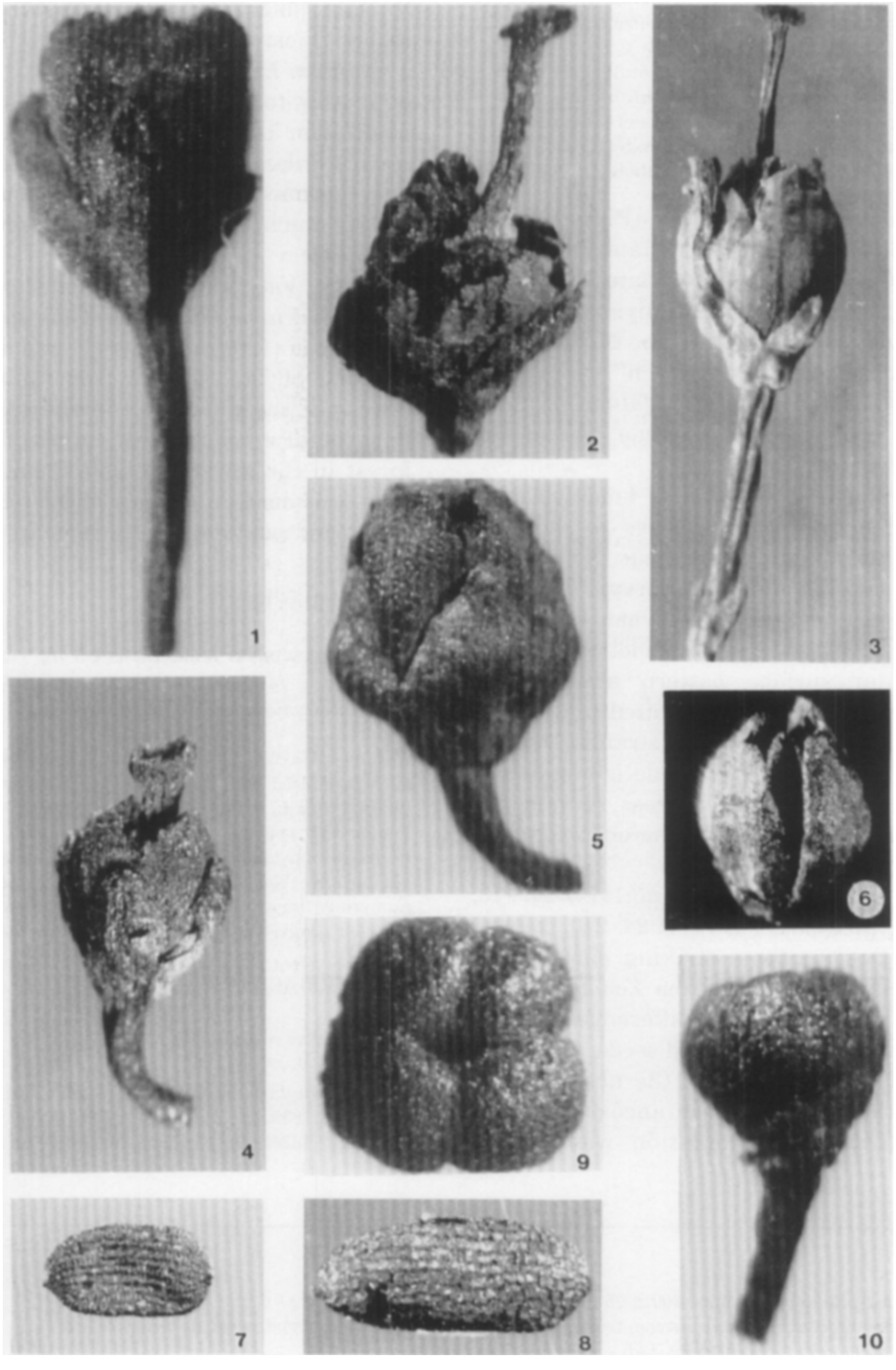
Leucothoe narbonnensis (Saporta) Mai

Material studied: Capsules; coll. no.8297-30: 2; 8300-13: 1; 13285-10: 6.

PLATE IV

1,2,4,5,6. *Erica palaeoarborea*; 1: Holotype, no.14401-40a; 25 ×. 2,4,5,6: Paratypes, no.14401-40b; 25 ×.
3. *Erica arborea*; Recent; 12.5 ×.
7. *Hypericum holyi*; no.7809-4; 25 ×.
8. *Hypericum* sp.; no.14401-49; 25 ×.
9,10. Ericaceae, gen et sp. indet. 2; no.14401-43; 25 ×.

PLATE IV



Ecology: Gregor (1980) and Mai (1964) reported the species from autochthonous floras. In the lower Rhenish basin it is known from allochthonous floras only. Thus the ecology of the species comprises different habitats, as pointed out by Van der Burgh (1983), units 3, 5 and 9.

Oxydendrum europaeum Van der Burgh

Material studied: Capsules; coll. no.8295-55: 1.
Ecology: See Van der Burgh (1983) (units 6, 7).

Vaccinium miocenicum nov. sp. (Plate V, 3, 4)
Holotype: Coll. no.14141-24a, (Plate V, 3)
Paratype: Coll. no.14141-24b, (Plate V, 4), Laboratory of Palaeobotany and Palynology of the State University of Utrecht, The Netherlands.
Locus typicus: Quarry "Hambach".
Stratum typicum: Indener Schichten.
Derivatio nominis: The Miocene age of the stratum typicum.
Description: The fruits are 3–4 mm circular flattened remains of subglobose to globular berries, containing up to six seeds. No remains of calyx or corolla could be observed. The seeds are 1–2 mm long and 1.0–1.5 mm wide, deformed, with a slightly isodiametric to elongate cellular surface pattern and a wall 0.10–0.15 mm thick. The elongated hilum is at the base of the more or less straight ventral side of the seed. The dorsal side is angular to curved or semiglobose. In cross section the seeds are triangular, due to the occurrence of 4–6, mostly 5 in a fruit.
Material studied: Fruits; coll. no.14141-24: 110; seeds; coll. no.8335-28: 1; 14141-24: 240.
Remarks: Despite some striking similarities, this material is different from *Zenobia fasterholtensis* (Friis, 1985). The differences are the greater size of both fruits and seeds, the lesser amount of seeds in a fruit, the absence of a calyx and the flattened appearance of the fruits pointing to a fleshy condition when fresh. Berries with rather few, 1–2 mm long seeds with a reticulate seedcoat are known from the Vaccinioideae. The seeds of *Gaylussacia* have a rather thick, stony appearance, while those of *Vaccinium* have a thin seedcoat. Our material is similar to that of *V. ovatum* Pursh. Fossil *Vaccinium* is known from Siberia (Dorofeev, 1963), Poland (Lancucka-Srodoniowa, 1979) and Germany (Mai, 1965). Our material however is much larger than that described in the literature.
Ecology: *Vaccinium* is a genus of forest on acidic soil in the Northern Hemisphere with a preference for rather wet conditions. The absence of this species from autochthonous floras and the abundance in one allochthonous flora point to a habitat outside the wetland forest in the lower Rhenish basin. It is therefore considered a species of acidic coniferous forest and peatbog vegetations, unit 7 and 9.

EUCOMMIACEAE

Eucommia europaea Mädler (Plate V, 6)

Material studied: Fruits; coll. no.8699-28: 1; 14141-23: 1; 14183-5: 2.
Remarks: Ca 20 × 66 mm elliptical fruits with a "hairy" surface caused by numerous threads of latex. They are identified as *E. europaea* Mädler (1939).
Ecology: This species has only been found in allochthonous floras, which might point to a habitat outside the boggy vegetations. The ecology of the recent species and the very numerous finds in a Pleistocene river channel deposit at Tegelen suggest upland forest as the habitat, unit 6.

EUPHORBIACEAE

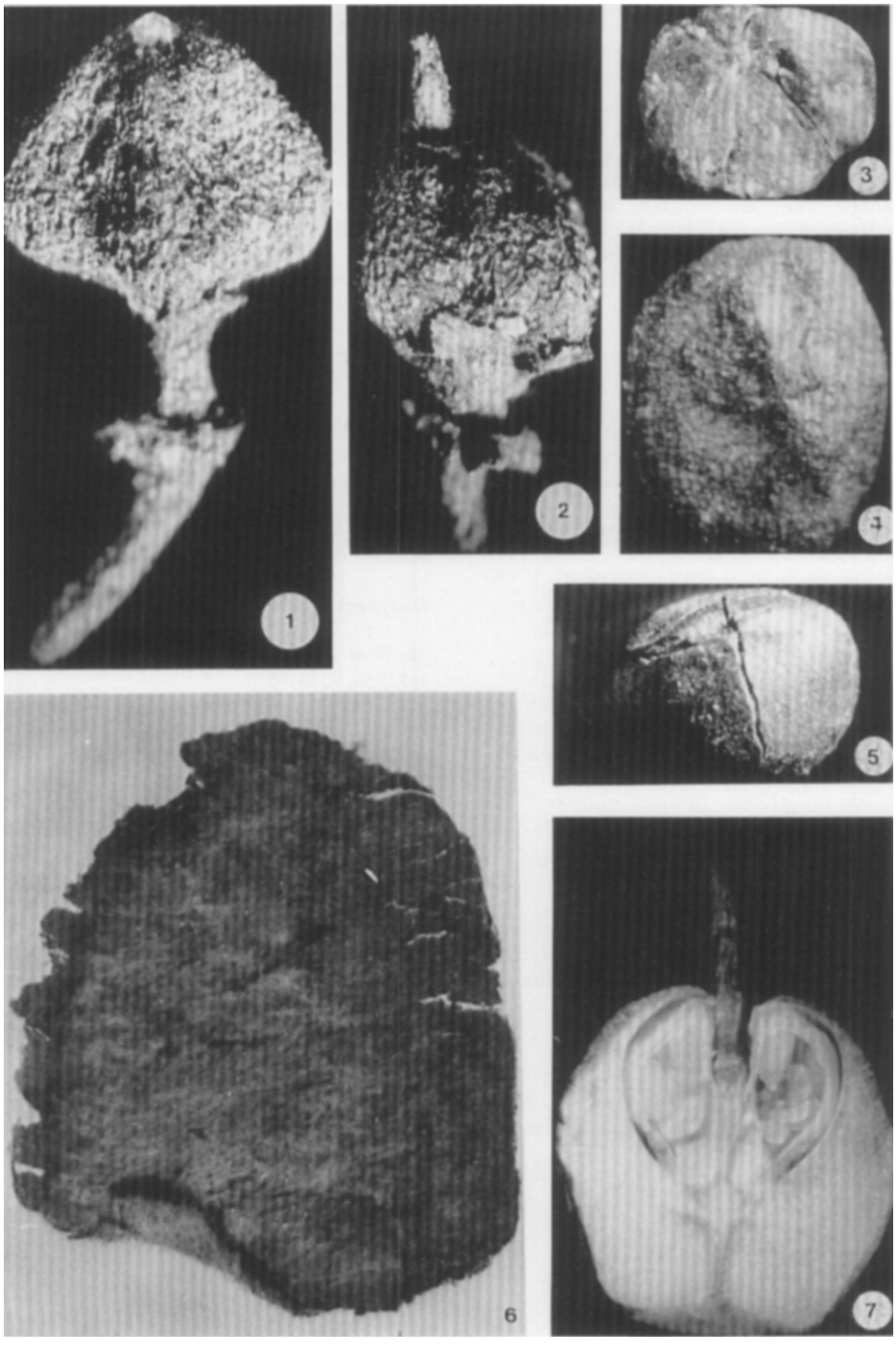
Homalanthus costatus Mai

Material studied: Seeds; coll. no.7808-4: 11; 8295-15: 26; 8297-19: 1; 8300-21: 1; 8699-42: 1; 8700-40: 1; 13285-5: 52; 13286-6: 3; 13349-19: 1; 14139-4: 28; 14140-10: 11; 14141-27: 1;

PLATE V

1,2. *Epacridicarpum mudense*; no.8300-2; 25 ×.
3,4. *Vaccinium miocenicum*; 3: Holotype, fruit, no.14141-24a; 12.5 ×. 4: Paratype, seed; no.14141-24b; 25 ×.
5. *Sapium germanicum*; no.8295-69; 12.5 ×.
6. *Eucommia europaea*; no.8699-28; 12.5 ×.
7. *Gaultheria procumbens*; Recent; median cut through a fruit; 12.5 ×.

PLATE V



14142-1: 5; 14143-15: 6; 14145-6: 47; 14146-10: 5; 14399-2: 4; 14400-2: 5; 14401-1: 2; 14402-1: 6.
Ecology: See Van der Burgh (in press) (unit 3).

Sapium germanicum Kirchheimer (Plate V, 5; VI, 6)

Material studied: Seeds; coll. no.8295-69: 33; 8699-18: 16; 8700-18: 7.
Remarks: Most of the material is broken and deformed. Several seeds, however, are complete and have retained their original shape. They are 4 × 3 mm, lenticular to globose, slightly flattened near the hilum. The wall is black and consists of palisade-like slightly curved elongate sclerenchymatous cells; a thin endothelium-like endotesta is sometimes preserved. This material is similar to *S. germanicum* apart from the size, which is smaller. There is a fair similarity to recent *S. sebiferum* Roxburgh and to a lesser degree to *S. japonicum* Pax et Hoffman.
Ecology: *Sapium* has been found in lignite in Eastern Germany (Mai, 1964) and in lignite and clay in S. Germany (Gregor, 1980). Our finds are from allochthonous deposits from one open cast mine only and the percentages are very low. Therefore, despite its absence so far in the lignitic clays and lignite of the lower Rhenish basin, it is still considered a plant of wetland forest, unit 3.

FAGACEAE

Fagus decurrens Reid et Reid

Material studied: Cupules; coll. no.7807-4: 1; 8295-30: 17; 8297-9: 5; 8699-4: 355; 8700-4: 63; 13286-1: 3; 13349-5: 1; 14141-17: 60; 14142-6: 3; 14145-30: 1; 14183-1: 5. Nuts; coll. no.8699-4: 110; 8700-4: 10; 14183-1: 12.
Ecology: See Van der Burgh (1983; in press) (unit 6).

Quercus robur L.

Material studied: Cupules; coll. no.8297-10: 1.
Ecology: *Quercus robur* is considered part of the vegetations from units 5, 6 and 7 (Van der Burgh, 1983). The single find in an allochthonous flora is not in contradiction with this habitat.

Trigonobalanus exacantha Mai (Plate VI, 3)

Material studied: Cupules; coll. no.14142-26: 2.
Remarks: These small, 4–6 × 3–4 mm three-valved cupules, of which the smaller contains remains of at least two triangular nuts are comparable to *I. exacantha* as described by Mai (1970a) and Gregor (1978a, 1980).
Ecology: This species of a genus of upland forest trees, both in America and Asia, has been found in allochthonous floras in S. Germany (Gregor, 1978a). Gregor (1980) reported it from a clay flora in which it might represent an allochthonous element. In our region it has been found in an allochthonous flora only. It is considered a plant of upland forest, unit 6.

GUNNERACEAE

Proserpinaca reticulata Reid et Reid

Material studied: Fruits; coll. no.8295-14: 8; 14401-9: 1; 14429-6: 9.
Ecology: See Van der Burgh (1983, in press) (unit 3).

HAMAMELIDACEAE

Corylopsis urselensis Reid et Reid

Material studied: Seeds; coll. no.14401-22: 1; 14403-3: 2.
Ecology: See Van der Burgh (in press) (units 3 and 9).

Distylium uralense Kolesnikova

Material studied: Seeds; coll. no.8295-50: 5; 13285-13: 11; 14141-43: 7; 14403-4: 2.
Ecology: See Van der Burgh (in press) (unit 3).

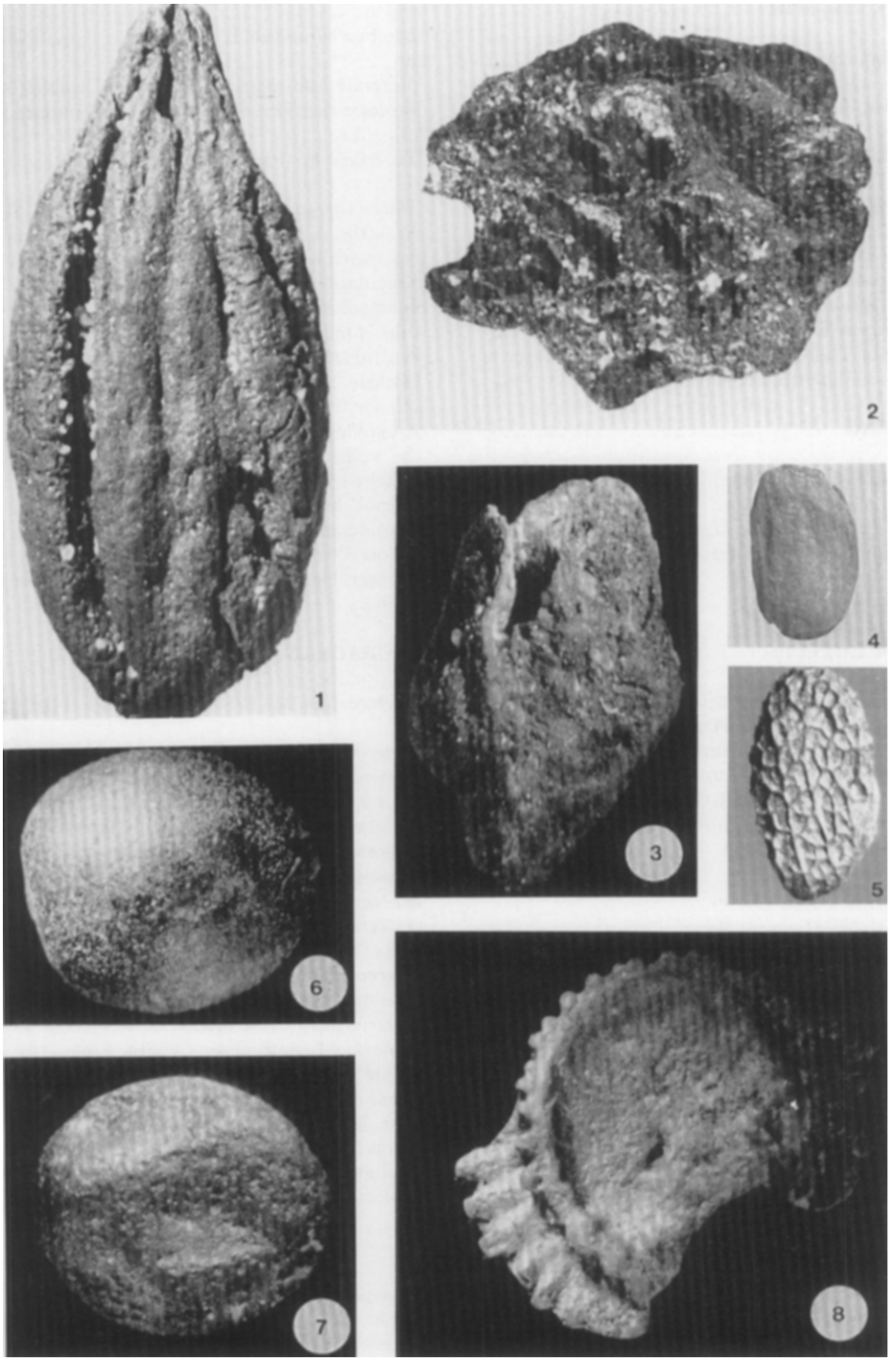
Liquidambar magniloculata Czeczott et Skirgiello (Plate VI, 2)

Material studied: Fruits; coll. no.8295-52: 4; 8699-10: 23; 8700-10: 2; 14139-27: 1; 14140-13: 1; 14141-21: 1; 14142-5: 2.
Remarks: All fruits clearly belong to one species, but not every fruit shows the necessary characteristics for identification with the species described in the literature. Material from sample 8699 and 14139 however enabled me to reconstruct the shape of the endocarps, which was in accordance with that of *L. magniloculata* as depicted by Gregor (1978a).
Ecology: *Liquidambar* is known from a clay in Bavaria (Gregor, 1982). Our finds are only from allochthonous floras which points to a somewhat dry habitat inside the lower Rhenish basin, units 5 and 6.

PLATE VI

1. *Mastixia thomsonii*; no.14145-5; 6 ×.
2. *Liquidambar magniloculata*; no.14139-27; 6 ×.
3. *Trigonobalanus exacantha*; no.14142-26; 12.5 ×.
4. *Tectocarya rhenana*; no.14140-3, 1 ×.
5. *Teucrium* sp.; no.14141-54; 25 ×.
6. *Sapium germanicum*; no.8295-69; 12.5 ×.
7. *Menyanthes carpathica*; no.8295-79; 25 ×.
8. *Sinomenium militzeri*; no.8295-27; 12.5 ×.

PLATE VI



HYPERICACEAE

Hypericum holyi Friis (Plate IV, 7)

Material studied: Seeds; coll. no.7809-4: 87; 8295-47: 2; 14401-45: 2.
Ecology: See Van der Burgh (in press) (units 2 and 3).

Hypericum sp. (Plate IV, 8)

Material studied: Seeds; coll. no.14401-49: 1.
Remarks: This 1.5 × 0.6 mm seed with a distinct square cellular pattern is also determined as *Hypericum*. It differs from the preceding species in its greater length and less strongly developed longitudinal cell walls.
Ecology: *Hypericum* is a genus of plants growing in very different habitats. Therefore, nothing about the ecology of this seed from an allochthonous flora can be said.

JUGLANDACEAE

Carya ventricosa (Von Sternberg) Unger

Material studied: Endocarps; coll. no.7807-1: 4; 8295-68: 1.
Ecology: See Van der Burgh (in press) (unit 3).

Carya vel *Juglans* sp.

Material studied: Endocarps; coll. no.8295-84: 1; 14142-19: 1; 14145-29: 1.
Remarks: Very small fragments; two of them are top fragments and one (14145-29) is a fragment of a thin walled endocarp with a narrow secondary ridge. It is therefore impossible to assign the fossils to anything more specific than a juglandaceous genus with large fruits (Mai, 1981).
Ecology: Nothing concerning the ecology of these fragmented material can be deduced.

Cyclocarya nucifera (Ludwig) Mai

Material studied: Endocarps; coll. no.8295-1: 2.
Ecology: This species has only been found in an allochthonous flora; the recent species of the genus occur in upland forest, which agrees with the fossil find. *C. nucifera* is therefore considered a plant of upland forest, unit 6.

Pterocarya limburgensis Reid et Reid

Material studied: Endocarps; coll. no.7807-20: 2; 8295-2: 5; 8297-14: 5; 8699-8: 23; 8700-8: 52; 13286-17: 1; 13349-9: 35; 14141-10: 81; 14142-7: 6; 14183-9: 6; 14428-2: 2; 14429-1: 9.
Ecology: See Van der Burgh (in press) (unit 3).

LABIATAE

Ajuga antiqua Reid et Reid

Material studied: Schizocarps; coll. no.8336-35: 1; 14183-22: 2.
Ecology: This species has only been found in allochthonous floras. Recent *Ajuga reptans*, to which our species is closely related, is a plant of moist forests. *A. antiqua* is therefore considered to be a plant of flood plain forest, unit 5.

Lycopus europaeus L.

Material studied: Schizocarps; coll. no.8700-42: 3.
Ecology: See Van der Burgh (1983) (unit 2).

Teucrium sp. (Plate VI, 5; Plate VIII, 8)

Material studied: Schizocarps; coll. no.14141-54: 1.
Remarks: A 2.6 × 1.6 mm dorsi-ventrally compressed schizocarp with a large circular contact area. The outer side is reticulate with basal longitudinal ridges, connected by anastomosing transversal ridges, at the top the reticulation is more or less isodiametric. The contact area has a central ridge ending in the apical half at the base of a style. Outside this ridge a reticulate pattern is present. This schizocarp is comparable with the Labiatae, subfamily Ajugoideae. Within this group there is a similarity with the schizocarps of the genus *Teucrium*. It cannot be matched with any of the living species and also the fossil species have a different shape, with the exception of *T. elongatum*, which however differs in size and ornamentation (Dorofeev, 1963).
Ecology: Nothing concerning the ecology of this species is known.

LAURACEAE

Laurocarpum sp. 1

Material studied: Endocarps; coll. no.8336-7: 2.
Remarks: Only the endocarps are preserved, they measure 5.0–6.0 × 4.0–4.5 mm, are compressed and slightly ovate to circular in outline. Although a similarity with fruits of *Cinnamomum* can be observed, it is impossible to identify them with this genus for the lack of cupules.
Ecology: Nothing is known about the ecology of this material.

Laurocarpum sp. 2

Material studied: Fruits; coll. no.14183-2: 1.
Remarks: Length 8 mm, width 5 mm; the fruit is compressed, the surface has a distinct lustre. At the base remains of a thickened pedicel and cupule are present. The fruit bears a certain resemblance to *Ocotea rhenana* Menzel. The material, however, is too incomplete to enable a reliable assignment to any genus within the Lauraceae.
Ecology: The ecology of this material is unknown.

