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Review of Palaeobotany and Palynology 101 (1998) 209–256

REVIEW OF PALAEOBOTANY AND PALYNOLOGY

Plant mega- and microfossil assemblages from the Brunssumian of 'Hambach' near Düren, B.R.D.

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Received 26 February 1997; revised version received 4 August 1997; accepted 11 September 1997

Abstract

A series of 19 carpological samples, 9 of them from a 50 cm thick section, were collected from Late Brunssumian deposits in the browncoal open-cast mine 'Hambach'. They were analyzed together with two leaf assemblages collected from the same horizon. They reveal a change from wetland forest to reed vegetation together with an increasing influence of allochthonous elements. Some plant species new to the region were found: *Carex appropinquata*, *Euphorbia palustris*, *Salix* sp. (seeds), *Urtica dubia*. The difference between the composition of leaf and carpological assemblage from the same deposits is elucidated. The incorporation of palynological data helps to clarify the nature of the vegetation.

Keywords: diaspores; Germany; leaves; palaeoecology; Pliocene; pollen; taphonomy

1. Introduction

In the opencast mine 'Hambach' (Fig. 1) a thick series of deposits, younger than the Miocene browncoal, is exposed. One of them consists of a double layer of clay, separated by a thin bed of sand. In the local stratigraphy these are designated as layer nos. 9 A, B, and C, from base to top. The sequence is also known as the Rotton Formation and is dated as Brunssumian, i.e. early, middle and late Brunssumian. In several places, the upper clay bed contains allochthonous leaf-compressions, which have been described by Van Lidth de Jeude and Van der Burgh (1989) and Belz (1992).

The base of the upper clay bed (9 C) is locally a very coaly, black humic clay, with a maximum thickness of ca. 50 cm. A number of leaf-compressions were collected from this layer during the late summer of 1982. In addition some samples for fruit/seed analysis were taken from the base as well as the top of this clay bed. Moreover, a sample was collected from a banded clay in a riverchannel at the top of the sand bed (9 B). During the summer of 1983 a section of the 9 C clay beds was sampled from top to bottom, and in 1995 a number of leaf-compressions were collected from a comparable position in a silt, which graded at the top into a silty reddish clay with the well known allochthonous leaf-compressions. As

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0034-6667/98/$19.00
PII S0034-6667(97)00076-6

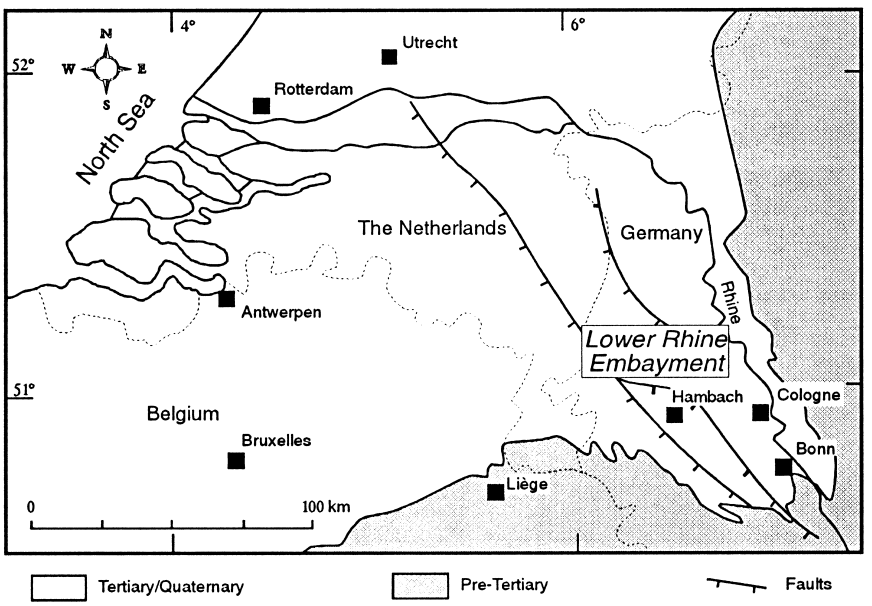


Fig. 1. Map of the lower Rhine embayment with the location of the Hambach opencast mine.

far as can be inferred from the situation in the field this deposit represents a lateral equivalent of that of 1982/1983. The leaf and fruit/seed assemblages from both collections have been studied and the results are reproduced here.

The leaves were identified with the help of cuticle analysis as well as gross morphology. However, the material of 1995 did not yield very good cuticle preparations.

Ca. 2 kg of dried clay or silt were taken from the leaf containing specimens of both collections, disaggregated with H_2O_2 10% and sieved. The same method has also been employed for processing the other fruit/seed samples. After drying, the material was sorted and the disseminules counted. The ecological analysis is made according to the method described by Van der Burgh (1983, 1987); Appendix A, ecological Tables A1–A21) and the results are graphically presented as histograms (Figs. 2–4).

The sediments, which were employed for the palynological investigation, came from the leaf horizon (9 C) sampled in 1982. The clastic sediments were treated by the standard extraction techniques involving HCL and HF, and using $CHBr_3$ as heavy liquid (Klaus, 1972). After acetolysis and examination of the pollen grains and the LM, these were transferred to a stub, where ethanol was used to remove the glycerine. The grains were then sputter-coated and examined under the SEM.

2. The leaf and carpological assemblages

Annotated list of species; only those species, not mentioned in earlier papers of the author (Van der Burgh, 1978, 1983, 1987, 1988, 1993, 1995; Van Lidth de Jeude and Van der Burgh, 1989) are briefly characterized. A review of the ecology is based on the study of more extensive literature (Weeda et al., 1985–1994) and a sequence of local floras, described in this paper. In comparison with previous papers, some changes in the assignment to the vegetational units are made.

Acer campestre L. fruits

Material studied: coll. no. 14380, 17648.
Ecology: This is a tree of forest borders and dry forest on lime-rich soil; units 4, 5.

Acer sp. fruits

Material studied: coll. no. 14132, 17646.
Remark: These seeds could not be identified to a specific level.

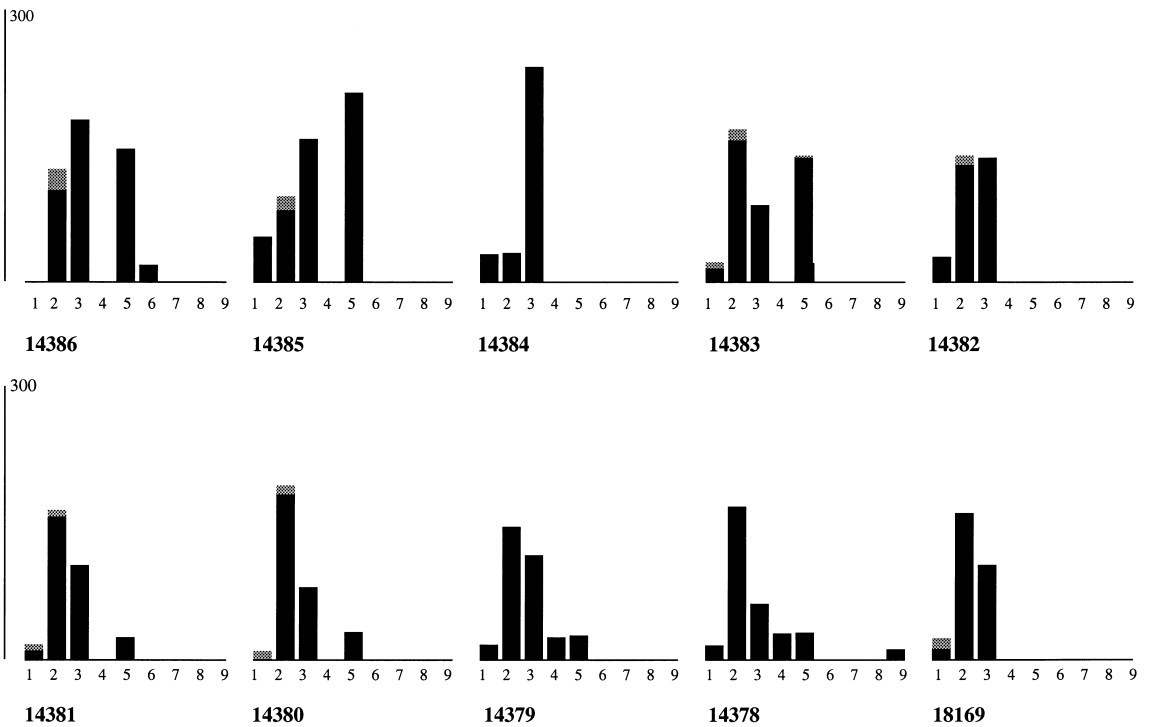


Fig. 2. Histograms of the changing vegetational composition through the section in the 9 C clay compared with that of the leaf clay 18169. Columns nos.: *1* = open water; *2* = streamside herbaceous vegetation; *3* = wetland forest; *4* = forest border; *5* = floodplain forest; *6* = upland forest; *7* = coniferous forest on poor soils; *8* = heath; *9* = peatbog. The height of the columns correspond to the vegetational figures, calculated with help of the ecological tables of the samples (see also Van der Burgh, 1983). The solid parts represent the arctotertiary figures, the non solid parts represent the palaeotropic figures.

Acer tricuspidatum Bronn ssp. *lusaticum* Walther leaves (Plate III, 9, 10; Plate IV, 1)

Material studied: coll. no. 12642, 12644, 12657, peel no. 165.
Remarks: Actinomorphous leaves with actinodromous venation; three primary veins diverging from the base of the leaf; margin coarsely dentate. Length/breadth 6–12 cm.

Cuticle: epidermal cells isodiametric, pentagonal, walls straight; diameter 15–20 μm. Stomata anomocytic, variously orientated, length of stomatal cells 20–32 μm, width ca. 12 μm; with thickened inner stomatal walls. Stomatal slit ca. 20 μm long. Numerous unicellular trichomes, 60–120 μm long present, especially over the veins. This material can be compared with that described by Mai and Walther (1988) and Belz (1992), although no striation of the epidermal cells could be observed.
Ecology: The distantly related species, *A. rubrum*, is common in swampy areas and along sluggish streams; based on numerous finds of the leaves of *A. tricuspidatum* in local clays dating from the Late Miocene, the species is considered to have shown the same ecology; unit 3.

Actinidia faveolata Reid et Reid seeds

Material studied: coll. no. 14149, 14375, 14378, 14382, 14383, 14384, 14385, 14386, 17646.
Ecology: Actinidia is a genus of lianas, which occur in forests but are normally fruiting only in a sunny position and therefore considered to be plants of the forest border; their regular presence in the samples of pure alder wetland forest, however, points to an occurrence in this type of forest; unit 3.

Aesculus hippocastanum L. leaves
(Plate IV, 2)

Material studied: coll. no. 12640, 12647, 12649,

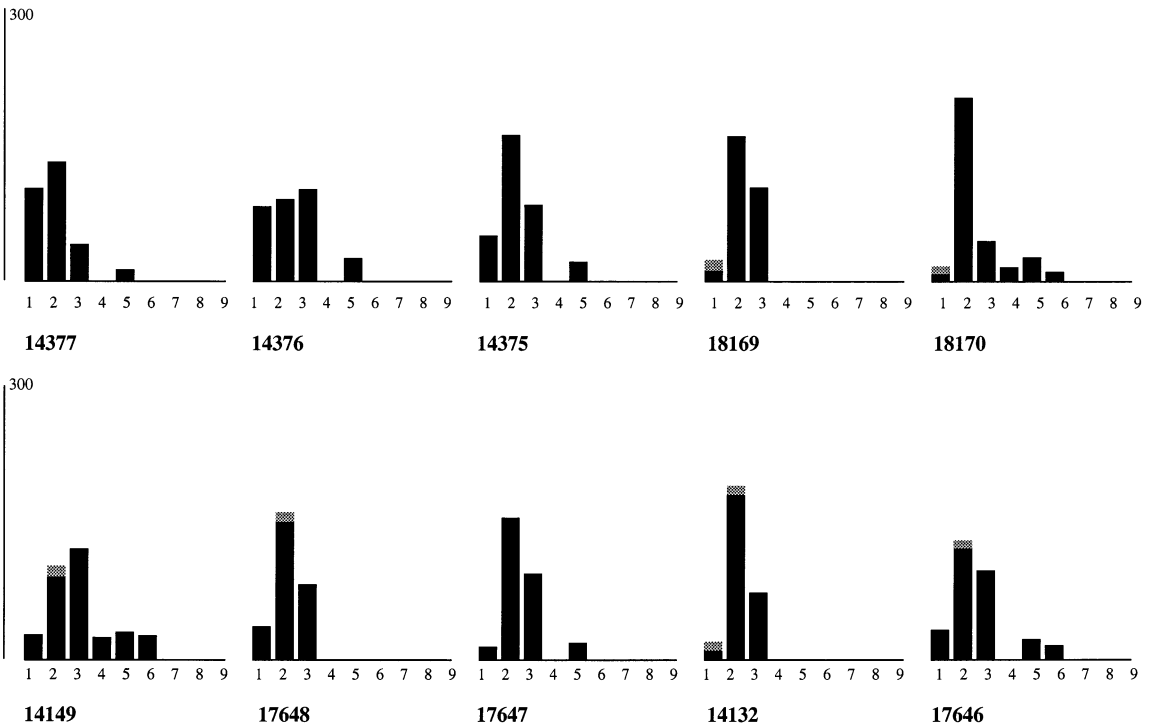


Fig. 3. Histograms of the vegetational composition of diverse clay samples compared with those of the leaf clays. For explanation of columns see Fig. 2.

12656, 12658, 12664, 2669, 17967, 17973, peel no 150, 151, 152, 159.
Remarks: The leaf material consists of laminae with a cuneate base and obovate shape. The margin is serrate, a stalk is normally absent. The length varies from 3.5 to 12 cm; the width from 2 to 5 cm. Venation: craspedodromous; angle of the straight secondaries to the primary all alike, veins of higher order not observed. The material matches the descriptions by Mai and Walther (1988) and Belz (1992) of *Aesculus hippocastanum*.
Ecology: Aesculus is a tree of nutrient-rich, river bottom forests, which are inundated during the winter (Fowells, 1965); unit 5.

Alisma plantago-aquatica L. seeds

Material studied: coll. no. 14132, 14149, 14375, 14378, 14379, 14380, 14381, 14382, 14383, 14386, 17646, 17648, 18170.
Ecology: This is a pioneer along the waterside, requiring carbonate-rich non-acidic water; unit 2.

Alnus cecropiaefolia (Ettingshausen) Berger leaves (Plate IV, 7)

Material studied: coll. no. 12640, 12641, 12645, 12646, 12647, 12649, 12650, 12652, 12654, 12655, 12656, 12657, 12658, 12660, 12661, 12662, 12663, 12664, 12665, 12666, 12668, 17960, 17867, 17969, 17970, 17973, peel no. 148, 149, 153, 154, 155, 1161, 170.
Ecology: A. glutinosa, with which this species can be compared, is a plant of alder wetland forest, on nutrient-rich, permanently humid soil. It is easily damaged by flowing water during the growing season; unit 3.

Alnus incana (L.) Moench leaves (Plate IV, 3–5; Plate VI, 4)

Material studied: coll. no. 12672, 12673, 12674, 12676, 12677, 12679, 12680, 12682, 12683, 12684, 12686, 12687, 12688, 12689, 12690, 12691, 12692, 12693, 12694, 12695, 12696, 12697, 12698, 12699, 12700, 17946, 17947, 17948, 17949, 17950, 17951,

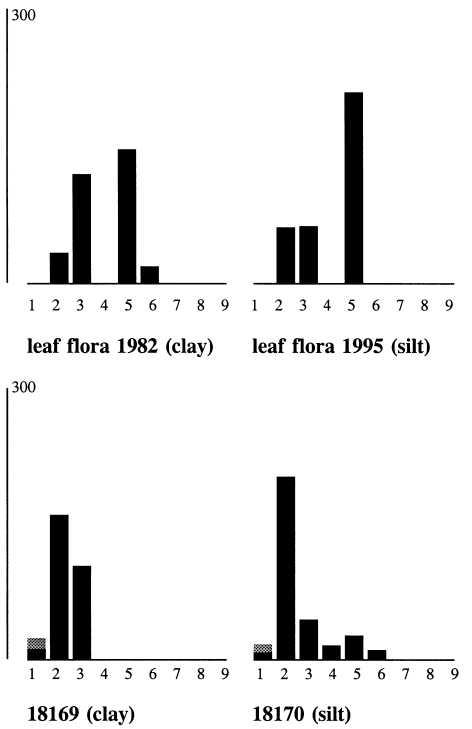


Fig. 4. Histograms of the vegetational composition of the leaf assemblages and the accompanying carpocoenoses. For explanation of columns see Fig. 2.

17952, 17953, 17954, 17955, 17956, 17957, 17958, 17960, 17961, peel no. 162.
Remarks: This material consists of mesophyllous leaves; length: 4.5–9 cm, width 3–7 cm. The shape is ovate, the base rotundate-cordate. The margin is biserrate. The venation is craspedodromous, the secondaries vary in angle to the primary, the angle decreasing from base to apex. The secondaries are straight or slightly bent. Tertiaries are straight, the angle with the secondaries is ca. 90º. They stand oblique to the primary, the angle decreasing towards the apex. They are densely placed, distance less than 5 mm. Some veins of the 4th order could be observed.

Cuticle: difficult to prepare, very thin; some 4-celled glandular hairbases, typical for *Alnus* could be observed. The stomata are anomocytic, 25–30 μm long, 22–25 μm wide. The epidermal cells are penta–hexagonal with straight walls. A hair base measured ca. 20 μm across and was surrounded by thickened cells. This material is comparable with that, described by Belz as *Alnus incana*. In older literature similar material is referred to as *Carpiniphyllum caudatum* Reymann (Reymann, 1912; Kräusel, 1919; Kownas, 1955).
Ecology: this species requires a lime-rich, light soil with a good drainage; unit 5.

Alnus tanaitica Dorofeev fruits (Plate I, 1)

Material studied: coll. no. 14132, 14149, 14375, 14376, 14377, 14378, 14379, 14380, 14381, 14382, 14383, 14384, 14385, 14386, 17646, 17647, 17648, 18169, 18170.
Remarks: Trapezoidal to irregularly oval-shaped nutlets. The apex is acute, the base heart-shaped to rotundate, sometimes with a very short stalk. The structure is woody, often with some longitudinal furrows. Size: length 2–2.4 mm, width 1.2–2 mm. The material is comparable with that described by Mai and Walther (1988) as *A. tanaitica*.
Ecology The material is similar to the nutlets of *A. incana*, but the material of the pure alder wetland forest and that of sample 18169, taken from an assemblage with dominant *A. cecropiaefolia*, contains the same type of nutlets. Therefore the material is considered to be typical for wetland alder forest; unit 3.

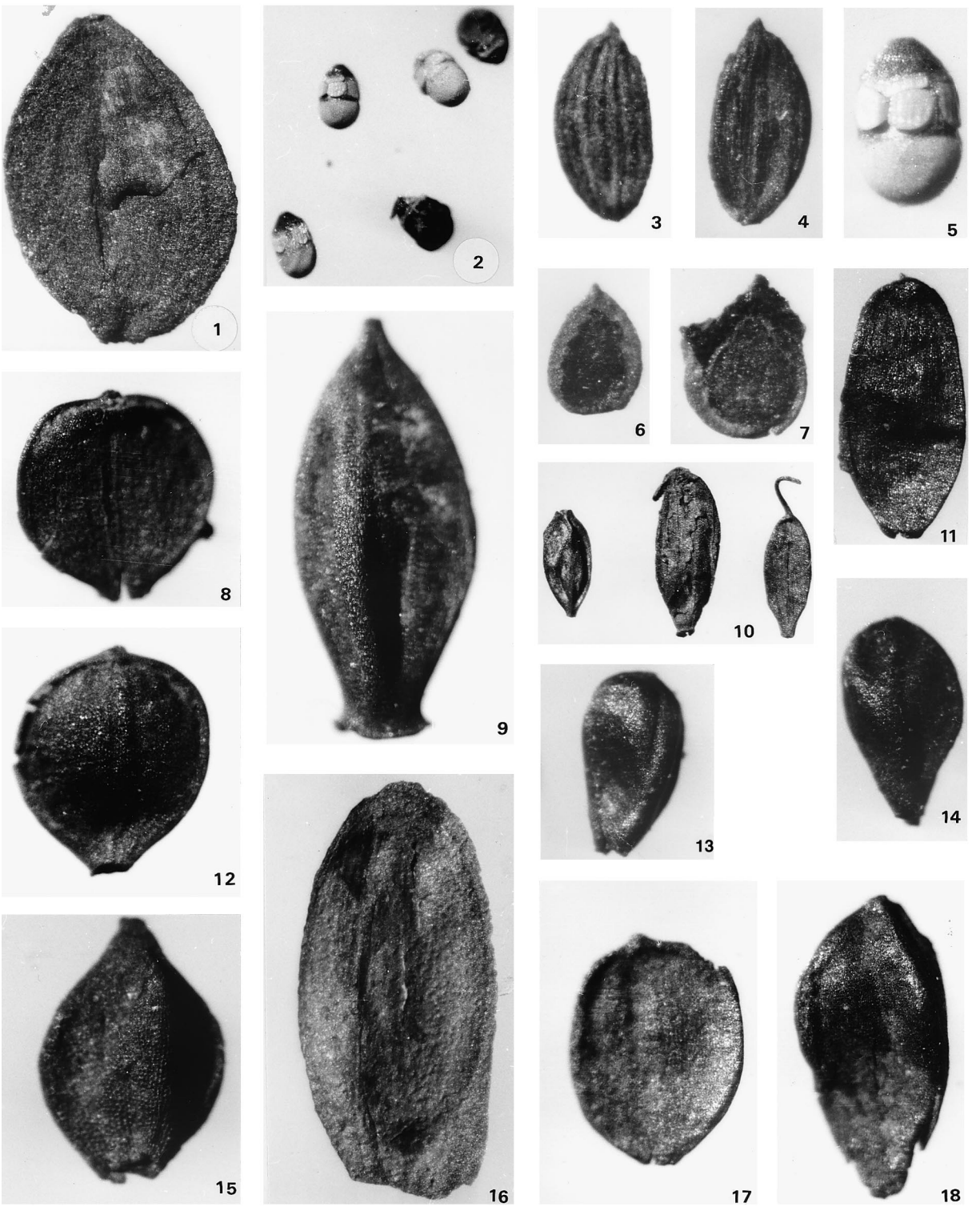
Apium repens (Jacquin) Lagasca et Segura fruits (Plate I, 3, 4)

Material studied: coll. no. 14132, 14375, 14376, 14377, 14378, 14379, 14380, 14381, 14383, 14386, 17647, 17648, 18179.
Remarks: The fruits are small, 1.2–1.5 by 0.7–0.9 mm, consisting of 2 one-seeded parts. The fruits bear on the outer side 5 ribs, between which are 4 glossy bands. On the flat inner side two such glossy bands are present. The material is comparable to that of *A. repens*.
Ecology: This is a plant of herbaceous vegetations which are shallowly inundated during the winter; unit 2.

