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THE BRYOPHYTE TORTELLA FLAVOVIRENS (BRUCH) BROTH. IN LATE GLACIAL SEDIMENTS FROM USSELO (THE NETHERLANDS) AND ITS SIGNIFICANCE AS A PALAEO-ENVIRONMENTAL INDICATOR

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SUMMARY

The presence of remains of *Tortella flavovirens* in a lake deposit of Bølling age (ca. 12,200 years B.P.) corroborates the idea that landscape, soils and vegetation in sandy areas in N.W.-Europe had certain characteristics in common with the present calcareous coastal sand dunes in Denmark, The Netherlands and Belgium.

1. INTRODUCTION

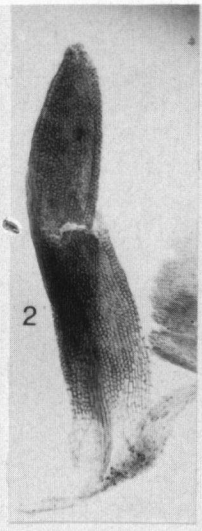
The Late Glacial period (c. 13,000–10,150 years B.P.) has been studied intensively in N.W.-Europe. Reconstructions of the climate of this period are mainly based on the present-day autecology of plant species found as micro- and macrofossils in sediments, and on relevant geological data. Overviews of the final phase of the last Ice Age have been given by GODWIN (1975), IVERSEN (1973), and OVERBECK (1975). Fundamental problems in environmental reconstruction, radiocarbon dating, and stratigraphical subdivision have been discussed recently by LOWE et al. (1980).

The site Usselo (52°12′N, 6°49′E) lies in a cover-sand area (cf. VAN DER HAMMEN & WIJMSTRA 1971) at c. 140 km from the North Sea coast. During the Late Glacial period the distance to the coast was much greater. A palynological study of the Late Glacial deposits of the Usselo site was carried out for the first time by VAN DER HAMMEN (1951). A detailed study of a section collected at Usselo in 1975, based on the analysis of pollen and a variety of micro- and macrofossils has been carried out by the second author (B.v.G.).

2. MATERIALS AND METHODS

Successive 0.5 cm thick samples for macrofossil analysis (each one c. 5 ml in volume) were boiled in 5% KOH for 5 minutes and strained through a sieve with 140 × 140 μm meshes. During the analysis as many recognisable, fossilised vegetable and animal remains were identified as possible (cf. VAN GEEL 1978).


1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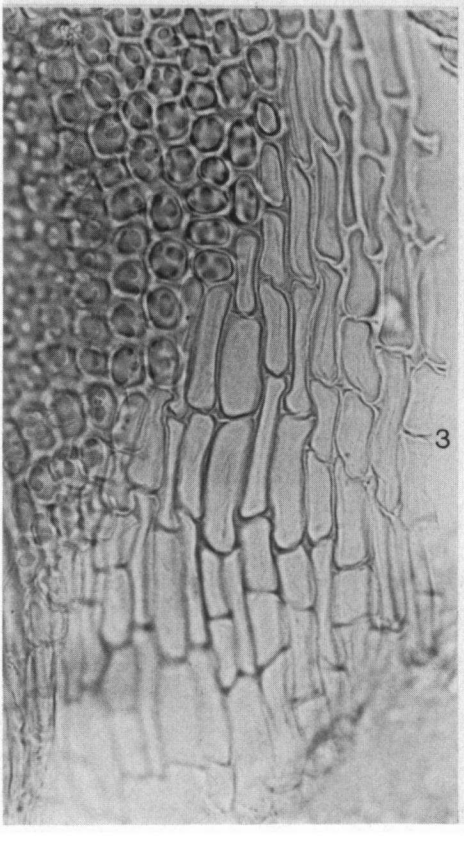
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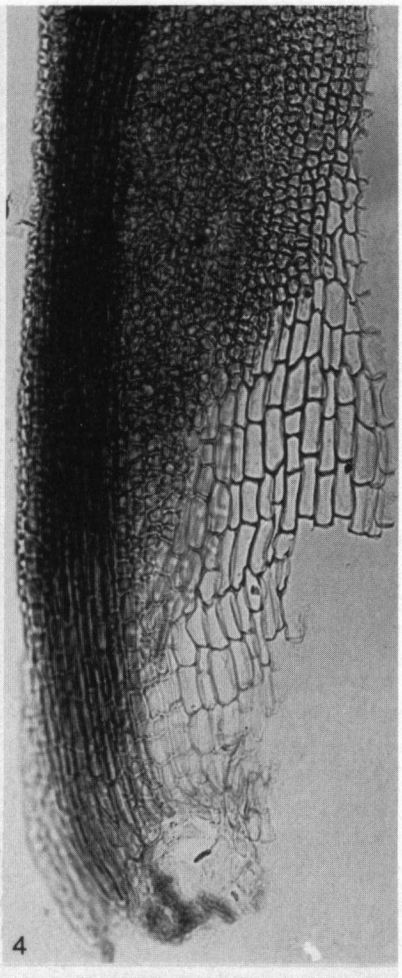
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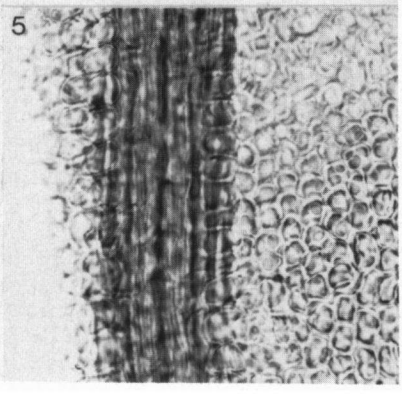
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Several hundred permanent voucher slides were made in order to identify epidermis fragments and mosses; identified fruits and seeds were stored in small plastic boxes. The first author studied the bryophyte remains. The identifications were made with a Leitz microscope.