Laurocarpum sp. 3

Material studied: Endocarps; coll. no.14142-27: 1.
Remarks: This very incomplete fragment of an endocarp bears some resemblance to those of *Persea* sp. described by Van der Burgh (1978); however, it is smaller. Due to its incompleteness an identification is impossible.
Ecology: The ecology of this material is unknown.

LORANTHACEAE

Viscum sp.

Material studied: Fruits; coll. no.8297-26: 5; 8700-33: 1; 13349-7: 147; 14402-14: 1.
Ecology: See Van der Burgh (in press) (unit 3).

LYTHRACEAE

Decodon globosus (Reid et Reid) Nikitin

Material studied: Seeds; coll. no.8297-27: 2; 8334-3: 1; 13349-16: 1; 14141-19: 13; 14183-27: 5; 14401-26: 2; 14428-9: 66; 14429-14: 49.
Ecology: See Van der Burgh (in press) (unit 2).

Mneme menzelii (E.M. Reid) Eyde

Material studied: Seeds; coll. no.7807-27: 4; 8336-31: 2; 14141-7: 44; 14429-13: 154.
Ecology: See Van der Burgh (in press) (unit 2).

MAGNOLIACEAE

Liriodendron geminatum Kirchheimer

Material studied: Seeds; coll. no.7807-22: 4; 8295-16: 22; 8297-17: 23; 8335-16: 2; 8336-26: 12; 13286-31: 1; 14183-29: 46; 13349-18: 12; 14402-20: 1.
Ecology: See Van der Burgh (in press) (units 3 and 5).

Magnolia burseracea (Menzel) Mai

Material studied: Seeds; coll. no.7807-3: 57; 7808-12: 8; 8295-18: 40; 8334-7: 1; 13285-6: 9; 13286-8: 1; 13349-1: 3; 14139: 1; 14140-11: 3; 14143-13: 1; 14145-4: 14; 14146-8: 1; 14183-6: 2; 14399-1: 8; 14428-14: 2.
Ecology: See Van der Burgh (in press) (unit 3).

Magnolia lignita (Unger) Mai

Material studied: Seeds; coll. no.7807-33: 2; 8295-83: 10; 14400-1: 6; 14402-2: 15.
Ecology: See Van der Burgh (in press) (unit 3).

Magnolia lusatica Kirchheimer

Material studied: Seeds; coll. no.7807-32: 3; 8295-82: 11; 13285-32: 2; 13349-26: 7; 14139-32: 8; 14140-32: 4; 14143-27: 3; 14145-33; 13.
Ecology: See Van der Burgh (in press) (unit 3).

Magnolia sp.

Material studied: Seeds; coll. no.7807-5: 72; 14142-17: 1; 14402-15: 2.
Ecology: See Van der Burgh (in press) (unit 3).

MASTIXIACEAE

Eomastixia persicoides (Unger) Mai

Material studied: Endocarps; coll. no.7807-2: 7; 8295-34: 32; 8699-22: 1; 14139-24: 2; 14140-2: 8; 14143-8: 1; 14145-21: 3; 14146-17: 2; 14402-3: 3.
Ecology: See Van der Burgh (in press) (unit 3).

Mastixia thomsonii Mai (Plate VI, 1)

Material studied: Endocarps; coll. no.8295-33: 127; 8699-21: 5; 13285-1: 25; 14140-5: 4; 14143-10: 11; 14145-5: 16; 14402-19: 1.
Remarks: These 10–22 mm long and 6–10 mm wide oval endocarps have a narrow germination pore and operculum. They bear, especially at the base, ridges, but these may be absent at the blunt apex. The endocarps are very variable in shape and size. This material is similar to *M. thomsonii* as described by Mai (1970c).
Ecology: See Van der Burgh (in press) (units 3 and 5).

Tectocarya rhenana Kirchheimer (Plate VI, 4)

Material studied: Fruits; coll. no.8295-35: 1; 8699-23: 1; 14140-3: 5; 14143-9: 2.
Remarks: Large fruits, 32–46 × 20–28 mm, with a smooth surface. At the base there is a large, sometimes conical hilum (12 mm diameter), while at the apex a narrow groove is present. This material is similar to that described by Kirchheimer (1934a, b) as *T. rhenana*.
Ecology: Mai (1964) reported the genus from clay and lignite next to sandy deposits. Such occurrences are unknown in our area; all our finds are in allochthonous floras, where it is found in small quantities. It is considered a plant of wetland forest and floodplain forest, units 3 and 5.

MENISPERMACEAE

Sinomenium militzeri Kirchheimer (Plate VI, 8)

Material studied: Seeds; coll. no.8295-27: 3; 14141-28: 1; 14183-8: 1.
Remarks: More or less circular campylotropous seeds with dentate ridges on the outer side. They measure 3.9–6.4 × 3.2–5.1 mm. The inner surface is glossy. They are identical to *S. militzeri*, as described by Kirchheimer (1943).
Ecology: This species has been found in allochthonous floras in very small numbers. The present-day habitat of this genus of vines is moist forest and thickets. It is therefore supposed to be a plant of floodplain forest and forest border and scrub vegetation, units 4 and 5.

MENYANTHACEAE

Menyanthes carpathica Jentys-Szaferowa et Truchanowiczowa (Plate VI, 7)

Material described: Seeds; coll. no.8295-79: 3.
Remarks: Small, ca 1.5 mm diameter circular seeds with a

glossy surface and 0.2 mm thick walls. The cellular structure of the wall is as described by Truchanowiczowa (1964) for *M. carpathica*.
Ecology: This typical shore and swamp plant has only been found in an allochthonous flora; this is however quite normal for plants of these habitats; unit 2.

MYRICACEAE

Comptonia costata Dorofeev

Material studied: Endocarps; coll. no.13285-28: 1.
Ecology: Recent *Comptonia* is a plant of moist to dry heath. The occurrence of a single endocarp in an allochthonous flora is in agreement with this, unit 8.

Myrica boveyana (Heer) Chandler

Material studied: Endocarps; coll. no.7808-19: 11; 14401-11: 1; 14403-2: 26.
Ecology: See Van der Burgh (in press) (units 3 and 9).

Myrica ceriferiformis Kownas

Material studied: Endocarps; coll. no.7807-19: 52; 7808-20: 16; 7809-1: 2171; 8335-1: 4; 8336-10: 2; 8699-11: 30; 14399-11: 51; 14400-6: 4; 14402-16: 10; 14403-8: 2.
Ecology: See Van der Burgh (in press) (unit 3).

Myrica minima Negru

Material studied: Endocarps; coll. no.7807-17: 171; 7808-17: 33; 7809-5: 98; 8295-46: 7500; 8335-8: 1; 8699-5: 369; 8700-5: 129; 13285-29: 1; 14139-18: 3; 14141-26: 35; 14142-13: 2; 14145-8: 41; 14146-6: 2; 14399-12: 15; 14400-7: 3; 14402-17: 54.
Ecology: See Van der Burgh (in press) (unit 3).

cf. *Myrica* sp.

Material studied: Endocarps; coll. no.13286-25: 3; 14141-33: 2.

Remarks: Compressed circular apotropous endocarps, 2.2–2.5 mm in diameter. No remains of a pericarp have been found. They are tentatively assigned to *Myrica*.
Ecology: The ecology of this material is unknown, but it may not differ very much from that of the other species of *Myrica*. It has been placed in units 3 and 9.

Myrica suppanii Kirchheimer

Material studied: Endocarps; coll. no.7807-18: 7; 8295-28: 2; 14139-5: 1; 14142-12: 1; 14145-26: 2; 14401-8: 1; 14403-1: 58; 14428-12: 1.
Ecology: See Van der Burgh (in press) (units 3 and 9).

NYMPHAEACEAE

Brasenia victoriae (Caspary) Weberbauer.

Material studied: Seeds; coll. no.8295-11: 20; 14401-4: 2.
Ecology: This plant has only been found in allochthonous floras. It is therefore considered a plant of open water, especially in not too muddy circumstances, unit 1.

Nymphaea alba L. (Plate VII, 1)

Material studied: Seeds; coll. no.14428-7: 3.
Remarks: Small, 1.5–2.2 × 1.1–1.6 mm, black oval seeds with a glossy surface and a distinct, transversely slightly elongated cellular pattern. The raphe is difficult to observe. Moreover, the germination pore (with operculum) is not very clearly marked. All these features are known from the recent *N. alba* to which the fossil material has been assigned.
Ecology: *Nymphaea* is a genus of open water vegetation and can be expected at all places where sediments have been accumulated on the bottom, unit 1.

Nymphaea sp.

Material studied: Seeds; coll. no.8336-32: 1.
Remarks: A fragment of a seed of the Nymphaeaceae. The length was ca. 4.4 mm, the width is unknown, the surface bears a distinct cellular pattern with very low elevated cells. It has been assigned to *Nymphaea*.
Ecology: See *N. alba*.

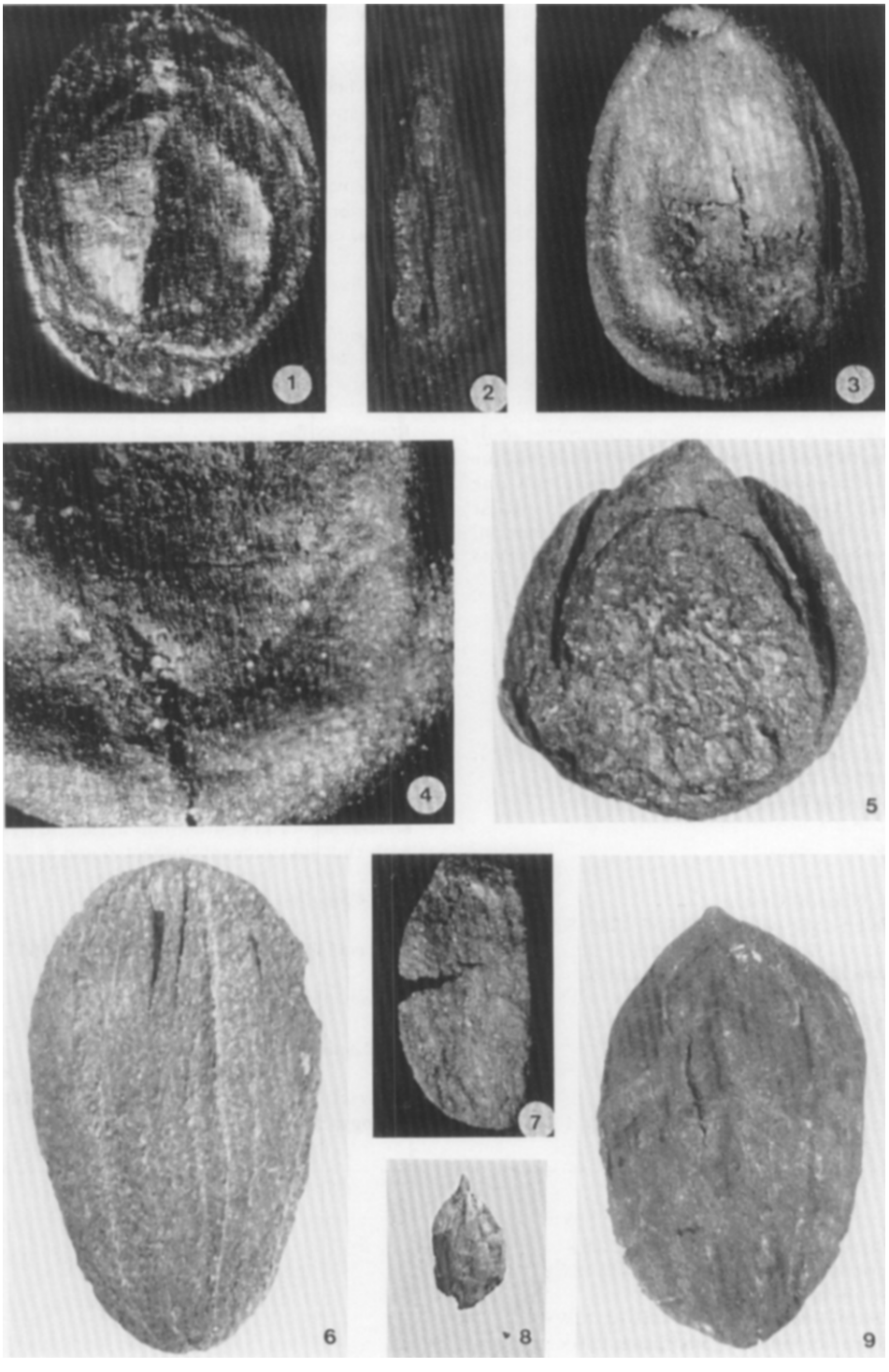
Pseudoeuryale europaea (Reid et Reid) Dorofeev (Plate VII, 2, 3, 4)

Material studied: Seeds; coll. no.8295-43: 1; 14141-45: 2; 14428-5: 5.
Remarks: Compressed, dark brown seeds, 4.6–6.3 × 3.7–4.8 mm. The walls are covered with elongate curved cells; the operculum of the germination pore contains only the micropyle and not the hilum. The material is similar to *P. europaea*, as described by Reid and Reid (as *Euryale europaea*) (1907), Mai (1973) and Dorofeev (1972) except for the dimensions which are smaller in the present material.

PLATE VII

1. *Nymphaea alba*; no.14428-7; 25 ×.
2,3,4. *Pseudoeuryale europaea*; no.14428-5; 2,4: 25 ×; 3: 12.5 ×.
5. *Paliurus sibiricus*; no.8297-23; 12.5 ×.
6,9. *Nyssa ornithobroma*; 9 with germination pore and valve; 6: no.8295-44; 9: no.14141-26; 6 ×.
7. *Crataegus angusticarpa*; no.8700-16; 12.5 ×.
8. *Rehderodendron ehrenbergii*; no.8295-29; 1 ×.

PLATE VII



Ecology: Mai (1964) reported the species from a lignite. Our material has been found in a silt (semiautochthonous flora) and in sand (allochthonous floras). It is a member of a typical family of waterplants which agrees with its occurrences, unit 1.

NYSSACEAE

Nyssa disseminata Kirchheimer

Material studied: Endocarps; coll. no.8295-3: 3; 8336-2: 1; 8699-34: 1; 13286-9: 1; 13349-14: 2; 14139-11: 3; 14140-20: 3; 14142-25: 1; 14146-9: 1; 14429-4: 3.
Ecology: See Van der Burgh (in press) (unit 3).

Nyssa ornithobroma Unger (Plate VII, 6, 9)

Material studied: Endocarps; coll. no.8295-14: 5; 8699-20: 5; 8700-20: 21; 13349-10: 2; 14141-16: 15.
Remarks: The large 9.5–15.5 × 3.7–8.2 mm compressed seeds bear 10–16 longitudinal grooves and ridges. Their outline is oblong-ovate to obovate; most of them have only one locule. The germination pores are covered by triangular opercula. The walls are fairly thin (0.1 mm). This material is very similar to that described as *N. ornithobroma* by Mai and Gregor (1982).
Ecology: See Van der Burgh (in press) (unit 3).

OLEACEAE

Chionanthus ruehlii Gregor

Material studied: Endocarps; coll. no.7807-26: 6; 13286-29: 1; 14399-17: 5; 14402-25: 3.
Ecology: See Van der Burgh (in press) (unit 3).

PUNICACEAE

Punica natans (Nikitin) Gregor
Material studied: Seeds; coll. no.8295-37: 1790; 8699-9: 128; 8700-41: 1; 14141-32: 37; 14401-25: 9; 14402-10: 10.
Ecology: See Van der Burgh (in press) (unit 6).

RHAMNACEAE

Paliurus sibiricus Dorofeev (Plate VII, 5)

Material studied: Endocarps; coll. no.8297-23: 1; 14141-53: 9.
Remarks: These 4–5 mm three-locular fruits with three valves over the germination pores are identical to the material described by Dorofeev (1963) from Western Siberia.
Ecology: Gregor (1978a, 1980, 1982, 1983) mentioned *Paliurus* from allochthonous and autochthonous floras in S. Germany and Greece. Our finds are from allochthonous floras only. The recent *P. ramosissimus* with which the species is comparable occurs in upland forests in the warmer parts of Japan, Taiwan and the mainland of Asia. Therefore *P. sibiricus* is considered a plant of upland forest, unit 6.

Ziziphus striata (Ludwig) Mai et Gregor

Material studied: Fruits; coll. no.8335-25: 1; 14142-20: 1; 14402-22: 1.
Ecology: See Van der Burgh (in press) (unit 3).

ROSACEAE

Crataegus angusticarpa Reid (Plate VII, 7; Plate VIII, 1, 2)

Material studied: Endocarps; coll. no.8699-38: 9; 8700-16: 20; 14141-31: 1; 14142-18: 1.
Remarks: These endocarps are triangular in cross section and sometimes bear a vein on the outer (dorsal) side. They are proximally fused, in the upper quarter completely free, being slimly covered by a glossy epidermis which extends to one quarter of the ventral side at most and covers the apex. The apex is slightly constricted. They measure 3.2–4.5 × 1.3–2.0 mm. This material is similar to *C. angusticarpa* as described by Reid (1923).
Ecology: The extant species of this genus are found in moist to dry locations, especially shrub and upland forest. The occurrence in allochthonous floras only is in agreement with this environment, units 4, 5 and 6.

Crataegus jonkeri Van der Burgh

Material studied: Endocarps; coll. no.8700-38: 24; 14141-34: 1.
Ecology: See the preceding species.

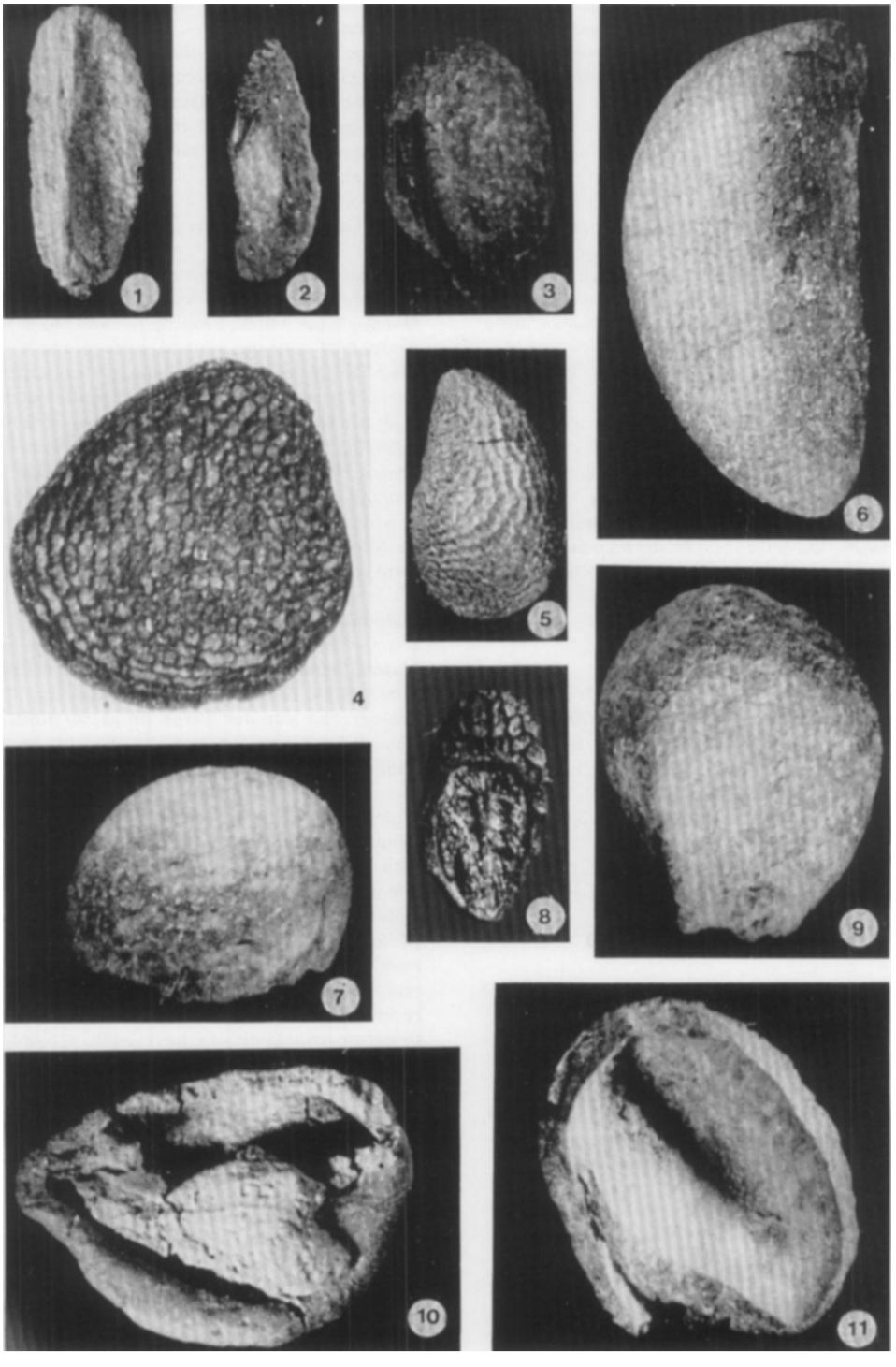
Crataegus nodulosa Reid

Material studied: Endocarps; coll. no.8297-31: 1; 8335-18: 4.
Ecology: See *C. angusticarpa*.

PLATE VIII

1,2. *Crataegus angusticarpa*; no.8700-16; 12.5 ×.
3,7. *Zanthoxylum ailanthiforme*; no.8295-8; 12.5 ×.
4. *Solanum nigrum*; no.14183-28; 25 ×.
5. *Phellodendron lusaticum*; no.14141-12; 12.5 ×.
6. *Toddalia naviculaeformis*; no.8295-7; 12.5 ×.
8. *Teucrium* sp.; ventral face; no.14141-54; 25 ×.
9,11. *Staphylea bessarabica*; 9: outer surface; 11: inner surface, raphesinus; no.8295-8; 12.5 ×.
10. *Meliosma wetteraviensis*; no.8297-22; 12.5 ×.

PLATE VIII



Crataegus sp. 1

Material studied: Endocarps; coll. no.8336-12: 1.
Remarks: This 4.8 × 2.7 mm endocarp bears a central vein on the dorsal side, it is contracted at the free apex and has traces of an epidermis-covered triangular lateral field. It is not possible to assign it to any known species.
Ecology: See *C. angusticarpa*.

Crataegus sp. 2

Material studied: Endocarps; coll. no.8297-34: 1; 8700-45: 4.
Remarks: Deformed, 4.2–5.5 × 1.9–3.0 mm endocarps with remains of a ventral ridge, a "hilum" and a free apex. The lateral faces are smooth, the dorsal one is rough. This material can be identified as belonging to *Crataegus*, but a further determination is impossible.
Ecology: See *C. angusticarpa*.

Crataegus sp. 3

Material studied: Endocarps; coll. no.8700-44: 2.
Remarks: These fragmented endocarps measure 3.1–3.3 × 1.8–2.0 mm. The dorsal side bears longitudinal nodular outgrowths, the lateral faces show remnants of a free apex. It has provisionally been assigned to *Crataegus*.
Ecology: See *C. angusticarpa*.

Rubus laticostatus Kirchheimer

Material studied: Endocarps; coll. no.7807-10: 17; 7808-3: 25; 8295-9: 20; 8297-21: 1; 8335-2: 1; 8699-19: 4; 8700-19: 106; 13285-18: 1; 13286-26: 2; 13349-11: 1; 14139-17: 2; 14140-27: 5; 14141-1: 80; 14146-5: 11; 14183-32: 8; 14399-13: 12; 14400-16: 9; 14402-8: 6; 14428-10: 5.
Ecology: See Van der Burgh (in press) (units 3, 4, 5, 6, 7 and 8).

Sorbus aria Crantz

Material studied: Seeds; coll. no.8295-85: 1; 8297-33: 1; 8336-33: 1.
Ecology: At present, this is a plant of upland forest. This agrees with the finds in allochthonous floras, unit 6.

Sorbus herzogenrathensis (Menzel) Gregor

Material studied: Endocarps; coll. no.7807-16: 2; 7808-7: 519; 14399-7: 7; 14402-9: 7.
Ecology: See Van der Burgh (in press) (unit 3).

RUTACEAE

Phellodendron lusaticum Kirchheimer (Plate VIII, 5)

Material studied: Seeds; coll. no.14139-15: 2; 14145-12: 3.
Remarks: These seeds measure 3.5–3.8 × 2.0–2.3 mm. They are black and bear a reticulate ornamentation. The testa is composed of sclerenchymatous isodiametric cells; in addition along the ventral side an inner layer of palisade cells is present. These seeds are smaller and with less sharp ornamentation ridges than those of *P. elegans* (Reid and Reid, 1915). They are similar to *P. lusatica* described by Kirchheimer (1940).
Ecology: This species has only been found in allochthonous floras. Gregor (1980) recorded it from a clay in which some allochthonous elements are present. The genus occurs in upland forest in the present day, which is in accordance with the recorded occurrence of the fossil material, unit 6.