Azolla tegeliensis Florschuetz macromassulae (Plate I, 2, 5)

Material studied: coll no. 18170.
Remarks: The material consists of macromassulae with one megaspore and 9 swimming bodies, the

PLATE I



length is 0.6 mm, the width 0.3 mm, the color is whitish, with the brownish remains of the megasporangium at the tip. It is similar to that described by Florschütz (1938).
Ecology: This is a plant of stagnant/sluggish water. As pointed out by Florschütz, it belongs to a section with a tropical distribution; unit 1.

Betula sp. fruits

Material studied: coll. no. 17648.

Betula subpubescens Goeppert leaf (Plate V, 1)

Material studied: coll. no. 12678.
Remarks: Length 4.2 cm, width 3.2 mm. The shape is ovate, the base is cordate, the apex acute. The seven secondaries are straight with the exception of the lowermost pair, which are bent downwards. The margin is serrate-dentate. The petiole is 8 mm long. Despite its cordate base the leaf is comparable to *B. subpubescens* as described by Belz (1992).
Ecology: Betula is a genus of predominantly pioneer species, that are not restricted to any special soil, but require light; units 3–7.

Boehmeria colchica Dorofeev seeds (Plate I, 6, 7)

Material studied: coll. no. 18169, 18170, 14375, 14376, 14378, 14379, 14380, 14381, 14383, 14384, 18169.

PLATE I

1. *Alnus tanaitica* Dorofeev; sample 14380. ×20.
2, 5. *Azolla tegeliensis* Florschuetz; sample 18170.
2. ×20.
5. ×40.
3, 4. *Apium repens* (Jacq.) Lag.; sample 18170. ×20.
6, 7. *Boehmeria colchica* Dorofeev; sample 18170. ×20.
8. *Carex appropinquata* Schumacher; sample 14383. ×20.
9. *Carex flagellata* Reid et Reid; sample 18170. ×20.
10. *Carex szaferi* Mai et Walther; sample 18170. ×10.
11. *Carex elongatoides* Lancucka-Srodoniowa; sample 14381. ×20.
12. *Carex helmensis* Mai et Walther; sample 18169. ×20.
13, 14. *Carex flavaeformis* Lancucka-Srodoniowa; sample 17646. ×20.
15. *Carex strigosoides* Lancucka-Srodoniowa; sample 17646. ×20.
16. *Cirsium palustre* (L.) Scop.; sample 18169. ×20.
17. *Carex cespitosa* L.; sample 14381. ×20.
18. *Carex riparia* Curtiss; sample 14149. ×20.

Remarks: The material consists of small endocarps and is comparable to that described by Mai and Walther (1988).
Ecology This species is comparable with some species from Japan (Mai and Walther, 1988), which belong to wet floodplain and wetland forest, units 3, 5.

Caldesia cylindrica (Reid) Dorofeev seed

Material studied: coll. no. 14375.
Ecology: This is a species from the reed vegetation along alkaline and nutrient-rich water courses; unit 2.

Caricoidea jugata (Nikitin ex Dorofeev) Mai fruits

Material studied: coll. no. 14381.
Ecology: The genus is known from clays and brown-coal deposits, therefore it is considered to belong to units 3, 9.

Carex acutiformis Ehrhart fruits

Material studied: coll. no. 14149, 14378, 18170.
Ecology: This plant, growing on nutrient-rich and alkaline soils, is a species of streamsides and wetland forest, e.g. alder forest; units 2, 3.

Carex appropinquata Schumacher fruits (Plate I, 8)

Material studied: coll. no. 14379, 14380, 14381, 14383.
Remarks: The nutlets of this species measure (1.6–2) × (1.2–1.4) mm. They are biconvex with a very fine cellular pattern. The shape is circular to ovate with rounded base and apex. The greatest width is in the middle of the nutlet, a style base is present.
Ecology: This material is comparable with that of the recent *C. appropinquata* Schumacher. This species requires a constant supply of nutrient-rich water, it is a plant of streamside vegetation on alkaline soil; unit 2.

Carex cespitosa L. fruits (Plate I, 17)

Material studied: coll. no. 14132, 14375, 14378, 14379, 14380, 14381, 14382, 14383, 17646, 17647, 17648, 18169, 18170.
Remarks: Size: length ca. 1.4 mm, width 1.2 mm. In this species the cellular pattern is somewhat coarser

and more easily observed than in the foregoing species. The nuts are also biconvex and circular to oval in shape, but the base is narrower, the style is very short.
Ecology: The recent species grows on nutrient-rich and alkaline but lime-free, peat-soil in streamside vegetation and alder forest; however, the complete absence of the material in the pure alder wetland forest points to a restriction to unit 2.

Carex elongatoides Lancucka-Srodoniowa fruits (Plate I, 11)

Material studied: coll. no. 14132, 14375, 14376, 14378, 14379, 14380, 14381, 14382, 14383, 14384, 17646.
Remarks: The material consists of flattened biconvex nutlets with a rounded elongate shape and a very fine cellular pattern. The length is 1.5–1.7 mm and the width 0.6–0.8 mm, the greatest width being in the middle of the nutlet. These nutlets are comparable with those described by Lancucka-Srodoniowa (1979) and Mai and Walther (1988).
Ecology: C. elongata is an inhabitant of nutrient-rich and alkaline alder wetland forest; unit 3.

Carex flagellata Reid et Reid fruits (Plate I, 9)

Material studied: coll. no. 14378, 14379, 14380, 14381, 14383, 17646, 18170.
Remarks: Mai and Walther divided the material formerly assigned to this species into two separate units, one of which (the coarser material) is still referred to this species. Our material is in agreement with the description of *C. flagellata* by these authors.
Ecology: According to Mai and Walther (1988) this species is related to *C. grayii*, a species of swamp vegetations in America; unit 2.

Carex flavaeformis Lancucka-Srodoniowa fruits (Plate I, 13, 14)

Material studied: coll. no. 14132, 14375, 14379, 14380, 14385, 17646.
Remarks: Some small triangular thick-walled nutlets agree with the description of this species. They measure 1.5 mm in length and 0.7–0.8 mm in width.
Ecology: C. flava L., the species with which this material is compared, is found in clearances in wet forest on alkaline soil; unit 3.

Carex helmensis Mai et Walther fruits (Plate I, 12)

Material studied: coll. no. 14377, 18169, 18170.
Remarks: This species has flattened biconvex nutlets. The surface shows a coarse cellular pattern. The base is narrow. Size: length 1.8–2.2 mm, width 1.2–1.4 mm. Although these measurements are slightly larger than those of the type material (Mai and Walther, 1988), this material is assigned to *C. helmensis*.
Ecology: The ecology of this species is hitherto unknown.

Carex pilulifera L. fruits

Material studied: coll. no. 18170.
Remarks: These are triangular nutlets, with a narrow tapering base and a rounded apex. The ribs along the sides are thickened.
Ecology: This is a plant of clearances in upland forest on acidic soil; unit 6.

Carex riparia Curtis fruits (Plate I, 18)

Material studied: coll. no. 14149, 14379, 17646.
Remarks: The material consists of rounded triangular nutlets, oval in shape, with strong short style bases. The fruit tapers to the narrow base, the apex is acute. The length is ca. 2.2 mm, width 1.2–1.3 mm.
Ecology: This is a species growing in nutrient-rich streamside vegetations; unit 2.

Carex sp. fruits

Material studied: coll. no. 14132, 14377, 14378, 14381, 14383, 17646, 17647, 17648, 18169, 18170.
Remark: These are remains, as yet unidentifiable beyond generic level.

Carex strichosoides Lancucka-Srodoniowa fruits (Plate I, 15)

Material studied: coll. no. 17646.
Remarks: This is a small triangular nutlet with a clear cellular pattern. The length is ca. 1.5 mm, width 1.2 mm, broadest at the middle of the fruit. It is comparable with the material described under this name by Lancucka-Srodoniowa (1979) and Mai and Walther (1988).
Ecology: C. strigosa, the modern counterpart of this species is a plant of places with nutrient-rich upwelling groundwater. It can withstand inundation for

some time and grows in ash and alder forests; units 3, 5.

Carex szaferi Mai et Walther fruits (Plate I, 10)

Material studied: coll. no. 14132, 14375, 14376, 14377, 14378, 14379, 14381, 17646, 17648, 18169, 18170.
Remarks: This is the smaller fraction of the material hitherto described as *C. flagellata*. It is a species with a very long repeatedly curved style. The nutlets are triangular, ovate with a long tapering base and acute apex. The cellular pattern is very clear and at the base a small discus is present. The length is 2.0–2.2 mm and the width 0.8–1.1 mm.
Ecology: According to Mai and Walther (1988) comparable fruits are found in some American species, which are known from streamside vegetation; unit 2.

Carpinus betulus L. fruits

Material studied: coll. no. 14149, 14378, 14379, 17646, 17648.

Carpinus grandis Unger, leaves

Material studied: coll. no. 12659, 12662, 12663, peel no. 156, 157, 158.
Ecology: This is a tree with a great demand for water, found on humid soils and along streamlets; units 5, 6.

Ceratophyllum submersum L. seeds

Material studied: coll. no. 14375, 14376, 14377, 17646, 18169.
Ecology: This plant inhabits carbonate-, phosphate- and nitrogen-rich quiet waters; unit 1.

Chamaecyparis sp. cone

Material studied: coll. no. 17646.
Remark: This small specimen could not be identified beyond the generic level.

Cirsium palustre (L.) Scopoli fruits (Plate I, 16)

Material studied: coll. no. 14132, 14383, 17648, 18169.
Remarks: The nutlets are oblong-oval, totally flattened, 3–3.5 mm long and 1.2–1.6 mm wide. At the base they are somewhat narrower and sometimes split. The apex is rounded, the surface bears transverse wavy elevations. It is similar to the material descibed by Mai and Walther (1988).
Ecology: This is a plant of reed vegetations on rather nutrient-rich soils; unit 2.

Cladium reidiorum Nikitin fruits

Material studied: coll. no. 14383, 17647, 18169.
Ecology: This is a very variable plant with respect to nutrients. It is an inhabitant of streamside vegetations; unit 2.

Crataegus nodulosa Van der Burgh endocarps

Material studied: coll. no. 14378, 14379.
Ecology: The material is supposed to represent forest border vegetation since this shrub-forming genus only fruits well in a sunny position; unit 4.

Decodon globosum (E.M. Reid) Nikitin fruits

Material studied: coll. no. 14132, 14149, 14375, 14376, 14377, 14378, 14379, 14380, 14381, 14382, 14383, 14384, 14385, 14386, 17646, 17647, 17648, 18169, 18170.
Ecology: The water willow is a plant of wet places along the water side; unit 2.

Dulichium spathaceum Reid et Reid fruits

Material studied: coll. no. 14132, 14149, 14375, 14377, 14378, 14379, 14380, 14381, 14382, 14383, 14385, 17646, 17647, 17648, 18169, 18170.
Ecology: Dulichium is a plant of wet places and belongs to the reed and streamside vegetation; unit 2.

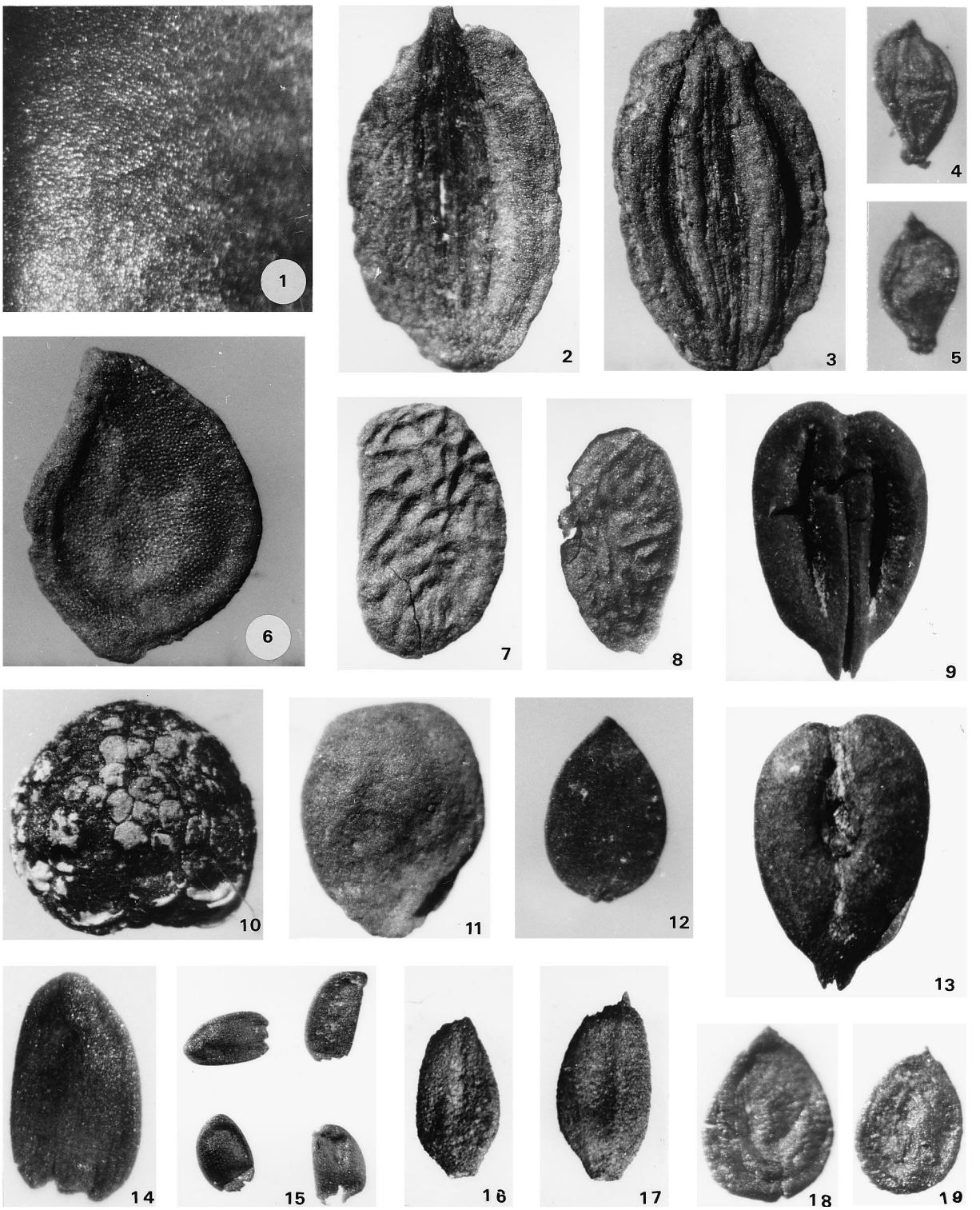
Dulichium vespiforme Reid et Reid fruits

Material studied: coll. no. 14378, 14380, 14381, 14383, 18169.
Ecology: See the foregoing species.

Eleocharis ovata (Roth) Roemer et Schultes fruit (Plate II, 4, 5)

Material studied: coll. no. 14380, 14381, 14383.
Remarks: ca. 1 mm long biconvex flattened fruit with traces of a stylocarp. It agrees with the description by Mai and Walther (1988).

PLATE II



Ecology: This is a plant growing in herbaceous vegetations on periodically inundated, wet nutrient-rich, but lime-free humic mudsoils along waterbodies; unit 2.

Eucommia europaea Maedler fruits

Material studied: coll. no. 14149.
Ecology: This tree is supposed to have been a pioneer on well drained not inundated mineral soils; unit 6.

Euphorbia palustris (L.) Scopoli seeds (Plate II, 1)

Material studied: coll. no. 14378, 14379, 17646.
Remarks: The seeds are black, ovoid with a glossy surface. They are: 2.5–2.8 mm in length and 1.6–2.0 mm in width. They are very much like those of *E. platyphyllos* L., described by Mai and Walther (1988), but are somewhat bigger and more particularly wider. Moreover the surface shows some undulation, which can be found also on seeds of *E. palustris*, but not on those of *E. platyphyllos*.
Ecology: This is a tall herb of the reed vegetation on wet nutrient-rich soils; unit 2.

Fagus decurrens Reid et Reid, cupules

Material studied: coll. no. 14149, 17646.
Ecology: F. sylvatica L. is a plant of lime-rich and also of lime-poor acidic forests, which are never inundated; another relative, *F. ferruginea* grows also in moist sites, but cannot stand prolonged inundation; unit 6.

PLATE II

1. *Euphorbia palustris* (L.) Scopoli; sample 14379. ×40.
2, 3. *Oenanthe lachenalii* C. Gmelin; sample 18170. ×20.
4, 5. *Eleocharis ovata* (Roth) Roem. et Schult.; sample 14383. ×20.
6. *Ranunculus repens* L.; sample 18170. ×20.
7, 8. *Rubus fruticosus* L.
7. Sample 17646.
8. Sample 14378. ×20.
9, 13. *Vitis sylvestris* C. Gmelin; sample 14378. ×20.
10. *Salvinia* sp.; sample 14380. ×20.
11. *Stachys palustris* L.; sample 14378. ×20.
12. *Urtica urens* L.; sample 18170. ×20.
14, 15. *Salix* sp.; sample 18170; 14: ×40; 15. ×20.
16, 17. *Sparganium neglectum* Beeby; sample 18170. ×10.
18, 19. *Urtica dubia* Forsk.; sample 14383. ×20.

Glyptostrobus europaeus (Brongniart) Heer seeds

Material studied: coll. no. 14149.
Ecology: The chinese water cypress is a plant from marshy places along water bodies; unit 3.

Hypericum sp. seeds

Material studied: coll. no. 14132, 18170.
Remark: The material could only be identified at the generic level.

Liriodendron geminatum Kirchheimer seeds

Material studied: coll. no. 14149, 14375, 14376, 14377, 14378, 14379, 14380, 14381, 14383.
Ecology: L. tulipifera is found on moderately moist, well-drained loose textured soils as usually found in floodplains; unit 5.

Lycopus europaeus L. fruits

Material studied: coll. no. 14132, 14377, 14378, 14380, 14381, 14383, 17647, 17648.
Ecology: This species grows in tall reed and streamside vegetation on nutrient-rich soils; unit 2.

Magnolia cor Ludwig seed

Material studied: coll. no. 17646.
Ecology: This species is considered to be a constituent of the bottomland wetland forest; unit 3.

Menyanthes carpatica Jentys-Szaferowa et Truchanowiczowa seed

Material studied: coll. no. 14132.
Ecology: Menyanthes loves nutrient-poor to rather nutrient-rich, slightly acidic shallow water over a peaty soil; unit 9.

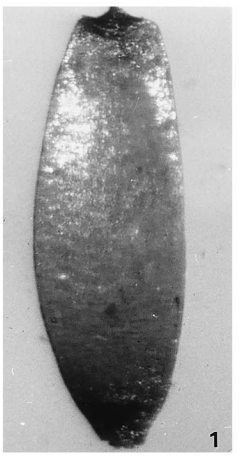
Monocotyledonophyllum sp. 1 leaves

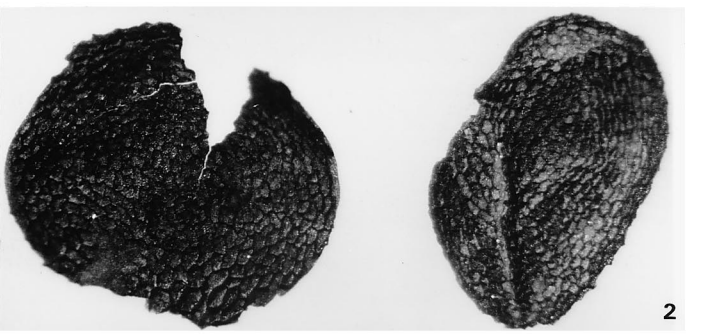
Material studied: coll. no. 12666, 12671, 12698, 12700, 17949, 17957, 17958, 17961, 17966.