Names of vascular plants follow HEUKELS-VAN OOSTSTROOM (1977), those of bryophytes MARGADANT & DURING (1982).

For the presentation of all other accumulated data several papers are in preparation.

3. RESULTS

3.1. Identification of the Tortella remains (see *plate 1, fig. 1–5*)

In one sample (slide no. BvG 587) from the lake deposit one shoot tip (*fig. 1*) and two detached leaves of *Tortella* were found. The identity of the material presented in *Plate 1* with *Tortella flavovirens* was assessed from the sharp transition of the V-shaped group of elongated and clear basal cells into the chlorophyllose lamina cells (*fig. 2, 4*), ranging in width from 9–14 μm (*fig. 3*), and from the quadrate cells covering the middle part of the nerve on the adaxial side of the leaf (not discernible in *plate 1*). The leaf tips were too much corroded to exhibit the shortly excurrent nerve, however. The areolation in the upper part of the leaf is clear and not obscured by a dense covering of papillae, as in the strongly resembling species *T. inclinata*. The determination was confirmed by H. J. DURING (pers. comm.). Both MARGADANT & DURING (1982) and SMITH (1978) describe two varieties of *T. flavovirens*, which are said to differ in the width of the chlorophyllose cells. From the size of these cells in the present material, the fossil remains show a greater resemblance to the var. *glareicola*. NYHOLM (1975) did not discern intraspecific taxa, but her description seems to pertain to the var. *flavovirens* rather than to the other one. Based on his revision of Dutch herbarium collections of *Tortella*, RUBERS (1973) concluded that the var. *glareicola* is the more common one of the two varieties in The Netherlands.

3.2. Some characteristics of the part of the section in which Tortella was found

A chronological framework covering the Late-Glacial period in The Netherlands was presented by LANTING & MOOK (1977). It is based on ^{14}C samples from the deposits at Usselo. The recent, detailed analysis of a section from the Usselo site has not yet been carbon-dated, but using palynological data for our

Plate 1. *Tortella flavovirens* (Bruch) Broth. fossil remains from Usselo.
Fig. 1. Shoot tip, × 50.
Fig. 2. Detached leaf, × 50.
Fig. 3. Detail of leaf base, showing distinct boundary between clear basal cells and papillose lamina cells, × 450.
Fig. 4. Leaf base, showing sharp V-shaped boundary between basal cells and lamina cells, × 200.
Fig. 5. Detail of dorsal side of nerve, × 370.

Table 1. A selection of micro-and macrofossil taxa in 10 successive, 0.5 cm thick samples of Bølling age from the section Usselo 1975.