Toddalia naviculaeformis (Reid) Gregor (Plate VIII, 6)

Material studied: Seeds; coll. no.8295-7: 24.
Remarks: The length is 5.5–7.2 mm, the width 3.0–3.9 mm. The seeds are black, anatropous and thick-walled, with a straight or concave ventral surface and a curved dorsal side. The outer surface is smooth or with low rounded warts. The walls are composed of isodiametric cells. These seeds are similar to material described from France by Reid (1923) (as *Martya naviculaeformis*) and from S. Germany by Gregor (1978b) as *Toddalia naviculaeformis*.
Ecology: Gregor (1983) recorded this species from a lignite in Aliveri, Greece. In our region it has only been found in an allochthonous flora. It is considered a bottomland plant, growing in wetland forest, unit 3.

Toddalia rhenana Gregor

Material studied: Seeds; coll. no.7807-8: 5; 7808-5: 1; 7809-2: 5; 8295-6: 14; 13286-19: 1; 14142-9: 4.
Ecology: See Van der Burgh (in press) (unit 3).

Zanthoxylum ailanthiforme (Gregor) Gregor (Plate VIII, 3, 7)

Material studied: Seeds; coll. no. 8295-8: 13.
Remarks: 4.0–5.0 × 3.0–3.5 mm, black anatropous seeds with a more or less reticulate ornamentation consisting of low rounded ridges and grooves. They are similar to material described by Gregor (1978b) from Bavaria.
Ecology: Gregor (1980, 1982) recorded the genus from some autochthonous floras in southern Germany. In our region it has been found only in allochthonous floras. The recent equivalent forms part of a moist forest and it is therefore considered to have been a plant of floodplain forest, unit 5.

SABIACEAE

Meliosma wetteraviensis (Ludwig) Mai (Plate VIII, 10)

Material studied: Seeds; coll. no.8297-22: 2; 8700-15: 1.
Remarks: Black, 5–6 × 4–5 mm, more or less triangular seeds with a large lighter-coloured hilum. They are similar to *M. wetteraviensis* as described by Mai (1973).
Ecology: Although our material has only been found in allochthonous floras, this and related species have been reported from autochthonous floras in Bavaria (Gregor, 1980, 1982). It is therefore considered to be a plant of the wetland forest, unit 3.

SOLANACEAE

Solanum nigrum L. (Plate VIII, 4)

Material studied: Seeds; coll. no.14183-28: 3.
Remarks: These are campylotropous seeds with a diameter of about 1.5 mm. The outline is more or less circular, the surface bears a reticulate sculpture. The seeds are identical to those of the recent *S. nigrum* L.
Ecology: *S. nigrum* is a plant of herbaceous vegetations on fertile soils, which develop after serious disturbance of the original vegetation, unit 2.

STAPHYLEACEAE

Staphylea bessarabica Negru (Plate VIII, 9, 11)

Material studied: Seeds; coll. no.8295-5: 3; 14142-16: 5; 14145-27: 1 seed.
Remarks: These are 5–6 × 4–5 mm anatropous seeds with the micropyle at the extremity of a conspicuous basal rim. The sinus of the raphe lies within a less distinct rim. The surface shows a fine isodiametric cellular pattern. These seeds are similar to *S. bessarabica* (Negru, 1972).
Ecology: *Staphylea* has only been found in allochthonous floras, which suggests a habitat either in the floodplain forest or the upland forest and forest border vegetation. Its occurrence in a clay together with other extra-local elements (Gregor, 1980) is in accordance with this assumption of a somewhat drier habitat, units 4, 5 and 6.

Staphylea sp.

Material studied: Seeds; coll. no.14183-13: 1.
Remarks: This is a markedly compressed seed which could not be identified at a more precise level than that of the genus.
Ecology: This seed may tentatively be placed in the same units as the preceding species, i.e. units 4, 5 and 6.

STYRACACEAE

Halesia crassa (Reid et Reid) Kirchheimer

Material studied: Endocarps; coll. no.8295-31: 156; 8336-8: 1; 8699-26: 5; 14140-14: 1; 14142-8: 4.
Ecology: This species has only been found in allochthonous floras. Recent *Halesia* occurs in upland forest and wetland forest. The presence in allochthonous floras is not in contradiction with this environment. However, its absence from autochthonous floras contradicts with wetland forest. Therefore *H. crassa* is considered to be a plant of upland forest only, unit 6.

Rehderodendron ehrenbergii (Kirchheimer) Mai (Plate VII, 8)

Material studied: Fruits, endocarps; coll. no.8295-29: 7.
Remarks: The endocarps, 14–24 × 5–17 mm, bear sharp, sometimes divaricating ridges. They are partly covered by mesocarp and exocarp. At the apex of the more complete fruits is a conical discus. When this is broken off, one to three pores are visible. This material is similar to that described under the name *Durania ehrenbergii* by Kirchheimer (1936) and redescribed under the present name by Mai (1970a,b).
Ecology: So far, *R. ehrenbergii* has only been found in allochthonous floras. Therefore this woody plant is considered as a member of forest vegetation, including floodplain forest, upland forest and forest border-scrub, units 4, 5 and 6.

Styrax maximus (Weber) Kirchheimer

Material studied: Seeds; coll. no.8295-19: 5; 8297-32: 1; 14141-29: 1; 14183-7: 1.
Ecology: *Styrax* has only been found in allochthonous floras, suggesting a rather dry habitat. Extant members of the genus occur either in wetland forest or upland forest. The absence from autochthonous floras points to a drier habitat, unit 6.

SYMPLOCACEAE

Symplocos germanica Mai

Material studied: Endocarps; coll. no.7808-11: 20; 8295-59: 2; 8297-28: 1; 8699-15: 1; 8700-34: 1; 13285-7: 46; 13286-4: 1; 14140-24: 44; 14143-19: 4; 14145-24: 4; 14146-13: 9; 14399-8: 11; 14400-8: 1; 14402-6: 11.
Ecology: See Van der Burgh (in press) (unit 3).

Symplocos gothanii Kirchheimer

Material studied: Endocarps; coll. no.7808-28: 79; 8295-60: 55; 8699-12: 15; 8700-12: 50; 14139-9: 27; 14142-23: 5; 14399-10: 38; 14400-9: 16; 14402-7: 13.
Ecology: See Van der Burgh (in press) (unit 3).

Symplocos lignitarum (Quenstedt) Kirchheimer

Material studied: Endocarps; coll. no.7807-31: 1; 7808-10: 9; 8295-62: 4159; 8297-12: 10; 8335-14: 1; 8336-3: 2; 8699-13: 40; 8700-13: 24; 13285-9: 33; 13286-5: 9; 14139-8: 4; 14140-22: 954; 14141-3: 11; 14142-22: 5; 14143-17: 111; 14145-15: 11; 14146-15: 269; 14399-9: 2; 14400-10: 1; 14402-28: 7.
Ecology: See Van der Burgh (in press) (units 3 and 5).

Symplocos minutula (Von Sternberg) Kirchheimer (Plate IX, 1)

Material studied: Endocarps; coll. no.8295-57: 20; 8335-23: 1; 13286-1: 1.
Remarks: These 4.8–9.5 × 3.5–5.0 mm endocarps are smooth or with numerous low ribs. The ribs merge into longitudinal rows of small tubercles. At the constricted base a circular groove with two or three pores is present. Although in most cases all the locules of the endocarp are fertile and well developed, these endocarps are comparable with *S. minutula* as described by Kirchheimer (1949).

Ecology: This species is known from Salzhausen where it occurs in rather large numbers in the carpolitic lignite. In our region it has been found only in low numbers in allochthonous floras. Based on the low numbers and the occurrence in Salzhausen it is considered a plant of wetland forest, unit 3.

Symplocos pseudogregaria Kirchheimer (Plate IX, 4, 6)

Material studied: Endocarps; coll. no.8295-58: 2; 13286-24: 2; 14140-23: 162; 14143-18: 20; 14145-10: 22; 14146-14: 73; 14401-2: 1.
Remarks: These endocarps measure 4.5–7.0 × 3.0–4.0 mm. The surface is covered by short longitudinal and oblique ridges and grooves. The endocarps are trilocular, the groove at the base is shallow with three pores. This material is similar to *S. pseudogregaria* as described by Kirchheimer (1938, 1949).
Ecology: Gregor (1980, 1982) reports this species from autochthonous floras in S. Germany. In our region we only have found it in allochthonous floras with occasionally high percentages, suggesting a drier habitat. It is therefore considered a plant of various environments, including wetland forest, but with a preference for the floodplain forest, (units 3 and 5).

Symplocos salzhausenensis (Ludwig) Kirchheimer

Material studied: Endocarps; coll. no.7808-8: 9; 8295-61: 106; 8297-11: 1; 8300-10: 4; 8335-13: 1; 8699-14: 2; 8700-14: 12; 13285-8: 1; 14143-21: 1; 14145-11: 1; 14146-11: 4; 14402-27: 18.
Ecology: See Van der Burgh (in press) (unit 3).

Symplocos schereri Kirchheimer

Material studied: Endocarps; coll. no.7808-8: 1; 8295-22: 26; 8297-13: 2; 8336-1: 1; 8699-16: 2; 13286-2: 1; 14139-7: 6; 14140-12: 8; 14143-20: 3; 14145-23: 3; 14146-12: 3.
Ecology: See Van der Burgh (in press) (units 5 and 6).

THEACEAE

Eurya lusatica Mai (Plate IX, 5)

Material studied: Seeds; coll. no.8300-7: 14.
Remarks: These are 2–2.5 mm, circular or slightly elongate campylotropous flat black seeds with a very characteristic reticulate sculpture on the surface. These seeds are larger than those of *E. stigmosa* and are similar to *E. lusatica* as described by Mai (1971).
Ecology: Mai (1964) and Gregor (1980) reported this species from autochthonous floras only. However, it can be found as an allochthonous fossil too, unit 3.

Eurya stigmosa Mai

Material studied: Seeds; coll. no.7807-9: 1; 7808-1: 680; 8295-10: 147; 8297-8: 5; 8300-11: 26; 8335-5: 22; 8336-11: 17; 8699-7: 17; 8700-39: 2; 13285-15: 7; 13286-18: 1; 14139-21: 15; 14140-15: 17; 14141-18: 11; 14142-14: 1; 14143-16: 5; 14145-16: 16; 14146-20: 23; 14183-16: 6; 14399-16: 575; 14400-11: 581; 14401-24: 1; 14402-18: 347; 14403-7: 1.
Ecology: See Van der Burgh (in press) (unit 3).

Polyspora lignitica (Menzel) Gregor (Plate IX, 3)

Material studied: Capsules; coll. no.8699-43: 1; 14183-14: 1.
Remarks: These are parts of loculicide capsules, 22 mm long and 7 mm wide. There is a similarity to the fruit *Polyspora lignitica*, as described by Gregor (1984).
Ecology: *Polyspora* is a plant of forests outside the direct influence of the rivers, i.e. upland forest. Our find in allochthonous floras is in accordance with this environment, unit 6.

Stewartia beckeriana Kirchheimer

Material studied: Capsules; coll. no.8699-27: 2; 8700-22: 1; 13285-16: 1.
Ecology: *Stewartia* is considered an upland forest plant (Van der Burgh, 1983) which agrees with its occurrence in allochthonous floras, unit 6.

TRAPACEAE

Trapa heerii Fritsch (Plate IX, 2, 7)

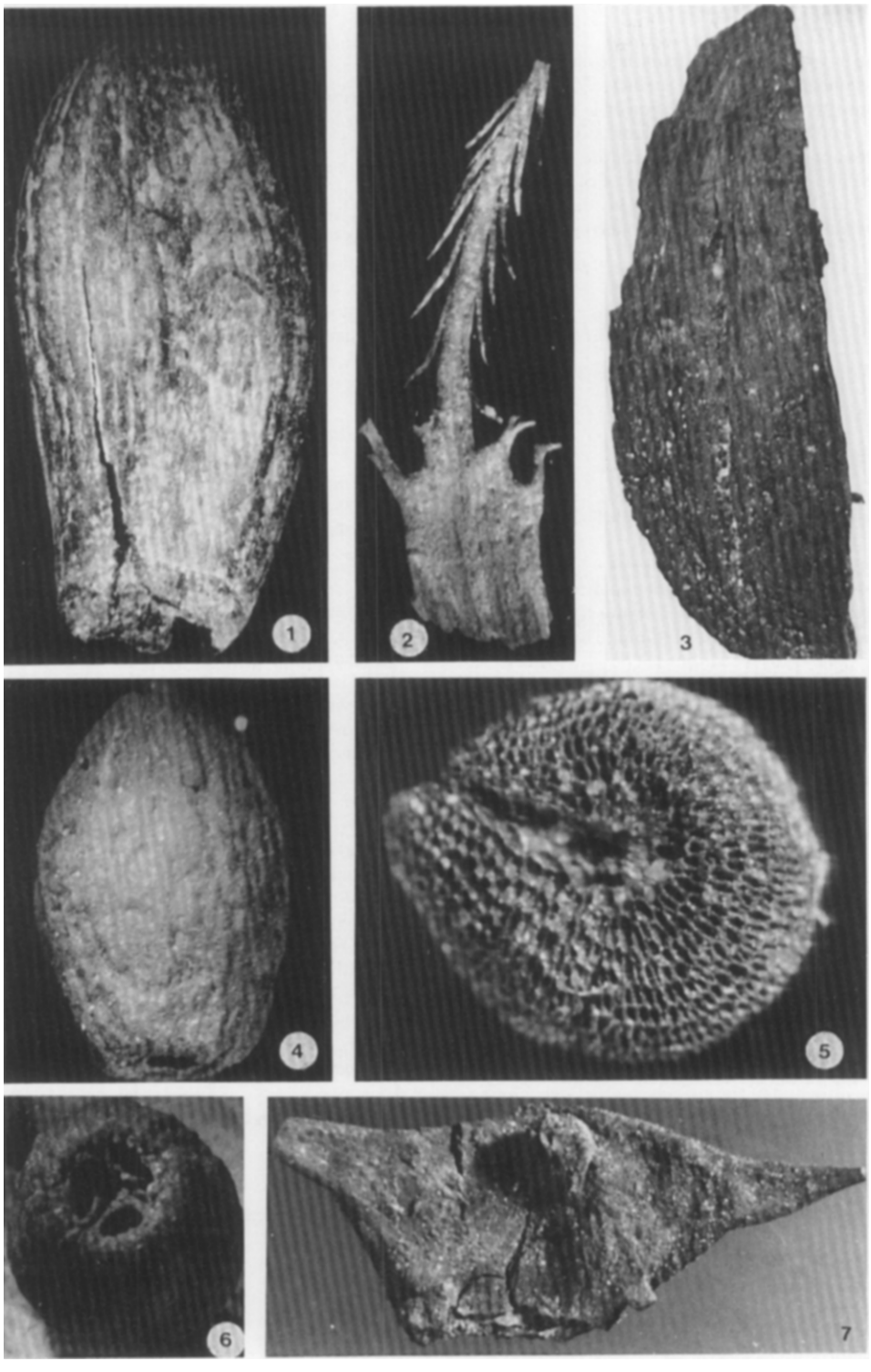
Trapa sp. in: Van der Burgh (in press)

Material studied: Fruits; coll. no.8295-56: 1; 13349-21: 5; 14428-3: 20.
Remarks: The fruits are very variable in size, the height ranging from 6–8 mm, the width (with spines) from 8–20 mm. The fruit bears two pairs of spines; a lower pair of small spines and an upper pair of long spines. Most fruits are much wider than long. These characteristics are known from *T. heerii*, *T. irtyshensis* and *T. natans*. *T. natans* however is too large and in *T. irtyshensis* the variability in size is smaller (Dorofeev, 1963), so our material resembles closely *T. heerii*. In sample 14428 numerous spinetips with small dents also occur.
Ecology: See Van der Burgh (in press) (unit 1).

PLATE IX

1. *Symplocos minutula*; no.8295-27; 12.5 ×.
2,7. *Trapa heerii*; no.14428-3; 2: 12.5 ×; 7: 6 ×.
3. *Polyspora lignitica*; no.14183-14; 6 ×.
4,6. *Symplocos pseudogregaria*; no.14140-23; 12.5 ×.
5. *Eurya lusatica*; no.8300-7; 25 ×.

PLATE IX



UMBELLIFERAE

Sium latifolium L. (Plate X, 1, 2)

Material studied: Fruits; coll. no.8334-6: 1.
Remarks: This 2.4 × 1.5 mm half fruit is compressed and split, which damaged the inner surface. Moreover the upper part, close to the base of the flower is missing. The outer surface bears five ribs with four slightly darker coloured depressions in between. Despite the preservation it is possible to identify this fruit as that of *S. latifolium* L.
Ecology: This fruit has been found in a clay deposit, which is consistent with the ecology of the modern plant, unit 2.

Umbelliferopsis molassicus Gregor

Material studied: Fruits; coll. no.14183-38: 1; 14399-19: 3; 14400-15: 1; 14402-26: 1.
Ecology: See Van der Burgh (in press) (unit 3).

VIOLACEAE

Viola canina L. (Plate X, 3, 4)

Material studied: Seeds; coll. no.8335-29: 1; 8336-36: 1; 8700-35: 1; 14141-5: 3; 14183-20: 7; 14401-29: 3.
Remarks: These are small, 1.6–1.8 × 0.9– 1.3 mm ovate anatropous seeds. They are compressed and folded irregularly. The inner surface of the testa shows the characteristic transverse cellular pattern of *Viola*. The irregularly folded testa is typical for *V. canina* L.
Ecology: *V. canina* is a species of forest margins and scrub vegetation on slightly acidic soil, not very rich in nutrients, unit 4. The fossils have only been found in allochthonous floras, which is in accordance with the recent habitat.

Viola rupestris Schmidt (Plate X, 5, 8)

Material studied: Seeds; coll. no.14183-19: 5.
Remarks: These are small, 2.0–2.2 × 1.3– 1.7 mm ovate anatropous seeds with the largest diameter close to the chalaza. The inner surface of the testa shows a transverse cellular pattern, characteristic for *Viola*. Parts of the outer surface are glossy, while other parts are lighter coloured and dull. These seeds are similar to those of *V. rupestris* Schmidt.
Ecology: *V. rupestris* is a species of pine forest in sandy soil, unit 7. The only find of the species in an allochthonous flora agrees with this.

VITACEAE

Ampelopsis malvaeformis (Von Schlotheim) Mai

A. ludwigii in: Van der Burgh (1983).

Material studied: Seeds; coll. no.8295-67: 1.
Remarks: As Mai and Gregor (1982) pointed out, the correct name for this species is not *A. ludwigii* but *A. malvaeformis*.
Ecology: In the lower Rhenish basin this species has been found in an allochthonous flora only. However, Mai (1964) and Mai and Gregor (1982) reported it from an autochthonous flora, while Gregor (1980) described it from a clay in which allochthonous elements were found in addition to an autochthonous flora. The recent species of the genus demonstrate a very wide ecological amplitude. Based on this *A. malvaeformis* is considered a species of floodplain forest, unit 5.

Tetrastigma lobata Chandler

Material studied: Seeds; coll. no.7808-6: 1; 8295-4: 65; 8300-5: 1; 13285-14: 2; 13286-15: 1; 14139-3: 12; 14140-19: 46; 14143-14: 3; 14145-7: 18; 14146-16: 29.
Ecology: See Van der Burgh (in press) (units 3 and 5).

Vitis lusatica Czeczott et Skirgiello (Plate X, 6, 7)

Material studied: Seeds; coll. no.8295-80: 11; 8297-20: 2; 8699-41: 8; 8700-21: 2; 14141-22: 2; 14142-30: 6; 14183-12: 3.
Remarks: Seeds of Vitaceae, 4.2–5.5 × 2.7– 3.9 mm, with the area around the chalaza grooved radially. The apex has a deep groove at the raphe sinus. The seeds narrow abruptly to the base which bears conspicuous warts. These seeds are similar to *V. lusatica* as described by Czeczott and Skirgiello (1959).
Ecology: *Vitis* is a genus of vines which prefers to grow in wet to dry forest and forest margins. *V. lusatica* has only been found in allochthonous floras, which suggests a preference for drier localities alongside the river. Gregor (1980) reported it from an autochthonous flora with some allochthonous influence; Mai (1964) reported it from a lignite. So there is also the possibility of an occurrence in wetland forest; units 3 and 5.

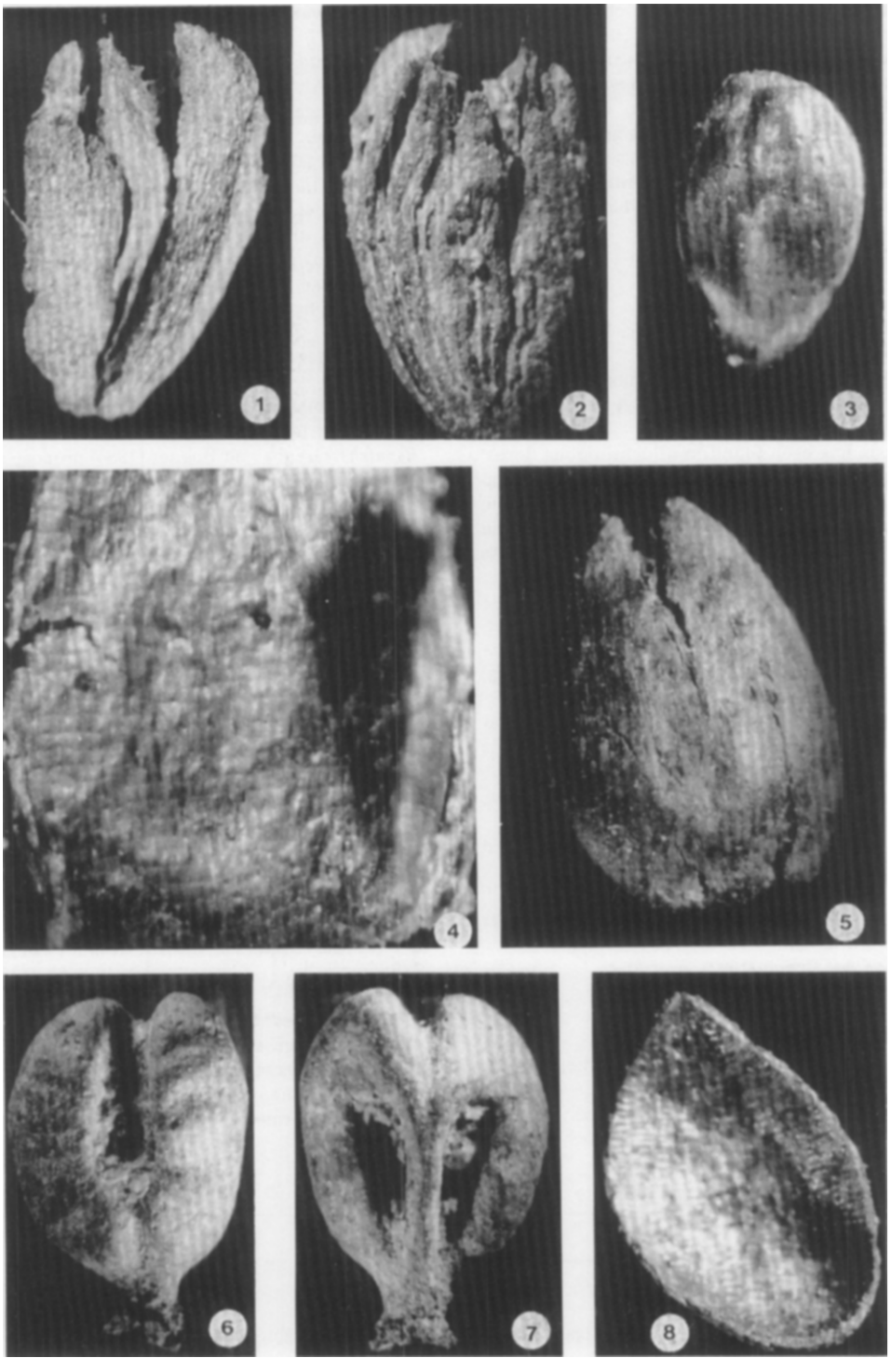
Vitis parasylvestris Kirchheimer (Plate XI, 1, 2)

Vitis sp. in: Van der Burgh (in press).

PLATE X

1,2. *Sium latifolium*; no.8334-6; 25 ×.
3,4. *Viola canina*; 3: no.14401-29; 24 ×; 4: no.14183-20; inner surface; 60 ×.
5,8. *Viola rupestris*; no.14183-19; 8: inner surface; 25 ×.
6,7. *Vitis lusatica*; no.8295-80; 12.5 ×.