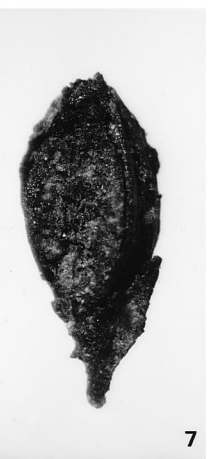
Monocotyledonophyllum sp. 2 leaves

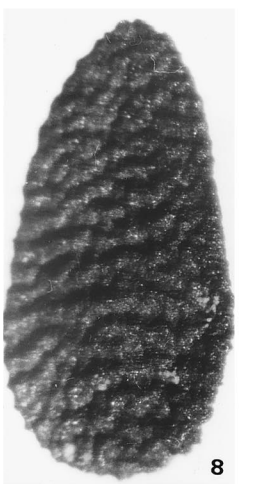
Material studied: coll. no. 12664, 12675, 12698, 12700, 17958, 17962, 17963, 17968.
Remarks: These are the compressions of two species of monocotyledonous leaves. *Monocotyledonophyllum* sp. 1 consists of up to 1.5 cm wide fragments

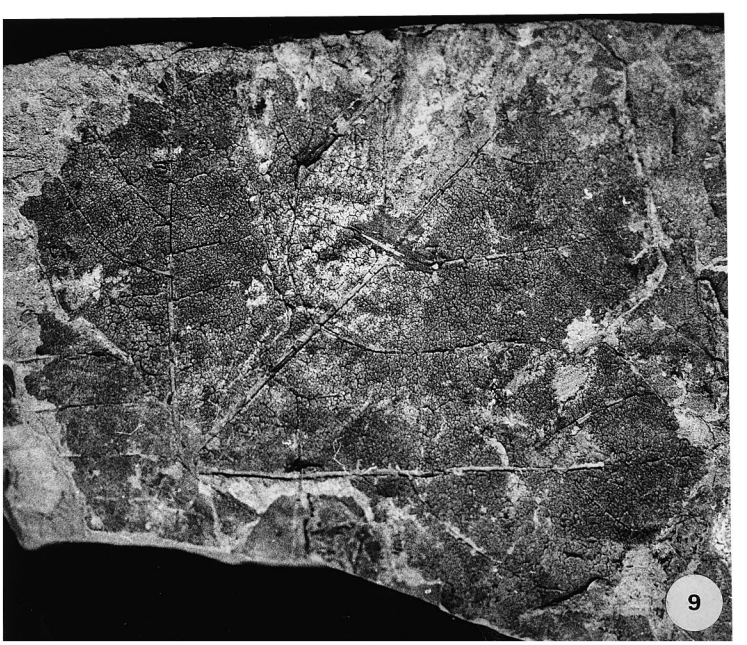
PLATE III

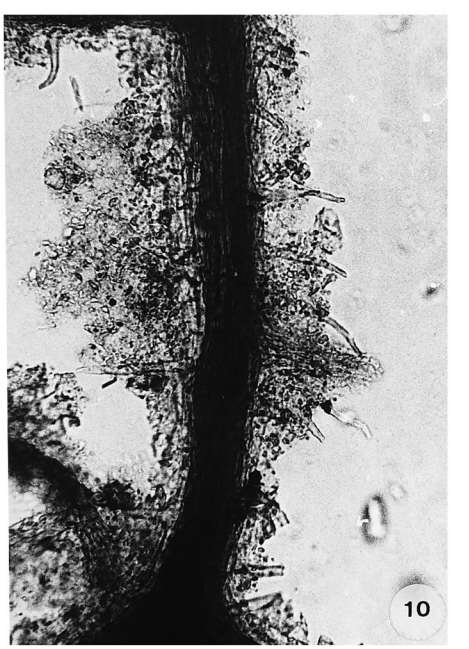












of ribbonlike leaves of unknown length; venation parallel, consisting of thin, closely spaced parallel veins.
Monocotyledonophyllum sp. 2 consists of up to 0.5 cm wide fragments of ribbon-like parallel-veined leaves.
Ecology: By absence of further details it can only be supposed to be a representative of grassy or reedlike vegetation; units 2, 3.

Nelumbo sp. seeds

Material studied: coll. no. 18169.
Ecology: This is a plant of rather nutrient-rich open water with a predominantly palaeotropical distribution; unit 1.

Nuphar luteum (L.) Smith seeds

Material studied: coll. no. 14149, 14376, 14377, 14381, 14382, 14383, 14384, 14385, 17648.
Ecology: A waterplant, growing in deep to rather shallow, nutrient-rich stagnant or sluggish water; unit 1.

Nymphaea alba L. seeds

Material studied: coll. no. 14377, 14378, 14379, 14382, 14383, 14385, 17646, 17648.
Ecology: This species grows in rather deep, stagnant, rather nutrient-rich to nutrient-poor water over a mud soil; unit 1.

Nyssa disseminata (Ludwig) Kirchheimer, endocarp

Material studied: coll. no. 14149.

PLATE III

1, 3. *Typha latifolia* L.; sample 18170.
1. ×40.
3. ×10.
2. *Solanum dulcamara* L.; sample 14378. ×20.
4, 5. *Sagittaria sagittifolia* L.; sample 18170. ×20.
6. *Thalictrum lucidum* L.; sample 18169. ×20.
7. *Rumex* sp.; sample 18169. ×20.
8. *Sambucus pulchella* Reid et Reid; sample 17646. ×20.
9. *Acer tricuspidatum* Bronn ssp. *lusaticum* Walther; specimen 12644. ×1.
10. *Acer tricuspidatum* Bronn ssp. *lusaticum* Walther; cuticle preparation 2955. ×160.

Ecology: N. disseminata has been found in autochthonous clay and clayey peat deposits; therefore it is considered a constituent of wetland forest and swamps; unit 3.

Oenanthe lachenalii C.Gmelin (Plate II, 2, 3) seeds

Material studied: coll. no. 14379, 14381, 14382, 14383, 17646, 17647, 17648, 18169, 18170.
Remarks: The fruits are oblong to obovate, with 3 dorsal and two lateral ribs; the lateral ones being much larger than the dorsal ones. These ribs alternate with lines of glossy material. The measurements are: length 2–3 mm; width 1.2–1.8 mm. These fruits are similar to those of the recent *Oenanthe lachenalii* and agree with the description by Mai and Walther (1988).
Ecology: This is a plant of reed vegetations on wet, temporarily inundated alkaline and nutrient-rich clay; unit 2.

Populus sp. leaves (Plate V, 2; Plate VI, 4)

Material studied: coll. no. 12677, 12681, 12692, 12699.
Remarks: Some fragments of rather large leaves, minimum width 6 cm, minimum length ca. 6 cm, with a suprabasal actinodromous venation and a crenate to sinuate margin. The veins are wavy towards the margin.

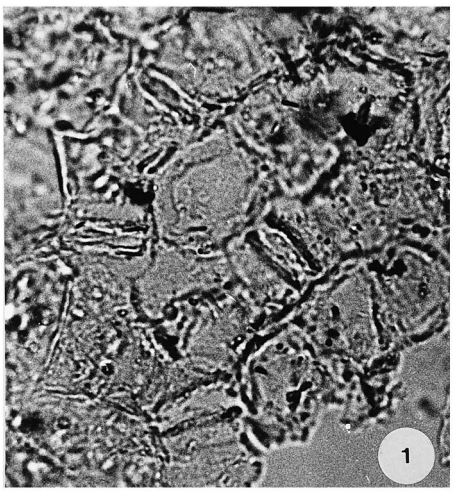
Cuticle: Cells penta–hexagonal, isodiametric with straight walls. Stomata brachyparacytic, with striations over the accessory cells; length 25–35 μm, width ca. 25 μm. This material can be compared with leaves of *Populus*, but the material does not allow for a detailed identification.
Ecology: Populus is a tree of the floodplain forest on humid, but rather well-drained soils; unit 5.

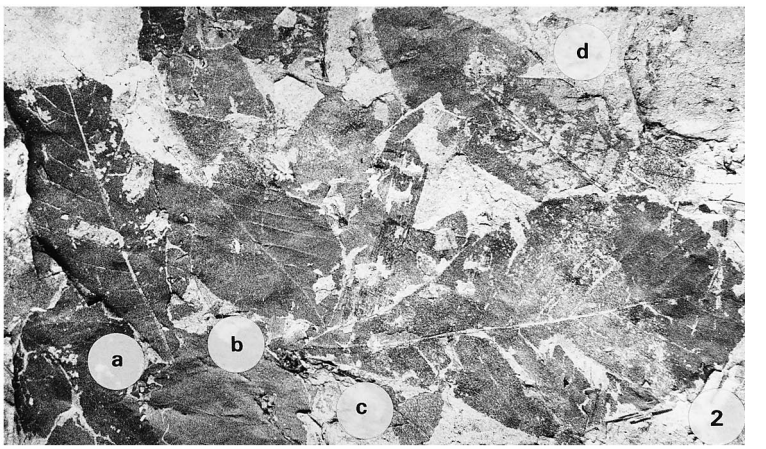
Populus alba L. leaf (Plate V, 3, 4)

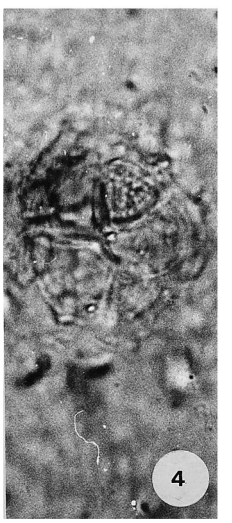
Material studied: peel no. 164.
Remarks: A fragment of a leaf with actinodromous venation, but unidentifiable based on its gross morphology.

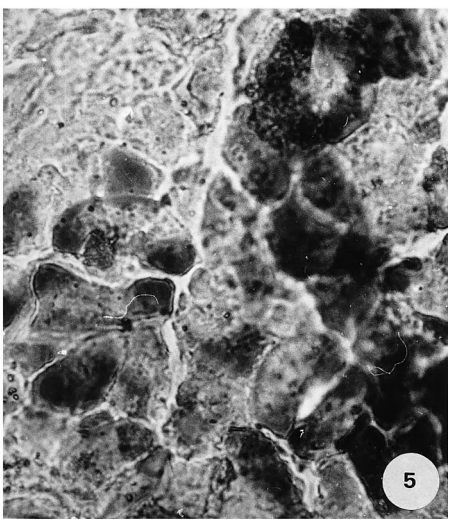
Cuticle: upper cuticle consisting of polygonal cells with sinuate walls, ca. 25–35 μm in diameter. Lower cuticle: folded, but cells still visible. These are irregular, isodiametric to elongate polygonal cells with sinuate walls. Diameter 15–25 μm.

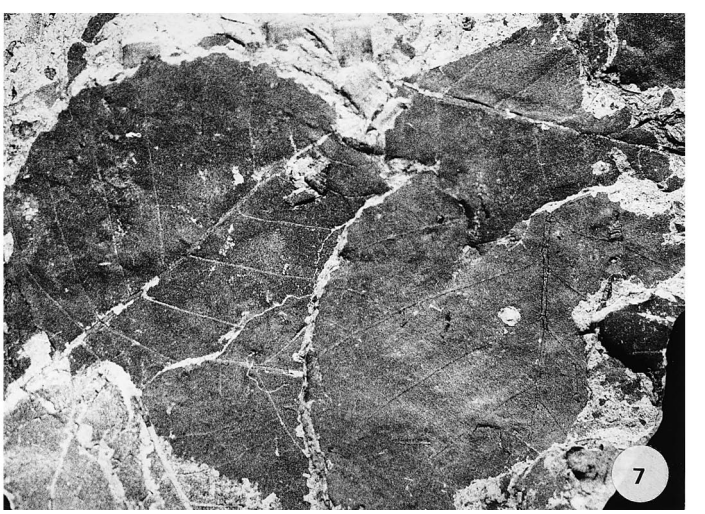
PLATE IV











Stomata brachyparacytic, with striae over the accessory cells; length 28–35 μm, width 15–20 μm. Stomatal slit 26–33 μm long, narrowed at the extremities. Guard cells with a thickened inner wall. This cuticle matches that of *P. alba* so that the material can be assigned to this species.
Ecology: P. alba requires a lime-rich, humid soil, which only dries out superficially during the growing season; unit 5.

Potamogeton sp. endocarps

Material studied: coll. no. 14132, 14149, 14375, 14376, 14377, 14378, 14379, 14385, 17646, 17647, 17648, 18170.
Remark: The material is abraded and can only be identified to the generic level.
Ecology: All *Potamogeton* spp. prefer open water biotopes; unit 1.

Proserpinaca reticulata Reid et Reid fruits

Material studied: coll. no. 14149, 14377, 14379, 14381, 14383, 17646, 17647, 18170.
Ecology: The American relative of this plant is known from Bald Cypress swamps in the southeastern USA; unit 3.

Prunus sp. endocarps

Material studied: coll. no. 17646, 18170.
Remark: This material could only be identified to the generic level.
Ecology: The genus is an inhabitant of several types of forest vegetation, ranging from wet to humid forest and from thick forest to scrub, units 4–7.

PLATE IV

1. *Acer tricuspidatum* Bronn ssp. *lusaticum* Walther; cuticle preparation 1950; stomatal face. ×650.
2. *Aesculus hippocastanum* L. (a–c); *Pterocarya paradisiaca* Iljinskaja (d); specimen 12640. ×0.5.
3. *Alnus incana* Moench; specimen 12673. ×2.
4. *Alnus incana* Moench; glandular trichome; cuticle preparation 3020. ×650.
5. *Alnus incana* Moench; cuticle preparation 3020; stomatal face. ×650.
6. *Sparganium* sp.; cuticle preparation 3014; stoma. ×650.
7. *Alnus cecropiaefolia* (Ettingshausen) Berger; specimen 17960. ×1.

Prunus spinosa L. endocarps

Material studied: coll. no. 14149, 14378, 14379.
Ecology: This species grows on dry to rather wet, alkaline to slightly acidic soils, in sunny places. This and the material of *Prunus* sp. are here considered to originate from more inland habitats as they certainly were woody plants; unit 4.

Pterocarya limburgensis Reid et Reid endocarps

Material studied: coll. no. 14132, 14149, 14376, 14378, 14379, 14380, 14381, 14382, 14383, 14384, 14385, 14386, 17646, 17647, 17648, 18169, 18170.

Pterocarya paradisiaca (Unger) Iljinskaja leaves (Plate IV, 2)

Material studied: coll. no. 12640, 12643, 12647, 12658, 12663, 12679, 17951, 17956.
Ecology: As this genus is known to thrive under wet conditions, inhabiting swampy sites, it is considered to be a plant of the wetland forest; unit 3.

Quercus pseudocastanea Goeppert leaves

Material studied: coll. no. 12644, 12654.
Ecology: The nearest living relative is *Quercus petraea* (Mattuschka) Liebl. This is a tree of rather acidic loamy soils. It requires a rather humid atmosphere; unit 6.

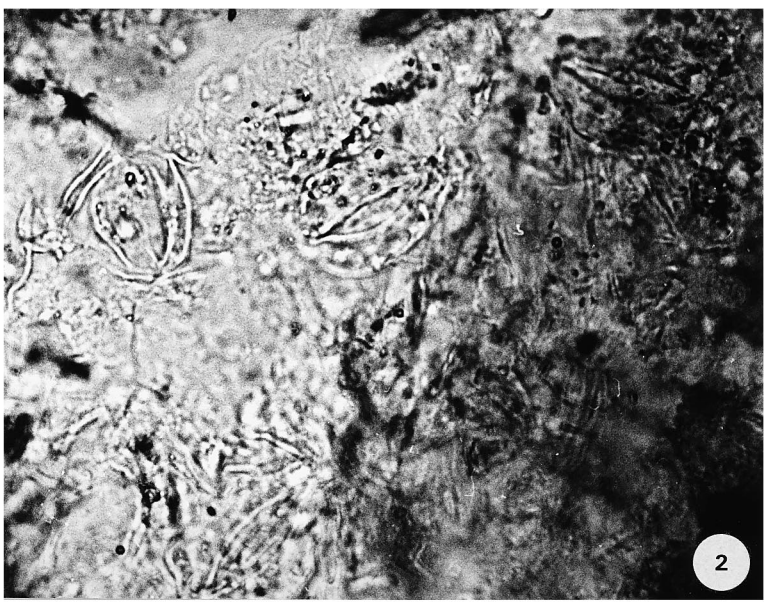
Ranunculus repens L. (Plate II, 6), fruits

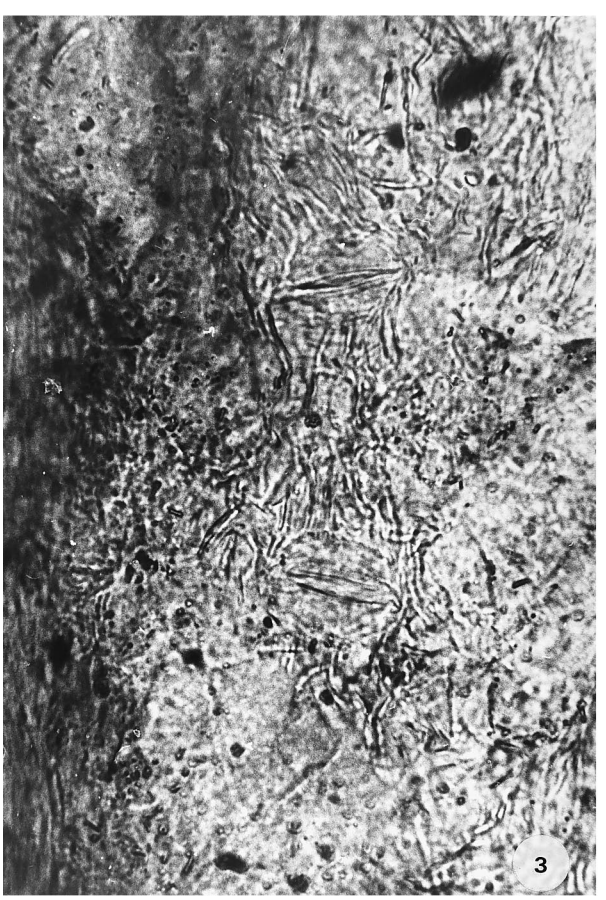
Material studied: coll. no. 18170.
Remarks: The material consists of thick-walled, flattened broadly oval fruits with a thickened margin. The surface structure is reticulate, formed by numerous small pits. The measurements are: length 2–3 mm; width 1.5–1.8 mm. These fruits are similar to those of recent *Ranunculus repens* and agree also with the description by Mai and Walther (1988).
Ecology: This plant prefers alternating water levels, and grows in very different vegetations but flowers only in a sunny position. It prefers streamside vegetation and willow floodplain forest; units 2–5.

Rubus fruticosus L. endocarps (Plate II, 7, 8)

Material studied: coll. no. 14149, 14378, 14379, 14380, 14381, 14382, 14383, 14384, 14385, 14386, 17646, 17648, 18169, 18170.

PLATE V





Remarks: These endocarps are flattened and the reticulum is rather coarse and deep. The measurements are: length 2–2.5 mm, width 0.6–1.5 mm. They can be partly identified as *R. polevskoyanus* Dorofeev (Dorofeev, 1970; Mai and Walther, 1988), partly as *R. fruticosus*, partly as neither of these. As it is clear, that it is impossible to decide between these species, the material is described as *R. fruticosus*, while this is already an aggregate species.
Ecology: this species prefers a rather nitrogen-poor, acidic soil, preferably in forest; units 3–7.

Rumex sp. fruits (Plate III, 7)

Material studied: coll. no. 14383, 18169.
Remarks: These are small, triangular nuts with remains of the perianth still adhering. They can be compared with *Rumex*, but a specific identification is as yet impossible.

Sagittaria sagittifolia L. seeds (Plate III, 4, 5)

Material studied: coll. no. 18169, 18170.
Remarks: The U shaped seedcoats of this species are similar to those of *Alisma plantago-aquatica* but differ in their size. They are over 2 mm long and the two straight parts are of unequal length. They are comparable to those of *Sagittaria sagittifolia* L. and agree with the description in Mai and Walther (1988).
Ecology: These plants are standing in water all year round, up to a depth of 1 m; the water may be stagnant or flowing, carbonate-rich, rather nutrient-rich on mineral soil; unit 2.

Salix sp. seeds (Plate II, 14, 15)

Material studied: coll. no. 18170.
Remarks: These are tiny elliptical to oval seeds with a cellular surface pattern. They show a thin, not very clear raphesinus. They show some resemblance with *S. repens* L.

Salix varians Goeppert leaves (Plate VI, 1, 2)

Material studied: coll. no. 12651.
Remarks: A fragment of a leaf, 2 cm wide and 4.5–5 cm long, the apex and base missing. The basal part is cuneate, the shape is oblong, margin serrate, venation camptodromous, angle of secondaries to primary sharp, secondaries numerous, straight, intersecondaries present.

Leaf amphistomatic, epidermis cells isodiametric pentagonal, with straight walls, diameter 30–40 μm. Over the wider veins the epidermal cells are elongate and striate. Between them some hair bases are present: small thick walled cells with a diameter of 20–24 μm. The stomata are brachyparacytic, the guard cells are 32–44 μm long and ca. 12 μm wide; the stomatal slit is ca. 8 μm wide and up to 28 μm long. This material is comparable with that described by Mai and Walther (1988) and Belz (1992) as *Salix varians*.
Ecology: Salix is common in the regularly inundated lower parts of well-drained floodplains; the genus being able to withstand rather strong currents; unit 5.

Salvinia sp. macrosori (Plate II, 10)

Material studied: coll. no. 14132, 14380, 14381, 14383.
Remarks: These are small flattened globular bodies enclosing remains of trilete macrospores. The sizes are 2–3 mm in diameter.
Ecology: This is a species covering nutrient-rich water bodies, occurring in oxbow lakes and other quiet places, often between reeds; unit 1.