Microfossils (percentages)			
Σ pollen taxa (n = 4373)		Other relevant taxa	
Artemisia	5.4	Centaurea jacea	+
Betula	25.7	C. scabiosa	+
Cyperaceae	23.1	Polemonium caeruleum	+
Ericales	+	Saxifraga oppositifolia type	+
Helianthemum	0.4	Sanguisorba minor	+
Hippophaë rhamnoides	0.2	S. officinalis	0.2
Juniperus communis	11.3		
Pinus	1.0	Botryococcus	40.4
Plantago	0.6	Gloeotrichia type	0.4
Poaceae	22.5	Pediastrum	4.5
Rumex	0.8		
Salix	6.3	Selaginella selaginoides, microspores	0.5
Thalictrum	2.7		
Macrofossils (total numbers)			
Betula nana, bud scales	32	cf. Amblystegium riparium	+
B. nana, ♀ catkin scales	18	Amblystegium serpens	+
Betula, seeds	22	Calliergonella cuspidata	+
Carex rostrata, fruits	18	Calliergon giganteum	+
Juniperus communis, seeds	2	C. stramineum	+
J. communis, needles	5	Drepanocladus aduncus	+
Potamogeton alpinus, seeds	3	D. exannulatus	+
P. praelongus, seed	1	Polytrichum longisetum	+
Salix, leaves and shoots	+	Scorpidium scorpioides	+
Characeae, oöspores	467	Sphagnum spec.	+
Selaginella selaginoides, megaspores	17	Tortella flavovirens	+

correlation, we can place the level containing the remains of *T. flavovirens* in the Bølling period (c. 12,200 years B.P.). During that period a lake deposit was formed in which also remains from the stands of vegetation around the lake were incorporated and preserved. The relatively small lake probably originated as a branch of a river that had already become blocked before the Bølling period. The sampling site was at ca. 6 m distance from the border of the lake.

In *table 1* the association of relevant micro- and macrofossils in a 5 cm thick layer of the sediment is presented. The palaeoecological significance of the occurrence of *Artemisia, Betula nana, Helianthemum, Hippophaë, Juniperus,* and other associated plants in Late Glacial deposits was given by IVERSEN (1973) and OVERBECK (1975). The spectrum of micro- and macrofossils in *table 1* indicates, as was to be expected, that the landscape during the Bølling period had a very open character (park-tundra), and sustained herbs and shrubs on the raw, unleached, and lime-rich sandy soil with a very low humus content. The soil material was deposited during the preceding Upper Pleniglacial period (VAN DER HAMMEN et al. 1967) as a result of solifluction and transport of cover-sand. During

the Bølling period there was no dense and continuous protective plant cover and, as a consequence, the uppermost layers of the soil, especially on slopes, were exposed to erosion by wind and rain. The sandy nature of the lake deposit of Bølling age at Usselo is also an indication of such conditions. *Tortella flavovirens,* with a "colonist strategy" sensu DURING (1979), is able to cope with the harsh conditions in this type of surroundings (LANDWEHR 1966).

IVERSEN (1973) compared similar Late Glacial conditions in Denmark with those of the recent sand dunes along the coast of W. Jutland (which are quite similar to those in The Netherlands and Belgium). In their descriptions of the ecology of *Tortella flavovirens* DIXON (1924), LANDWEHR (1966), MARGADANT & DURING (1982), NYHOLM (1975), and SMITH (1978) all emphasise its occurrence in calcareous dune systems near the sea. The present find shows that a calcareous, sandy habitat with a low vegetation cover is likely to be of higher importance than a site at a short distance from the sea, which BATES (1975) on the basis of ordination of bryophytes from a small island, stresses as an important factor.

Other taxa reflecting the vegetation types in the vicinity of the lake and tending to have a preference for soils with a basic character are, e.g., *Centaurea jacea, C. scabiosa, Helianthemum, Hippophaë rhamnoides, Polemonium caeruleum, Sanguisorba minor,* and *S. officinale. Juniperus communis* and *Selaginella selaginoides* may also be found growing in lime-rich habitats. Submerged taxa that lived in the lake, and are sometimes common in waters with a considerable Ca^{2+} content are also represented: *Scorpidium scorpioides,* Characeae, and *Gloeotrichia*-type (cf. VAN GEEL et al. 1983).

3.3. Palaeoelogical significance of the remains of Tortella flavovirens in the section Usselo

The occurrence of *Tortella flavovirens* in an inland lake deposit of Bølling age corroborates the idea that during that period soils, landscape, and vegetation in sandy areas in NW-Europe shared certain characteristics with the present calcareous coastal sand dunes in Denmark, The Netherlands, and Belgium. From the species spectrum in *table 1,* found in this layer of lake deposit, one may deduce that around the lake, plant communities found at sites with a rather open sward liable to wind erosion, closed turfs at both relatively dry and fairly wet sites, and locally also scrub vegetation were present.

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