PLATE X



Material studied: Seeds; coll. no.7808-16: 2; 8295-17: 8.
Remarks: These are seeds of Vitaceae, 5.0– 6.5 × 3.4–4.0 mm, with a smooth area around the chalaza, a very shallow groove for the raphe sinus at the apex and a gradual narrowing at the base. The base bears conspicuous warts. This material is similar to *V. parasylvestris* Kirchheimer (Mai, 1964).
Ecology: *V. parasylvestris* has been found in two samples, one containing an allochthonous flora, the other an autochthonous flora. In both the percentages are very low. It is therefore impossible to decide between units 3 and 5.

Vitis sp.

Material studied: Seeds; coll. no.8300-25: 1; 13286-23: 1; 14399-18: 1; 14402-13: 1; 14428-13: 1.
Remarks: These are very small fragments of seeds, sufficiently complete to identify the genus, but too incomplete for any further identification.
Ecology: *Vitis* sp. has been found in allochthonous floras. It is therefore expected to have been growing alongside rivers. As the percentages are very low, like the other identified species, it is very probable that the habitat of this unidentified material was similar too, units 3 and 5.

Vitis teutonica A. Braun

Material studied: Seeds; coll. no.7808-15: 1; 8295-81: 29; 8699-25: 4; 14142-2: 6.
Ecology: Van der Burgh (in press) (units 3 and 5).

MONOCOTYLEDONAE

ALISMATACEAE

Alisma plantago-aquatica L.

Material studied: Fruits; coll. no.8334-4: 1; 14183-34: 1; 14428-18: 1.
Ecology: See Van der Burgh (1983) (unit 2).

Caldesia cylindrica (Reid) Dorofeev

Material studied: Fruits; coll. no.8295-49: 3; 13349-3: 13; 14141-52: 1; 14183-17: 1.
Ecology: See Van der Burgh (in press) (unit 2).

ARACEAE

Aracispermum canaliculatum Nikitin

Material studied: Seeds; coll. no.14429-16: 17.
Remarks: Although the similarity to *Calla palustris* is less close as suggested in a previous paper, the presence of a long raphe marks it as belonging to the same group within the family.
Ecology: The ecology of the species can be interpreted from its occurrence in a flora containing herbaceous vegetation and wetland forest. As the species does not occur in any other autochthonous flora and a fair amount of seeds has been extracted, it is still supposed to be a member of herbaceous vegetation, unit 2.

Epipremnites ornatus (Reid et Chandler) Gregor et Bogner

Material studied: Seeds; coll. no.8700-26: 1; 13285-19: 3; 14401-14: 1; 14429-10; 6.
Remarks: Gregor and Bogner (1984) propose a distribution of fossil *Epipremnum* over three genera: *Urospathites* (*Epipremnum cristatum*); *Epipremnites* (*Epipremnum ornatum*); and *Scindapsites* (*Epipremnum crassum*).
Ecology: See Van der Burgh (in press) (unit 2).

Scindapsites crassus (Reid et Reid) Gregor et Bogner

Epipremnum crassum in: Van der Burgh (1978).

Material studied: Seeds; coll. no.8295-38: 5; 8300-18: 1; 14140-26: 1.
Ecology: According to Gregor and Bogner (1984) *Scindapsites crassus* is related to *Scindapsus*, which is a liana in tropical forests. The finds of seeds however in the Upper Tertiary and lower Pleistocene point to an extratropical, even temperate forest, and the association with a fair number of herbaceous plants to an environment of wet herbaceous vegetations, unit 2.

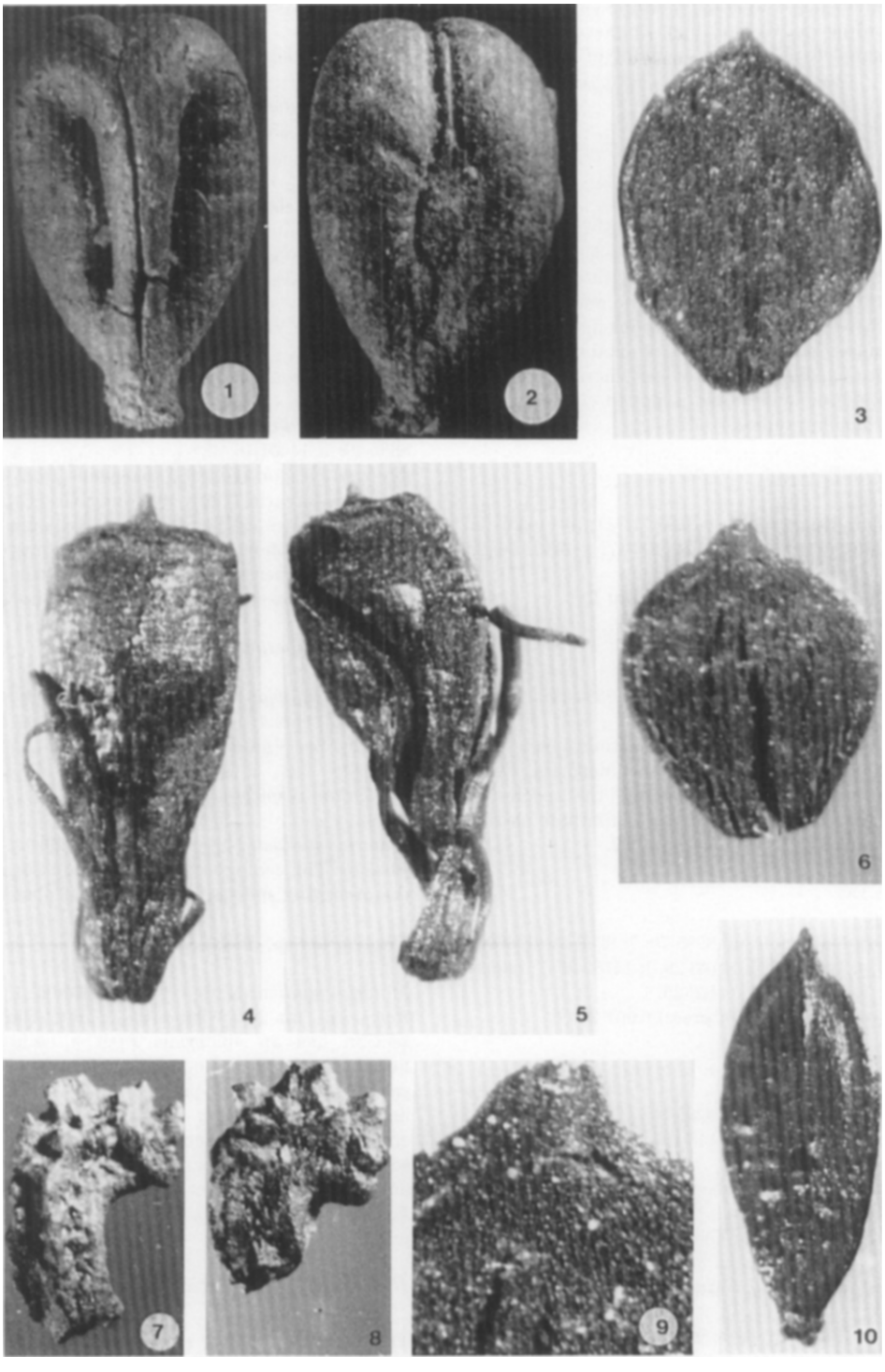
Urospathites cristatus (Nikitin) Gregor et Bogner (Plate XI, 7, 8)

Material studied: Seeds; coll. no.14141-11: 37.
Remarks: These are 2.5–4.0 × 1.9–2.5 mm campylotropous seeds with rows of warty protuberances on the lateral and dorsal sides. The surface is brown and has a dull lustre, the epidermis is formed of parallel rows of elongated rectangu-

PLATE XI

1,2. *Vitis parasylvestris*; no.8295-17; 12.5 ×.
3. *Carex acuta*; no.14183-35; 25 ×.
4,5. *Rhynchospora tertiaria*; 4: Holotype, no.14401-32a; 5: Paratype, no.14401-32b; 25 ×.
6,9. *Scirpus melanospermus*; no.8334-8; 6: 25 ×; 9: 60 ×.
7,8. *Urospathites cristatus*; no.14141-11; 12.5 ×.
10. *Eriophorum* sp.; no.14401-35; 25 ×.

PLATE XI



lar cells. These seeds are similar to *Epipremnum cristatum*, as described by Dorofeev (1963). Gregor and Bogner (1984) assigned it to their new genus *Urospathites*.
Ecology: According to Gregor and Bogner (1984) this material is related to *Urospatha*, a plant of wet places, unit 2.

CYPERACEAE

Carex acuta L. (Plate XI, 3)

Material studied: Nuts; coll. no.8334-9: 1; 8335-22: 7; 8336-34: 1; 8700-32: 25; 14141-42: 6; 14143-28: 1; 14183-35: 1.
Remarks: Flat, 1.4–1.6 × 0.8–1.2 mm nuts with a superficial cellular pattern in longitudinal rows. The apex is acuminate, as is the base, but with a hilum wider than the stylebase. These nuts are similar to those of extant *C. acuta* L.
Ecology: Extant *C. acuta* is a plant of wet places and banks. Our finds in allochthonous floras is not in contradiction with this environment, unit 2.

Carex acutiformis Ehrhard

Material studied: Nuts; coll. no.8295-71: 11; 14140-29: 9; 14141-35: 6; 14145-17: 1; 14183-15: 1; 14400-17: 2; 14401-36: 3; 14429-24: 5.
Ecology: See Van der Burgh (in press) (unit 2).

Carex flagellata Reid et Reid

Material studied: Nuts; coll. no.8295-75: 2; 8334-10: 2; 8335-17: 1; 8336-22: 4; 8700-25: 30; 14141-36: 3.
Ecology: The highest percentages of this extinct species are observed in floras originating from clay deposits. Even these percentages are low and therefore the species is considered to have lived in the same conditions as the other species: banks and wet places, unit 2.

Carex hostiana DC.

Material studied: Nuts; coll. no.8295-70: 7; 8336-21: 6; 8700-31: 21; 14140-30: 4; 14141-38: 5; 14143-29: 1; 14183-36: 1; 14399-20: 8; 14400-18: 1; 14401-37: 2; 14429-25: 1.
Ecology: See Van der Burgh (in press) (unit 2).

Carex sp.

Material studied: Nuts; coll. no.8295-74: 3; 8335-30: 1; 8700-30: 5; 13285-17: 3; 14143-24: 2; 14146-1: 1; 14183-33: 4; 14401-33: 1; 14429-26: 11.
Remarks: This material is too damaged to be identified at the specific level.
Ecology: As *Carex* is not confined to banks, but can also occur in forest, heath and peat bog; nothing can be said concerning this unidentified material.

Caricoidea jugata (Nikitin et Dorofeev) Mai

Material studied: Fruits; coll. no.7807-23: 13; 8295-87: 16; 8297-24: 1; 8335-21: 4; 8336-25: 5; 8700-36: 11; 13285-21: 1; 14140-28: 24; 14143-23: 10; 14145-18: 4; 14146-2: 9; 14399-14: 11; 14400-13: 4; 14401-41: 91; 14402-11: 4; 14429-15: 37.
Ecology: See Van der Burgh (in press) (unit 2).

Cladiocarya europaea Mai

Material studied: Endocarps; coll. no.7807-11: 1; 7808-18: 4; 8336-15: 4; 13286-28: 1; 14141-22: 2; 14399-15: 2; 14429-23: 6.
Ecology: See Van der Burgh (in press) (unit 2).

Cladiocarya trebovensis (Buzek) Mai

Material studied: Endocarps; coll. no.7809-6: 13; 8295-88: 3; 8300-9: 3; 8335-9: 3; 13285-33: 2; 14399-21: 1; 14401-17: 141; 14429-27: 25.
Ecology: See Van der Burgh (in press) (unit 2).

Cladium reidiorum Nikitin

Material studied: Endocarps; coll. no.8295-86: 2; 8300-14: 2; 8335-19: 1; 14401-16: 42.
Ecology: Gregor recorded the genus from autochthonous floras in Bavaria (1980, 1982) and Greece (1983). On this basis it is considered a plant of reedswamps and peaty soil. Our allochthonous fruits are not in contradiction to this view, for the percentages are very low, like those of other plants from these habitats in allochthonous floras, unit 2.

Dulichium spathaceum Reid et Reid

Material studied: Nuts; coll. no.8295-78: 1; 8336-18: 5; 8700-17: 29; 14141-8: 4; 14428-17: 1; 14429-12: 10.
Ecology: See Van der Burgh (1983) (unit 2).

Dulichium vespiforme Reid et Reid

Material studied: Nuts; coll. no.8336-29: 1.
Ecology: The ecology of this species is the same as that of the preceding species, banks and wet places, unit 2.

Eriophorum sp. (Plate XI, 10)

Material studied: Nuts; coll. no.14401-35: 1.
Remarks: This 2.4 × 0.9 mm black nut, triangular in cross section has an epidermis with a cellular pattern of longitudinal rows of cells. The sides of the nut are not smooth as in other Cyperaceae, but show weak longitudinal ridges, suggesting a less massive wall beneath the epidermis. Within recent Cyperaceae such a character is sometimes observed within the genus *Eriophorum*. The material has been described as *Eriophorum* sp.
Ecology: *Eriophorum* is a genus of peat colonizing plants, unit 9.

Rhynchospora tertiaria nov. sp. (Plate XI, 4, 5)

Holotype: Coll. no.14401-32a (Plate XI, 4).
Paratypus: Coll. no.14401-32b (Plate XI, 5).
Locus typicus: Quarry "Zukunft West".

Stratum typicum: Indener schichten.
Derivatio nominis: The first species to be described from Tertiary deposits.
Description: Flat, 2.1 × 0.7–0.9 mm nuts with bristles at the base and a broad apex with a cicatrix of a broad attached flat style. In the middle of the apex a short spine is present. The surface shows longitudinally elongated cells but also transversely orientated rugulae. The bristles are at least as long as the nutlet.
Material studied: Nuts; coll. no.14401-32: 34.
Remarks: Flat nutlets with broadly attached styles are only known to the author from *Rhynchospora*. *R. fusca* also shows the transversely orientated rugulae caused by transverse rows of cells in the epidermis. This species however has a much shorter nut and our material cannot be matched with it. Hence it is described as a new species.
Ecology: *Rhynchospora* is a plant of oligotrophic peat vegetations. It has only been found in an allochthonous flora from a sand deposit directly over a lignite seam. Previously the same species had been collected in a sand deposit within a Pliocene lignite in the open cast mine Frechen (sample 7805-18: 16 nuts). It was not recorded in Van der Burgh (1983), as it was not recognised at that time. Both localities strongly suggest an influence of lignite vegetation, which is in accordance with the recent habitat of the genus, unit 9.

Scirpus lacustris L.

Material studied: Nuts; coll. no.8295-73: 2; 14401-38: 4.
Ecology: This plant has only been found in allochthonous floras. At the present day it is a plant of swamp vegetations along banks of open water, unit 2.

Scirpus melanospermus C.A. Mey. (Plate XI, 6, 9)

Material studied: Nuts; coll. no.8295-72: 1; 8334-8: 84; 13285-22: 1; 14401-28: 3; 14428-15: 1.
Remarks: These small, 1.6–2.5 × 0.9–1.4 mm nuts, flat to lenticular in cross section sometimes display remains of bristles at the base. The surface consists of an epidermis with longitudinal rows of cells. The lower layers of the wall of the nut are formed by longitudinally arranged sclerenchymatous fibres. These nuts are similar to material described as *S. melanospermus* C.A. Mey. by Dorofeev (1963).
Ecology: *S. melanospermus* is present with very low percentages in some allochthonous floras. In a backswamp clay (no.8334) however it is dominant (70% of the material). It is therefore considered to have lived in the same environments as the preceding species, unit 2.

Scirpus tabernaemontani C.C. Gmelin

Material studied: Nuts; coll. no.8334-11: 1; 14141-37: 1; 14401-34: 5; 14428-16: 1.
Ecology: See *S. lacustris*, unit 2.

HYDROCHARITACEAE

Stratiotes tuberculatus Reid

Material studied: Seeds; coll. no.8295-24: 12; 14401-5: 1.
Ecology: At the present day *Stratiotes* is a plant of open water, where it grows in leeward places with very little disturbance. The finds of Gregor (1980, 1982) in autochthonous floras are in accordance with this ecosystem, unit 1.

POTAMOGETONACEAE

Potamogeton extremitatus nov. sp. (Plate XII, 1, 2)

Holotype: Coll. no.14428-8a, Laboratory of Palaeobotany and Palynology of the State university of Utrecht, the Netherlands (Plate XII, 1).
Paratype: Coll. no.14428-8b, Laboratory of Palaeobotany and Palynology of the state university of Utrecht, the Netherlands (Plate XII, 2).
Locus typicus: Quarry "Hambach".
Stratum typicum: Indener Schichten.
Derivatio nominis: The long spinelike projections at the base of the endocarp.
Description: Endocarp with projections 3.4 × 1.9 mm; without projections 2.2 × 1.8 mm. A short shoulder is present between style and germination pore. The lateral sides are flat with small depressions. On the back there is a spine in the middle, at the base there are ca 1 mm long spinelike projections on either side of the endocarp and a short spine on the lid of the germination pore, which also bears some short dentlike spines.
Material studied: Endocarps; coll. no.14428-8: 14.
Remarks: This material is very complete and yet unknown from the literature. It has therefore been described as a new species.

Ecology: This genus is typically a waterplant; the totally unabraded state of the fruits of this species points to its presence at the place of deposition of the sediment, unit 1.

Potamogeton sp.

Material studied: Endocarps; coll. no.8334-12: 2; 8336-28: 2; 8699-33: 1; 13286-22: 1; 13349-8: 4; 14141-25: 1; 14183-18: 1; 14401-15: 1.
Remarks: This is abraded material which cannot be identified at the specific level.
Ecology: Members of this genus of typical water plants can be expected in all allochthonous floras, unit 1.

Ruppia palaeomaritima Negru (Plate XII, 3, 4)

Material studied: Fruits; coll. no.8336-30: 1; 14401-23: 14.
Remarks: These are 1.2–1.6 × 0.8–1.0 mm black fruits, preserved with exocarp. The germination valve extends to the base of the style, so no shoulder is present. The lateral sides are semiglobose, no depression is present. These fruits are similar to *R. palaeomaritima* as described by Negru (1968, 1972).
Ecology: *Ruppia* is a genus of coastal aquatic and marine plants. Thus it is a marker of marine influence, unit 1.

SPARGANIACEAE

Sparganium haentzschelii Kirchheimer (Plate XII, 5, 11)

Material studied: Endocarps; coll. no.8295-63: 10; 8297-25: 1; 8300-26: 1; 8699-32: 1; 8700-24: 33; 14139-16: 1; 14141-14: 24; 14142-15: 3; 14183-37: 1.
Remarks: These 2.8–4.0 × 1.9–2.2 mm endocarps with a germination pore at the base of the style bear a variable number of longitudinal ridges and shallow grooves. This material is similar to *S. haentzschelii* described by Kirchheimer (1941).
Ecology: *Sparganium* is a genus of plants of shallow water and banks, unit 2.

Sparganium minimum (Hartmann) Fries

Material studied: Endocarps; coll. no.8295-26: 2.
Ecology: See the preceeding species, unit 2.

Sparganium sp.

Material studied: Endocarps; coll. no.14429-23: 6.
Remarks: Small endocarps with a germination pore at the base of the style. They cannot be identified at the specific level.
Ecology: See *Sparganium haentzschelii*, unit 2.

TYPHACEAE

Typha sp. (Plate XII, 6, 7)

Material studied: Fruits; coll. no.7809-3: 190; 14428-19: 3.
Ecology: See Van der Burgh (in press) (unit 1).

ZINGIBERACEAE

Spirematospermum wetzleri (Heer) Chandler

Material studied: Seeds; coll. no.7807-13: 2; 8334-1: 20; 14141-9: 2; 14429-4: 12.
Ecology: See Van der Burgh (in press) (unit 2).

INCERTAE SEDIS

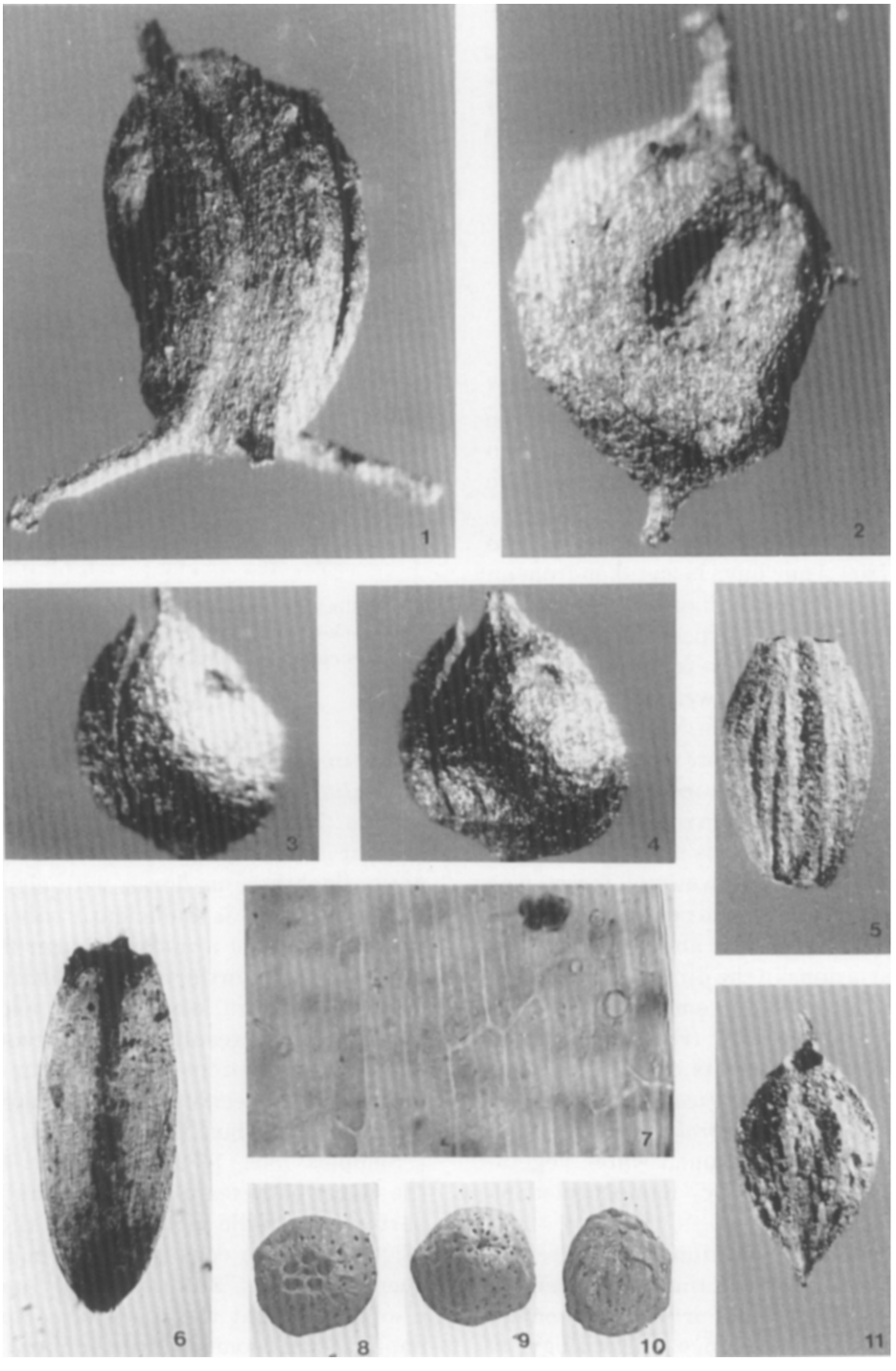
Palliopora symplocoides Kirchheimer (Plate XII, 8–10)

Material studied: Fruits; coll. no.8295-36: 17; 8699-24: 2; 13285-3: 1; 14140-1: 31; 14142-11: 5; 14146-18: 1.
Remarks: These are globular to oviform 14–29 mm long endocarps with 4–5 pores at the base around the abscission mark of the stalk. At the apex there is a narrow circular groove. Several fruits still bore remains of the exocarp. In the walls of the endocarp there are numerous small pores, communicating with lacunes which are connected with each other and form a spongelike structure around the massive central part of the endocarp which contains the locules. This material is similar to *Palliopora symplocoides* as described and figured by Kirchheimer (1934b, 1949). Concerning the systematic position of this genus, the presence of an exocarp, the smooth surface of the endocarp and the place of the germination pores at the base of the fruit link it with *Sphenotheca* and *Symplocos*, more than with any other genus of fossil or recent plants.
Ecology: This species has been found in allochthonous floras only. It is probable that such large woody fruits originated from a woody plant. Based on this and on the absence from autochthonous floras, the ecological amplitude has been confined to units 4, 5 and 6.