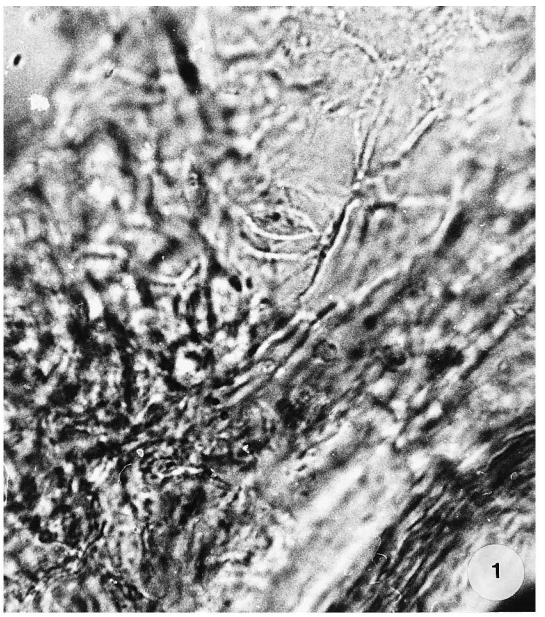
Sambucus pulchella Reid et Reid seeds (Plate III, 8)

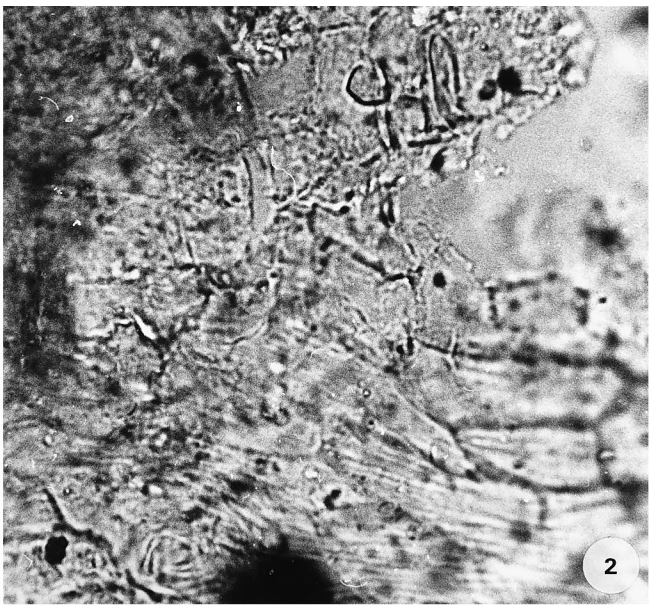
Material studied: coll. no. 14149, 14385, 14386, 17646.
Remarks: These are small, black elliptical seeds with transverse wrinkles. Measurements: length 2–3 mm; breadth 1.2–1.5 mm. They agree with the descriptions by Reid and Reid (1915) and Mai and Walther (1988).
Ecology: Sambucus grows only on very nitrogen rich soils, the nitrogen derived either from flotsam or

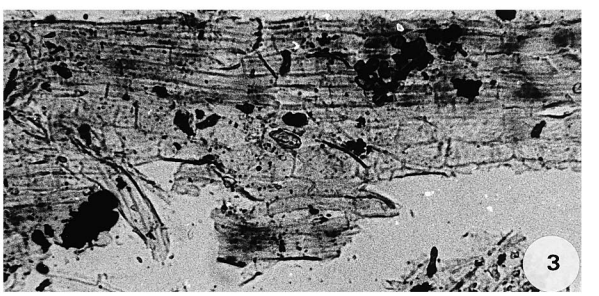
PLATE V

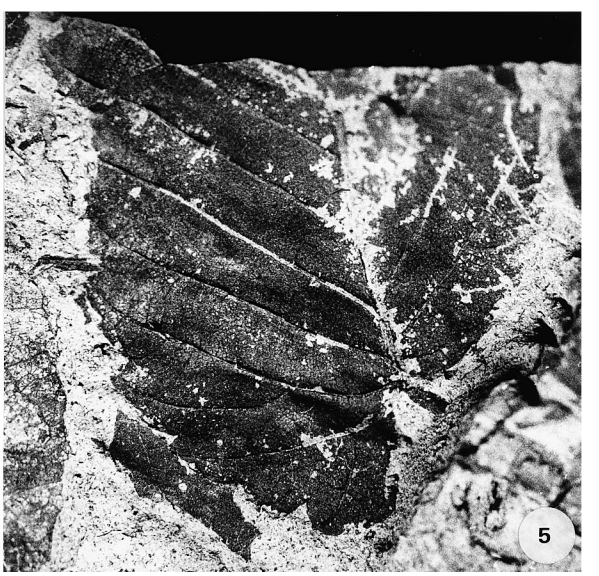
1. *Betula subpubescens* Goeppert; specimen no. 12678. ×1.5.
2. *Populus* sp.; cuticle preparation 3036; stomatal face. ×650.
3, 4. *Populus alba* L.; cuticle preparation 1202; stomatal face.
4. Folds suggesting cellular pattern. ×650.

PLATE VI









other organic source. The plant only flowers profusely in sunny positions. The absence from the samples with remains from as well allochthonous as autochthonous vegetations and the presence in pure alder wetland forest indicates, that the species was an integral part of the alder wetland forest; units 3–5.

Scindapsites crassus (Reid et Reid) Gregor et Bogner seed

Material studied: coll. no. 14383.
Ecology: This genus is so far known as a plant from wet herbaceous vegetations; unit 2.

Scirpus melanospermus C.A. Meyer fruits

Material studied: coll. no. 14375, 14376, 14377, 14380, 14381, 14382, 14383, 14385, 14386, 17646, 17648, 18170.
Ecology: This species grows on inundated nutrient-rich, alkaline soils along streamsides of stagnant or sluggish streaming water; unit 2.

Scirpus pliocenicus Szafer fruits

Material studied: coll. no. 14149, 14375, 14377, 14378, 14379, 14380, 14381, 14382, 14383, 14385, 17646, 17648, 18170.
Ecology: Scirpus generally is a genus of moist places with herbaceous vegetation and therefore this species is considered a member of such reed vegetation; unit 2.

Scirpus sp. fruit

Material studied: coll. no. 17647.
Remark: This material could only be determined to the generic level.
Ecology: See the foregoing species; unit 2.

PLATE VI

1, 2. *Salix varians* Goeppert; cuticle preparation 2954.
1. Stoma.
2. Striation. ×650.
3. *Sparganium* sp.; bands of different cells; cuticle preparation 3014. ×160.
4. *Alnus incana* Moench (a); *Populus* sp.(b); *Ulmus carpinoides* Goeppert (c); specimen no. 12677. ×0.7.
5. *Ulmus carpinoides* Goeppert; specimen no. 17955. ×2.

Scirpus tabernaemontani C. Gmelin fruits

Material studied: coll. no. 14149, 17646, 18170.
Ecology: This is a pioneer on the border between open water and streamside vegetation; it can withstand rather salinic situations; unit 2.

Solanum dulcamara L. seeds (Plate III, 2)

Material studied: coll. no. 14378, 14379.
Remarks: The campylotropous seeds agree with those of *Solanum dulcamara* in shape, size and reticular surface sculpture.
Ecology: This species requires a nutrient-rich and carbonate-rich, wet to dry soil. It is an inhabitant of streamsides and forest borders (of alder forest in particular); however, the complete absence of the species in the pure alder wetland forest points to a restriction of the species to more open sites; unit 2.

Sorbus aucuparia L. seeds

Material studied: coll. no. 14132, 14378, 14379, 14381, 14383, 14384, 14385.
Ecology: At present this tree grows on dry to rather wet, acidic, nutrient-poor soil, fruiting best in sunny position; its presence in assemblages of the pure alder wetland forest points to its presence in this type of vegetation; units 3, 4.

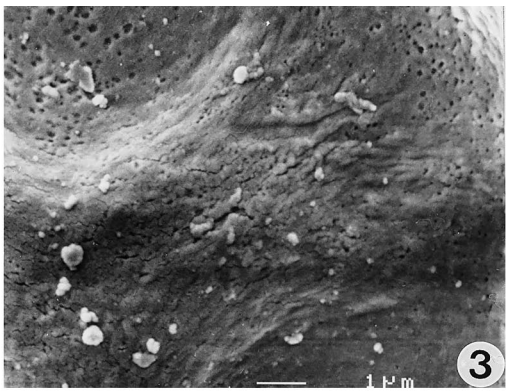
Sparganium neglectum Beeby endocarps (Plate II, 16, 17)

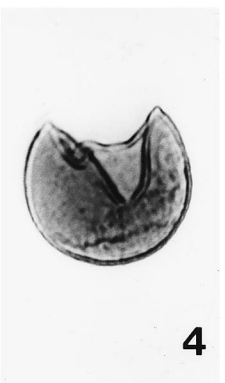
Material studied: coll. no. 14375, 14377, 14378, 14379, 17646, 17647, 17648, 18169, 18170.
Remarks: The endocarps of this species, 2.8–3.5 mm long and 1.5–2.2 mm wide, have a very coarse surface with several wide longitudinal ribs. At the base is a circular groove, at the truncate apex sometimes a small, pointed stylar base is to be observed. They agree with the description of Mai and Walther (1988).
Ecology: This plant grows in shallow water in reed and streamside vegetations; unit 2.

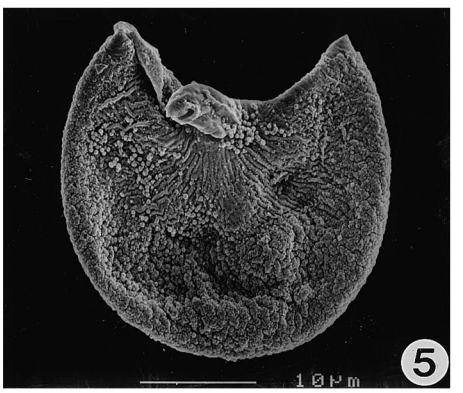
Sparganium noduliferum Reid et Reid endocarps

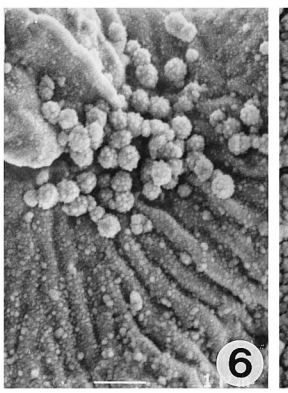
Material studied: coll. no. 14149.
Ecology: See the foregoing species; unit 2.

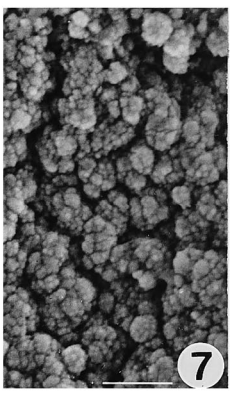
PLATE VII

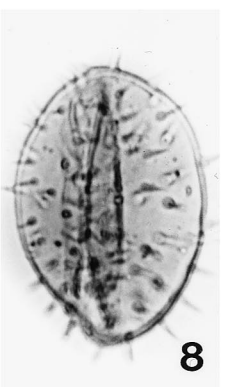


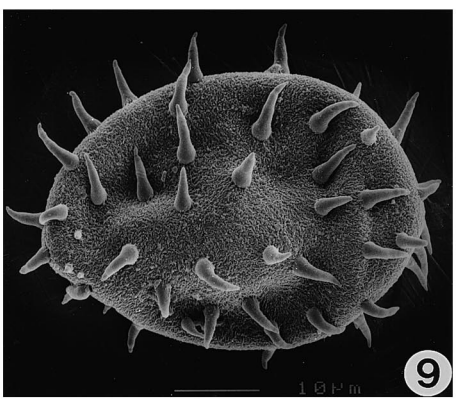


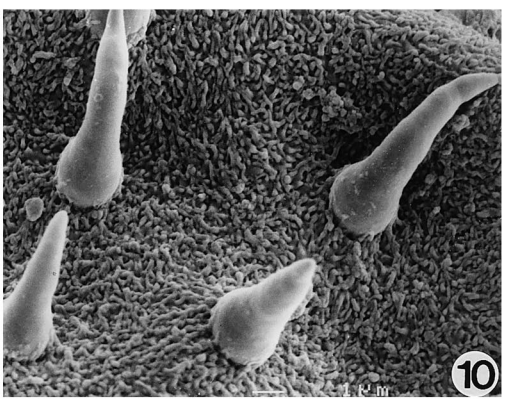


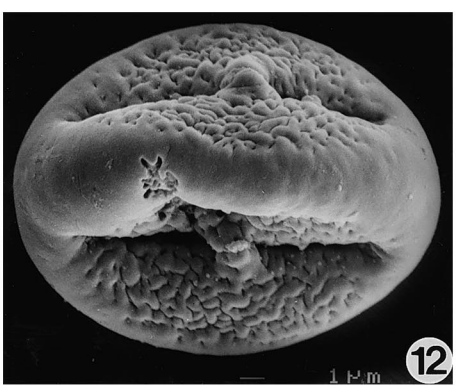


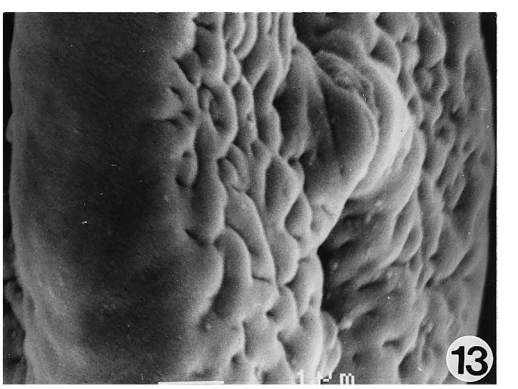












Sparganium sp. leaves (Plate IV, 6; Plate VI, 3)

Material studied: coll. no. 12670, 12675, 12682, 12687, 12698, 12700, 17949, 17962, 17968.
Remarks: Ribbon-like up to 2 cm wide fragments of leaves with parallel venation. Thick veins ca. 2 mm apart, in between several regularly spaced thinner veins present; length unknown.

Cuticle: Cells over the veins narrow elongate, with rather thick walls; in between strips of about three cells wide, cells thin walled, slightly irregular rectangular, 40–50 μm long and 15–20 μm wide. In these strips of irregular thinwalled cells longitudinally orientated stomata present; these are 35–38 μm long and ca. 15 μm wide. This material can be compared with leaves and cuticle of *Sparganium*. However, the material and preservation did not allow a more detailed description, so no specific identification was possible.

Spirematospermum wetzleri (Heer) Chandler seeds

Material studied: coll. no. 14132, 14149, 14380, 14381, 14382, 14383, 14385, 14386, 17646, 17648.
Ecology: The Recent relatives of this extinct plant are plants of herbaceous streamside vegetation in tropical Asia; unit 2.

Stachys palustris L. fruits (Plate II, 11)

Material studied: coll. no. 14132, 14377, 14378, 14379, 14380, 14382, 17647, 18170.

PLATE VII

1–3. *Sphagnum* sp.
1. Polar view, LM. ×850.
2. Polar view, SEM. ×1400.
3. Sculpturing, SEM. ×6500.
4–7. *Glyptostrobus* sp.
4. Equatorial view, LM. ×850.
5. Equatorial view, SEM. ×1500.
6. Sculpturing near the aperture, SEM. ×7000.
7. Sculpturing of the equatorial area, SEM. ×9000.
8–10. *Nuphar* sp.
8. Polar view (distal), LM. ×850.
9. Polar view (proxumal), SEM. ×1150.
10. Sculpturing of the polar area, SEM. ×4000.
11–13. *Decodon* sp.
11. Equatorial view, LM. ×850.
12. Equatorial view, SEM. ×3000.
13. Sculpturing of mesocolpium, SEM. ×8500.

Remarks: The nuts are rather wide and obovate in shape, with a convex outer side, and displaying a large hilum proximally. The nuts are 1.6–2.2 mm in length and 1.2–1.5 mm in width. They are comparable with recent material of the species and with the description of Mai and Walther (1988).
Ecology: This species grows in reed vegetations on a nutrient-rich, humic, neutral to acidic wet soil; unit 2.

Stratiotes tuberculatus E.M. Reid seeds

Material studied: coll. no. 14149, 14375.
Ecology: This is a plant of very quiet circumstances in open highly eutrophic water, which is alkaline to slightly acidic; unit 1.

Taxodium dubium (Sternberg) Heer seed

Material studied: coll. no. 14132.
Ecology: The American relatives of this *Taxodium* grow on very wet soils with permanently abundant moisture. The soils themselves are rather nutrient-rich and vary from alkaline to acidic; unit 3.

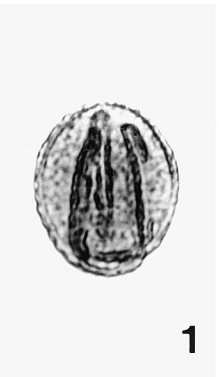
Thalictrum lucidum L. fruits (Plate III, 6)

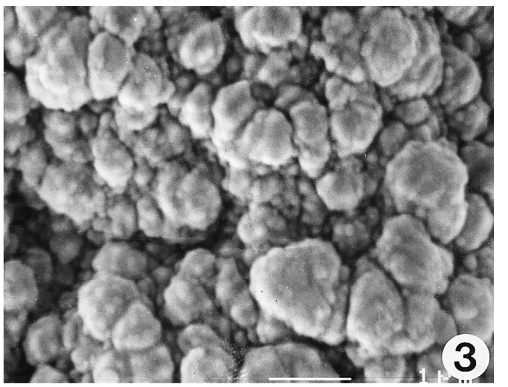
Material studied: coll. no. 17647, 18169.
Remarks: Compressed oval fruits 2–2.5 mm in length with several longitudinal ribs. They are comparable with those of recent *T. lucidum*.
Ecology: This herb is a plant of floodplain forest and scrub on wet, alkaline and nutrient-rich soil; units 3, 5.

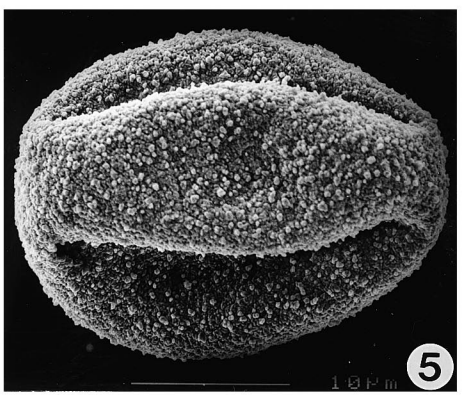
Typha latifolia L. seeds (Plate III, 1, 3)

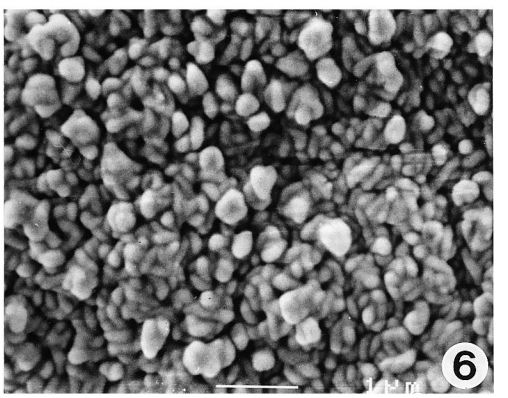
Material studied: coll. no. 14382, 18170.
Remarks: These are very small, narrowly oval seed coats with a circular germination valve at the truncated apex, showing a distinct lustre. The cellular pattern consists of oblong cells with straight walls. The measurements are: ca. 1 mm in length, ca. 0.3 mm in width. They are identical to those of recent *T. latifolia* and are also in agreement with the description of this species by Mai and Walther, 1988.
Ecology: This is a plant of shallow to rather deep water, thriving in localities with contrasting circumstances, it does not stand up to strong wave action, but prefers quiet places with a muddy soil. The habitat must be rich in nutrients; unit 2.

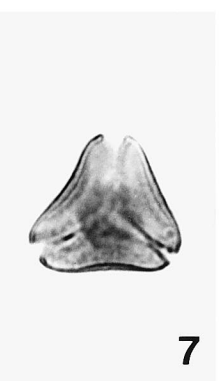
PLATE VIII

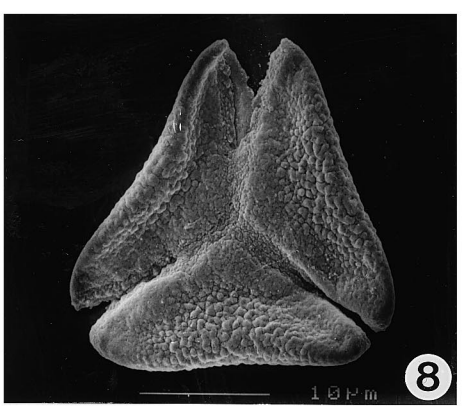


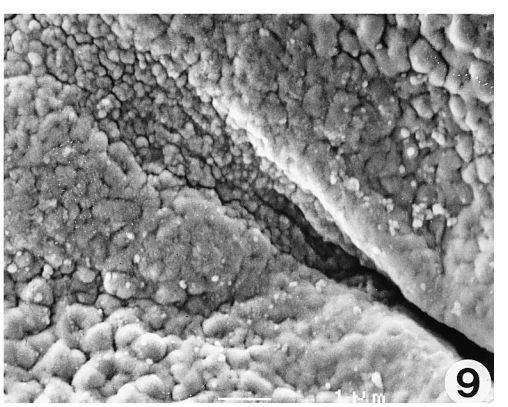


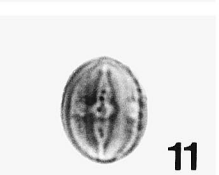


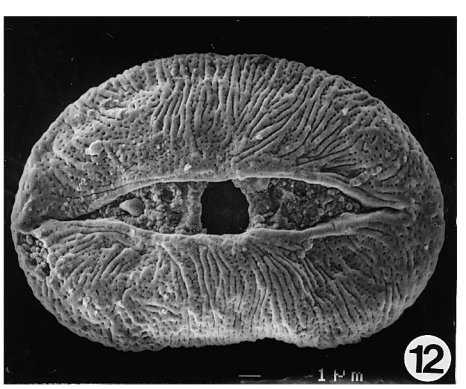


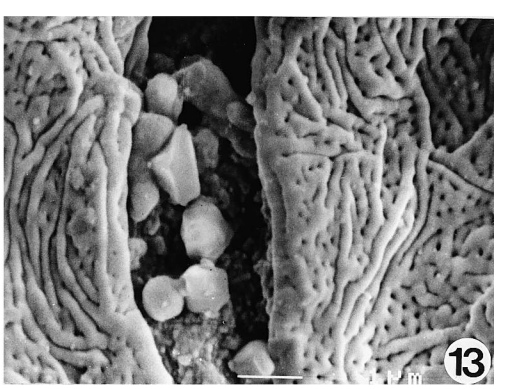












Ulmus pyramidalis Goeppert, leaves (Plate VI, 4a, 5)

Material studied: coll. no. 12653, 12654, 12656, 12677, 12689, 17950, 17953, 17955.
Remarks: Leaves ovate, base asymmetrical cordate, apex acute, shape oval, margin bidentate, petiole not observed. Venation medium thick to thin, craspedodromous with ca. 13 secondaries per side; secondaries straight, rather densely spaced (2–3 mm apart), angle to primary vein variable, decreasing towards the apex; intersecondaries sometimes present.

Cuticle thin, stomata hardly discernable, ca. 20 μm long; 10–12 μm wide; apparently anomocytic; restricted to areoli. The material is comparable with that described by Belz (1992) as *Ulmus pyramidalis*.
Ecology: This tree requires a habitat with a damp soil which only dries out superficially in the growing season. It thrives in places with a good drainage, which may be inundated for a short period during winter; unit 5.

Urtica dubia Forskøl seeds (Plate II, 18, 19)

Material studied: coll. no. 14375, 14378, 14379, 14380, 14381, 14382, 14383, 18169, 18170.
Remarks: the material consists of flattened, small seeds sometimes with a wrinkled surface. The seeds are oval, the apex is acute with remains of the style still present, the base is rounded. Measurements: length 1–1.3 mm, width 0.7–0.9 mm. They are comparable to those of *U. dubia* (frequently cited as *U. membranacea*).
Ecology: This annual species is a member of the Mediterranean flora, growing on walls or in humic and/or shaded circumstances; units 2, 3.

Urtica urens L. seeds (Plate II, 12)

Material studied: coll. no. 14132, 14383, 17647, 18169, 18170.
Remarks: These fruits are bigger than those of the foregoing species; size ca. 1.5 mm in length by ca. 1 mm in width, the base is rounded and the surface dull, punctate. They are comparable to those of recent *U. urens* and the description of it by Mai and Walther (1988).
Ecology: This is a plant of perturbed, ammonia-rich soils, it prefers a sunny position and might have been an inhabitant of alluvial soils near watering places; unit 2.

Viola palustris L. seeds

Material studied: coll. no. 14378.
Ecology: V. palustris is typical for damp to wet, acidic, rather nutrient-poor, sandy peat or peaty soils. It grows very often in the company of *Carex nigra*; unit 9.

Vitis sylvestris C. Gmelin seeds (Plate II, 9, 13)

Material studied: coll. no. 14149, 14378, 14379, 14380, 14381, 14383, 17646, 17647, 18170.
Remarks: This material is very like that described by the author as *V. teutonica*. It is also similar to material described as *V. sylvestris* by Reid and Reid (1907, 1915), and Mai and Walther (1988).
Ecology: This species is a liana from floodplain forest, also occurring in forest border communities. It grows on well drained, humid, alkaline and nutrient-rich mineral soils; units 4, 5.

The ecological composition tables and histograms (Tables A1–A20; Figs. 2–4) were constructed with help of the ecological data listed above.

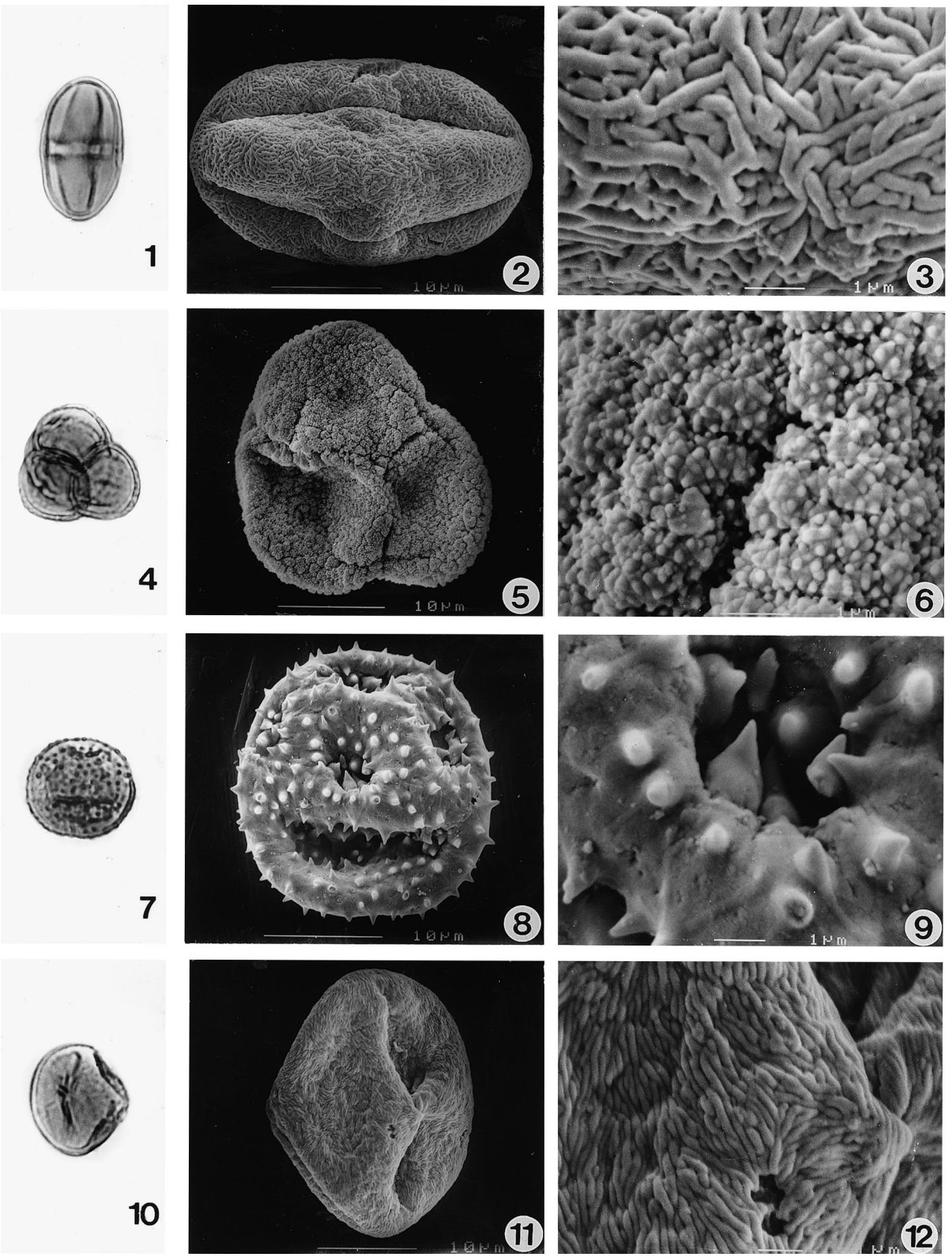
3. The palynological assemblage

The present account represents the preliminary results of a palynological investigation based on material from the leaf horizon at the base of the upper

PLATE VIII

1–3. *Quercus* sp.1.
1. Equatorial view, LM. ×850.
2. Equatorial view, SEM. ×1700.
3. Sculpturing, SEM. ×10000.
4–6. *Quercus* sp.2.
4. Equatorial view, LM. ×850.
5. Equatorial view, SEM. ×2100.
6. Sculpturing, SEM. ×10000.
7–9. *Loranthus* sp.
7. Polar view, LM. ×850.
8. Polar view, SEM. ×1700
9. Sculpturing, SEM. ×7000.
10–13. *Aesculus* sp.
10. Equatorial view, LM. ×850.
11. Equatorial view, LM. ×850.
12. Equatorial view, SEM. ×2500.
13. Colpus with spinulae and striate mesocolpium, SEM. ×8500.

PLATE IX



clay bed (9 C). The assemblage can therefore be directly compared with the macrofossil assemblages. The complete list of genera is included in Table 1. What follows is an account of a number of the more noteworthy taxa encountered in the clay sediments.

Aesculus sp. (Plate VIII, 10–13)

Remarks: Pollen grains subprolate or prolate, elliptical in equatorial view (P = 15–20 μm, E = 11–13 μm). Tricolporate, colpi with acute apices and a characteristic widening towards the equator as well as a small margo; membranes of the colpi covered with prominent angular spinules (1 μm), endopori circular or sometimes slightly lalongate, each surrounded by a costa. Exine tectate, tectum perforate, ectexine thicker than the endexine. Sculpturing striate, striae in the mesocolpium perpendicular to the polar axis; between long striae frequently areas with short striae and perforations.
Ecology: See Section 2.

Apium sp. (Plate IX, 1–3)

Remarks: Pollen grains prolate, elliptical in equatorial view (P = 30–33 μm, E = 18–28 μm). Tricolporate with long ectocolpi and rectangular pori (endocolpi). Exine tectate, tectum perforate, ectexine thicker than the endexine, ectexine slightly thicker in the mesocolpia than in the polar regions. Sculpturing rugulate, elongate elements arranged in an irregular pattern.
Ecology: See Section 2.

PLATE IX

1–3. *Apium* sp.
1. Equatorial view, LM. ×850.
2. Equatorial view, SEM. ×1800.
3. Sculpturing of mesocolpium, SEM. ×10,000.
4–6. *Corema*/*Ceratiola* sp.
4. Tetrad, LM. ×850.
5. Tetrad (equatorial view), SEM. ×1750.
6. Sculpturing, SEM. ×11500.
7–9. *Sagittaria* sp.
7. LM. ×850.
8. SEM. ×2000.
9. Sculpturing around aperture, SEM. ×8500.
10–12. Rosaceae gen. et spec. indet.
10. Equatorial view, LM. ×850.
11. Equatorial view, SEM. ×1750.
12. Sculpturing of mesocolpium, SEM. ×7000.

Corema/*Ceratiola* sp. (Plate IX, 4–6)

Remarks: Pollen grains united in tetrahedral tetrads (25–29 μm), heteropolar, radially symmetrical. Tricolporate, colpi narrow, pori lalongate (slit-like). Exine tectate, tectum thin, footlayer thick, endexine thin. Exine subdivided into insular elements, which are dome-shaped in SEM. Sculpturing spinulose, spinules being of approximately similar size and shape. The pollen grains of *Corema* and *Ceratiola* display a similar sculpturing.
Ecology: These genera are frequent today on open sand ridges and oligotrophic soils; unit 8.

Decodon sp. (Plate VII, 11–13)

Remarks: Pollen grains subprolate, elliptical in equatorial view (P = 14–18 μm, E = 10–12 μm). Tricolporate, colpi frequently with obtuse apices, pori slightly lalongate. Exine tectate, rugulate or fossulate over a broad area around the apertures. Between these areas and in the polar regions the tectum is smooth, ectexine thicker than the endexine, especially so in the polar regions.
Ecology: See Section 2.

Glyptostrobus sp. (Plate VII, 4–7)

Remarks: Pollen grains inaperturate (E = 23–28 μm), heteropolar, with a prominent papilla, frequently split, especially in the distal polar region. Papilla (5–7 μm) slightly curved with an apical pore. Exine tectate, ectexine thicker than the endexine, although it is thinner and characterized by radiating ridges in the distal polar region. Sculpturing cauliflower-like in the proximal and equatorial regions, distal region covered by small particles of sporopollenin. Nanno-gemmae (<1 μm) are scattered over the surface especially in the distal area.
Ecology: See Section 2.

Loranthus sp. (Plate VIII, 7–9)

Remarks: Pollen grains oblate, triangular lobate in polar view (E = 24–28 μm). Syncolpate with three simple colpi fused in the polar area; costae colpi are present along the whole colpi. Exine tectate, ectexine thicker than the endexine, especially in the central mesocolpium areas. Sculpturing verrucate.
Ecology: This monotypic genus is parasitic on *Quercus* and *Castanea*; unit 6.

Table 1
Summary of the probable life forms, dispersal mechanisms and physiognomic signatures of the Hambach taxa based on the representation of the different plant parts in the assemblages. The number of crosses gives an indication of the frequency of the microfossils (x = present; xx = common; xxx = very common)

Family	Genus	Leaves	Pollen-spores	Diaspores	Primary dispersal mechanism	Life form	Deciduous/ evergreen	Leaf margin entire
BRYOPHYTES:								
Sphagnaceae	Sphagnum		x		wind	hydrophite		
FERNS								
Osmundaceae	*Osmunda*		x		wind	hemicryptophyte		
Polypodiaceae	gen. indet.		x		wind	geo-/hemicryptophyte		
Salviniaceae	*Azolla*		x		nautochory	hydrophyte		
	Salvinia		x		nautochory	hydrophyte		
GYMNOSPERMS								
Cupressaceae s.s.	*Chamaecyparis*			•	wind	phanerophyte	E	
Pinaceae	*Abies*		x		wind	phanerophyte	E	
	Picea		x		wind	phanerophyte	E	
	Pinus		xx(4)		wind	phanerophyte	E	
	Tsuga		x		wind	phanerophyte	E	
Sciadopityaceae	*Sciadopitys*		x		wind	phanerophyte	E	
Taxodiaceae s.s.	*Glyptostrobus*		x	•	wind	phanerophyte	D	
	Taxodium			•	wind	phanerophyte	D	
	gen. indet.		x		wind	phanerophyte	D/E	
ANGIOSPERMS								
DICOTYLEDONS:								
Aceraceae	*Acer*	●●●	x	•(2)	wind	phanerophyte	D	no
Actinidiaceae	*Actinidia*			•	endozoochory	phanerophyte-liana	D	rarely
Altingiaceae	*Liquidambar*		x		wind	phanerophyte	D	no
Apiaceae	*Apium*		x	●●●	endozoochory?	hemicryptophyte	H	H
(Umbelliferae)	*Oenanthe*			●●●	nautochory	hemicryptophyte	H	H
	gen. indet.		x		wind/endozoo-exozoochory	geophyte/hemicryptophyte/therophyte	H	H
Aquifoliaceae	*Ilex*		x		endozoochory	phanerophyte	D/E	yes/no
Asteraceae	*Artemisia*		x		wind/endozoo-exozoochory	chamae-hemicrypto-/therophyte	H	H
(Compositae)	*Cisium*		x	•	wind	hemicryptophyte	H	H
Betulaceae s.l.	*Alnus*	●●●●●(2)	xxx	●●●●●●	wind	phanerophyte	D	no
	Betula	●●	x	•	wind/endozoochory	phanerophyte	D	no
	Carpinus	●●●	x	••	wind	phanerophyte	D	no
Caprifoliaceae	*Sambucus*			•	endozoochory	phanerophyte	D	no
Ceratophyllaceae	*Ceratophyllum*			•	endozoo-/nautochory	hydrophyte	H	H
Chenopodiaceae	gen. indet.		x		wind/endozoo-/exozoo-/ nautochory	hemicrypto-/phanero-/therophyte	H	H
Empetraceae	*Corema/ Ceratiola*		x		endozoochory	chamaephyte	E	yes
Ericacaea	*Erica*		x		wind	chamaephyte	E	yes
	gen. indet.		xx(3)		wind/endozoochory	chamaephyte/phanerophyte	D/E	yes/no
Eucommiaceae	*Eucommia*		x	•	wind	phanerophyte	D	no
Euphorbiaceae	*Euphorbia*			•	autochory?/nautochory?	hemicryptophyte	H	H
Fagaceae	*Fagus*		x	•	dyschory	phanerophyte	D	yes/no
	Quercus	••	xx(2)		dyschory	phanerophyte	D	no
Haloragidaceae	*Proserpinaca*			•	endozoochory	hemicryptophyte	H	H
Hippocastanaceae	*Aesculus*	●●●●	x		dyschory	phanerophyte	D	no

Hypericaceae	*Hypericum*			•	auto-/endozoo-/exozoochory	chamae-/hemicrypto-/phanero-/therophyte	D/E	yes
Juglandaceae	*Carya*		x		dyschory	phanerophyte	D	no
	Pterocarya	●●●	x	●●●●	wind	phanerophyte	D	no
Lamiaceae	*Lycopus*			●●	endozoo-/nautochory	chamaephyte	H	H
(Labiatae)	*Stachys*			•	nautochory	geophyte	H	H
Lythraceae	*Decodon*		x	●●●●●	auto-/endozoo-/nautochory	hemicryptophyte	H	H
Magnoliaceae	*Liriodendron*			●●	wind	phanerophyte	D	yes
	Magnolia			•	endozoochory	phanerophyte	D/E	yes
Menyanthaeae	*Menyanthes*			•	endozoo-/nautochory	hydrophyte	H	H
Myricaceae	*Myrica*		x		endozoochory	phanerophyte	D/E	yes/no
Nelumbonaceae	*Nelumbo*			•	nautochory	hydrophyte	H	H
Nymphaeceae	*Nuphar*		x	●●	endozoo-/nautochory	hydrophyte	H	H
	Nymphaea		?	●●	endozoo-/nautochory	hydrophyte	H	H
Nyssaceae	*Nyssa*		x	•	endozoochory	phanerophyte	D	yes/no
Oleaceae	*Fraxinus*		x		wind	phanerophyte	D	yes/no
Platanaceae	*Platanus*		?		wind	phanerophyte	D	no
Polygonaeae	*Rumex*		x	•	wind/endozoo-/exozoo-/ myrmeco-/nautochory	chamae-/hemicrypto-/hydro-/therophyte	H	H
Ranunculaceae	*Ranunculus*			•	endozoo-/nautochory	hemicryptophyte	H	H
	Thalictrum			•	wind/endozoo-/nautochory	hemicryptophyte	H	H
Rosaceae s.l.	*Crataegus*			•	endozoochory	phanerophyte	D	no
	Prunus			●●(2)	endozoochory	phanerophyte	D	no
	Rubus			●●●	endozoochory	phanerophyte	D	no
	Sorbus			●●	endozoochory	phanerophyte	D	rarely
	gen. indet.		x		wind/endozoo-/exozoochory	chamae-/hemicrypto-/phanero-/therophyte	D/E	yes/no
Salicaceae	*Populus*	●●●(2)			wind	phanerophyte	D	no
	Salix	●●	x	●●	wind	phanerophyte	D	no
Solanaceae	*Solanum*			•	endozoochory	chamaephyte/phanerophyte-liana	D	yes
Tiliaceae	*Tilia*		x		wind	phanerophyte	D	no
Ulmaceae	*Ulmus*	●●●	x		wind	phanerophyte	D	no
	Zelkova		x		wind	phanerophyte	D	no
Urticaceae	*Boehmeria*			●●●	endozoo-/exozoochory	hemicryptophyte/phanerophyte	?	rarely
	Urtica		x	●●●(2)	endozoo-/myrmecochory	therophyte	H	H
Violaceae	*Viola*			•	auto-/endozoo-/nautochory	hemicryptophyte	H	H
Vitaceae	*Vitis*			●●	endozoochory	phanerophyte, mostly liana	D/E	no
MONOCOTYLEDONS:								
Alismataceae	*Alisma*			●●●	endozoo-/exozoo-/nautochory	hydrophyte		
	Caldesia			•	nautochory?	hydrophyte		
	Sagittaria		x	●●	endozoo-/nautochory	hydrophyte		
Araceae	*Scindapsites*†			•	endozoochory	geophyte?/hydrophyte?		
Cyperaceae	*Carex*			●●●●(12)	endozoo-/exozoo-/nautochory	geophyte/hemicryptophyte		
	Caricoidea†			•	endozoo-/nautochory	hemicryptophyte		
	Cladium			●●	endozoo-/exozoo-/nautochory	geophyte		
	Dulichium			●●●●(2)	endozoo-/exozoochory	hemicryptophyte		
	Eleocharis			•	endozoo-/nautochory	therophyte		
	Scirpus			●●●●(4)	endozoo-/exozoo-/nautochory	geophyte/hemicryptophyte		
	gen. indet.		x		endozoo-/exozoo-/nautochory	geo-/hemicrypto-/therophyte		
Hydrocharitaceae	*Stratiotes*			•	nautochory	hydrophyte		
Potamogetonaceae	*Potamogeton*			●●●	endozoo-/exozoo-/nautochory	hydrophyte		
Sparganiaceae	*Sparganium*	●●●●	x	●●(2)	endozoo-/nautochory	hydrophyte		
Typhaceae	*Typha*		x	●●●●	wind	hydrophyte		
????	*Spirematospermum*		x	●●	endozoochory	hemicryptophyte		

Nuphar sp. (Plate VII, 8–10)

Remarks: Pollen grains oblate, elliptical in equatorial view, heteropolar (P = 45–48 μm, E = 33–34 μm). Monosulcate, sulcus with obtuse apices. Exine tectate, ectexine thicker than the endexine, Sculpturing consisting of more or less densely woven short rod-like elements, sometimes free-ending, large spinae (5–8 μm) scattered over the whole surface.
Ecology: See Section 2.

Quercus sp. 1 (Plate VIII, 1–3)

Remarks: Pollen grains subprolate or prolate, elliptical in equatorial view (P = 28–32 μm, E = 23–25 μm), tricolporoidate. Exine tectate, tectum perforate, ectexine thicker than the endexine. Sculpturing consists of two tiers of sculpture elements, a basal tier of mall verrucae with irregularly shaped verrucae (±1 μm diameter) in between.
Ecology: The micromorphology of the pollen grains resembles those of deciduous, roburoid oaks, unit 6.

Quercus sp. 2 (Plate VIII, 4–6)

Remarks: Pollen grains prolate, elliptical in equatorial view, the polar regions frequently flattened (P = 26–29 μm, E = 20–23 μm), tricolporoidate. Exine tectate, tectum perforate, ectexine thicker than the endexine. Sculpturing consists of two tiers of sculpture elements, a basal tier of short rod-like elements, with irregularly scattered microverrucae.
Ecology: See *Quercus* sp. 1.

Rosaceae gen. et spec. indet. (Plate IX, 10–12)

Remarks: Pollen grains subprolate or prolate, elliptical or rhomboidal obtuse in equatorial view (P = 24–26 μm, E = 20–23 μm). Tricolporate, colpi long, constricted at the equator, where the ectexine arches over endexine, pori small, aperture covered by an operculum. Exine tectate, tectum perforate, ectexine thicker than the endexine. Sculpturing consists of gently undulate surface covered by striae of different lengths, sometimes interwoven.
Ecology: Until these pollen grains are more accurately identified, the ecological signal will remain uncertain.

Sagittaria sp. (Plate IX, 7–9)

Remarks: Pollen grains spheroidal (E = 18–21 μm. Pantoporate, 12 pori situated in slightly sunken areas, pore membranes covered by 4–6 spinulae. Exine tectate, tectum with small perforations, ectexine thicker than endexine. Sculpturing consists of regularly arranged spinulae.
Ecology: See Section 2.

Sphagnum sp. (Plate VII, 1–3)

Remarks: Spores triangular obtuse (subtriangular), with convex sides (E = 30–35 μm) heteropolar, trilete mark with rather short laesurae, their extremities giving rise to radiating ridges extending to the spore margin. Spore wall two-layered, outer layer with more or less smooth sculpturing, which may be due to the loss of the outermost coat.
Ecology: Moist forests and open habitats in oligotrophic environments, units 2, 3, 9.

4. Discussion

It is possible to draw a number of interesting conclusions from a comparison of the megafossil and microfossil assemblages (see Table 1). On the one hand, the dominance of *Alnus* in the leaf- and diaspore assemblages, which is taken as evidence of an alder carr, is corroborated by the pollen record. Likewise, plants of reed and streamside vegetation are found in both the megafossil and microfossil assemblages. On the other hand, a number of qualitative and quantitative differences are apparent. Thus 56% of the seed plant families are only represented by either leaves/diaspores or pollen. This could mean any of a number of things (Ferguson, 1995), e.g. (1) the dispersed organs are not all easily identified, (2) the plant parts display different potentials for fossilization, or (3) some of the plants did not grow close to the depositional area. The spheroidal, inaperturate pollen of Cupressaceae is difficult to differentiate from those of a number of other gymnosperms. On the other hand, *Populus* and Magnoliaceae pollen and those of many aquatic plants do not fossilize well. However, these two factors are not responsible for all the differences. The better representation in the pollen record of broad-leaved trees requiring good drainage point to an extra-local origin for (some of) these elements (Potter, 1976). This could explain why *Quercus* is qualitatively and quantitatively better rep-

resented in the pollen record. However, judging from the presence of *Tilia* pollen, which is poorly dispersed (Keatinge, 1982), these trees were probably growing on hammocks not far from the site of deposition. The lack of any megafossils of the Pinaceae, which also prefer well-drained sites, is noteworthy. As abscised cones and needles of the Pinaceae are only found close to their source, these would have little chance of being incorporated into the clastic sediments if the parent plants were growing on dunes. Pollen of the Empetraceae and Ericaceae could indicate that these shrubs played a part in the undergrowth of such pinewoods. On the other hand they could imply a certain amount of heathland vegetation. There is no sign of this in the megafossil record.