PLATE XII

1,2. *Potamogeton extremitatus*; 1: Holotypes, no.14428-8a; 2: Paratype, no.14428-8b; 25 ×.
3,4. *Ruppia palaeomaritima*; no.14401-23; 25 ×.
5,11. *Sparganium haentzschelii*; 5: bilocular endocarp; no.8700-24; 12.5 ×.
6,7. *Typha* sp.; both pictures in transmitting light; 7: cellular structure of the subepidermal layer; no.7809-3; 6: 50 ×; 7: 500 ×.
8,9,10. *Palliopora symplocoides*; 8: exocarp partly preserved; no.14140-1; 1 ×.

PLATE XII



Sphenotheca incurva Kirchheimer

Material studied: Endocarps; coll. no.8295-32: 17; 13285-4: 1; 14139-2: 3; 14140-4: 5; 14142-12: 4; 14145-25: 3.
Ecology: This species has been found in allochthonous floras only, where it forms low percentages. It is therefore considered a plant of the drier parts of the river valley vegetation as well as other habitats. The woody fruit most probably originated from a woody plant. Thus its ecological conditions include units 4, 5 and 6.

Discussion (Figs.1–6, for legenda see Fig.2)

Zukunft West

From the Ville Schichten in "Zukunft West" six samples were studied; together with three other samples (one from "Zukunft West", two from "Hambach") they were used to define the local vegetation (unit 2, 3 and 9).

Stratigraphically the oldest samples are no.7807 and 7809. They have been taken from an argillaceous lignite and a lignitic clay respectively. Therefore one can expect the vegetation to have been mesotrophic to eutrophic. Sample 7807 (Fig.1.a) represents a wetland forest with some influence from outside, which may have been transported to the site with the water which also carried the clay component of the sediment. The representation of unit 6 is a clear marker of this allochthonous influence.

The vegetation of this wetland forest was rather diverse, reflecting the comparative richness in nutrients of the soil and possibly other ecological variations in the direct environment of the sample site. This is emphasised by the contrast with sample 7809 (Fig.1.b) from the same horizon, which reflects only three types of vegetation: Scrub of *Myrica* with an admixture of *Hypericum*, *Glyptostrobus* and the vine *Toddalia* and swamp and open water vegetation, both dominated by monocotyledons (*Typha*, *Caricoidea*).

The first type of vegetation, *Myrica* scrub, might have been present in the flora of sample 7809, for most of its species are also present in this sample. This difference in ecology is probably the reason for the difference in representation of the palaeotropical floral element in the samples. In sample 7809 only *Toddalia* represents this floral element; in sample 7807 a true mastixioidean flora is present. Although species-poor in comparison with allochthonous floras, with eleven taxa in this sample it is sufficiently diverse to be characterised as a mastixioidean flora. However, the arctotertiary floral element is dominant in this flora, which can be explained for instance as a result of the mesotrophic to eutrophic conditions which favour deciduous plants. These deciduous plants mainly belong to the arctotertiary floral element.

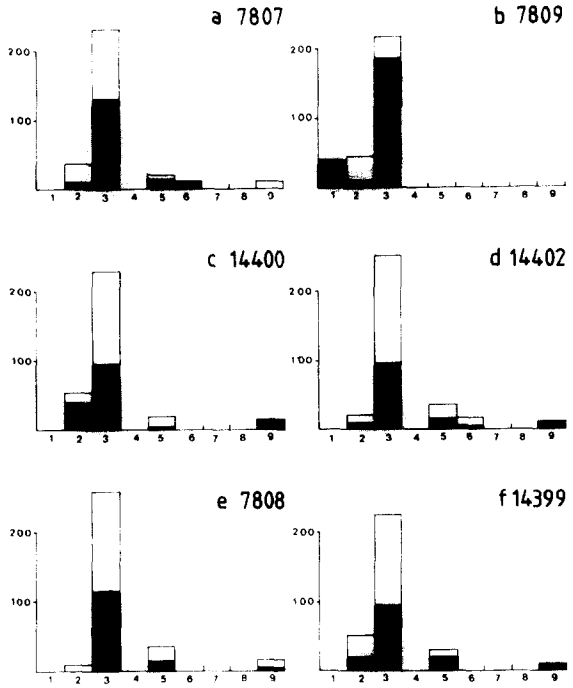


Fig.1. Block diagrams of the vegetational composition of the samples 7807, 7808, 7809, 14399, 14400 and 14402. The numbers correspond with the vegetational units.

Samples 7808, 14399, 14400 and 14402 from the Garzweiler seam represent the uppermost part of the Ville Schichten of the Miocene (Fig.1.c–d). The coal is locally impure in the open cast mine "Zukunft West" and this was also the case at the place of sampling. This implies that some allochthonous influences can be expected. As could be expected, unit 3 (wetland forest) is dominant; floodplain forest

is not very well represented and of the typical upland vegetational units 6, 7 and 8, unit 6 is only represented in one sample (14402) and only as a minor component (14). Thus the allochthonous influence is not marked. Typical for all these floras is the total absence of open water vegetation and forest border-scrub, which points to a wide plain covered with vegetation growing in rather stable conditions. The rivers which may have carried the allochthonous elements must have been present at some distance from the site of deposition, nearly all the allochthonous material being filtered out before arriving at the place of sampling.

The small number of taxa recognised also points to a local vegetation (Van der Burgh, in press), but the flora is sufficiently rich to allow for an interpretation of a rather diverse vegetation ranging from oligotrophic to mesotrophic. The palaeotropical floral element is well represented: in all samples vegetational unit 3 is dominated by it. Unit 5, representing drier circumstances, is rather poorly represented. In three of the four samples this unit is dominated by palaeotropical plants, in sample 14399 the arctotertiary floral element is dominating. Also in unit 2 the palaeotropical floral element is dominating in three of the four samples; in this case sample 14400 is the exception.

Overlying the Ville Schichten are a series of sediments known as the Indener Schichten in the western part and as Fischbach Schichten in the eastern part of the lower Rhenish basin. In "Zukunft West" the Indener Schichten consist of a basal part of marine sediment, a lignite seam ("upper seam") which locally shows marine erosion at the top and a series of fluviatile deposits, interfingering with marine sediments in the eastern part of the open cast mine. The edge of the marine erosion and sediments lies parallel to the Weisweiler fault at a short distance from it.

The lignite of the "upper seam" is very pure and therefore the flora can be expected to be local. One of the difficulties with this pure lignite is that it has been homogenised so

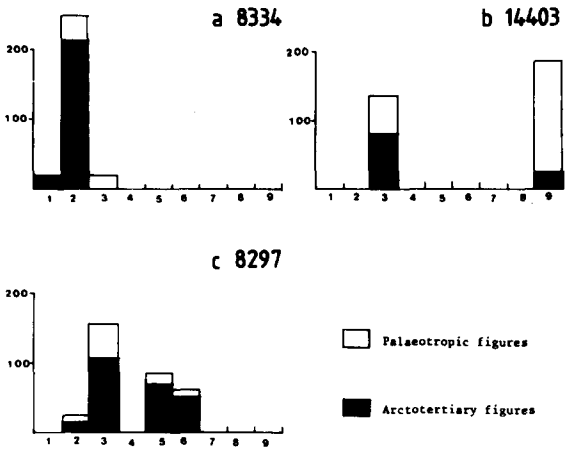


Fig.2. Block diagrams of the vegetational composition of the samples 8297, 8334 and 14403. The numbers correspond with the vegetational units.

thoroughly that, with the exception of some wood remains, no macrofossils could be obtained from it. In one sample however (no.14403, Fig.2.b), a flora could be extracted. It comprises ten taxa of which eight could be identified. Only vegetational unit 3 and 9 were present, the latter dominating. A peat bog represents an oligotrophic vegetation and its dominance is therefore a marker of a highly reduced or absent allochthonous element. The presence of unit 3, wetland forest, can be ascribed to taxa able to survive in oligotrophic circumstances, the four taxa are all present in very reduced numbers. Thus, they may have been present in small dispersed stands of only a few taxa.

The arctotertiary taxa are dominant in unit 3, and the palaeotropical taxa are dominant in the oligotrophic unit 9, as can be expected from a vegetational type which is favourable for evergreen taxa (Monk, 1966; Van der Burgh, 1973).

In the samples from allochthonous deposits a subdivision can be made according to the type of sediment. Sample 8334 (Fig.2.a) originates from a clay in overbank position and the flora is a reflection of it. It can be considered as autochthonous with a very minor allochthonous influence (only one seed of *Magnolia*).

The herbaceous vegetation of swamps and river banks is dominant, and the vegetation of open water is only represented by two abraded endocarps of *Potamogeton*. The vegetation consisted of herbaceous plants, was dominated by Cyperaceae and *Spirematospermum* and can be considered as eutrophic. In this sample, though stratigraphically clearly correlated with samples having mastixioidean floras, no such flora is present. The palaeotropical element is restricted to the allochthonous *Magnolia* and the autochthonous *Spirematospermum*. This can be explained by the wealth of nutrients, which is in favour of arctotertiary taxa. Sample 8297, (Fig.2.c) from a sandy clay represents much more turbulent sedimentation. Consequently the number of taxa is higher and also the dispersion over the vegetational units is more even. Wetland forest dominates, but floodplain forest and upland forest are also rather well represented; the herbaceous vegetation is present but rare. Moreover, the arctotertiary floral element is dominant and again this could only be expected in a flora which represents local and sublocal vegetation growing in eutrophic conditions.

Floras from sands in river channels are clearly allochthonous. They represent the vegetation from a larger area upstream from their place of deposition. The river channel in "Zukunft West" had a south to north course and according to the general topography of the layers can be expected to have flowed in the same direction, with the sea to the north-east, parallel to the Weisweiler fault. As the base of the channel is nowhere in direct contact with the lignite of the "upper seam" within the pit, there is a fair possibility that all the peat bog taxa originate from still actively growing peatbogs in the vicinity. Numerous samples contained reworked material from peat bogs, which in most taxa was very easy to distinguish from freshly deposited material. However, not in all cases this was clear. These samples could therefore not be used for the present study which has been carried out on samples containing no recognisable reworked material. From this river channel three samples were studied: 8300, 8335 and 13285 (Fig.3.a–c). The peat bog was dominated by ericaceous taxa, notably *Epacridicarpum*. As this is considered to be a palaeotropical element, the flora of unit 9 is dominated by the palaeotropical floral element, which is entirely in accordance with what we found in the lignite of the "upper seam", where *Epacridicarpum* was also present, though not dominant. In unit 3, Wetland forest, the palaeotropical floral element is more or less codominant with the arctotertiary flora, except in sample 8335, where the arctotertiary element only prevails. This points to more variation in the wetland forest than is found in the autochthonous floras and also to a wetland forest growing at least locally under less favourable conditions for arctotertiary taxa, possibly less eutrophic soil.

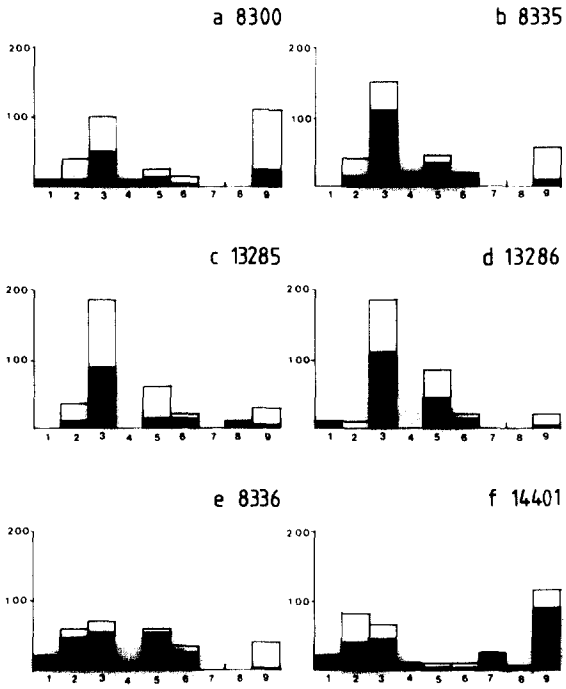


Fig.3. Block diagrams of the vegetational composition of the samples 8300, 8335, 8336, 13285, 13286 and 14401. The numbers correspond with the vegetational units.

In all the three samples the upland forest is only poorly represented, the floodplain forest is

represented by a moderate occurrence, as is the herbaceous vegetation. Open water is not or only poorly represented.

These samples are a reflection of a river flowing through in rather stable conditions in a wide plain, containing wetland forest, peat bog and to a limited extent floodplain forest. Upland vegetation is not present or only to a very limited degree. Open water conditions such as lakes and ponds are hardly represented in the flora and may therefore have been of very limited extent.

The presence of a coast line in the area is of interest for the vegetation. Part of the marine-abraded lignite is covered by marine sands and shore deposits, part is covered by fluviatile sediments, so the coastline fluctuated with time. A clay deposit (sample 8336, Fig.3.e) and an accumulation of organic material in sand (sample 13286, Fig.3.d) were analysed. The organic material yields a flora which is fairly comparable to those obtained from the river channel: Dominance of wetland forest, good representation of floodplain forest, very poor representation of upland forest, open water and herbaceous vegetation. The representation of the peat bog is not marked, being dominated by the palaeotropical *Epacridicarpum*. Possibly this represents an accumulation of material, transported by the river(s) and not or only slightly influenced by their marine environment.

Sample 8336 shows a more even dispersion of the taxa over the units: from the upland vegetational units 3, 6, 7 and 8, only 6 is represented by moderate numbers. Similarly, peat bog environments are represented by a moderate occurrence, with the palaeotropical *Epacridicarpum* dominant. The herbaceous vegetation is represented by a rather high figure, indicating that in comparison with other samples rather more herbaceous vegetation was present. Regarding the distribution of the vegetation types little can be deduced from these two samples: Peat bogs mostly represent an inland vegetation and the same can be said for upland forest and forest border-scrub. However, the latter may have developed along the shore. Herbaceous vegetation, wetland forest and floodplain forest prefer more shelter. Therefore, either some shelter, for instance a sheltered bay, or a marked influence of upstream vegetation types can be assumed. The open water vegetation is also not very distinctive: *Nymphaea* is an inland genus, *Potamogeton* can be found in fresh and in brackish water, whereas *Ruppia* is a marine plant. Thus, the location and preservation of the samples point to marine sedimentation. However, the flora only weakly endorses this hypothesis by the somewhat higher amounts of herbaceous vegetation and the presence of a marine element.

Sample 14401 (Fig.3.f) was collected in a sand covering a lignite with clear marks of drainage by the nearby sea, but not showing any signs of transgression. The flora is typified by the presence of all nine vegetation units: The peat bog, herbaceous vegetation and wetland forest are represented by high figures, the coniferous forest by a moderate figure, all other units by small figures only. Particularly noteworthy are *Corema*, a typical coastal heather, *Cupressoconus*, which comes from a genus which is known to thrive also in coastal conditions, various species of *Pinus*, and *Ruppia*, a plant of marine open water.

The drainage of the peat bog by meandering canals was still visible and this may have caused its superficial desiccation and consequently a humification of the surface, enabling the development of herbaceous vegetation on the peat. The vegetation may have formed a mosaic with the herbaceous vegetation on the better drained parts and peat bog plants on the still very wet parts. In this situation *Pinus* and *Cupressus*, which are able to colonise poor soils, may have been present. In the peat bog vegetation ericaceous plants were still present, but as long as they are unidentified or belong to *Erica*, they are considered to be of arctotertiary affinity or their position is unknown. This implies that with the present knowledge dominance of palaeotropical floral elements in this vegetation cannot be found. The reason why these ericaceous plants are not found in other

samples with strong representation of bog vegetation is as yet unknown. They may have been restricted to the somewhat drier habitats. On the peat there was a grassy vegetation with *Eriophorum*, *Rhynchospora*, *Carex*, *Caricoidea*, *Cladiocarya*, *Cladium* and *Scirpus*, with occasionally tussocks of the peat vegetation and Ericaceae. At times the sea rose and drowned the land, leaving some seeds of *Ruppia* and a thin layer of sand, which was subsequently bleached in the presence of acidic oligotrophic peat.

Fortuna

In the open cast mine "Fortuna" three samples (nos.8295, 8699, 8700, Fig.4.a–c) have been collected in the Fischbach Schichten. They were taken from a channel of a former river. Two samples were collected from a sand layer, the third from a silt layer over the sand, representing rather quiescent conditions during the last stage of sedimentation in the channel. In all three samples wetland forest is dominant, followed by herbaceous vegetation in the silt sample (no.8700) and by floodplain forest in the samples from the sand. Upland forest is represented by moderate figures and even by a high figure in sample 8699; open water vegetation, forest border-scrub, coniferous forest, heath and peat bog are not represented or only by low figures.

Typical is the overall dominance of the arctotertiary vegetation, with the exception of sample 8295, in which the flora is very diverse (87 recognised taxa) and in which the palaeotropical floral element dominates the floodplain forest and upland forest. Compared with the river channel sediments of "Zukunft West" (Fig.3.a–c) bog vegetation is very poorly represented and therefore this river is considered to have flowed through a landscape with rather stable conditions, but with peat bog virtually lacking. The latter is in accordance with the absence of the "upper seam" in the vicinity.

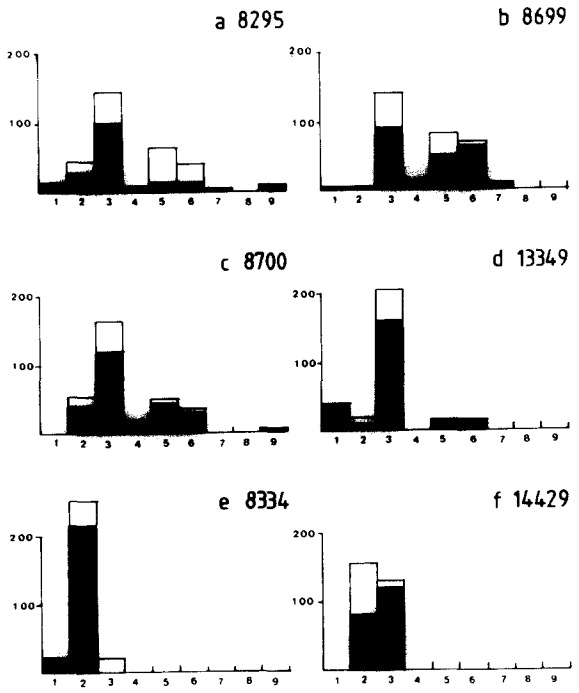


Fig.4. Block diagrams of the vegetational composition of the samples 8295, 8334, 8699, 8700, 13349 and 14429. The numbers correspond with the vegetational units.

Hambach

In the open cast mine "Hambach" most samples were collected in the uppermost division of the Indener Schichten, the top clay. Sample 14429 (Fig.4.f) was collected below this top clay in a clay-filled channel. Only units 2 and 3 are present: although clay is clearly of allochthonous origin, the dense plant cover, as suggested by the numerous compressions of monocotyledonous leaves, sieved all plant debris from outside the direct environment and so only the vegetation of the depression and its borders is represented. Both vegetational units are dominated by arctotertiary plants, a situation more or less similar to that in sample 8334 (Fig.4.e) from "Zukunft West", which was deposited in comparable circumstances. The same explanation as given for the latter sample may be used here. A lignitic clay representing the uppermost part of the top clay of the Indener Schichten offers a comparable situation (Sample 13349, Fig.4.d). It reflects a local vegetation consisting of a wetland forest, as

shown by leaf compressions of *Taxodium*, *Alnus*, *Viscum* and *Magnolia* and various remains of stems and branches of trees. However, in this sample the flora contained some allochthonous elements (open water vegetation, floodplain forest, upland forest). The arctotertiary flora is likewise dominant in this sample.

The other samples originate from allochthonous sediments: No.14141 (Fig.6.b) is from a sand-filled channel below the top clay. Although wetland forest is dominant, the material is rather evenly dispersed over the other vegetational units with the exception of coniferous forest, heath and peat bog, which are not represented and herbaceous vegetation, which is rather markedly represented. Although some typical palaeotropical taxa are present, the flora as a whole is arctotertiary.

Samples nos.14139, 14140, 14142, 14143, 14145 and 14146 (Fig.5.a–f) are from shallow channels in the top clay. Unit 3 is dominant, followed by unit 5 and in most cases by unit 6.

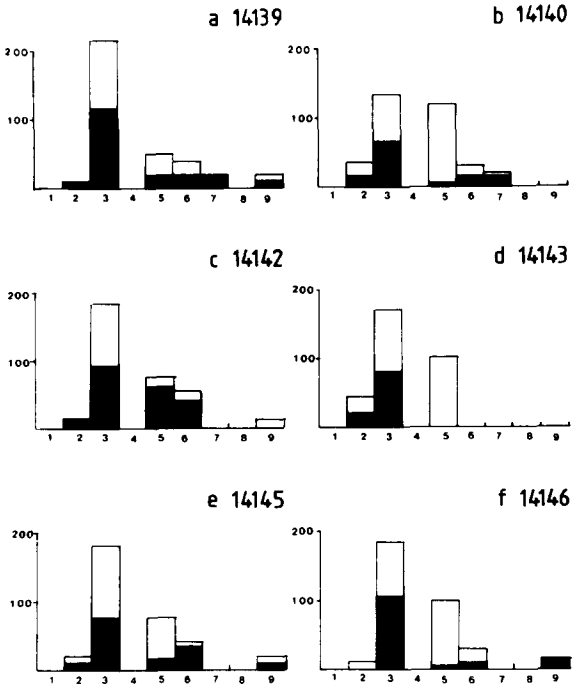


Fig.5. Block diagrams of the vegetational composition of the samples 14139, 14140, 14142, 14143, 14145 and 14146. The numbers correspond with the vegetational units.

However, in two samples unit 2 is also of some importance. Units 7 and 9 are sometimes present, while units 1, 4 and 8 are lacking. Translated into the composition of a landscape: The river channels traversed a wide plain or valley of a major river. The plain, on a clay soil, was partly waterlogged and supported wetland forest and floodplain forest. In some dry places of limited extent or more probably outside the river valley upland forest types were present, notably upland forest (unit 6) and coniferous forest (unit 7). Locally there was some peat formation (still visible as a lignite seam within the clay). The vegetation was partly dominated by palaeotropical plants, especially in unit 5 (5 times out of 6), 3 (3 times), 9 and 6 (both once). In all cases a concentration of palaeotropical taxa in unit 3 and often a still greater concentration in unit 5 is significant. This points to a comparatively less favourable environment in these localities for arctotertiary plants. Combined with the effect of nutrient deficiency on the relation between arctotertiary and palaeotropical plants, this means that once more the dominance of arctotertiary plants is a result of sufficient nutrients in the low-lying wetland forest, and the dominance of the palaeotropical floral element in floodplain forest (unit 5) is a result of more oligotrophic circumstances in somewhat drier places. The macroclimate as a whole favoured the presence of palaeotropical taxa, whereas the microclimate and edaphic factors were the principal criteria for their numbers. Therefore we can consider these vegetations in "Hambach" as rather poor in nutrients, and thus mesotrophic. If we compare this with samples from the other mines, it appears that also in these pits the palaeotropical taxa are concentrated in units 3 and 5, apart from a concentration in peat bog.

Since the scarcity in nutrients favour palaeotropical plants, one might expect this to apply to the upland vegetations as well. However, we find them dominated by arctotertiary taxa. If we compare these Upper Miocene floras with the *Fagus*-dominated leaf compression floras of the same deposits, it becomes clear that outside

the river valleys and coastal plains, the arctotertiary floral element was dominant in the vegetation, giving these vegetations a "Pliocene" aspect — the leaf compression floras are comparable to the Pliocene leaf compression floras. Because clearly outside the river valleys and coastal plains nutrient deficiency must have existed on the deeply weathered alluvial soils, mainly sands, it is evident that some major factor inhibited the dominance of palaeotropical plants. We consider this major factor to be a climatic one, in other words: outside the direct influence of the sea basin and the shelter of valleys, the climate in the Upper Miocene was already unfavourable for palaeotropical taxa. We may drive this argument a little farther: As climate is a matter of greater entities, we may assume that the main climate in the Upper Miocene was already unfavourable for palaeotropical plants in the greater part of Northwestern Europe. Only in sheltered positions and in coastal areas could these floras survive or become dominant. In all other places the seasons were already too extreme for these plants. One of these relict areas was within the lower Rhenish basin and this was the reason for the survival in this area of many of the palaeotropical taxa, part of which can again be found in Brunssumian deposits.

Sample 14428 (Fig.6.c) was collected from a silt in the same channel as no.14140 (Fig.6.a). The differences are striking: much more local influence, dominance of river bank herbaceous vegetation, followed by that of open water. Also fewer palaeotropical plants, which are again concentrated in units 3 and 9. The local flora is even more dominant as in the comparable sample from "Fortuna" (no.8700, Fig.6.e). Sample 14138 (Fig.6.d) was collected in a cyclic alternation of clay and sand overlying the top clay of the Indener Schichten. Whether it belongs to the Hauptkiesserie or to the Indener Schichten is still unclear. The flora is a reflection of rather unstable conditions with a dominance of floodplain forest, followed by wetland forest and herbaceous vegetation. Only bog and heathland vegetation are absent.

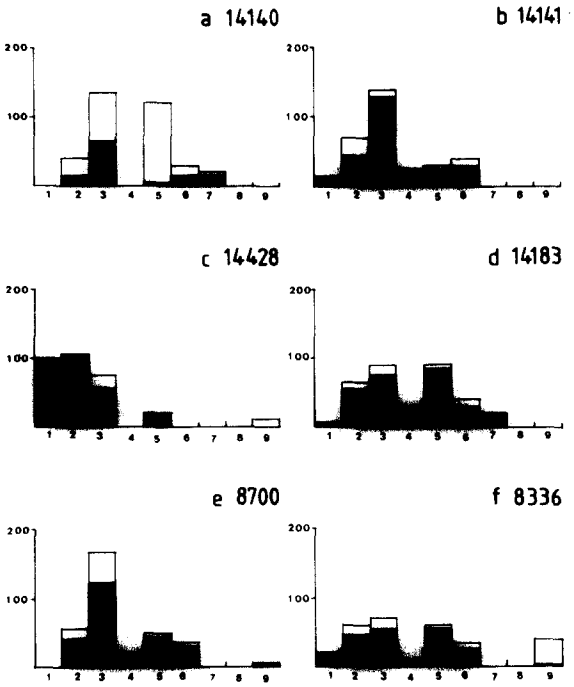


Fig.6. Block diagrams of the vegetational composition of the samples 8336, 8700, 14140, 14141, 14183 and 14428. The numbers correspond with the vegetational units.

On the one hand it is more or less comparable with sample 14141 (Fig.6.b) located in a series of sands, where rivers did not follow stable courses, but eroded and deposited very rapidly. On the other hand, it is also comparable with the marine clay deposit from sample 8336 (Fig.6.f), which also reflects a situation outside stable river deposits. In this flora dominance of palaeotropical taxa is not present.

Conclusions

During the late Miocene the lower Rhenish basin was a flat deltaic landscape, traversed by sluggish shallow rivers with wide swampy bottomlands. Apart from open water and places affected by erosion or comparatively rapid deposition, the vegetation was dominated by forest.

In the open water Nymphaeaceae and submerged vegetations occurred, along the banks there were vegetation types consisting mainly

of monocotyledons, merging into more diverse herbaceous vegetations on drier sites.

In the wet bottomlands wetland forest dominated. It very often formed peat and probably had a very wide distribution in these badly drained surroundings.

On less often flooded places (e.g. levees) floodplain forest occurred, but this type of vegetation was of limited extent.

The upland forest also was of limited distribution and occurred outside the river valleys on only occasionally flooded soil. If these dry soils were poor in nutrients, coniferous forest developed. This also was of limited extent.

Heath was not very well developed, only in coastal areas it might have been of some importance.

Oligotrophic peat bog vegetation was present in places where there was plenty of water and lack of nutrients. In the wet climate of the late Miocene (Mai, 1967; Van der Burgh, 1983), it may have been of considerable extent. The lack of nutrients also favoured the development of the Mastixioideae-flora in those situations where the climate was sufficiently warm for its development, which was only in the valleys and in the coastal area.

Acknowledgements

The author wishes to thank the board of the "Rheinbraun" for permission to collect in their quarries. Furthermore he is very grateful to Ir Nehring, Ir Kothen and their collaborators at the staff division B 41 of "Rheinbraun" for help and support in collecting. Also thanks are due to the staff at the quarries. The author thanks his colleague, Dr. J.R. Boersma, for help and advise in sedimentological questions and his colleagues from the laboratory of Palaeobotany and Palynology at Utrecht for discussion and stimulation. Thanks are also due to Mr H.A. Elsendoorn for his invaluable help in preparing the photographs and Prof Dr. D.K. Ferguson for critical reading of the manuscript.

Appendix[1]

Sample 7807

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alnus sp.	3*			3*						
Caricoidea jugata	13*		13*							
Carya ventricosa	4*			4*						
Cladiocarya europaea	1*		1*							
Cornus bugloviana	3*			3*						
Eomastixia persicoides	7*			7*						
Eurya stigmosa	1*			1*						
Fagus decurrens	1*						1*			
Glyptostrobus europaeus	18*			18*						
Ilex thuringiaca	1*			1*						
Liriodendron geminatum	4*			4		4*				
Magnolia burseracea	57*			57*						
Magnolia lignita	2*			2*						
Magnolia lusatica	3*			3*						
Magnolia sp.	72*			72*						
Mneme menzelii	4*		4*							
Myrica ceriferiformis	52*			52*						
Myrica minima	171*			171*						
Myrica suppanii	7*			7						7*
Pterocarya limburgensis	2*			2*						
Rubus laticostatus	17			17	17	17	17	17	17	
Sambucus pulchella	1			1	1	1				
Sorbus herzogenrathensis	2*			2*						
Spirematospermum wetzleri	2*		2*							
Symplocos lignitarum	1*			1		1*				
Taxodium dubium	3*			3*						
Toddalia rhenana	5*			5*						

[1]Taxa which are considered characteristic for a vegetational unit have been marked with an asterisk. Palaeotropical taxa have been marked with an underline. For further information see p.301: Ecology.

Sample 7807 (*continued*)

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9		
?	30																			
?	10																			
?	4																			
?	3																			
?	1																			
Σ taxa	32		4	13%	22	69%	2		4	13%	2	6%	1		1		1	3%		
Σ characteristic taxa	25		4	16%	17	68%			2	8%	1	4%					1	4%		
Σ fruits and seeds	507		20		436		18		23		18		17		17		7			
Σ char. fruits and seeds	441		20	5%	406	92%			5	1%	1	×					7	2%		
Vegetation figures				34		229				22		10						9		
Σ palaeotropic taxa	13		3	9%	10	31%			1	3%							1	3%		
Σ pal. char. taxa	13		3	12%	8	32%			1	4%							1	4%		
Σ pal. char. vrts and seeds	172		16	4%	148	34%			1	×							7	2%		
Palaeotropic figures				25		97				7								9		
Arctotertiary figures				9		132				15		10								

Sample 7808

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9		
Chionanthus ruehlii	6*				6*															
Cladiocarya europaea	4*		4*																	
Cornus bugloviana	1*				1*															
Eurya stigmosa	680*				680*															
Glyptostrobus europaeus	5*				5*															
Homalanthus costatus	11*				11*															
Ilex jonkeri	1				1						1		1							
Ilex saxonica	2				2						2		2							
Juniperus oxycedrus	2*				2*															
Magnolia burseracea	8*				8*															
Myrica boveyana	11*				11												11*			
Myrica ceriferiformis	16*				16*															
Myrica minima	33*				33*															
Pinaceae	1				1						1		1				1			
Rubus laticostatus	25				25		25		25		25		25		25					
Sequoia langsdorfii	17*				17*															
Sorbus herzogenrathensis	519*				519*															
Symplocos germanica	20*				20*															
Symplocos gothanii	79*				79*															
Symplocos lignitarum	9*				9				9*											
Symplocos salzhausenensis	9*				9*															
Symplocos schereri	1								1		1									
Tetrastigma lobata	1*				1				1*											
Toddalia rhenana	1*				1*															
Vitis parasylvestris	2				2				2											
Vitis teutonica	1*				1				1*											
?	5																			
?	1																			
Σ taxa	28		1	4%	24	86%	1		6	21%	5		4		1		2	7%		
Σ characteristic taxa	20		1	5%	15	75%			3	15%							1	5%		
Σ fruits and seeds	1471		4		1460		25		39		30		29		25		12			
Σ char. fruits and seeds	1433		4	×	1407	98%			11	1%							11	1%		
Vegetation figures				9		259				37								13		
Σ palaeotropic taxa	15		1	4%	13	46%			3	11%	3		2				1	4%		
Σ pal. char. taxa	12		1	5%	8	40%			2	10%							1	5%		
Σ pal. char. frts and seeds	835		4	×	813	57%			10	1%							11	1%		
Palaeotropic figures				9		143				22								10		
Arctotertiary figures						116				15								3		

Sample 7809

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Cladiocarya trebovensis	13*			13*																	
Glyptostrobus europaeus	1*					1*															
Hypericum holyi	87			87		87															
Myrica ceriferiformis	2171*					2171*															
Myrica minima	98*					98*															
Toddalia rhenana	5*					5*															
Typha sp.	190*	190*																			
?	13																				
Σ taxa	8	1	13%	2	25%	5	62%														
Σ characteristic taxa	6	1	17%	1	17%	4	66%														
Σ fruits and seeds	2578	190		100		2362															
Σ char. fruits and seeds	2465	190	8%	13	1%	2275	91%														
Vegetation figures			38		43		219	–		–		–		–		–		–			
Σ palaeotropic taxa	2	–		1	13%	1	13%														
Σ pal. char. taxa	2	–		1	17%	1	17%														
Σ pal. char. frts and seeds	18	–		13	1%	5	×														
Palaeotropic figures			–		31		30	–		–		–		–		–		–			
Arctotertiary figures			38		12		189	–		–		–		–		–		–			

Sample 8297

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Alnus sp.	1*					1*															
Caricoidea jugata	1*			1*																	
Crataegus nodulosa	1							1		1		1									
Crataegus sp.	1							1		1		1									
Decodon globosus	2*			2*																	
Eurya stigmosa	5*					5*															
Fagus decurrens	5*											5*									
Glyptostrobus europaeus	8*					8*															
Homalanthus costatus	1*					1*															
Leucothoe narbonnensis	2					2				2								2			
Liriodendron geminatum	23*					23				23*											
Meliosma wetteraviensis	2*					2*															
Ostrya carpinifolia	3*											3*									
Ostrya scholzii	32*									32*											
Paliurus sibiricus	1*											1*									
Pterocarya limburgensis	5*					5*															
Quercus robur	1									1		1		1							
Rubus laticostatus	1					1		1		1		1		1		1					
Sequoia langsdorfii	44*					44*															
Sorbus aria	1*											1*									
Sparganium haentzschelii	1*			1*																	
Styrax maximus	1*											1*									
Symplocos germanica	1*					1*															
Symplocos lignitarum	10*					10				10*											
Symplocos salzhausenensis	1*					1*															
Symplocos schereri	2									2		2									
Taxodium dubium	17*					17*															
Viscum sp.	5*					5*															
Vitis lusatica	2*					2*				2*											
?	2																				
?	20																				
Σ taxa	31	–		3	10%	16	52%	3		10	32%	10	32%	2		1		1			
Σ characteristic taxa	23	–		3	13%	11	48%	–		4	17%	5	22%	–		–		–			
Σ fruits and seeds	202	–		4		128		3		75		17		2		1		2			
Σ char. fruits and seeds	173	–		4	2%	90	54%	–		67	39%	11	6%	–		–		–			

Sample 8297 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Vegetation figures					25		154				88		60								
Σ palaeotropic taxa	9			1	3%	6	19%			2	6%	2	6%								
Σ pal. char. taxa	8			1	4%	5	22%			1	4%	1	4%								
Σ pal. char. frts and seeds	22			1	1%	10	6%			10	6%	1	1%								
Palaeotropic figures					8		47				16		11								
Arctotertiary figures					17		107				72		49								

Sample 8300

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Acanthopanax solutus	2*											2*									
Actinidia faveolata	1*							1*													
Alnus sp.	1*					1*															
Ceratophyllum submersum	2*	2*																			
Cladiocarya trebovensis	3*			3*																	
Cladium reidiorum	2*			2*																	
Empetrum nigrum	1*					1												1*			
Epacridicarpum mudense	340*					340												340*			
Eurya lusatica	14*					14*															
Eurya stigmosa	26*					26*															
Gaylussacia rhenana	2													2				2			
Homalanthus costatus	1*					1*															
Ilex fortunensis	1*					1						1		1							
Leucothoe narbonnensis	1					1				1								1			
Ostrya scholzii	2*									2*											
Pinaceae	2					2						2		2				2			
Scindapsites crassus	1*			1*																	
Sequoia langsdorfii	38*					38*															
Sparganium haentzschelii	1*			1*																	
Symplocos salzhausenensis	4*					4*															
Tetrastigma lobata	1*					1				1*											
Vitis sp.	1					1				1											
?	1																				
?	1																				
?	1																				
?	1																				
?	1																				
?	1																				
Σ taxa	28	1	4%	4	14%	13	46%	1	4%	4	14%	3	11%	3				6	21%		
Σ characteristic taxa	17	1	6%	4	24%	6	35%	1	6%	2	12%	1	6%					2	12%		
Σ fruits and seeds	453	2		7		432		1		5		5		5				346			
Σ char. fruits and seeds	440	2	×	7	2%	84	19%	1	×	3	1%	2	×					341	77%		
Vegetation figures			10		40		100		10		27		17						110		
Σ palaeotropic taxa	11			3	11%	6	21%			1	4%	2	7%	1				1	4%		
Σ pal. char. taxa	10			3	18%	3	18%			1	6%	1	6%					1	6%		
Σ pal. char. frts and seeds	394			6	1%	44	10%			1	×	2	×					340	77%		
Palaeotropic figures					30		49				10		13						87		
Arctotertiary figures			10		10		51		10		17		4						23		

Sample 8334

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Alisma plantago-aquatica	1*			1*																	
Carex acuta	1*			1*																	
Carex flagellata	2*			2*																	
Decodon globosus	1*			1*																	
Magnolia burseracea	1*					1*															
Potamogeton sp.	2*	2*																			
Scirpus melanospermus	84*			84*																	
Scirpus tabernaemontani	1*			1*																	
Sium latifolium	1*			1*																	
Spirematospermum wetzleri	20*			20*																	
?	1																				
Σ taxa	11	1	9%	8	73%	1	9%	–		–		–		–		–		–			
Σ characteristic taxa	10	1	10%	8	80%	1	10%	–		–		–		–		–		–			
Σ fruits and seeds	115	2		111		1		–		–		–		–		–		–			
Σ char. fruits and seeds	114	2	2%	111	97%	1	1%	–		–		–		–		–		–			
Vegetation figures			21		250		20		–		–		–		–		–		–		
Σ palaeotropic taxa	2	–		1	9%	1	9%	–		–		–		–		–		–			
Σ pal. char. taxa	2	–		1	10%	1	10%	–		–		–		–		–		–			
Σ pal. char. frts and sds	21	–		20	18%	1	1%	–		–		–		–		–		–			
Palaeotropic figures			–		37		20		–		–		–		–		–		–		
Arctotertiary figures			21		213		–		–		–		–		–		–		–		

Sample 8335

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Acer sp.	1							1		1											
Alnus sp.	11*					11*															
Carex acuta	7*			7*																	
Carex flagellata	1*			1*																	
Carex sp. div.	1																				
Caricoidea jugata	4*			4*																	
Cladiocarya trebovensis	3*			3*																	
Cladium reidiorum	1*			1*																	
Crataegus nodulosa	4							4		4		4									
Empetrum nigrum	1*					1													1*		
Epacridicarpum mudense	167*					167													167*		
Eurya stigmosa	22*					22*															
Ilex protogaea	1*					1*															
Liriodendron geminatum	2*					2				2*											
Myrica ceriferiformis	4*					4*															
Myrica minima	1*					1*															
Ostrya carpinifolia	2*											2*									
Ostrya scholzii	34*									34*											
Rubus laticostatus	1					1		1		1		1		1		1					
Sequoia langsdorfii	209*					209*															
Symplocos lignitarum	1*					1				1*											
Symplocos minutula	1*					1*															
Symplocos salzhausenensis	1*					1*															
Vaccinium miocenicum	1													1					1		
Viola canina	1*							1*													
Ziziphus striata	1*					1*															
?	5																				
Σ taxa	27	–		5	19%	14	52%	4	15%	6	22%	4	15%	2		1			3	11%	
Σ characteristic taxa	21	–		5	24%	9	43%	1	5%	3	14%	1	5%	–		–			2	10%	
Σ fruits and seeds	488	–		16		423		7		43		8		2		1			169		
Σ char. fruits and seeds	475	–		16	3%	251	53%	1	×	37	8%	2	×	–		–			168	35%	

Sample 8335 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Vegetation figures					41		148		20		44		20						56		
Σ palaeotropic taxa	8			3	11%	5	19%			1	4%							1	4%		
Σ pal. char. taxa	8			3	14%	3	14%			1	5%							1	5%		
Σ pal. char. frts and seeds	200			8	2%	24	5%			1	×							167	35%		
Palaeotropic figures					27		38				9								44		
Arctotertiary figures					14		110		20		35		20						12		

Sample 8336

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Acanthopanax solutus	2*											2*									
Acer sp. cf *rufinerve*	9*											9*									
Ajuga antiqua	1*									1*											
Alnus sp.	7*					7*															
Carex acuta	1*			1*																	
Carex flagellata	4*			4*																	
Carex hostiana	6*			6*																	
Caricoidea jugata	5*			5*																	
Cladiocarya europaea	4*			4*																	
Crataegus sp.	1							1		1		1									
Dulichium spathaceum	5*			5*																	
Dulichium vespiforme	1*			1*																	
Epacridicarpum mudense	75*					75												75*			
Eurya stigmosa	17*					17*															
Gaylussacia rhenana	1													1				1			
Glyptostrobus europaeus	1*					1*															
Halesia crassa	1*											1*									
Laurocarpum sp.	2																				
Liriodendron geminatum	12*					12				12*											
Mneme menzelii	2*			2*																	
Myrica ceriferiformis	2*					2*															
Nymphaea sp.	1*	1*																			
Nyssa disseminata	1*					1*															
Ostrya scholzii	65*									65*											
Potamogeton sp.	2*	2*																			
Ruppia palaeomaritima	1*	1*																			
Sambucus pulchella	1					1		1		1											
Sequoia langsdorfii	23*					23*															
Sorbus aria	1*											1*									
Symplocos lignitarum	2*					2				2*											
Symplocos schereri	1									1		1									
Taxodium dubium	2*					2*															
Viola canina	1*							1*													
?	20																				
?	4																				
?	3																				
?	1																				
?	1																				
?	1																				
?	1																				
Σ taxa	41	3	7%	8	20%	11	27%	3	7%	7	17%	6	15%	1				2	5%		
Σ characteristic taxa	29	3	10%	8	28%	7	24%	1	3%	4	14%	4	14%					1	3%		
Σ fruits and seeds	292	4		28		143		3		83		15		1				76			
Σ char. fruits and seeds	257	4	2%	28	11%	53	21%	1	×	80	31%	13	5%					75	30%		
Vegetation figures			19		59		72		10		62		34						38		
Σ palaeotropic taxa	8			2	5%	3	7%			2	5%	2	5%					1	3%		
Σ pal. char. taxa	6			2	7%	1	3%			1	3%	1	3%					1	3%		
Σ pal. char. frts and seeds	105			9	4%	17	7%			2	1%	2	1%					75	30%		
Palaeotropic figures					16		17				9		9						36		
Arctotertiary figures			19		43		55		10		53		25						2		

Sample 13285

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Alnus sp.	1*						1*												
Arctostaphyloides menzelii	5*						5											5*	
Asimina brownii	1*										1*								
Carex sp. div.	3																		
Caricoidea jugata	1*			1*															
Cladiocarya trebovensis	2*			2*															
Comptonia costata	1*															1*			
Distylium uralense	11*						11*												
Epacridicarpum mudense	37*						37											37*	
Epipremnites ornatus	3*			3*															
Eurya stigmosa	7*						7*												
Homalanthus costatus	52*						52*												
Leucothoe narbonnensis	6						6				6							6	
Magnolia burseracea	9*						9*												
Magnolia lusatica	2*						2*												
Mastixia thomsonii	25*						25				25*								
Myrica minima	1*						1*												
Palliopora symplocoides	1								1		1		1						
Pinaceae	1						1						1		1			1	
Rubus laticostatus	1						1		1		1		1		1		1		
Scirpus melanospermus	1*			1*															
Sequoia langsdorfii	218*						218*												
Sphenotheca incurva	1								1		1		1						
Stewartia beckeriana	1*												1*						
Symplocos germanica	46*						46*												
Symplocos lignitarum	33*						33				33*								
Symplocos salzhausenensis	1*						1*												
Tetrastigma lobata	2*						2				2*								
?	4																		
Σ taxa	29	–		4	14%	18	62%	3		8	28%	5	17%	2		2	7%	4	14%
Σ characteristic taxa	22	–		4	18%	10	45%	–		4	18%	1	5%	–		1	5%	2	9%
Σ fruits and seeds	477	–		7		458		3		70		5		2		2		49	
Σ char. fruits and seeds	460	–		7	2%	348	76%	–		61	13%	1	×	–		1	×	42	9%
Vegetation figures			–		34		183		–		59		22		–		12		32
Σ palaeotropic taxa	16	–		3	10%	11	38%	2		5	17%	2	7%	–		–		2	7%
Σ pal. char. taxa	14	–		3	14%	6	27%	–		3	14%	–		–		–		2	9%
Σ pal. char. frts and seeds	225	–		6	1%	117	25%	–		60	13%	–		–		–		42	9%
Palaeotropic figures			–		25		91		–		44		7		–		–		25
Arctotertiary figures			–		9		92		–		15		15		–		12		7

Sample 13286

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Alnus sp.	4*						4*												
Chionanthus ruehlii	1*						1*												
Cladiocarya europaea	1*			1*															
Epacridicarpum mudense	8*						8											8*	
Eurya stigmosa	1*						1*												
Fagus decurrens	3*											3*							
Glyptostrobus europaeus	11*						11*												
Homalanthus costatus	3*						3*												
Ilex saxonica	1						1					1		1					
Liriodendron geminatum	1*						1				1*								
Magnolia burseracea	1*						1*												
Myrica sp.	3						3											3	
Nyssa disseminata	1*						1*												
Ostrya scholzii	27*										27*								
Pinus sp.	2						2							2				2	
Potamogeton sp.	1*	1*																	
Pterocarya limburgensis	1*						1*												
Rubus laticostatus	2						2		2		2		2		2				

Sample 13286 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Sequoia langsdorfii	32*					32*															
Symplocos germanica	1*					1*															
Symplocos lignitarum	9*					9				9*											
Symplocos minutula	1*					1*															
Symplocos pseudogregaria	2					2				2*											
Symplocos schereri	1									1		1									
Taxodium dubium	3*					3*															
Tetrastigma lobata	1*					1				1*											
Toddalia rhenana	1*					1*															
Vitis sp.	1					1				1											
?	11																				
?	3																				
?	1																				
Σ taxa	31	1	3%	1	3%	23	74%	1		8	26%	4	13%	3		1		3	10%		
Σ characteristic taxa	22	1	5%	1	5%	13	59%	–		5	23%	1	5%					1	5%		
Σ fruits and seeds	139	1		1		91		2		44		7		5		2		13			
Σ char. fruits and seeds	114	1	1%	1	1%	61	54%	–		40	35%	3	3%					8	7%		
Vegetation figures			9		9		187		–		84		21				–		22		
Σ palaeotropic taxa	14	–		1	3%	12	39%	–		4	13%	2	6%	1				1	3%		
Σ pal. char. taxa	12	–		1	5%	7	32%	–		3	14%							1	5%		
Σ pal. char. frts and seeds	29	–		1	1%	9	8%	–		12	11%	–		–				8	7%		
Palaeotropic figures			–		9		79		–		38		6						15		
Arctotertiary figures			9		–		108				46		15				–		7		

Sample 14399

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Carex hostiana	8*			8*																	
Caricoidea jugata	11*			11*																	
Cladiocarya europaea	2*			2*																	
Cladiocarya trebovensis	1*			1*																	
Chionanthus ruehlii	5*					5*															
Empetrum nigrum	1*					1												1*			
Eurya stigmosa	575*					575*															
Glyptostrobus europaeus	47*					47*															
Homalanthus costatus	4*					4*															
Ilex saxonica	2					2						2		2							
Magnolia burseracea	8*					8*															
Myrica ceriferiformis	51*					51*															
Myrica minima	15*					15*															
Ostrya scholzii	1*									1*											
Rubus laticostatus	12					12		12		12		12		12		12					
Sequoia langsdorfii	208*					208*															
Sorbus herzogenrathensis	7*					7*															
Symplocos germanica	11*					11*															
Symplocos gothanii	38*					38*															
Symplocos lignitarum	2*					2				2*											
Umbelliferopsis molassicus	3*			3*																	
Vitis sp.	1					1				1											
?	100																				
Σ taxa	23			5	22%	16	70%	1		4	17%	2		2		1		1	4%		
Σ characteristic taxa	19	–		5	26%	11	58%	–		2	11%	–						1	5%		
Σ fruits and seeds	1113	–		25		985		12		16		14		14		14		1			
Σ char. fruits and seeds	998	–		25	3%	969	97%	–		3	×	–				–		1	×		

Sample 14399 (*continued*)

Species																			
	Vegetational units																		
	1		2			3			4		5			6		7		8		9
Vegetation figures	–		51			225			–		28			–		–		–		9
Σ palaeotropic taxa	11	–	3	13%	8	35%	–		1	4%	1		1			–		–		
Σ pal. char. taxa	10	–	3	16%	6	32%	–		1	5%	–		–			–		–		
Σ pal. char. frts and seeds	657	–	14	1%	641	64%	–		2	×	–		–			–		–		
Palaeotropic figures	–		30			131			–		9			–		–		–		–
Arctotertiary figures	–		21			94			–		19			–		–		–		9