The section through the 9 C clay bed (Table 2, samples g–o, 14378–14386) reveals a difference between the lower three samples and the uppermost six samples (Fig. 2.) The samples g–i show a strictly local taphocoenosis of only 19 taxa. In these the species mostly occurring in wetland forest are dominant. In the upper part of the sequence, the flora is much more diverse. In addition to the species of the alder forest, several species of open grassland and especially reed marsh are present; one species has disappeared: *Sambucus pulchella*. Moreover a number of species from 'floodplain forest' and even 'upland forest' are present. The sediment is more silty, the macroscopical remains are scarce and in the uppermost sample (Table 2, o, 14378) the matrix is a sandy clay. Based on this a drowning of the site resulting in wetter conditions with a more open vegetation is postulated. The vegetation consisted of a mosaic of alder forest and reedmarsh. In this situation the river had easier access to the site and this resulted in the presence of several allochthonous floral elements. The uppermost two samples show the strongest allochthonous influence (greatest number of vegetational units represented).

Furthermore, a slight reversion in the vegetational development is visible in sample 14382, resulting in a drier phase with codominance between 'wetland forest' and 'reedland vegetation'.

This transition from a strictly local flora to a more diverse, allochthonously influenced one enables us to unravel the ecology of the individual taxa. From their presence in the alder forest, it is clear that *Actinidia faveolata, Sambucus pulchella,* and *Sorbus aucuparia* were inhabitants of the alder forest. Another interesting thing is that, based on their recent ecology, *Carex cespitosa, Solanum dulcamara* and *Urtica dubia* would be expected to be present in the alder forest, However, although regularly present in the section, they were absent from the pure alder forest.

The presence of *Spirematospermum wetzleri* in pure alder forest as well as in somewhat more open habitats, together with larger numbers in these open reedland vegetation units points to an ecology, which centers on open reedmarsh vegetation.

The carpological assemblages from samples of the base of the 9 C clay bed (nos. 14132, 17647, 17648, Table 2, b–d) agree most with the assemblages of the middle part of the section (Fig. 3). Once again the reedland vegetation dominated, although accompanied by some elements from floodplain forest (*Vitis sylvestris, Acer* sp., *Carpinus betulus*). So, despite the strongly autochthonous signature of these samples, one must conclude that these samples represent a more open vegetation.

The carpological assemblages of the top of the 9 C clay bed (nos. 14375, 14376, 14377, 17646, Table 2, r–u) display the best agreement with those from the top of the section, being much more diverse and in some cases strongly allochthonously influenced (Fig. 3).

The assemblage from the channel deposit (sample 14149) (Table 2, w) just below the onset of the Upper Brunssumian basal clay deposit shows a typical spectrum of an allochthonous assemblage: several (6) vegetation units are represented, and although vegetation units 2 and 3 (streamside vegetation and wetland-forest) dominate the sample, their dominance is not very great. The material contains some typical allochthonous influences, not found in the overlying clay bed, e.g. *Glyptostrobus europaeus, Eucommia europaea, Nyssa disseminata, Sparganium noduliferum* (Fig. 3).

The carpological assemblage from the 1982 leaf bed (sample 18169) closely resembles the carpocoenoses collected from the middle part of the section through the 9 C clay bed, although 'Floodplain forest' is not present in sample 18169 (Fig. 2). Once again local vegetation dominated. The similarity to the samples with only local vegetation in the lower part of the 1983 section (samples 14386–14384) is less marked, while our material contains many more

Table 2
Comparison between local assemblages (a–d), alder forest/reed vegetation succession (g–o) and allochthonously influenced reed vegetation assemblages (r–w); for this table only taxa, occurring in more than one sample are taken into account

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Sambucus pulchella	.	.	.	.	.	x	x	x	.	.	.	.	.	.	.	.	x	.	.	.	x	.	x
Actinidia faveolata	.	.	.	.	.	x	x	x	x	x	x	.	.	.	x	x	x	x	.	.	x	.	x
Alisma plantago–aquatica	.	x	.	x	x	x	x	.	.	x	x	x	x	x	x	x	x	x	.	.	x	x	x
Alnus tanaitica	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Apium repens	.	x	x	x	x	x	x	.	.	x	.	x	x	x	x	x	x	x	x	x	.	x	.
Carex elongatoides	.	.	.	x	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.
Carex flavaeformis	.	.	.	x	x	x	.	x	.	.	.	.	x	x	.	x	x	x	.	.	x	.	.
Decodon globosum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dulichium spathaceum	x	x	x	x	x	x	.	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Nuphar luteum	.	x	.	.	x	x	.	x	x	x	x	x	.	.	.	x	x	.	x	x	.	.	x
Nymphaea alba	.	x	.	.	x	x	.	x	.	x	x	.	.	x	x	x	x	.	.	x	x	.	.
Potamogeton sp.	.	x	x	x	x	x	.	x	.	.	.	.	.	x	x	x	x	x	x	x	x	x	x
Pterocarya limburgensis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	.	x	x	x
Rubus fruticosus	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	x	.	x
Scirpus pliocenicus	.	x	.	.	x	x	.	x	.	x	x	x	x	x	x	x	x	x	.	x	x	x	x
Scirpus melanospermus	.	x	.	.	x	x	x	x	.	x	x	x	x	.	.	x	x	x	x	x	x	x	x
Sorbus aucuparia	.	.	.	x	x	x	.	x	x	x	.	x	.	x	x	x	.	.	.	.	.	.	.
Spirematospermum wetzleri	.	x	.	x	x	x	x	x	.	x	x	x	x	.	.	x	x	.	.	.	x	.	x
Boehmeria colchica	x	.	.	.	x	x	.	.	x	x	.	x	x	x	x	x	x	x	x	.	.	x	.
Carex acutiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	.	x	x
Carex appropinquata	.	.	.	.	.	.	.	.	.	x	.	x	x	x	.	x	.	.	.	.	.	.	.
Carex cespitosa	x	x	x	x	x	.	.	.	.	x	x	x	x	x	x	x	x	x	.	.	x	x	.
Carex flagellata	.	.	.	.	.	.	.	.	.	x	.	x	x	x	x	x	x	.	.	.	x	x	.
Carex riparia	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	x	x	.	.	.	x	.	x
Carex szaferi	x	x	.	x	x	.	.	.	.	.	.	x	.	x	x	x	x	x	x	x	x	x	.
Dulichium vespiforme	x	.	.	.	x	.	.	.	.	x	.	x	x	.	x	x	.	.	.	.	.	.	.
Eleocharis ovata	.	.	.	.	.	.	.	.	.	x	.	x	x	.	.	x	.	.	.	.	.	.	.
Euphorbia palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	.	.	.	x	.	.
Liriodendron geminatum	.	.	.	.	.	.	.	.	.	x	.	x	x	x	x	x	x	x	x	x	.	.	x
Lycopus europaea	.	x	x	x	x	.	.	.	.	x	.	x	x	.	x	x	x	.	.	x	.	x	.
Oenanthe lachenalii	x	x	x	.	x	.	.	.	.	x	x	x	.	x	.	x	x	.	.	.	x	x	.
Urtica dubia	x	.	.	.	x	.	.	.	.	x	x	x	x	x	x	x	x	x	.	.	.	x	.
Proserpinaca reticulata	.	.	x	.	x	.	.	.	.	x	.	x	.	x	.	x	x	.	.	x	x	x	x
Salvinia sp.	.	.	.	x	x	.	.	.	.	x	.	x	x	.	.	x	.	.	.	.	.	.	.
Solanum dulcamara	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	.	.
Sparganium neglectum	x	x	x	.	x	.	.	.	.	.	.	.	.	x	x	x	x	x	.	x	x	x	.
Stachys palustris	.	.	x	x	x	.	.	.	.	.	x	.	x	x	x	x	x	.	.	x	.	x	.
Typha latifolia	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	x	x	.	.	.	.	x	.
Vitis sylvestris	.	.	x	.	x	.	.	.	.	x	.	x	x	x	x	x	x	.	.	.	x	x	x
Acer spp.	.	x	.	x	x	.	.	.	.	.	.	.	x	.	.	x	x	.	.	.	x	.	.
Carpinus betulus	.	x	.	.	x	.	.	.	.	.	.	.	.	x	x	x	x	.	.	.	x	.	x
Crataegus nodulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	.	.
Prunus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	.	.	.	x	x	x
Fagus decurrens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	x	.	x
Viola palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.
Thalictrum lucidum	x	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cladium reidiorum	x	.	x	.	x	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex helmensis	x	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	x	.
Sagittaria sagittifolia	x	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	x	.
Ceratophyllum submersum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	x	x	.	.	.
Stratiotes tuberculatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	x
Scirpus tabernaemontani	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	x	.	.	x	x

a = sample 18169; b = sample 17648; c = sample 17647; d = sample 14132; e = summary of a–d; f = summary of g–i; g = sample 14386; h = sample 14385; i = sample 14384; j = sample 14383; k = sample 14382; l = sample 14381; m = sample 14380; n = sample 14279; o = sample 14378; p = summary of k–o; q = summary of r–w; r = sample 14375; s = sample 14376; t = sample 14377; u = sample 17646; v = sample 18170; w = sample 14149.

open grass- and reedland vegetation elements (*Carex cespitosa*, *C. szaferi*, *Lycopus europaeus*, *Oenanthe lachenalii*, *Sparganium neglectum*, *Stachys palustris*, *Spirematospermum wetzleri*, *Urtica dubia*) (Fig. 2). The resemblance to the assemblages from samples 14132, 17647 and 17648 (Table 2, b–d) from the basal part of the clay bed is also striking (Fig. 3).

The carpological signature of the leaf bed (sample 18170) (Table 2, v), collected in 1995 is different. The matrix consisted of a silt. The assemblage shows stronger allochthonous influences, e.g. it contains disseminules from at least 6 different vegetation units, including floodplain forest and upland forest. In agreement with this is the very strong dominance of reed vegetation. Although it was collected from the basal portion of the clay bed, its content is comparable with that of the uppermost part of the section of the clay bed collected in 1983 (sample 14378, 14379) and the other samples from the top of the clay bed (Figs. 2 and 3; Table 2, n, o, r–u).

From the above it can be concluded that we are dealing with a river environment with various vegetational and sedimentological environments. The result is a series of clays, containing autochthonous assemblages, and silts or sandy clays with allochthonous elements.

In the clays as well as in the silt leaf compressions were found. The assemblage in the clay horizon was probably only slightly influenced by the extra local vegetation (comparable to the middle part of the section 14386–14378); the silt assemblage was possibly derived from communities growing under wetter conditions, with direct river influence, hence the coarser sediment. During the analysis of these leaf compressions not only a difference between these two assemblages was found, but also a marked distinction with the accompanying carpological assemblages (Fig. 4).

The leaf assemblage from the clay bed displays a strong representation of leaves from the ‘floodplain forest’, fewer from the ‘wetland forest’ and a poor showing of ‘streamside vegetation’ and ‘upland forest’. The leaves of *Alnus cecropiaefolia* virtually dominate the assemblage (62%). However, material from forest on somewhat higher, better drained alluvial soils is also important, consisting of some more species (at least 4) and constituting altogether 28% of the leaf compressions.

This is in marked contrast to the composition of the fruit/seed assemblages from the same deposit. The latter is typically autochthonous, consisting of material of the local vegetation and its immediate surroundings. It consists of ‘open water vegetation’, ‘streamside and reed vegetation’, and ‘wetland forest vegetation’. The very fine clay points to quiet depositional circumstances, allowing for a dominance of the local vegetation which, judging from the numerous branches must have been a mixture of reedland and alder forest.

As the flora of the better drained floodplain is not represented in the carpological material, one may assume, that this flora was extralocal with reference to our source locality. That certain taxa are only represented by leaves is due to the operation of different transport mechanisms (wind and water versus water), which causes the leaf compression flora to be more allochthonous than the carpological assemblage.

The leaf compressions of the bed sampled in 1995 represent a different origin. *Alnus cecropiaefolia* is no longer dominant, but *A. incana*, a tree from the better drained and less often inundated floodplains. It dominates the leaf compression flora by attaining a percentage of 72%. The second most important community is the ‘streamside vegetation’, here extremely rich in reeds. The ‘wetland forest’ vegetation is only third in importance.

The carpological material of this horizon also displays marked allochthonous influences as stated above, but the local reed vegetation dominates the assemblage. Some parallels can be found with the carpological and leaf assemblages collected in 1982: in both the leaf and carpological assemblages of 1995 the allochthonous element as well as the streamside vegetation element are better represented than in those from 1982. The better representation of the streamside vegetation element is explicable when this represented the local vegetation. Consequently the other elements (open water vegetation, diverse forest vegetations) must have arrived by transport. This is also the case in the leaf compression assemblage. The forest vegetation is strongly dominated by allochthonous elements; so again the leaf compression flora is more allochthonous than the carpocoenosis. This underscores the idea that the taphonomic history of leaves is different from that of seeds/fruits.

The best fit for this flora is, as already mentioned, with the top of the sequence 14386–14378 and with the top clay sample 17646.

Acknowledgements

The authors wish to thank the board and collaborators of the 'Rheinbraun' for the permission to collect in their opencast mines. They also thank their colleagues for helpful discussions and coping with stress when the paper neared completion. They are also grateful to Professor David Ferguson, who made a number of improvements to the manuscript. A special word of thank is due to Mr H.A. Elsendoorn for the very prompt processing of the photographs for Plates I–VI. This paper is NSG publication no. 960101.

Appendix A. Ecological tables

Table A1. Sample 14386

Species		Vegetational units									
		1	2		3		4	5	6	7	8	9
Actinidia faveolata	1*	–	–		1*		–	–	–	–	–	–
Alisma plantago-aquatica	1*	–	1*		–		–	–	–	–	–	–
Alnus tanaitica	74*	–	–		74*		–	–	–	–	–	–
Apium repens	1*	–	1*		–		–	–	–	–	–	–
Decodon globosus	5*	–	5*		–		–	–	–	–	–	–
Pterocarya limburgensis	3*	–	–		3*		–	–	–	–	–	–
Rubus fruticosus	1	–	–		1		1	1	1	1	1	–
Sambucus pulchella	3	–	–		3		3	3	–	–	–	–
Scirpus melanospermus	1*	–	1*		–		–	–	–	–	–	–
Spirematospermum wetzleri	1*	–	1*		–		–	–	–	–	–	–
∑ taxa	10	–	5	50%	5	50%	–	–	–	–	–	–
∑ characteristic taxa	8	–	5	63%	3	38%	–	–	–	–	–	–
∑ char. fruits and seeds	87	–	9	11%	78	90%	–	–	–	–	–	–
Vegetation figures		–	124		178		–	–	–	–	–	–
∑ palaeotropic taxa	1	–	1	10%	–		–	–	–	–	–	–
∑ Palaeotr. characteristic taxa	1	–	1	13%	–		–	–	–	–	–	–
∑ Pal. charact. fruits	1	–	1	1%	–		–	–	–	–	–	–
Palaeotropic figures		–	24		–		–	–	–	–	–	–
Arctotertiary figures		–	100		178		–	–	–	–	–	–

Table A2. Sample 14385

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alnus tanaitica	100*	–	–	100*	–	–	–	–	–	–
Carex flavaeformis	1*	–	–	1*	–	–	–	–	–	–
Decodon globosus	20*	–	20*	–	–	–	–	–	–	–
Dulichium spathaceum	1*	–	1*	–	–	–	–	–	–	–
Nuphar luteum	2*	2*	–	–	–	–	–	–	–	–
Nymphaea alba	2*	2*	–	–	–	–	–	–	–	–
Potamogeton sp.	1*	1*	–	–	–	–	–	–	–	–
Pterocarya limburgensis	3*	–	–	3*	–	–	–	–	–	–
Rubus fruticosus	8	–	–	8	8	8	8	8	8	–
Sambucus pulchella	3	–	–	3	3	3	–	–	–	–

Table A2 (continued)

Species		Vegetational units												
		1		2		3		4	5	6	7	8	9	
Scirpus melanospermus	1*	–		1*		–		–	–	–	–	–	–	
Scirpus pliocenicus	2*	–		2*		–		–	–	–	–	–	–	
Sorbus aucuparia	12	–		–		12		12	–	–	–	–	–	
Spirematospermum wetzleri	2*	–		2*		–		–	–	–	–	–	–	
∑ taxa	15	3	20%	5	33%	7	47%	–	–	–	–	–	–	
∑ characteristic taxa	12	3	25%	5	42%	4	33%	–	–	–	–	–	–	
∑ char. fruits and seeds	136	5	4%	26	19%	105	77%	–	–	–	–	–	–	
Vegetation figures		49		94		157		–	–	–	–	–	–	
∑ palaeotropic taxa	1	–		1	7%	–		–	–	–	–	–	–	
∑ Palaeotr. characteristic taxa	1	–		1	8%	–		–	–	–	–	–	–	
∑ Pal. charact. fruits and seeds	2	–		2	1%	–		–	–	–	–	–	–	
Palaeotropic figures		–		16		–		–	–	–	–	–	–	
Arctotertiary figures		49		78		157		–	–	–	–	–	–	

Table A3. Sample 14384

Species		Vegetational units											
		1		2		3		4	5	6	7	8	9
Actinidia faveolata	1*	–		–		1*		–	–	–	–	–	–
Alnus tanaitica	211*	–		–		211*		–	–	–	–	–	–
Boehmeria colchica	2	–		–		2		–	2	–	–	–	–
Carex elongatoides	1*	–		–		1*		–	–	–	–	–	–
Decodon globosus	9*	–		9*		–		–	–	–	–	–	–
Nuphar luteum	6*	6*		–		–		–	–	–	–	–	–
Pterocarya limburgensis	8*	–		–		8*		–	–	–	–	–	–
Rubus fruticosus	7	–		–		7		7	7	7	7	7	–
Sorbus aucuparia	2	–		–		2		2	–	–	–	–	–
∑ taxa	9	1	11%	1	11%	7	77%	–	–	–	–	–	–
∑ characteristic taxa	6	1	16%	1	16%	4	66%	–	–	–	–	–	–
∑ char. fruits and seeds	236	6	3%	9	4%	221	94%	–	–	–	–	–	–
Vegetation figures		30		31		237		–	–	–	–	–	–
∑ palaeotropic taxa		–		–		–		–	–	–	–	–	–
Arctotertiary figures		30		31		237		–	–	–	–	–	–

Table A4. Sample 14383

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	5*	–	–	5*	–	–	–	–	–	–
Alisma plantago-aquatica	19*	–	19*	–	–	–	–	–	–	–
Alnus tanaitica	335*	–	–	335*	–	–	–	–	–	–
Apium repens	10*	–	10*	–	–	–	–	–	–	–
Boehmeria colchica	17	–	–	17	–	17	–	–	–	–
Carex appropinquata	4*	–	4*	–	–	–	–	–	–	–
Carex cespitosa	70*	–	70*	–	–	–	–	–	–	–
Carex elongatoides	74*	–	–	9*	–	–	–	–	–	–
Carex flagellata	5*	–	5*	–	–	–	–	–	–	–
Carex sp.	2	–	–	–	–	–	–	–	–	–

Table A4 (continued)

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
Cirsium palustre	1*	–		1*		–		–	–		–	–	–	–
Cladium reidiorum	2*	–		2*		–		–	–		–	–	–	–
Decodon globosus	139*	–		139*		–		–	–		–	–	–	–
Dulichium spathaceum	60*	–		60*		–		–	–		–	–	–	–
Dulichium vespiforme	2*	–		2*		–		–	–		–	–	–	–
Eleocharis ovata	7*	–		7*		–		–	–		–	–	–	–
Liriodendron geminatum	10*	–		–		–		–	10*		–	–	–	–
Lycopus europaeus	11*	–		11*		–		–	–		–	–	–	–
Nuphar luteum	10*	10*		–		–		–	–		–	–	–	–
Nymphaea alba	2*	2*		–		–		–	–		–	–	–	–
Oenanthe lachenalii	53*	–		53*		–		–	–		–	–	–	–
Proserpinaca reticulata	1*	–		–		1*		–	–		–	–	–	–
Pterocarya limburgensis	38*	–		–		38*		–	–		–	–	–	–
Rubus fruticosus	27	–		–		27		27	27		27	27	–	–
Rumex sp.	1	–		–		–		–	–		–	–	–	–
Salvinia sp.	1*	1*		–		–		–	–		–	–	–	–
Scindapsites crassus	1*	–		1*		–		–	–		–	–	–	–
Scirpus melanospermus	94*	–		94*		–		–	–		–	–	–	–
Scirpus pliocenicus	2*	–		2*		–		–	–		–	–	–	–
Sorbus aucuparia	3	–		–		3		3	–		–	–	–	–
Spirematospermum wetzleri	2*	–		2*		–		–	–		–	–	–	–
Urtica dubia	10	–		10		10		–	–		–	–	–	–
Urtica urens	1*	–		1*		–		–	–		–	–	–	–
Vitis sylvestris	7*	–		–		–		7	7*		–	–	–	–
∑ taxa	34	3	9%	19	56%	9	26%	–	4	11%	–	–	–	–
∑ characteristic taxa	28	3	11%	18	64%	5	18%	–	2	7%	–	–	–	–
∑ char. fruits and seeds	966	13	1%	483	50%	388	40%	–	17	2%	–	–	–	–
Vegetation figures		21		168		84		–	20		–	–	–	–
∑ palaeotropic taxa	3	1	3%	2	6%	–		–	–		–	–	–	–
∑ Palaeotr. characteristic taxa	3	1	4%	2	7%	–		–	–		–	–	–	–
∑ Pal. charact. fruits and seeds	4	1 x		3 x		–		–	–		–	–	–	–
Palaeotropic figures		7		13		–		–	–		–	–	–	–
Arctotertiary figures		14		155		84		–	20		–	–	–	–

Table A5. Sample 14382

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alisma plantago-aquatica	2*	–	2*	–	–	–	–	–	–	–
Alnus tanaitica	154*	–	–	154*	–	–	–	–	–	–
Carex cespitosa	4*	–	4*	–	–	–	–	–	–	–
Carex elongatoides	6*	–	–	6*	–	–	–	–	–	–
Decodon globosus	10*	–	10*	–	–	–	–	–	–	–
Dulichium spathaceum	9*	–	9*	–	–	–	–	–	–	–
Indet.	17	–	–	–	–	–	–	–	–	–
Nuphar luteum	3*	3*	–	–	–	–	–	–	–	–
Nymphaea alba	4*	4*	–	–	–	–	–	–	–	–
Oenanthe lachenalii	5*	–	5*	–	–	–	–	–	–	–
Pterocarya limburgensis	10*	–	–	10*	–	–	–	–	–	–

Table A5 (continued)

Species		Vegetational units											
		1		2		3		4	5	6	7	8	9
Rubus fruticosus	2	–		–		2		2	2	2	2	2	–
Scirpus melanospermus	3*	–		3*		–		–	–	–	–	–	–
Scirpus pliocenicus	2*	–		2*		–		–	–	–	–	–	–
Spirematospermum wetzleri	1*	–		1*		–		–	–	–	–	–	–
Stachys palustris	1*	–		1*		–		–	–	–	–	–	–
Typha latifolia	1*	–		1*		–		–	–	–	–	–	–
Urtica dubia	1	–		1		1		–	–	–	–	–	–
∑ taxa	19	2	11%	11	58%	6	32%	–	–	–	–	–	–
∑ characteristic taxa	16	2	13%	10	63%	4	25%	–	–	–	–	–	–
∑ char. fruits and seeds	216	7	3%	38	18%	172	79%	–	–	–	–	–	–
Vegetation figures		27		139		136		–	–	–	–	–	–
∑ palaeotropic taxa	1	–		1	5%	–		–	–	–	–	–	–
∑ Palaeotr. characteristic taxa	1	–		1	6%	–		–	–	–	–	–	–
∑ Pal. charact. fruits and seeds	1	–		1 x		–		–	–	–	–	–	–
Palaeotropic figures		–		11		–		–	–	–	–	–	–
Arctotertiary figures		27		128		136		–	–	–	–	–	–

Table A6. Sample 14381

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alisma plantago-aquatica	17*	–	17*	–	–	–	–	–	–	–
Alnus tanaitica	233*	–	–	233*	–	–	–	–	–	–
Apium repens	7*	–	7*	–	–	–	–	–	–	–
Boehmeria colchica	13	–	–	13	–	13	–	–	–	–
Caricoidea jugata	1	–	–	1	–	–	–	–	–	1
Carex appropinquata	2*	–	2*	–	–	–	–	–	–	–
Carex cespitosa	36*	–	36*	–	–	–	–	–	–	–
Carex elongatoides	144*	–	–	144*	–	–	–	–	–	–
Carex flagellata	1*	–	1*	–	–	–	–	–	–	–
Carex sp.	1	–	–	–	–	–	–	–	–	–
Carex szaferi	11*	–	11*	–	–	–	–	–	–	–
Decodon globosus	145*	–	145*	–	–	–	–	–	–	–
Dulichium spathaceum	59*	–	59*	–	–	–	–	–	–	–
Dulichium vespiforme	2*	–	2*	–	–	–	–	–	–	–
Eleocharis ovata	3*	–	3*	–	–	–	–	–	–	–
Liriodendron geminatum	10*	–	–	–	–	10*	–	–	–	–
Lycopus europaeus	6*	–	6*	–	–	–	–	–	–	–
Nuphar luteum	1*	1*	–	–	–	–	–	–	–	–
Oenanthe lachenalii	22*	–	22*	–	–	–	–	–	–	–
Proserpinaca reticulata	6*	–	–	6*	–	–	–	–	–	–
Pterocarya limburgensis	33*	–	–	33*	–	–	–	–	–	–
Rubus fruticosus	5	–	–	5	5	5	5	5	5	–
Salvinia sp	1*	1*	–	–	–	–	–	–	–	–
Scirpus melanospermus	12*	–	12*	–	–	–	–	–	–	–
Scirpus pliocenicus	5*	–	5*	–	–	–	–	–	–	–
Sorbus aucuparia	6	–	–	6	6	–	–	–	–	–
Spirematospermum wetzleri	1*	–	1*	–	–	–	–	–	–	–
Urtica dubia	28	–	28	28	–	–	–	–	–	–
Vitis sylvestris	1*	–	–	–	1	1*	–	–	–	–

Table A6 (continued)

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
∑ taxa	29	2	7%	16	55%	9	31%	–	4	14%	–	–	–	–
∑ characteristic taxa	23	2	9%	15	65%	4	17%	–	2	9%	–	–	–	–
∑ char. fruits and seeds	758	2 x		329	43%	416	55%	–	11	1%	–	–	–	–
Vegetation figures		16		163		103		–	24		–	–	–	–
∑ palaeotropic taxa	1	1	3%	1	3%	–		–	–		–	–	–	–
∑ Palaeotr. characteristic taxa	1	1	4%	1	4%	–		–	–		–	–	–	–
∑ Pal. charact. fruits and seeds	1	1 x		1 x		–		–	–		–	–	–	–
Palaeotropic figures		7		7		–		–	–		–	–	–	–
Arctotertiary figures		9		156		103		–	24		–	–	–	–

Table A7. Sample 14380

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
Acer campestre	1	–		–		–		1	1		–	–	–	–
Alisma plantago-aquatica	17*	–		17*		–		–	–		–	–	–	–
Alnus tanaitica	195*	–		–		195*		–	–		–	–	–	–
Apium repens	37*	–		37*		–		–	–		–	–	–	–
Boehmeria colchica	18	–		–		18		–	18		–	–	–	–
Carex appropinquata	16*	–		16*		–		–	–		–	–	–	–
Carex cespitosa	46*	–		46*		–		–	–		–	–	–	–
Carex elongatoides	15*	–		–		15*		–	–		–	–	–	–
Carex flagellata	11*	–		11*		–		–	–		–	–	–	–
Carex flavaeformis	1*	–		–		1*		–	–		–	–	–	–
Decodon globosus	103*	–		103*		–		–	–		–	–	–	–
Dulichium spathaceum	80*	–		80*		–		–	–		–	–	–	–
Dulichium vespiforme	2*	–		2*		–		–	–		–	–	–	–
Eleocharis ovata	1*	–		1*		–		–	–		–	–	–	–
Indet.	2	–		–		–		–	–		–	–	–	–
Liriodendron geminatum	8*	–		–		–		–	8*		–	–	–	–
Lycopus europaeus	6*	–		6*		–		–	–		–	–	–	–
Pterocarya limburgensis	13*	–		–		13*		–	–		–	–	–	–
Rubus fruticosus	10	–		–		10		10	10		10	10	10	–
Salvinia sp.	1*	*1**		–		–		–	–		–	–	–	–
Scirpus melanospermus	103*	–		103*		–		–	–		–	–	–	–
Scirpus pliocenicus	2*	–		2*		–		–	–		–	–	–	–
Spirematospermum wetzleri	4*	–		4*		–		–	–		–	–	–	–
Stachys palustris	5*	–		5*		–		–	–		–	–	–	–
Urtica dubia	5	–		5		5		–	–		–	–	–	–
Vitis sylvestris	2*	–		–		–		2	2*		–	–	–	–
∑ taxa	26	1	4%	15	58%	7	27%	–	5	19%	–	–	–	–
∑ characteristic taxa	21	1	5%	14	67%	4	19%	–	2	10%	–	–	–	–
∑ char. fruits and seeds	669	1 x		433	65%	224	33%	–	10	1%	–	–	–	–
Vegetation figures		9		190		79		–	30		–	–	–	–
∑ palaeotropic taxa	2	1	4%	1	4%	–		–	–		–	–	–	–
∑ Palaeotr. characteristic taxa	1	1	5%	1	5%	–		–	–		–	–	–	–
∑ Pal. charact. fruits and seeds	1	1 x		4	1%	–		–	–		–	–	–	–
Palaeotropic figures		9		10		–		–	–		–	–	–	–
Arctotertiary figures		–		180		79		–	30		–	–	–	–

Table A8. Sample 14379

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alisma plantago-aquatica	20*	–	20*	–	–	–	–	–	–	–
Alnus tanaitica	840*	–	–	840*	–	–	–	–	–	–
Apium repens	20*	–	20*	–	–	–	–	–	–	–
Boehmeria colchica	20	–	–	20	–	20	–	–	–	–
Carex appropinquata	44*	–	44*	–	–	–	–	–	–	–
Carex cespitosa	125*	–	125*	–	–	–	–	–	–	–
Carex elongatoides	40*	–	–	40*	–	–	–	–	–	–
Carex flagellata	3*	–	3*	–	–	–	–	–	–	–
Carex flavaeformis	5*	–	–	5*	–	–	–	–	–	–
Carex riparia	6*	–	6*	–	–	–	–	–	–	–
Carex szaferi	40*	–	40*	–	–	–	–	–	–	–
Carpinus betulus	5	–	–	–	–	5	5	–	–	–
Crataegus nodulosa	2*	–	–	–	2*	–	–	–	–	–
Decodon globosus	35*	–	35*	–	–	–	–	–	–	–
Dulichium spathaceum	84*	–	84*	–	–	–	–	–	–	–
Euphorbia palustris	15*	–	15*	–	–	–	–	–	–	–
Liriodendron geminatum	10*	–	–	–	–	10*	–	–	–	–
Nymphaea alba	31*	31*	–	–	–	–	–	–	–	–
Oenanthe lachenalii	10*	–	10*	–	–	–	–	–	–	–
Potamogeton sp.	1*	1*	–	–	–	–	–	–	–	–
Proserpinaca reticulata	2*	–	–	2*	–	–	–	–	–	–
Prunus spinosa	3*	–	–	–	3*	–	–	–	–	–
Pterocarya limburgensis	12*	–	–	12*	–	–	–	–	–	–
Rubus fruticosus	23	–	–	23	23	23	23	23	23	–
Scirpus pliocenicus	6*	–	6*	–	–	–	–	–	–	–
Solanum dulcamara	1*	–	1*	–	–	–	–	–	–	–
Sorbus aucuparia	10	–	–	10	10	–	–	–	–	–
Sparganium neglectum	8*	–	8*	–	–	–	–	–	–	–
Stachys palustris	2*	–	2*	–	–	–	–	–	–	–
Urtica dubia	30	–	30	30	–	–	–	–	–	–
Vitis sylvestris	16*	–	–	–	16	16*	–	–	–	–
∑ taxa	31	2 6%	16 52%	9 29%	5 16%	5 16%	–	–	–	–
∑ characteristic taxa	24	2 8%	15 63%	5 21%	2 8%	2 8%	–	–	–	–
∑ char. fruits and seeds	1349	32 2%	409 30%	899 67%	5 x	26 2%	–	–	–	–
Vegetation figures		16	145	114	24	26	–	–	–	–
∑ palaeotropic taxa		–	–	–	–	–	–	–	–	–
Arctotertiary figures		16	145	114	24	26	–	–	–	–

Table A9. Sample 14378

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alisma plantago-aquatica	3*	–	3*	–	–	–	–	–	–	–
Alnus tanaitica	44*	–	–	44*	–	–	–	–	–	–
Apium repens	8*	–	8*	–	–	–	–	–	–	–
Boehmeria colchica	22	–	–	22	–	22	–	–	–	–
Carex acutiformis	2	–	2	2	–	–	–	–	–	–
Carex cespitosa	15*	–	15*	–	–	–	–	–	–	–

Table A9 (continued)

Species		Vegetational units														
		1		2		3		4		5		6	7	8	9	
Carex elongatoides	8*	–		–		8*		–		–		–	–	–	–	
Carex flagellata	1*	–		1*		–		–		–		–	–	–	–	
Carex sp.	1	–		–		–		–		–		–	–	–	–	
Carex szaferi	61*	–		61*		–		–		–		–	–	–	–	
Carpinus betulus	5*	–		–		–		–		5		5	–	–	–	
Crataegus nodulosa	10*	–		–		–		10*		–		–	–	–	–	
Decodon globosus	65*	–		65*		–		–		–		–	–	–	–	
Dulichium spathaceum	78*	–		78*		–		–		–		–	–	–	–	
Dulichium vespiforme	17*	–		17*		–		–		–		–	–	–	–	
Euphorbia palustris	8*	–		8*		–		–		–		–	–	–	–	
Liriodendron geminatum	2*	–		–		2		–		2*		–	–	–	–	
Lycopus europaeus	8*	–		8*		–		–		–		–	–	–	–	
Nymphaea alba	3*	3*		–		–		–		–		–	–	–	–	
Potamogeton sp.	1*	1*		–		–		–		–		–	–	–	–	
Prunus spinosa	31*	–		–		–		31*		–		–	–	–	–	
Pterocarya limburgensis	5*	–		–		5*		–		–		–	–	–	–	
Rubus fruticosus	10	–		–		10		10		10		10	10	10	–	
Scirpus pliocenicus	3*	–		3*		–		–		–		–	–	–	–	
Solanum dulcamara	4*	–		4*		–		–		–		–	–	–	–	
Sorbus aucuparia	5	–		–		5		5		–		–	–	–	–	
Sparganium neglectum	6*	–		6*		–		–		–		–	–	–	–	
Stachys palustris	1*	–		1*		–		–		–		–	–	–	–	
Urtica dubia	4	–		4		4		–		–		–	–	–	–	
Viola palustris	17*	–		–		–		–		–		–	–	–	17*	
Vitis sylvestris	20*	–		–		–		20		20*		–	–	–	–	
∑ taxa	32	2	6%	16	50%	10	31%	5	16%	5	16%	–	–	–	1	3%
∑ characteristic taxa	26	2	8%	14	54%	4	15%	2	8%	2	8%	–	–	–	1	4%
∑ char. fruits and seeds	411	4	1%	256	63%	61	15%	41	10%	22	5%	–	–	–	17	4%
Vegetation figures		15		167		61		28		29		–	–	–	11	
∑ palaeotropic taxa	–	–		–		–		–		–		–	–	–	–	
Arctotertiary figures		14		160		66		33		28		–	–	–	11	

Table A10. Sample 14377

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alnus tanaitica	28*	–	–	28*	–	–	–	–	–	–
Apium repens	8*	–	8*	–	–	–	–	–	–	–
Carex helmensis	1	–	–	–	–	–	–	–	–	–
Carex sp.	1	–	–	–	–	–	–	–	–	–
Carex szaferi	5*	–	5*	–	–	–	–	–	–	–
Ceratophyllum submersum	4*	4*	–	–	–	–	–	–	–	–
Decodon globosus	8*	–	8*	–	–	–	–	–	–	–
Dulichium spathaceum	3*	–	3*	–	–	–	–	–	–	–
Indet.	1	–	–	–	–	–	–	–	–	–
Liriodendron geminatum	1*	–	–	–	–	1*	–	–	–	–
Lycopus europaeus	3*	–	3*	–	–	–	–	–	–	–
Nuphar luteum	34*	34*	–	–	–	–	–	–	–	–
Nymphaea alba	10*	10*	–	–	–	–	–	–	–	–
Potamogeton sp.	61*	61*	–	–	–	–	–	–	–	–

Table A10 (continued)

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
Proserpinaca reticulata	3*	–		–		3*		–	–		–	–	–	–
Scirpus melanospermus	16*	–		16*		–		–	–		–	–	–	–
Scirpus pliocenicus	8*	–		8*		–		–	–		–	–	–	–
Sparganium neglectum	2*	–		2*		–		–	–		–	–	–	–
Stachys palustris	1*	–		1*		–		–	–		–	–	–	–
∑ taxa	19	4	21%	9	47%	2	11%	–	1	5%	–	–	–	–
∑ characteristic taxa	16	4	25%	9	56%	2	13%	–	1	6%	–	–	–	–
∑ char. fruits and seeds	195	109	56%	54	28%	31	16%	–	1	1%	–	–	–	–
Vegetation figures		102		131		40		–	12		–	–	–	–
∑ palaeotropic taxa	–	–		–		–		–	–		–	–	–	–
Arctotertiary figures		102		131		40		–	12		–	–	–	–

Table A11. Sample 14376

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
Alnus tanaitica	35*	–		–		35*		–	–		–	–	–	–
Apium repens	4*	–		4*		–		–	–		–	–	–	–
Boehmeria colchica	1	–		–		1		–	1		–	–	–	–
Carex elongatoides	13*	–		–		13*		–	–		–	–	–	–
Carex szaferi	5*	–		5*		–		–	–		–	–	–	–
Ceratophyllum submersum	1*	1*		–		–		–	–		–	–	–	–
Decodon globosus	4*	–		4*		–		–	–		–	–	–	–
Dulichium spathaceum	1*	–		1*		–		–	–		–	–	–	–
Indet.	4	–		–		–		–	–		–	–	–	–
Liriodendron geminatum	3*	–		–		–		–	3*		–	–	–	–
Nuphar luteum	1*	1*		–		–		–	–		–	–	–	–
Potamogeton sp.	36*	36*		–		–		–	–		–	–	–	–
Pterocarya limburgensis	2*	–		–		2*		–	–		–	–	–	–
Scirpus melanospermus	1*	–		1*		–		–	–		–	–	–	–
∑ taxa	14	3	21%	5	36%	4	29%	–	2	14%	–	–	–	–
∑ characteristic taxa	12	3	25%	5	42%	3	25%	–	1	8%	–	–	–	–
∑ char. fruits and seeds	106	38	36%	15	14%	50	47%	–	3	3%	–	–	–	–
Vegetation figures		82		90		101		–	25		–	–	–	–
∑ palaeotropic taxa		–		–		–		–	–		–	–	–	–
Arctotertiary figures		82		90		101		–	25		–	–	–	–

Table A12. Sample 14375

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alisma plantago-aquatica	50*	–	50*	–	–	–	–	–	–	–
Alnus tanaitica	22*	–	–	22*	–	–	–	–	–	–
Apium repens	4*	–	4*	–	–	–	–	–	–	–

Table A12 (continued)

Species		Vegetational units											
		1	2	3	4	5	6	7	8	9			
Boehmeria colchica	8	–	–	8	–	8	–	–	–	–			
Caldesia cylindrica	1*	–	1*	–	–	–	–	–	–	–			
Carex cespitosa	16*	–	16*	–	–	–	–	–	–	–			
Carex elongatoides	111*	–	–	111*	–	–	–	–	–	–			
Carex flavaeformis	1*	–	–	1*	–	–	–	–	–	–			
Carex szaferi	38*	–	38*	–	–	–	–	–	–	–			
Ceratophyllum submersum	7*	7*	–	–	–	–	–	–	–	–			
Decodon globosus	37*	–	37*	–	–	–	–	–	–	–			
Dulichium spathaceum	31*	–	31*	–	–	–	–	–	–	–			
Liriodendron geminatum	20*	–	–	–	–	20*	–	–	–	–			
Potamogeton sp.	57*	57*	–	–	–	–	–	–	–	–			
Scirpus melanospermus	30*	–	30*	–	–	–	–	–	–	–			
Scirpus pliocenicus	1*	–	1*	–	–	–	–	–	–	–			
Sparganium neglectum	2*	–	2*	–	–	–	–	–	–	–			
Stratiotes tuberculatus	12*	12*	–	–	–	–	–	–	–	–			
Urtica dubia	4	–	4	4	–	–	–	–	–	–			
∑ taxa	20	3	15%	11	55%	6	30%	–	2	10%	–	–	–	–
∑ characteristic taxa	18	3	17%	10	56%	5	22%	–	1	6%	–	–	–	–
∑ char. fruits and seeds	421	76	18%	210	50%	139	32%	–	20	5%	–	–	–	–
Vegetation figures		50		161		84		–	21		–	–	–	–
∑ palaeotropic taxa	–	–		–		–		–	–		–	–	–	–
Arctotertiary figures		50		161		84		–	21		–	–	–	–

Table A13. Sample 14149

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alisma plantago-aquatica	1*	–	1*	–	–	–	–	–	–	–
Alnus tanaitica	86*	–	–	86*	–	–	–	–	–	–
Carex acutiformis	5	–	5	5	–	–	–	–	–	–
Carex riparia	9*	–	9*	–	–	–	–	–	–	–
Carpinus betulus	18	–	–	–	–	18	18	–	–	–
Decodon globosus	7*	–	7*	–	–	–	–	–	–	–
Dulichium spathaceum	9*	–	9*	–	–	–	–	–	–	–
Eucommia europaea	2*	–	–	–	–	–	2*	–	–	–
Fagus decurrens	2*	–	–	–	–	–	2*	–	–	–
Glyptostrobus europaeus	3*	–	–	3*	–	–	–	–	–	–
Liriodendron geminatum	1*	–	–	–	–	1*	–	–	–	–
Nuphar luteum	5*	5*	–	–	–	–	–	–	–	–
Nyssa disseminata	1*	–	–	1*	–	–	–	–	–	–
Potamogeton sp.	1*	1*	–	–	–	–	–	–	–	–
Proserpinaca reticulata	2*	–	–	2*	–	–	–	–	–	–
Prunus spinosa	11*	–	–	–	11*	–	–	–	–	–
Pterocarya limburgensis	56*	–	–	56*	–	–	–	–	–	–
Rubus fruticosus	3	–	–	3	3	3	3	3	3	–
Sambucus pulchella	7	–	–	7	7	7	–	–	–	–
Scirpus melanospermus	15*	–	15*	–	–	–	–	–	–	–
Scirpus pliocenicus	3*	–	3*	–	–	–	–	–	–	–

Table A13 (continued)