Sample 14400

Species																			
	Vegetational units																		
	1		2			3			4		5			6		7		8		9
Carex acutiformis	2*		2*																
Carex hostiana	1*		1*																
Caricoidea jugata	4*		4*																
Empetrum nigrum	2*					2												2*	
Eurya stigmosa	581*					581*													
Glyptostrobus europaeus	11*					11*													
Homalanthus costatus	5*					5*													
Magnolia lignita	6*					6*													
Myrica ceriferiformis	4*					4*													
Myrica minima	3*					3*													
Rubus laticostatus	9					9		9			9			9		9		9	
Sequoia langsdorfii	297*					297*													
Symplocos germanica	1*					1*													
Symplocos gothanii	16*					16*													
Symplocos lignitarum	1*					1					1*								
Umbelliferopsis molassicus	1*		1*																
Σ taxa	16	–	4	26%	12	75%	1		2	13%	1		1			1		1	6%
Σ characteristic taxa	15	–	4	27%	9	59%	–		1	7%	–		–			–		1	7%
Σ fruits and seeds	945	–	7		937		9		10		9		9			9		2	
Σ char. fruits and seeds	936	–	7	1%	925	99%	–		1	×	–		–			–		2	×
Vegetation figures	–		54			232			–		20			–		–		–		13
Σ palaeotropic taxa	7	–	1	6%	6	38%	–		1	6%	–		–			–		–	
Σ pal. char. taxa	7	–	1	7%	5	33%	–		1	7%	–		–			–		–	
Σ pal. char. frts and seeds	614	–	4	×	609	65%	–		1	×	–		–			–		–	
Palaeotropic figures	–		13			136			–		13			–		–		–		–
Arctotertiary figures	–		41			96			–		7			–		–		–		13

Sample 14401

Species																			
	Vegetational units																		
	1		2			3			4		5			6		7		8		9
Arctostaphyloides menzelii	30*					30													30*
Brasenia victoriae	2*	2*																	
Carex acutiformis	3*		3*																
Carex hostiana	2*		2*																
Carex sp. div.	1																		
Caricoidea jugata	91*		91*																
Cladiocarya trebovensis	141*		141*																
Cladium reidiorum	42*		42*																
Corema intermedia	25*																25*		
Corylopsis urselensis	1*					1													1*
Cupressoconus rhenanus	108*														108*				
Decodon globosus	2*		2*																
Empetrum nigrum	2*					2													2*
Epacridicarpum mudense	60*					60													60*
Epipremnites ornatus	1*		1*																

Sample 14401 (*continued*)

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Erica palaeoarborea	99*																	99*	
Ericaceae, gen. et sp. indet.1	309*																	309*	
Ericaceae, gen. et sp. indet.2	14*																	14*	
Eriophorum sp.	1*																	1*	
Eurya stigmosa	1*						1*												
Glyptostrobus europaeus	1*						1*												
Homalanthus costatus	2*						2*												
Hypericum sp.	1			1			1												
Ilex protogaea	1*						1*												
Myrica boveyana	1*						1											1*	
Myrica suppanii	1*						1											1*	
Pinaceae	17						17					17		17				17	
Pinus spinosa	1						1							1				1	
Pinus thomasiana	3						3							3				3	
Pinus uranii	14						14							14				14	
Potamogeton sp.	1*	1*																	
Proserpinaca reticulata	1*						1*												
Punica natans	9*											9*							
Rhynchospora tertiaria	34*																	34*	
Ruppia palaeomaritima	14*	14*																	
Sambucus pulchella	1						1		1		1								
Scirpus lacustris	4*			4*															
Scirpus melanospermus	3*			3*															
Scirpus tabernaemontani	5*			5*															
Sequoia langsdorfii	44*						44*												
Stratiotes tuberculatus	1*	1*																	
Symplocos pseudogregaria	1*						1				1*								
Viola canina	3*								3*										
?	40																		
Σ taxa	44	4	9%	11	25%	19	43%	2	5%	2	5%	2	5%	5	11%	1	2%	15	34%
Σ characteristic taxa	36	4	11%	10	28%	6	17%	1	3%	1	3%	1	3%	1	3%	1	3%	11	31%
Σ fruits and seeds	1138	18		295		183		4		2		26		143		25		587	
Σ char. fruits and seeds	1059	18	2%	294	28%	50	5%	3	×	1	×	9	1%	108	10%	25	2%	552	52%
Vegetation figures			22		81		65		8		8		9		24		7		117
Σ palaeotropic taxa	12	–		4	9%	7	16%	–		1	2%	1	2%					4	9%
Σ pal. char. taxa	12	–		4	11%	2	6%			1	3%	1	3%					4	11%
Σ pal. char. frts and seeds	380	–		275	26%	3	×			1	×	9	1%					92	9%
Palaeotropic figures			–		46		22		–		5		6				–		29
Arctotertiary figures			22		35		43		8		3		3		24		7		88

Sample 14402

Species		Vegetational units																	
		1		2		3		4		5		6		7		8		9
Caricoidea jugata	4*		4*															
Chionanthus ruehlii	3*				3*													
Empetrum nigrum	3*				3												3*	
Eomastixia persicoides	3*				3*													
Eurya stigmosa	347*				347*													
Glyptostrobus europaeus	10*				10*													
Homalanthus costatus	6*				6*													
Liriodendron geminatum	1*				1				1*									
Magnolia lignita	15*				15*													
Magnolia sp.	2*				2*													
Mastixia thomsonii	1*				1				1*									
Myrica ceriferiformis	10*				10*													
Myrica minima	54*				54*													
Punica natans	10*										10*							
Rubus laticostatus	6				6		6		6		6		6		6			
Sequoia langsdorfii	26*				26*													
Sorbus herzogenrathensis	7*				7*													
Symplocos germanica	11*				11*													

Sample 14402 (*continued*)

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9	
Symplocos gothanii	13*					13*													
Symplocos lignitarum	7*					7				7*									
Symplocos salzhausenensis	18*					18*													
Umbelliferopsis molassicus	1*			1*															
Viscum sp.	1*					1*													
Vitis sp.	1					1				1									
Ziziphus striata	1*					1*													
?	3																		
Σ taxa	26	–		2	8%	22	85%	1		5	19%	2	8%	1		1		1	4%
Σ characteristic taxa	23	–		2	9%	16	70%	–		3	13%	1	4%	–		–		1	4%
Σ fruits and seeds	564	–		5		545		6		16		16		6		6		3	
Σ char. fruits and seeds	554	–		5	1%	527	94%	–		9	2%	10	2%	–		–		3	1%
Vegetation figures			–		18		249		–		34		14		–		–		9
Σ palaeotropic taxa	13	–		1	4%	11	42%	–		2	8%	1	4%	–		–		–	
Σ pal. char. taxa	13	–		1	4%	9	39%	–		2	9%	1	4%	–		–		–	
Σ pal. char. frts and seeds	436	–		4	1%	418	74%	–		8	1%	10	2%	–		–		–	
Palaeotropic figures			–		9		155		–		18		10		–		–		–
Arctotertiary figures			–		9		94		–		16		4		–		–		9

Sample 14403

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9	
Corylopsis urselensis	2*					2												2*	
Distylium uralense	2*					2*													
Epacridicarpum mudense	20*					20												20*	
Eurya stigmosa	1*					1*													
Myrica boveyana	26*					26												26*	
Myrica ceriferiformis	2*					2*													
Myrica suppanii	58*					58												58*	
Sequoia langsdorfii	1*					1*													
?	1																		
?	2																		
Σ taxa	10	–		–		8	80%	–		–		–		–		–		4	40%
Σ characteristic taxa	8	–		–		4	50%	–		–		–		–		–		4	50%
Σ fruits and seeds	115	–		–		112		–		–		–		–		–		106	
Σ char. fruits and seeds	112	–		–		6	5%	–		–		–		–		–		106	95%
Vegetation figures			–		–		135		–		–		–		–		–		185
Σ palaeotropic taxa	4	–		–		4	40%	–		–		–		–		–		3	30%
Σ pal. char. taxa	4	–		–		1	13%	–		–		–		–		–		3	38%
Σ pal. char. frts and seeds	105	–		–		1	1%	–		–		–		–		–		104	93%
Palaeotropic figures			–		–		54		–		–		–		–		–		161
Arctotertiary figures			–		–		81		–		–		–		–		–		24

Sample 8295

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9	
Acanthopanax solutus	1*											1*							
Actinidia faveolata	1*							1*											
Alnus sp.	6*					6*													
Ampelopsis malvaeformis	1*									1*									
Arctostaphyloides menzelii	4*					4												4*	
Brasenia victoriae	20*	20*																	
Caldesia cylindrica	3*			3*															

Sample 8295 (*continued*)

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Carex acutiformis	11*		11*							
Carex flagellata	2*		2*							
Carex hostiana	7*		7*							
Carex sp. div.	3									
Carpinus betulus	5*					5*				
Caricoidea jugata	16*		16*							
Carya ventricosa	1*			1*						
Carya sp. vel *Juglans* sp.	1									
Ceratophyllum demersum	3* 3*									
Chenopodium album	7*		7*							
Cladiocarya trebovensis	3*		3*							
Cladium reidiorum	2*		2*							
Corylus avellana	1*				1*					
Cyclocarya nucifera	2*						2*			
Distylium uralense	5*			5*						
Dulichium spathaceum	1*		1*							
Eomastixia persicoides	32*			32*						
Epacridicarpum mudense	2*			2						2*
Eurya stigmosa	147*			147*						
Fagus decurrens	17*						17*			
Glyptostrobus europaeus	11*			11*						
Halesia crassa	156*						156*			
Homalanthus costatus	26*			26*						
Hypericum holyi	2		2	2						
Ilex saxonica	1			1			1	1		
Liquidambar magniloculata	4					4	4			
Liriodendron geminatum	22*			22		22*				
Magnolia burseracea	40			40*						
Magnolia lignita	10*			10*						
Magnolia lusatica	11*			11*						
Mastixia thomsonii	127*			127		127*				
Menyanthes carpathica	3*		3*							
Myrica minima	7500*			7500*						
Myrica suppanii	2*			2						2*
Nyssa disseminata	3*			3*						
Nyssa ornithobroma	5*			5*						
Ostrya scholzii	27*					27*				
Oxydendrum europaeum	1						1	1		
Palliopora symplocoides	17				17	17	17			
Picea omorikoides	1*							1*		
Pinaceae	9			9			9	9		9
Proserpinaca reticulata	8*			8*						
Pseudoeuryale limburgensis	1* 1*									
Pterocarya limburgensis	5*			5*						
Punica natans	1790*						1790*			
Rehderodendron ehrenbergii	7				7	7	7			
Rubus laticostatus	20			20	20	20	20	20	20	
Sapium germanicum	33*			33*						
Scindapsites crassus	5*		5*							
Scirpus lacustris	2*		2*							
Scirpus melanospermus	1*		1*							
Sequoia langsdorfii	3579*			3579*						
Sinomenium militzeri	3				3	3				
Sorbus aria	1*						1*			
Sparganium minimum	2*		2*							
Sparganium haentzschelii	10*		10*							
Sphenotheca incurva	17				17	17	17			
Staphylea bessarabica	3				3	3	3			
Stellaria media	1*		1*							
Stratiotes tuberculatus	12* 12*									
Styrax maximus	5*						5*			
Symplocos germanica	2*			2*						
Symplocos gothanii	55*			55*						
Symplocos lignitarum	4159*			4159		4159*				
Symplocos minutula	20*			20*						
Symplocos pseudogregaria	2*			2		2*				
Symplocos salzhausenensis	106*			106*						
Symplocos schereri	26					26	26			
Taxodium dubium	97*			97*						

Sample 8295 (*continued*)

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Tectocarya rhenana	1						1				1								
Tetrastigma lobata	65*						65				65*								
Toddalia naviculaeformis	24*						24*												
Toddalia rhenana	14*						14*												
Trapa heerii	1*	1*																	
Vitis lusatica	11*						11				11*								
Vitis parasylvestris	8						8				8								
Vitis teutonica	29*						29				29*								
Zanthoxylum ailanthiforme	13*										13*								
?	120																		
?	6																		
Σ taxa	87	5	6%	17	20%	40	46%	8	9%	20	23%	17	20%	5	6%	1	4	5%	
Σ characteristic taxa	70	5	7%	16	23%	24	34%	2	3%	12	17%	7	10%	1	1%	–	3	4%	
Σ fruits and seeds	18533	37		78		16193		69		4567		2077		32		20	17		
Σ char. fruits and seeds	18306	37	x	76	x	11731	64%	2	x	4483	24%	1972	11%	1	x	–	8	x	
Vegetation figures			13		43		144		12		64		41		7		–		9
Σ palaeotropic taxa	38	–		5	6%	21	24%	4	5%	12	14%	10	11%	1	1%	–		3	3%
Σ pal. char. taxa	29	–		5	7%	12	17%	–		6	9%	3	4%	–		–		3	4%
Σ pal. char. frts and seeds	6732	–		29	x	494	3%	–		4367	24%	1796	10%	–		–		8	x
Palaeotropic figures			–		13		44		5		47		25		1		–		7
Arctotertiary figures			13		30		100		7		17		16		6		–		2

Sample 8699

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	4*				4*					
Alnus sp.	1*			1*						
Asimina brownii	2*					2*				
Crataegus acuticarpa	9				9	9	9			
Eomastixia persicoides	1*			1*						
Eucommia europaea	1*						1*			
Eurya stigmosa	17*			17*						
Fagus decurrens	465*						465*			
Halesia crassa	5*						5*			
Homalanthus costatus	1*			1*						
Liquidambar magniloculata	23					23	23			
Mastixia thomsonii	5*			5		5*				
Myrica ceriferiformis	30*			30*						
Myrica minima	369*			369*						
Nyssa disseminata	1*			1*						
Nyssa ornithobroma	5*			5*						
Ostrya scholzii	418*					418*				
Palliopora symplocoides	2*				2	2	2			
Picea omorikoides	1*							1*		
Pinaceae	2			2			2	2		2
Polyspora lignitica	1*					1*				
Potamogeton sp.	1*	1*								
Pterocarya limburgensis	23*			23*						
Punica natans	128*						128*			
Rubus laticostatus	4			4	4	4	4	4	4	
Sapium germanicum	16*			16*						
Sequoia langsdorfii	261*			261*						
Sparganium haentzschelii	1*		1*							
Stewartia beckeriana	2*						2*			
Symplocos germanica	1*			1*						
Symplocos gothanii	15*			15*						
Symplocos lignitarum	40*			40		40*				
Symplocos salzhausenensis	2*			2*						
Symplocos schereri	2					2	2			
Taxodium dubium	211*			211*						
Tectocarya rhenana	1			1		1				

Sample 8699 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9
Vitis lusatica	8*					8				8*									
Vitis teutonica	4*					4				4*									
?	30																		
?	17																		
?	2																		
Σ taxa	41	1	2%	1	2%	21	51%	4	10%	13	32%	11	27%	3	7%	1		1	
Σ characteristic taxa	31	1	3%	1	3%	13	42%	1	3%	7	23%	5	16%	1	3%				
Σ fruits and seeds	2132	1		1		978		19		519		643		7		4		2	
Σ char. fruits and seeds	2040	1		1		944	47%	4		478	23%	601	29%	1					
Vegetation figures			5		5		140		13		78		72		10				
Σ palaeotropic taxa	13					10	24%	1	2%	6	15%	2	5%						
Σ pal. char. taxa	10					7	23%			3	10%								
Σ pal. char. frts and seeds	99					53	3%			46	2%								
Palaeotropic figures							50		2		27		5						
Arctotertiary figures			5		5		90		11		51		67		10				

Sample 8700

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Acer sp.	1				1	1	1			
Alnus sp.	8*			8*						
Carex acuta	25*		25*							
Carex flagellata	30*		30*							
Carex hostiana	21*		21*							
Carex sp. div.	5									
Caricoidea jugata	11*		11*							
Cornus sp.	6				6		6			
Crataegus angusticarpa	20				20	20	20			
Crataegus jonkeri	24				24	24	24			
Crataegus sp.1	2				2	2	2			
Crataegus sp.2	4				4	4	4			
Dulichium spathaceum	29*		29*							
Empetrum nigrum	7*			7						7*
Epipremnites ornatus	1*		1*							
Eurya stigmosa	2*			2*						
Fagus decurrens	63*						63*			
Glyptostrobus europaeus	3*			3*						
Homalanthus costatus	1*			1*						
Liquidambar magniloculata	2					2	2			
Lycopus europaeus	3*		3*							
Meliosma wetteraviensis	1*			1*						
Myrica minima	129*			129*						
Nyssa ornithobroma	21*			21*						
Ostrya scholzii	247*					247*				
Pterocarya limburgensis	52*			52*						
Punica natans	1*						1*			
Rubus laticostatus	106			106	106	106	106	106	106	
Sapium germanicum	7*			7*						
Sequoia langsdorfii	13*			13*						
Sparganium haentzschelii	33*		33*							
Symplocos germanica	1*			1*						
Symplocos gothanii	50*			50*						
Symplocos lignitarum	24*			24		24*				
Symplocos salzhausenensis	12*			12*						
Taxodium dubium	918*			918*						
Viola canina	1*				1*					
Viscum sp.	1*			1*						
Vitis lusatica	2*			2		2*				
?	36									
?	25									
?	2									

Sample 8700 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9
Σ taxa	42	–		8	19%	19	45%	8	19%	10	24%	10	24%	1		1		1	2%
Σ characteristic taxa	30	–		8	27%	15	50%	1	3%	3	10%	2	7%	–		–		1	3%
Σ fruits and seeds	1950	–		153		1358		164		432		229		106		106		7	
Σ char. fruits and seeds	1716	–		153	9%	1218	71%	1	x	273	16%	64	4%	–		–		7	x
Vegetation figures			–		55		166		22		50		35		–		–		5
Σ palaeotropic taxa	11	–		2	5%	8	19%	–		1	2%	1	2%	–		–		–	
Σ pal. char. taxa	11	–		2	7%	7	23%	–		1	3%	1	3%	–		–		–	
Σ pal. char. frts and seeds	111	–		12	1%	73	4%	–		24	1%	1	x	–		–		–	
Palaeotropic figures			–		13		46		–		6		5		–		–		–
Arctotertiary figures			–		42		120		22		44		30		–		–		5

Sample 13349

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Alnus sp.	49*					49*													
Caldesia cylindrica	13*			13*															
Ceratophyllum submersum	70*	70*																	
Decodon globosus	1*			1*															
Fagus decurrens	1*											1*							
Glyptostrobus europaeus	17*					17*													
Homalanthus costatus	1*					1*													
Liriodendron geminatum	12*					12*				12*									
Magnolia burseracea	3*					3*													
Magnolia lusatica	7*					7*													
Nyssa disseminata	2*					2*													
Nyssa ornithobroma	2*					2*													
Potamogeton sp.	4*	4*																	
Pterocarya limburgensis	35*					35*													
Rubus laticostatus	1					1		1		1		1		1		1			
Taxodium dubium	688*					688*													
Trapa heerii	5*	5*																	
Viscum sp.	147*					147*													
?	34																		
?	3																		
?	1																		
?	1																		
Σ taxa	22	3	14%	2	9%	12	55%	1		2	9%	2	9%	1		1		–	
Σ characteristic taxa	17	3	18%	2	12%	10	59%	–		1	6%	1	6%	–		–		–	
Σ fruits and seeds	1097	79		14		964		1		13		2		1		1		–	
Σ char. fruits and seeds	1057	79	8%	14	1%	951	90%	–		12	1%	1		–		–		–	
Vegetation figures			40		22		204		–		16		15		–		–		–
Σ palaeotropic taxa	4	–		1	5%	3	14%	–		–		–		–		–		–	
Σ pal. char. taxa	4	–		1	6%	3	18%	–		–		–		–		–		–	
Σ pal. char. frts and seeds	24	–		13	1%	11	1%	–		–		–		–		–		–	
Palaeotropic figures			–		12		43		–		–		–		–		–		–
Arctotertiary figures			40		10		161		–		16		15		–		–		–

Sample 14139

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Acanthopanax solutus	1*						1*			
Asimina brownii	2*					2*				
Eomastixia persicoides	2*			2*						
Eurya stigmosa	15*			15*						

Sample 14139 (*continued*)

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Glyptostrobus europaeus	6*			6*						
Homalanthus costatus	28*			28*						
Liquidambar magniloculata	1					1	1			
Magnolia burseracea	1*			1*						
Magnolia lusatica	8*			8*						
Myrica minima	3*			3*						
Myrica suppanii	1*			1						1*
Nyssa disseminata	3*			3*						
Phellodendron lusaticum	2*						2*			
Picea omorikoides	1*							1*		
Pinaceae	17			17			17	17		17
Pinus leitzii	12			12				12		12
Rubus laticostatus	2			2	2	2	2	2	2	
Sequoia langsdorfii	169*			169*						
Sparganium haentzschelii	1*	1*								
Sphenotheca incurva	3				3	3	3			
Symplocos gothanii	27*			27*						
Symplocos lignitarum	4*			4		4*				
Symplocos schereri	6					6	6			
Tetrastigma lobata	12*			12		12*				
?	1									
Σ taxa	25	1	4%	16	64% 2	7	28%	7	28% 4	16% 1	3	12%
Σ characteristic taxa	18	1	6%	10	56%	3	17%	2	11% 1	6%	1	6%
Σ fruits and seeds	325	1		310	5	30		32	32	2	30	
Σ char. fruits and seeds	283	1		262	93%	18	6%	3	1% 1		1	
Vegetation figures			10	213			51		40	22		18
Σ palaeotropic taxa	12			9	36% 1	4	16%	3	12%		1	4%
Σ pal. char. taxa	10			6	33%	2	11%	1	6%		1	6%
Σ pal. char. frts and seeds	99			81	29%	16	6%	1			1	
Palaeotropic figures				98			33		18			10
Arctotertiary figures			10	115			18		22	22		8

Sample 14140

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Carex acutiformis	9*	9*								
Carex hostiana	4*	4*								
Caricoidea jugata	24*	24*								
Eomastixia persicoides	8*			8*						
Eurya stigmosa	17*			17*						
Glyptostrobus europaeus	185*			185*						
Halesia crassa	1*						1*			
Homalanthus costatus	11*			11*						
Ilex saxonica	3			3			3	3		
Liquidambar magniloculata	1					1	1			
Magnolia burseracea	3*			3*						
Magnolia lusatica	4*			4*						
Mastixia thomsonii	4*			4		4*				
Nyssa disseminata	3*			3*						
Palliopora symplocoides	31				31	31	31			
Picea sp.	1*							1*		
Pinaceae	2			2			2	2		2
Pinus spinosa	1			1				1		1
Rubus laticostatus	5			5	5	5	5	5	5	
Scindapsites crassus	1*	1*								
Sequoia langsdorfii	283*			283*						
Sphenotheca incurva	5				5	5	5			
Symplocos germanica	44*			44*						
Symplocos lignitarum	954*			954		954*				
Symplocos pseudogregaria	162*			162		162*				
Symplocos schereri	8					8	8			

Sample 14140 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Tectocarya rhenana	5						5				5										
Tetrastigma lobata	46						46				46*										
?	1																				
?	1																				
?	1																				
?	1																				
?	1																				
?	1																				
Σ taxa	34	–		4	12%	18	53%	3		10	29%	8	24%	5	15%	1		2			
Σ characteristic taxa	19	–		4	21%	9	47%	–		4	21%	1	5%	1	5%	–		–			
Σ fruits and seeds	1832	–		38		1740		41		1221		56		12		5		3			
Σ char. fruits and seeds	1718	–		38	2%	599	35%	–		1166	68%	1	x	1	x	–		–			
Vegetation figures			–		35		135		–		118		29		20		–		–		
Σ palaeotropic taxa	17	–		2	6%	12	35%	2		8	24%	4	12%	1	3%	–		–			
Σ pal. char. taxa	12	–		2	11%	6	32%	–		4	21%	–		–		–		–			
Σ pal. char. frts and seeds	1278	–		25	1%	87	5%	–		1166	68%	–		–		–		–			
Palaeotropic figures			–		18		72		–		113		12		3		–		–		
Arctotertiary figures			–		17		63		–		5		17		17		–		–		

Sample 14141

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Acer sp. cf *rufinerve*	9*											9*									
Actinidia faveolata	15*							15*													
Alnus sp.	48*						48*														
Caldesia cylindrica	1*				1*																
Carex acuta	6*				6*																
Carex acutiformis	6*				6*																
Carex flagellata	3*				3*																
Carex hostiana	5*				5*																
Caricoidea jugata	17*				17*																
Ceratophyllum submersum	1*	1*																			
Cornus bugloviana	3*						3*														
Crataegus angusticarpa	1							1		1		1									
Crataegus jonkeri	1							1		1		1									
Decodon globosus	13*				13*																
Distylium uralense	7*						7*														
Eucommia europaea	1*											1*									
Eurya stigmosa	11*						11*														
Fagus decurrens	60*											60*									
Glyptostrobus europaeus	11*						11*														
Homalanthus costatus	1*						1*														
Liquidambar magniloculata	1									1		1									
Mneme menzelii	44*				44*																
Myrica minima	35*						35*														
Myrica sp.	2						2													2	
Nyssa ornithobroma	16*						16*														
Ostrya scholzii	52*									52*											
Paliurus sibiricus	9*											9*									
Potamogeton sp.	1*	1*																			
Pseudoeuryale limburgensis	2*	2*																			
Pterocarya limburgensis	81*						81*														
Punica natans	37*											37*									
Rubus laticostatus	80						80		80		80	80		80		80					
Sambucus pulchella	1						1		1		1										
Scirpus tabernaemontani	1*				1*																
Sequoia langsdorfii	1*						1*														
Sinomenium militzeri	1								1		1										
Sparganium haentzschelii	24*				24*																
Spirematospermum wetzleri	2*				2*																
Styrax maximus	1*											1*									

Sample 14141 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Symplocos lignitarum	11*					11				11*											
Taxodium dubium	1407*					1407*															
Teucrium sp.	1																				
Urospathites cristatus	37*			37*																	
Vaccinium miocenicum	350														350				350		
Viola canina	3*							3*													
Vitis lusatica	2*					2				2*											
?	80																				
Σ taxa	48	3	6%	13	27%	16	33%	8	17%	9	19%	10	21%		2		1		2		
Σ characteristic taxa	38	3	8%	13	26%	11	26%	2	5%	3	8%	5	13%								
Σ fruits and seeds	2505	4		163		1717		102		150		200			430		80		352		
Σ char. fruits and seeds	1988	4	x	163	8%	1621	82%	18	1%	64	3%	117	6%								
Vegetation figures			14		69		141		23		30		40								
Σ palaeotropic taxa	9			4	8%	3	6%			1	2%	2	4%								
Σ pal. char. taxa	9			4	11%	2	5%			1	3%	2	5%								
Σ pal. char. frts and seeds	118			57	3%	12	1%			11	1%	38	2%								
Palaeotropic figures					22		12				6		11								
Arctotertiary figures			14		47		129		23		24		29								

Sample 14142

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Carya vel *Juglans*	1																				
Crataegus angusticarpa	1							1		1		1									
Eurya stigmosa	1*					1*															
Fagus decurrens	3*											3*									
Halesia crassa	4*											4*									
Homalanthus costatus	5*					5*															
Laurocarpum sp.3	1																				
Liquidambar magniloculata	2									2		2									
Magnolia sp.	1*					1*															
Myrica minima	2*					2*															
Myrica suppanii	1*					1												1*			
Nyssa disseminata	1*					1*															
Ostrya scholzii	1*									1*											
Pterocarya limburgensis	6*					6*															
Sequoia langsdorfii	2*					2*															
Sparganium haentzschelii	3*			3*																	
Staphylea bessarabica	5							5		5		5									
Symplocos gothanii	5*					5*															
Symplocos lignitarum	5*					5				5*											
Taxodium dubium	6*					6*															
Toddalia rhenana	4*					4*															
Trigonobalanus exacantha	2*											2*									
Vitis lusatica	6*					6				6*											
Vitis teutonica	6*					6				6*											
Ziziphus striata	1*					1*															
?	1																				
Σ taxa	26			1	4%	15	58%	2		7	27%	6	23%						1	4%	
Σ characteristic taxa	19			1	5%	11	58%			4	21%	3	16%						1	5%	
Σ fruits and seeds	76			3		52		6		24		17							1		
Σ char. fruits and seeds	64			3	5%	34	53%			18	28%	9	14%						1	2%	
Vegetation figures					14		169				76		53							11	
Σ palaeotropic taxa	9					7	27%			1	4%	1	4%						1	4%	
Σ pal. char. taxa	7					5	26%			1	5%	1	5%						1	5%	
Σ pal. char. frts and seeds	23					16	25%			5	8%	2	3%						1	2%	
Palaeotropic figures							78				17		12							11	
Arctotertiary figures					14		91				59		41								

Sample 14143

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Carex acuta	1*		1*							
Carex hostiana	1*		1*							
Carex sp. div.	2									
Caricoidea jugata	10*		10*							
Cladiocarya europaea	2*		2*							
Eomastixia persicoides	1*			1*						
Eurya stigmosa	5*			5*						
Glyptostrobus europaeus	31*			31*						
Homalanthus costatus	6*			6*						
Magnolia burseracea	1*			1*						
Magnolia lusatica	3*			3*						
Mastixia thomsonii	11*			11		11*				
Palliopora symplocoides	5				5	5	5			
Pinaceae	4			4			4	4		4
Pinus leitzii	6			6				6		6
Pinus thomasiana	3			3				3		3
Sequoia langsdorfii	104*			104*						
Sphenotheca incurva	4				4	4	4			
Symplocos germanica	4*			4*						
Symplocos lignitarum	111*			111		111*				
Symplocos pseudogregaria	20*			20		20*				
Symplocos salzhausenensis	1*			1*						
Symplocos schereri	3					3	3			
Tectocarya rhenana	2			2		2				
Tetrastigma lobata	3*			3		3*				
?	3									
Σ taxa	26 –		4 15%	17 65%	2	8 31%	4	3	–	3
Σ characteristic taxa	17 –		4 24%	9 53%	–	4 24%	–	–	–	–
Σ fruits and seeds	345 –		12	296	9	159	16	13	–	13
Σ char. fruits and seeds	315 –		12 4%	156 50%	–	145 46%	–	–	–	–
Vegetation figures		–	43	168	–	101	–	–	–	–
Σ palaeotropic taxa	17 –		2 8%	11 42%	–	8 31%	–	–	–	–
Σ pal. char. taxa	15 –		2 12%	7 41%	–	4 24%	–	–	–	–
Σ pal. char. frts and seeds	178 –		12 4%	18 6%	–	145 46%	–	–	–	–
Palaeotropic figures		–	24	89	–	101	–	–	–	–
Arctotertiary figures		–	19	79	–	–	–	–	–	–

Sample 14145

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Asimina brownii	4*					4*				
Carex acutiformis	1*		1*							
Caricoidea jugata	4*		4*							
Carya sp. vel *Juglans* sp.	1									
Eomastixia persicoides	3*			3*						
Eurya stigmosa	16*			16*						
Fagus decurrens	1						1*			
Glyptostrobus europaeus	1*			1*						
Homalanthus costatus	47*			47*						
Ilex aquifolium	1*						1*			
Magnolia burseracea	14*			14*						
Magnolia lusatica	13*			13*						
Mastixia thomsonii	16*			16		16*				
Myrica minima	41*			41*						
Myrica suppanii	2*			2						2*
Phellodendron lusaticum	3*						3*			
Pinaceae	12			12			12	12		12
Pinus leitzii	18			18				18		18
Pinus sp.	7			7				7		7
Sequoia langsdorfii	74*			74*						
Sphenotheca incurva	3				3	3	3			

Sample 14145 (*continued*)

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9	
Staphylea bessarabica	1						1			1		1							
Symplocos germanica	4*				4*														
Symplocos lignitarum	11*				11					11*									
Symplocos pseudogregaria	22*				22					22*									
Symplocos salzhausenensis	1*				1*														
Symplocos schereri	3									3		3							
Tetrastigma lobata	18*				18					18*									
?	7																		
Σ taxa	29	–	2	7%	18	62%	2		8	28%	7	24%	3				4	14%	
Σ characteristic taxa	21		2	10%	10	48%			5	24%	3	14%					1	5%	
Σ fruits and seeds	348		5		304		4		78		24		37				39		
Σ char. fruits and seeds	296		5	2%	214	72%	–		71	24%	5	2%					2	1%	
Vegetation figures				19		182				76		40						20	
Σ palaeotropic taxa	15	–	1	3%	12	41%	1		6	21%	2	7%					1	3%	
Σ pal. char. taxa	13	–	1	5%	7	33%	–		4	19%	–						1	5%	
Σ pal. char. frts and seeds	171	–	4	1%	98	33%	–		67	23%						–	2	1%	
Palaeotropic figures				9		107				63		7						9	
Arctotertiary figures				10		75				13		33						11	

Sample 14146

Species		Vegetational units																		
		1		2		3		4		5		6		7		8		9	
Acanthopanax solutus	1*										1*								
Carex sp. div.	1																		
Caricoidea jugata	9*		9*																
Empetrum nigrum	1*				1												1*		
Eomastixia persicoides	2*				2*														
Eurya stigmosa	23*				23*														
Glyptostrobus europaeus	82*				82*														
Homalanthus costatus	5*				5*														
Ilex protogaea	1*				1*														
Magnolia burseracea	1*				1*														
Myrica minima	2*				2*														
Nyssa disseminata	1*				1*														
Palliopora symplocoides	1						1			1		1							
Pinaceae	1				1							1		1			1		
Rubus laticostatus	11				11		11			11		11		11		11			
Sequoia langsdorfii	181*				181*														
Symplocos germanica	9*				9*														
Symplocos lignitarum	269*				269					269*									
Symplocos pseudogregaria	73*				73					73*									
Symplocos salzhausenensis	4*				4*														
Symplocos schereri	3									3		3							
Tetrastigma lobata	29*				29					29*									
?	7																		
Σ taxa	23	–	1	4%	17	74%	2		6	26%	4	22%	2		1		2	7%	
Σ characteristic taxa	17		1	6%	11	65%			3	18%	1	6%			–		1	6%	
Σ fruits and seeds	717		9		695		12		386		17		12		11		2		
Σ char. fruits and seeds	693	–	9	1%	311	45%	–		371	54%	1	x			–		1	x	
Vegetation figures				11		184				98		28						13	
Σ palaeotropic taxa	13	–	1	4%	9	39%	1		5	22%	3	13%			–				
Σ pal. char. taxa	11	–	1	6%	6	35%	–		3	18%	1	6%			–		–		
Σ pal. char. frts and seeds	425	–	9	1%	44	6%	–		371	54%	1	x			–		–		
Palaeotropic figures		–		11		80		–		94		19				–		–	
Arctotertiary figures		–				104		–		4		9				–		13	

Sample 14183

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Acer campestre	1							1		1									
Actinidia faveolata	2*							2*											
Ajuga antiqua	2*									2*									
Alisma plantago-aquatica	1*			1*															
Alnus sp.	5*					5*													
Betula sp.	7					7		7		7		7		7					
Caldesia cylindrica	1*			1*															
Carex acuta	1*			1*															
Carex acutiformis	1*			1*															
Carex hostiana	1*			1*															
Carex sp. div.	4																		
Decodon globosus	5*			5*															
Eucommia europaea	2*											2*							
Eurya stigmosa	6*					6*													
Fagus decurrens	17*											17*							
Laurocarpum sp.2	1																		
Liriodendron geminatum	46*					46				46*									
Magnolia burseracea	2*					2*													
Ostrya scholzii	34*									34*									
Pinaceae	3					3						3		3				3	
Pinus sp.	4					4								4				4	
Polyspora lignitica	1*									1*									
Potamogeton sp.	1*	1*																	
Pterocarya limburgensis	6*					6*													
Rubus laticostatus	8					8		8		8		8		8		8			
Sambucus pulchella	9					9		9		9									
Sequoia langsdorfii	6*					6*													
Sinomenium militzeri	1							1		1									
Solanum nigrum	3*			3*															
Sparganium haentzschelii	1*			1*															
Staphylea sp.	1							1		1		1							
Styrax maximus	1*											1*							
Taxodium dubium	42*					42*													
Umbelliferopsis molassicus	1*			1*															
Viola canina	7*							7*											
Viola rupestris	5*													5*					
Vitis lusatica	3*					3				3*									
?	60																		
Σ taxa	38	1	3%	9	24%	13	34%	8	21%	11	29%	7	18%	5	13%	1		2	
Σ characteristic taxa	27	1	4%	9	33%	6	22%	2	7%	5	19%	3	11%	1	4%	–		–	
Σ fruits and seeds	302	1		15		147		36		113		43		27		8		7	
Σ char. fruits and seeds	203	1	x	15	7%	67	33%	9	4%	86	42%	20	10%	5	2%	–		–	
Vegetation figures			7		64		89		32		90		19		19		–		–
Σ palaeotropic taxa	6	–		1	3%	2	5%	–		1	3%	1	3%	–		–		–	
Σ pal. char. taxa	5	–		1	4%	2	7%	–		1	4%	1	4%	–		–			
Σ pal. char. frts and seeds	11	–		1	x	8	4%	–		1	x	1	x	–		–		–	
Palaeotropic figures			–		7		16		–		7		7		–		–		–
Arctotertiary figures			7		57		73		32		83		32		19		–		–

Sample 14428

Species			Vegetational units																
			1		2		3		4		5		6		7		8		9
Alisma plantago-aquatica	1*			1*															
Alnus sp.	5*					5*													
Carpinus betulus	1*									1*									
Ceratophyllum submersum	2*	2*																	
Decodon globosus	66*			66*															
Dulichium spathaceum	1*			1*															
Magnolia burseracea	2*					2*													
Myrica suppanii	1*					1												1*	
Nymphaea alba	3*	3*																	

Sample 14428 (*continued*)

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Potamogeton extremitatus	14*	14*																			
Pseudoeuryale limburgensis	5*	5*																			
Pterocarya limburgensis	2*					2*															
Rubus laticostatus	5					5		5		5		5		5		5					
Scirpus melanospermus	1*			1*																	
Scirpus tabernaemontani	1*			1*																	
Taxodium dubium	12*					12*															
Trapa heerii	20*	20*																			
Typha sp.	3*	3*																			
Vitis sp.	1					1				1											
?	3																				
Σ taxa	20	6	30%	5	25%	7	35%	1		3	15%	1		1		1		1		5	
Σ characteristic taxa	17	6	35%	5	29%	4	24%			1	6%							1		6	
Σ fruits and seeds	149	47		70		28		5		7		5		5		5		1			
Σ char. fruits and seeds	140	47	34%	70	50%	21	15%			1	1%							1		1	
Vegetation figures			99		104		74				22									12	
Σ palaeotropic taxa	2					2	10%											1		5	
Σ pal. char. taxa	2					1	6%											1		6	
Σ pal. char. frts and seeds	3					2	1%											1		1	
Palaeotropic figures					17															12	
Arctotertiary figures			99		104		57				22										

Sample 14429

Species			Vegetational units																		
			1		2		3		4		5		6		7		8		9		
Alnus sp.	96*					96*															
Aracispermum canaliculatum	17*			17*																	
Carex acutiformis	5*			5*																	
Carex hostiana	1*			1*																	
Carex sp. div.	11																				
Caricoidea jugata	37*			37*																	
Cladiocarya europaea	6*			6*																	
Cladiocarya trebovensis	25*			25*																	
Decodon globosus	49*			49*																	
Dulichium spathaceum	10*			10*																	
Epipremnites ornatus	6*			6*																	
Glyptostrobus europaeus	215*					215*															
Ilex saxonica	13					13						13		13							
Mneme menzelii	154*			154*																	
Nyssa disseminata	3*					3*															
Proserpinaca reticulata	9*					9*															
Pterocarya limburgensis	9*					9*															
Spirematospermum wetzleri	12*			12*																	
Taxodium dubium	176*					176*															
?	12																				
?	3																				
?	2																				
Σ taxa	22			11	50%	7	32%					1		1							
Σ characteristic taxa	17			11	65%	6	35%														
Σ fruits and seeds	871			322		521						13		13							
Σ char. fruits and seeds	830			322	39%	508	61%														
Vegetation figures					154		128														
Σ palaeotropic taxa	7			6	27%	1	5%														
Σ pal. char. taxa	6			6	35%																
Σ pal. char. frts and seeds	103			103	12%																
Palaeotropic figures					74		5														
Arctotertiary figures					80		123														

References

Chandler, M.E.J., 1960. Plant remains of the Hengistbury and Barton beds. Bull. Br. Mus. (Nat. Hist.), 4: 193–238.

Czeczott, H. and Skirgiello, A., 1959. The fossil flora of Turow near Bogatynia. Pr. Muz. Ziemi, 3: 1–128.

Dorofeev, P.I., 1963. Tertiary Floras of Western Siberia. Akad. Nauk. SSSR, Bot. Inst. Komarov, Leningrad, 287 pp. (in Russian).

Dorofeev, P.I., 1972. On the taxonomy of the ancestral forms of *Euryale*. Bot. Zh., 57: 1047–1054 (in Russian).

Friis, E.M., 1985. Angiosperm fruits and seeds from the Middle Miocene of Jutland (Denmark). The Royal Danish Acad. of Sciences and Letters, Biol. Skrifter, 24, 3: 1–102.

Gregor, H.J., 1977. Subtropische Elemente im europäischen Tertiär II, (Fruktifikationen). Paläontol. Z., 51: 199–226.

Gregor, H.J., 1978a. Die Miozänen Frucht und Samenfloren der Oberpfälzer Braunkohle, I. Funde aus den sandigen Zwischenmitteln. Palaeontographica, B, 167: 8–103.

Gregor, H.I., 1978b. Subtropische Elemente im europäischen Tertiär, III. Rutaceae. Die Gattungen *Toddalia* und *Zanthoxylum*. Acta Palaeobot. Cracov, 19: 21–40.

Gregor, H.J., 1980. Die Miozänen Frucht und Samenfloren der Oberpfälzer Braunkohle II Funde aus den Kohlen und tonigen Zwischenmitteln. Palaeontographica, B, 174: 7–94.

Gregor, H.J., 1982. Die Jungtertiären Floren Süddeutschlands. Enke, Stuttgart, 278 pp.

Gregor, H.J., 1983. A lower Miocene fruit- and seedflora from the browncoal of Aliveri (Island of Evia, Greece). Documenta naturae, 6: 1–26.

Gregor, H.J., 1984. Subtropische Elemente im europäischen Tertiär IV. Doc. Nat., 16: 1–37.

Gregor, H.J. and Bogner, J., 1984. Fossile Araceen Mitteleuropas und ihre rezenten Vergleichsformen. Doc. Nat., 19: 1–12.

Kilpper, K., 1968a. Koniferen aus den tertiären Deckschichten des Niederrheinischen Hauptflözes, 2. Genus *Pinus* L. Palaeontographica, B, 123: 213–227.

Kilpper, K., 1968b. Koniferen aus der tertiären Deckschichten des Niederrheinischen Hauptflözes, 3. Taxodiaceae und Cupressaceae. Palaeontographica, B, 124: 102–111.

Kirchheimer, F., 1934a. Bau und botanische Zugehörigkeit der Datteln aus der Braunkohle des Niederrheins und der Niederlausitz. Braunkohle, 33: 617–618.

Kirchheimer, F., 1934b. Neue Ergebnisse und Probleme paläobotanischer Braunkohlenforschungen. Braunkohle, 33: 769–774 and 788–793.

Kirchheimer, F., 1936. Über die Pflanzenresten in den Begleitschichten der Braunkohle von Düren. Palaeontol. Z., 18: 213–227.

Kirchheimer, F., 1938. Beiträge zur näheren Kenntnis der Mastixioideenflora des deutschen Mittel bis Oberoligozäns. Beih. Bot. Centralbl., B, 58: 303–375.

Kirchheimer, F., 1940. Ein neuer Beitrag zur Kenntnis der Frucht- und Samenfossilien aus den Braunkohlenschichten Sachsens und Thüringens. Botan. Arch., 41: 276–294.

Kirchheimer, F., 1941. Ein neuer Beitrag zur Kenntnis der Braunkohlenflora in der Lausitz. Beitr. Biol. Pflanz., 27: 189–231.

Kirchheimer, F., 1943. Bemerkenswerte Frucht- und Samenreste, besonders aus den Braunkohlenschichten. Bot. Arch., 44: 362–430.

Kirchheimer, F., 1949. Die Symplocaceen der erdgeschichtlichen Vergangenheit. Palaeontographica, B, 90: 1–52.

Lancucka-Srodoniowa, M., 1979. Macroscopic plant remains from the freshwater Miocene of the Nowy Sacz Basin (West Carpathians, Poland). Acta Palaeobot. Cracov, 20: 3–117.

Mädler, K., 1939. Die Pliozäne Flora von Frankfurt am Main. Abh. Senckenb. Naturforsch. Ges., 446: 1–202.

Mai, D.H., 1964. Die Mastixioideen Floren im Tertiär der Oberlausitz. Paläontol. Abh. Berl., B, 2: 1–192.

Mai, D.H., 1965. Eine Pliozäne Flora von Kranichfeld in Thüringen. Mitt. Zentr. Geol. Inst., 1: 37–64.

Mai, D.H., 1967. Die Florenzonen, der Florenwechsel und die Vorstellungen über dem Klimaablauf im Jungtertiär der Deutschen Demokratischen Republik. Abh. Zentr. Geol. Inst., 10: 55–81.

Mai, D.H., 1970a. Die tertiären Arten von *Trigonobalanus* Forman (Fagaceae) in Europe. Jahrb. Geol., 3: 381–409.

Mai, D.H., 1970b. Neue Arten aus Tertiären Lorbeerwaldern. Feddes Repert., 81: 347–370.

Mai, D.H., 1970c. Subtropische Elemente im Europäischen Tertiar. Paläontol. Abh. Berl., B, 3: 441–503.

Mai, D.H., 1971. Über fossile Lauraceae und Theaceae im Mitteleuropa. Feddes Repert., 82: 313–341.

Mai, D.H., 1973. Die Revision der Originale von R. Ludwig 1857, — Ein Beitrag zur Flora des unteren Villafranchien. Acta Palaeobot. Cracov, 14: 89–117.

Mai, D.H., 1981. Der Formenkreis der Vietnam-Nuss (*Carya poilanei* (Chev) Leroy) in Europa. Feddes Repert., 92: 339–385.

Mai, D.H., 1983. Studien an Endokarpien europäischer und westasiatischer Arten der Gattung *Acer* L. (Aceraceae). Gleditschia, 10: 37–57.

Mai, D.H., 1984. Die Endokarpien bei der Gattung *Acer* L. (Aceraceae) — Eine biosystematische Studie. Gleditschia, 11: 17–46.

Mai, D.H. and Gregor, H.J., 1982. Neue und interessante Arten aus dem Miozän von Salzhausen im Vogelsberg. Feddes Repert., 93: 405–435.

Mai, D.H. and Walther, H., 1978. Die Floren der Haselbachserie im Weisselster Becken (Bezirk Leipzig, DDR). Abh. Staatl. Mus. Min. Geol. Dresden, 28: 1–200.

Monk, C.D., 1966. An ecological significance in evergreenness. Ecology, 47: 504–505.

Negru, A.G., 1968. Fossil fruits of Ruppiaceae and Potamogetonaceae from the Buglovian deposits of Moldavia. Bot. Zh., 9: 1300–1304.

Negru, A.G., 1972. Early Sarmatic Flora from northeast Moldavia. Akad. Nauk. SSSR, Kishinev, 169 pp (in Russian).

Reid, C. and Reid, E.M., 1907. The fossil flora of Tegelen

sur Meuse, near Venlo, in the province of Limburg. Verh. Kon. Akad. Wet., 2e Sectie, 13(6): 1–26.

Reid, C. and Reid, E.M., 1914. A new fossil *Corema*. J. Bot., 52: 113–114.

Reid, C. and Reid, E.M., 1915. The Pliocene floras of the dutch-prussian border. Meded. Rijksopsporing Delfstoffen, 6: 1–78.

Reid, E.M., 1923. Nouvelles rècherchges sur les graines du Pliocène inférieur du Pont-de-Gail (Cantal). Bull. Soc. Géol. Fr., 23: 308–355.

Schloemer-Jäger, A., 1960. Koniferenzapfen aus der Niederrheinischen Braunkohle. Senckenbergiana Lethaea, 41: 209–253.

Thomson, P.W., 1954. *Asimina browni* sp. n., Braunkohle, 6: 314–315.

Truchanowiczowa, J., 1964. Fossil seeds of the genus *Menyanthes* in Eurasia. Acta Palaeobot. Cracov., 5: 25–53.

Van der Burgh, J., 1964. Hölzer der Niederrheinischen Braunkohlenformation. I. Acta Bot. Neerl., 13: 250–301.

Van der Burgh, J., 1973. Hölzer der Niederrheinischen Braunkohlenformation. II. Rev. Palaeobot. Palynol., 15: 73–275.

Van der Burgh, J., 1978. The Pliocene flora of Fortuna Garsdorf, I Fruits and seeds of Angiosperms. Rev. Palaeobot. Palynol., 26: 173–211.

Van der Burgh, J., 1983. Allochthonous seed and fruit floras from the Pliocene of the lower Rhine basin. Rev. Palaeobot. Palynol., 40: 33–90.

Van der Burgh, J., in press. Some local floras from the Neogene of the lower Rhenish basin. Tertiary Research special paper.