Species		Vegetational units														
		1		2		3		4		5		6		7	8	9
Scirpus tabernaemontani	5*	–		5*		–		–		–		–		–	–	–
Sparganium noduliferum	4*	–		4*		–		–		–		–		–	–	–
Spirematospermum wetzleri	10*	–		10*		–		–		–		–		–	–	–
Stratiotes tuberculatus	1*	1*		–		–		–		–		–		–	–	–
Vitis sylvestris	4*	–		–		–		4		4*		–		–	–	–
∑ taxa	27	3	11%	10	37%	9	33%	4	15%	5	19%	4	15%	–	–	–
∑ characteristic taxa	23	3	13%	9	39%	6	26%	1	4%		29%	2	9%	–	–	–
∑ char. fruits and seeds	239	7	3%	63	26%	149	62%	11	5%	5	2%	4	2%	–	–	–
Vegetation figures		27		102		121		24		30		26		–	–	–
∑ palaeotropic taxa	1	–		1	4%	–		–		–		–		–	–	–
∑ Palaeotr. characteristic taxa	1	–		1	4%	–		–		–		–		–	–	–
∑ Pal. charact. fruits and seeds	10	–		10	4%	–		–		–		–		–	–	–
Palaeotropic figures		–		12		–		–		–		–		–	–	–
Arctotertiary figures		27		90		121		24		30		26		–	–	–

Table A14. Sample 17648

Species		Vegetational units														
		1		2		3		4		5		6		7	8	9
Acer campestre	1	–		–		–		1		1		–		–	–	–
Alisma plantago-aquatica	5*	–		5*		–		–		–		–		–	–	–
Alnus tanaitica	217*	–		–		217*		–		–		–		–	–	–
Apium repens	5*	–		5*		–		–		–		–		–	–	–
Betula sp.	2	–		–		2		2		2		2		–	–	–
Carex cespitosa	34*	–		34*		–		–		–		–		–	–	–
Carex sp.	3	–		–		–		–		–		–		–	–	–
Carex szaferi	3*	–		3*		–		–		–		–		–	–	–
Carpinus betulus	2	–		–		–		–		2		2		–	–	–
Cirsium palustre	3*	–		3*		–		–		–		–		–	–	–
Decodon globosus	39*	–		39*		–		–		–		–		–	–	–
Dulichium spathaceum	27*	–		27*		–		–		–		–		–	–	–
Indet. 1	1	–		–		–		–		–		–		–	–	–
Indet. 2	1	–		–		–		–		–		–		–	–	–
Lycopus europaeus	4*	–		4*		–		–		–		–		–	–	–
Nuphar luteum	22*	22*		–		–		–		–		–		–	–	–
Nymphaea alba	5*	5*		–		–		–		–		–		–	–	–
Oenanthe lachenalii	18*	–		18*		–		–		–		–		–	–	–
Potamogeton sp.	1*	1*		–		–		–		–		–		–	–	–
Pterocarya limburgensis	4*	–		–		4*		–		–		–		–	–	–
Rubus fruticosus	12	–		–		12		12		12		12		12		–
Scirpus melanospermus	3*	–		3*		–		–		–		–		–	–	–
Scirpus pliocenicus	5*	–		5*		–		–		–		–		–	–	–
Sparganium neglectum	1*	–		1*		–		–		–		–		–	–	–
Spirematospermum wetzleri	3*	–		3*		–		–		–		–		–	–	–
∑ taxa	25	3	12%	13	52%	4	16%	–		–		–		–	–	–
∑ characteristic taxa	18	3	17%	13	72%	2	11%	–		–		–		–	–	–
∑ char. fruits and seeds	399	28	7%	149	37%	221	55%	–		–		–		–	–	–
Vegetation figures		36		161		82		–		–		–		–	–	–

Table A14 (continued)

Species		Vegetational units								
		1	2		3	4	5	6	7	8	9
∑ palaeotropic taxa	1	–	1	4%	–	–	–	–	–	–	–
∑ Palaeotr. characteristic taxa	1	–	1	6%	–	–	–	–	–	–	–
∑ Pal. charact. fruits and seeds	3	–	3	1%	–	–	–	–	–	–	–
Palaeotropic figures		–	11		–	–	–	–	–	–	–
Arctotertiary figures		36	150		82	–	–	–	–	–	–

Table A15. Sample 17647

Species		Vegetational units												
		1		2		3		4	5		6	7	8	9
Alnus tanaitica	71*	–		–		71*		–	–		–	–	–	-
Apium repens	1*	–		1*		–		–	–		–	–	–	-
Carex cespitosa	1*	–		1*		–		–	–		–	–	–	-
Carex sp.	2	–		–		–		–	–		–	–	–	-
Cladium reidiorum	45*	–		45*		–		–	–		–	–	-	-
Decodon globosus	3*	–		3*		–		–	–		–	–	–	-
Dulichium spathaceum	4*	–		4*		–		–	–		–	–	–	-
Indet.	26	–		–		–		–	–		–	–	–	-
Lycopus europaeus	1*	–		1*		–		–	–		–	–	-	-
Oenanthe lachenalii	3*	–		3*		–		–	–		–	–	–	-
Potamogeton sp.	4*	4*		–		–		–	–		–	–	–	-
Proserpinaca reticulata	4*	–		–		4*		–	–		–	–	–	-
Pterocarya limburgensis	3*	–		–		3*		–	–		–	–	–	-
Scirpus sp.	1*	–		1*		–		–	–		–	–	–	-
Sparganium neglectum	1*	–		1*		–		–	–		–	–	–	-
Stachys palustris	1*	–		1*		–		–	–		–	–	–	-
Thalictrum lucidum	1	–		–		1		–	1		–	–	–	-
Urtica urens	1*	–		1		–		–	–		–	–	–	-
Vitis sylvestris	1*	–		–		–		1	1*		–	–	–	-
∑ taxa	19	1	5%	11	58%	4	21%	–	2	11%	–	–	–	-
∑ characteristic taxa	16	1	6%	10	63%	3	19%	–	1	6%	–	–	–	-
∑ char. fruits and seeds	145	4	3%	61	42%	78	54%	–	1	1%	–	–	–	-
Vegetation figures		14		155		94		–	18		–	–	–	-
∑ palaeotropic taxa	–	–		–		–		–	–		–	–	–	-
Arctotertiary figures		14		155		94		–	18		–	–	–	-

Table A16. Sample 14132

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Acer sp.	1	–	–	–	–	–	–	–	–	–
Alisma plantago-aquatica	4*	–	4*	–	–	–	–	–	–	–
Alnus tanaitica	77*	–	–	77*	–	–	–	–	–	–
Apium repens	16*	–	16*	–	–	–	–	–	–	–
Carex cespitosa	2*	–	2*	–	–	–	–	–	–	–
Carex elongatoides	8*	–	–	8*	–	–	–	–	–	–

Table A16 (continued)

Species		Vegetational units									
		1		2		3		4	5	6	7	8	9
Carex flavaeformis	1*	–		–		1*		–	–	–	–	–	–
Carex sp.	1	–		–		–		–	–	–	–	–	–
Carex szaferi	1*	–		1*		–		–	–	–	–	–	–
Cirsium palustre	1*	–		1*		–		–	–	–	–	–	–
Decodon globosus	455*	–		455*		–		–	–	–	–	–	–
Dulichium spathaceum	1*	–		1*		–		–	–	–	–	–	–
Hypericum sp.	1	–		–		–		–	–	–	–	–	–
indet.	20	–		–		–		–	–	–	–	–	–
Lycopus europaeus	17*	–		17*		–		–	–	–	–	–	–
Menyanthes carpatica	1	–		1		–		–	–	–	–	–	1
Potamogeton sp.	1*	1*		–		–		–	–	–	–	–	–
Pterocarya limburgensis	41*	–		–		41*		–	–	–	–	–	–
Salvinia sp.	1*	1*		–		–		–	–	–	–	–	–
Sorbus aucuparia	2	–		–		2		2	–	–	–	–	–
Spirematospermum wetzleri	7*	–		7*		–		–	–	–	–	–	–
Stachys palustris	4*	–		4*		–		–	–	–	–	–	–
Taxodium dubium	1*	–		–		1*		–	–	–	–	–	–
Urtica urens	2*	–		2*		–		–	–	–	–	–	–
∑ taxa	24	2	8%	12	50%	6	25%	–	–	–	–	–	–
∑ characteristic taxa	18	2	11%	11	61%	5	28%	–	–	–	–	–	–
∑ char. fruits and seeds	640	2 x		510	80%	128	20%	–	–	–	–	–	–
Vegetation figures		19		191		73		–	–	–	–	–	–
∑ palaeotropic taxa	2	1	4%	1	4%	–		–	–	–	–	–	–
∑ Palaeotr. characteristic taxa	2	1	6%	1	6%	–		–	–	–	–	–	–
∑ Pal. charact. fruits and seeds	8	1 x		7	1%	–		–	–	–	–	–	–
Palaeotropic figures		10		11		–		–	–	–	–	–	–
Arctotertiary figures		9		180		73		–	–	–	–	–	–

Table A17. Sample 17646

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Acer sp.	1	–	–	–	–	–	–	–	–	–
Actinidia faveolata	1*	–	–	1*	–	–	–	–	–	–
Alisma plantago-aquatica	2*	–	2*	–	–	–	–	–	–	–
Alnus tanaitica	48*	–	–	48*	–	–	–	–	–	–
Carex cespitosa	9*	–	9*	–	–	–	–	–	–	–
Carex elongatoides	5*	–	–	5*	–	–	–	–	–	–
Carex flagellata	12*	–	12*	–	–	–	–	–	–	–
Carex flavaeformis	4*	–	–	4*	–	–	–	–	–	–
Carex riparia	1*	–	1*	–	–	–	–	–	–	–
Carex sp.	4	–	–	–	–	–	–	–	–	–
Carex strichosoides	2	–	–	2	–	2	–	–	–	–
Carex szaferi	1*	–	1*	–	–	–	–	–	–	–
Carpinus betulus	10	–	–	–	–	10	10	–	–	–
Ceratophyllum submersum	2*	2*	–	–	–	–	–	–	–	–
Chamaecyparis sp.	1	–	–	–	–	–	–	–	–	–
Decodon globosus	8*	–	8*	–	–	–	–	–	–	–
Dulichium spathaceum	52*	–	52*	–	–	–	–	–	–	–

Table A17 (continued)

Species		Vegetational units												
		1	2	3	4	5	6	7	8	9				
Euphorbia palustris	3*	–	3*	–	–	–	–	–	–	–				
Fagus decurrens	1*	–	–	–	–	–	1*	–	–	–				
Indet. 1	3	–	–	–	–	–	–	–	–	–				
Indet. 2	1	–	–	–	–	–	–	–	–	–				
Indet. 3	12	–	–	–	–	–	–	–	–	–				
Magnolia cor	1*	–	–	1*	–	–	–	–	–	–				
Nymphaea alba	2*	2*	–	–	–	–	–	–	–	–				
Oenanthe lachenalii	2*	–	2*	–	–	–	–	–	–	–				
Potamogeton sp.	37*	37*	–	–	–	–	–	–	–	–				
Proserpinaca reticulata	6*	–	–	6*	–	–	–	–	–	–				
Prunus sp.	1	–	–	–	1	1	1	1	–	–				
Pterocarya limburgensis	71*	–	–	71*	–	–	–	–	–	–				
Rubus fruticosus	15	–	–	15	15	15	15	15	15	–				
Sambucus pulchella	4	–	–	4	4	4	–	–	–	–				
Scirpus melanospermus	5*	–	5*	–	–	–	–	–	–	–				
Scirpus pliocenicus	5*	–	5*	–	–	–	–	–	–	–				
Scirpus tabernaemontani	1*	–	1*	–	–	–	–	–	–	–				
Sparganium neglectum	17*	–	17*	–	–	–	–	–	–	–				
Spirematospermum wetzleri	5*	–	5*	–	–	–	–	–	–	–				
Vitis sylvestris	6*	–	–	–	6	6*	–	–	–	–				
∑ taxa	37	3	8%	14	38%	10	27%	–	6	16%	4	11%	–	–	–
∑ characteristic taxa	27	3	11%	14	52%	7	26%	–	1	4%	1	4%	–	–	–
∑ char. fruits and seeds	309	41	13%	123	40%	136	44%	–	6	2%	1 x		–	–	–
Vegetation figures		32		130		97		–	22		15		–	–	–
∑ palaeotropic taxa	1	–		1	3%	–		–	–		–		–	–	–
∑ Palaeotr. characteristic taxa	1	–		1	4%	–		–	–		–		–	–	–
∑ Pal. charact. fruits and seeds	5	–		5	2%	–		–	–		–		–	–	–
Palaeotropic figures		–		9		–		–	–		–		–	–	–
Arctotertiary figures		32		121		97		–	22		15		–	–	–

Table A18. Sample 18169

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alnus tanaitica	152*	–	–	152*	–	–	–	–	–	–
Boehmeria colchica	11	–	–	11	–	11	–	–	–	–
Carex cespitosa	3*	–	3*	–	–	–	–	–	–	–
Carex helmensis	7	–	–	–	–	–	–	–	–	–
Carex sp.	5	–	–	–	–	–	–	–	–	–
Carex szaferi	7*	–	7*	–	–	–	–	–	–	–
Ceratophyllum submersum	1*	1*	–	–	–	–	–	–	–	–
Cirsium palustre	4*	–	4*	–	–	–	–	–	–	–
Cladium reidiorum	1*	–	1*	–	–	–	–	–	–	–
Decodon globosus	49*	–	49*	–	–	–	–	–	–	–
Dulichium spathaceum	15*	–	15*	–	–	–	–	–	–	–
Dulichium vespiforme	2*	–	2*	–	–	–	–	–	–	–
Indet.	15	–	–	–	–	–	–	–	–	–
Nelumbo sp.	2*	2*	–	–	–	–	–	–	–	–
Oenanthe lachenalii	11*	–	11*	–	–	–	–	–	–	–

Table A18 (continued)

Species		Vegetational units											
		1		2		3		4	5	6	7	8	9
Pterocarya limburgensis	2*	–		–		2*		–	–	–	–	–	–
Rubus fruticosus	1	–		–		1		1	1	1	1	1	–
Rumex sp.	1	–		–		–		–	–	–	–	–	–
Sagittaria sagittifolia	2*	–		2*		–		–	–	–	–	–	–
Sparganium neglectum	4*	–		4*		–		–	–	–	–	–	–
Thalictrum lucidum	10	–		–		10		–	10	–	–	–	–
Urtica dubia	3	–		3		3		–	–	–	–	–	–
Urtica urens	3*	–		3*		–		–	–	–	–	–	–
∑ taxa	23	2	9%	12	52%	7	30%	–	–	–	–	–	–
∑ characteristic taxa	15	2	13%	11	73%	2	13%	–	–	–	–	–	–
∑ char. fruits and seeds	258	3	1%	101	39%	154	60%	–	–	–	–	–	–
Vegetation figures		23		160		103		–	24	–	–	–	–
∑ palaeotropic taxa	1	1	4%	–		–		–	–	–	–	–	–
∑ Palaeotr. characteristic taxa	1	1	7%	–		–		–	–	–	–	–	–
∑ Pal. charact. fruits and seeds	2	2	1%	–		–		–	–	–	–	–	–
Palaeotropic figures		12		–		–		–	–	–	–	–	–
Arctotertiary figures		11		160		103		–	24	–	–	–	–

Table A19. Sample 18170

Species		Vegetational units								
		1	2	3	4	5	6	7	8	9
Alisma plantago-aquatica	15*	–	15*	–	–	–	–	–	–	–
Alnus tanaitica	87*	–	–	87*	–	–	–	–	–	–
Apium repens	1*	–	1*	–	–	–	–	–	–	–
Azolla tegeliensis	22*	22*	–	–	–	–	–	–	–	–
Boehmeria colchica	22	–	–	22	–	22	–	–	–	–
Carex acutiformis	2	–	2	2	–	–	–	–	–	–
Carex cespitosa	2*	–	2*	–	–	–	–	–	–	–
Carex flagellata	4*	–	4*	–	–	–	–	–	–	–
Carex helmensis	4	–	–	–	–	–	–	–	–	–
Carex pilulifera	3*	–	–	–	–	–	3*	–	–	–
Carex sp.	1	–	–	–	–	–	–	–	–	–
Carex szaferi	28*	–	28*	–	–	–	–	–	–	–
Decodon globosus	30*	–	30*	–	–	–	–	–	–	–
Dulichium spathaceum	59*	–	59*	–	–	–	–	–	–	–
Hypericum sp.	2	–	–	–	–	–	–	–	–	–
indet.	85	–	–	–	–	–	–	–	–	–
Lycopus europaeus	5*	–	5*	–	–	–	–	–	–	–
Oenanthe lachenalii	2*	–	2*	–	–	–	–	–	–	–
Potamogeton sp.	2*	2*	–	–	–	–	–	–	–	–
Proserpinaca reticulata	3*	–	–	3*	–	–	–	–	–	–
Prunus sp.	1*	–	–	–	1*	–	–	–	–	–
Pterocarya limburgensis	8*	–	–	8*	–	–	–	–	–	–
Ranunculus repens	4	–	4	4	4	4	–	–	–	–
Rubus fruticosus	4	–	–	4	4	4	4	4	4	–
Sagittaria sagittifolia	31*	–	31*	–	–	–	–	–	–	–
Salix sp.	41*	–	–	–	–	41*	–	–	–	–
Scirpus melanospermus	18*	–	18*	–	–	–	–	–	–	–
Scirpus pliocenicus	1*	–	1*	–	–	–	–	–	–	–

Table A19 (continued)

Species		Vegetational units													
		1		2		3		4		5		6		7	8	9
Scirpus tabernaemontani	4*	–		4*		–		–		–		–		–	–	–
Sparganium neglectum	7*	–		7*		–		–		–		–		–	–	–
Stachys palustris	1*	–		1*		–		–		–		–		–	–	–
Typha latifolia	684*	–		684*		–		–		–		–		–	–	–
Urtica dubia	20	–		20		20		–		–		–		–		
Urtica urens	19*	–		19*		–		–		–		–		–	–	–
Vitis sylvestris	1*	–		–		–		1		1*		–		–	–	–
∑ taxa	35	2	6%	19	54%	8	23%	4	11%	5	14%	2	6%	–	–	–
∑ characteristic taxa	25	2	8%	16	64%	3	12%	1	4%	2	8%	1	4%	–	–	–
∑ char. fruits and seeds	1057	24	2%	892	84%	98	9%	1 x		42	4%	3 x		–	–	–
Vegetation figures		16		202		44		15		26		10		–	–	–
∑ palaeotropic taxa	1	1	3%	–		–		–		–		–		–	–	–
∑ Palaeotr. characteristic taxa	1	1	4%	–		–		–		–		–		–	–	–
∑ Pal. charact. fruits and seeds	22	22	2%	–		–		–		–		–		–	–	–
Palaeotropic figures		9		–		–		–		–		–		–	–	–
Arctotertiary figures		7		202		44		15		26		10		–	–	–

Table A20. Assemblage 1982

Species		Vegetational units													
		1	2		3		4	5		6		7	8	9	
Acer tricuspidatum	5*	–	–		–		–	4*		–		–	–	–	
Aesculus hippocastanum	20*	–	–		–		–	20*		–		–	–	–	
Alnus cecropiaefolia	96*	–	–		96*		–	–		–		–	–	–	
Alnus incana	4*	–	–		–		–	4*		–		–	–	–	
Carpinus grandis	7*	–	–		–		–	7*		–		–	–	–	
Monocotyledonophyllum sp. 1	1	–	1		1		–	–		–		–	–	–	
Monocotyledonophyllum sp. 2	5	–	5		5		–	–		–		–	–	–	
Populus alba	1*	–	–		–		–	1*		–		–	–	–	
Pterocarya paradisiaca	7*	–	–		7*		–	–		–		–	–	–	
Quercus pseudocastanea	2*	–	–		–		–	–		2*		–	–	–	
Salix varians	1*	–	–		–		–	1*		–		–	–	–	
Sparganium sp.	1*	–	1*		–		–	–		–		–	–	–	
Ulmus pyramidalis	4*	–	–		–		–	4*		–		–	–	–	
∑ taxa	13	–	3	23%	4	31%	–	7	54%	1	8%	–	–	–	
∑ characteristic taxa	11	–	1	9%	2	18%	–	7	64%	1	9%	–	–	–	
∑ char. leaves	148	–	1	1%	103	70%	–	41	28%	2	1%	–	–	–	
Vegetation figures		–	33		119		–	146		18		–	–	–	
∑ palaeotropic taxa	–	–	–		–		–	–		–		–	–		
Arctotertiary figures	–	–	33		119		–	146		18		–	–	–	

Table A21. Assemblage 1995

Species		Vegetational units											
		1	2		3		4	5		6	7	8	9
Aesculus hippocastanum	1*	–	–		–		–	1*		–	–	–	–
Alnus cecropiaefolia	1*	–	–		1*		–	–		–	–	–	–
Alnus incana	76*	–	–		–		–	76*		–	–	–	–
Betula subpubescens	1	–	–		1		–	1		–	–	–	–
Monocotyledonophyllum sp. 1	21	–	18		18		–	–		–	–	–	–
Monocotyledonophyllum sp. 2	9	–	9		9		–	–		–	–	–	–
Populus sp.	4*	–	–		–		–	3*		–	–	–	–
Sparganium sp.	12*	–	12*		–		–	–		–	–	–	–
Ulmus pyramidalis	9*	–	–		–		–	9*		–	–	–	–
$\sum$ taxa	9	–	3	33%	4	44%	–	5	56%	–	–	–	–
$\sum$ characteristic taxa	6	–	1	17%	1	17%	–	4	67%	–	–	–	–
$\sum$ char. leaves	105	–	12	11%	1	1%	–	89	85%	–	–	–	–
Vegetation figures		–	61		62		–	208		–	–	–	–
$\sum$ palaeotropic taxa		–	–		–		–	–		–	–	–	–
Arctotertiary figures		–	61		62		–	208		–	–	–	–

Table A22. List of samples used for carpological analysis

Carpoflora sample from leaf assemblage, collected 1982	18169
Sub-basal banded clay sample, collected 1982, field number 12	14149
Basal clay sample, collected 1982, field number 36	17648
Basal clay sample, collected 1982, field number 18	17647
Basal clay sample, collected 1982, field number 19	14132
Basal clay sample, collected 1982, field number 43c	14377
Top clay sample, collected 1982, field number 11	17646
Top clay sample, collected 1983, field number 43a	14375
Top clay sample, collected 1983, field number 43b	14376
Sequence of samples from section 1983, Field numbers top to bottom: 44a to 44i	
Field number 44a	14378
Field number 44b	14379
Field number 44c	14380
Field number 44d	14381
Field number 44e	14382
Field number 44f	14383
Field number 44g	14384
Field number 44h	14385
Field number 44i	14386
Carpoflora sample from leaf assemblage, collected 1995	18170

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