LATE-GLACIAL DEPOSITS AT NAZEING IN THE LEA VALLEY, NORTH LONDON

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With a Report on Small Mammalia by M. A. C. Hinton, F.R.S.

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At Nazeing, Essex, in the valley of the River Lea, a series of deposits has been investigated which extends back in time from the Post-Glacial climatic optimum to Late-Glacial times in the widest sense of that term. They are of special importance as bridging the time gap between the well-known 'Arctic Plant Bed' of the Ponder's End stage (which occurs also at Nazeing), and the established Post-Glacial vegetational and climatic sequence. Pollen analysis of the main organic beds has permitted a general dating to be given to the various stages of formation of the deposits and this has been supplemented by a radio-carbon assay.

Through the gravel sheet of the Ponder's End stage a wide channel was cut which persisted with vicissitudes until Boreal time. At first this channel and the surrounding gravel plain were covered with organic muds and marls of a shallow lake containing stunted Mollusca of close affinity with those of Ponder's End, and pollen indicative of rich herbaceous vegetation and an unwooded countryside. The channel was re-cut and the mere drained, and in the bed of the new channel, above an infilling of gravel, there began deposition of organic muds and then peats, a process which continued without interruption until, after a third short phase of erosion and drying in Mid-Boreal time (zone VI), the whole valley of the Lea was converted to fen. The later Boreal and succeeding Atlantic peats (zone VII) are sealed in by river flood clay.

The Mollusca (whose determination is largely that of the late Santer Kennard) retain the general character of the Ponder's End aggregate through the mere deposits, and the channel deposits up to the third erosion stage. The progress of drying of the mere is shown by the increasing proportion of land- to fresh-water shells.

From the base of the channel which is referred to zone III, the close of the Late-Glacial period, the calcareous muds have yielded an extensive collection of plant remains, chiefly fruits and seeds belonging to 'arctic-alpine', 'marsh' and 'ruderal' species. Some of the species recognized have hitherto been regarded as weeds and introductions by man to the British flora; others have now a very restricted range.

The pollen analyses of both the mere and channel-bottom deposits show great abundance and range of pollen of herbaceous plants, including many familiar already as Late-Glacial species and some, such as *Polemonium coeruleum*, newly recognized as such.

It is apparent that conditions of the Late-Glacial period greatly favoured the spread of certain categories of plants, and that knowledge of this period is of the utmost importance in establishing the history of the British Flora.

In the calcareous muds of the channel (zone III) and in the earlier muds beneath the lake marl the remains have been identified of four mammals of late Pleistocene character (including two species of lemming). At the close of zone III the calcareous muds yielded abundant bones of *Bufo* and *Rana* together with *Lacerta vivipara*. At the Early Boreal drying surface (Mx) of the channel there are also abundant land shells, and at this stage the molluscan fauna has a new and characteristic Holocene stamp, although small mammals of Late Pleistocene type survive, notably *Ochotona spelaea* (pika) and *Microtus anglicus*.

A general correlation is attempted for all the phenomena described, geological, floristic and faunistic, and they are tentatively related to corresponding phenomena in Britain and north-western Europe.

1. GENERAL STRATIGRAPHY AND FAUNA

(S. H. Warren)

(*a*) Introduction: position of the site

Throughout the basin of the Thames and its tributaries there is usually a marked break between the Pleistocene and Holocene deposits. On the floor of the Lea Valley, in the Nazeing and Broxbourne district, we have a well-defined group of deposits that are transitional between the two periods.

The plan (figure 1) shows the three pits of the St Albans Sand Co., on Nazeing Mead, about $\frac{3}{4}$ mile farther up-stream than Broxbourne railway station, and on the east side of the river. A former course of the river, which I have called the Nazeing channel, with its infilled deposits belonging to zones III–VI of the pollen-analysis sequence, crosses the middle pit from north-east to south-west. The north face of the pit was not seen, but the channel was seen in the middle of the pit, and it did not turn to cross either the east or west faces. The width of the channel varied; it reached 60 yd. at the southern end and was much wider at M 4, although this width represented a shifting channel and was probably not occupied by the river at any one moment of time. The position of the various sites referred to in the text is indicated on the plan and sections.

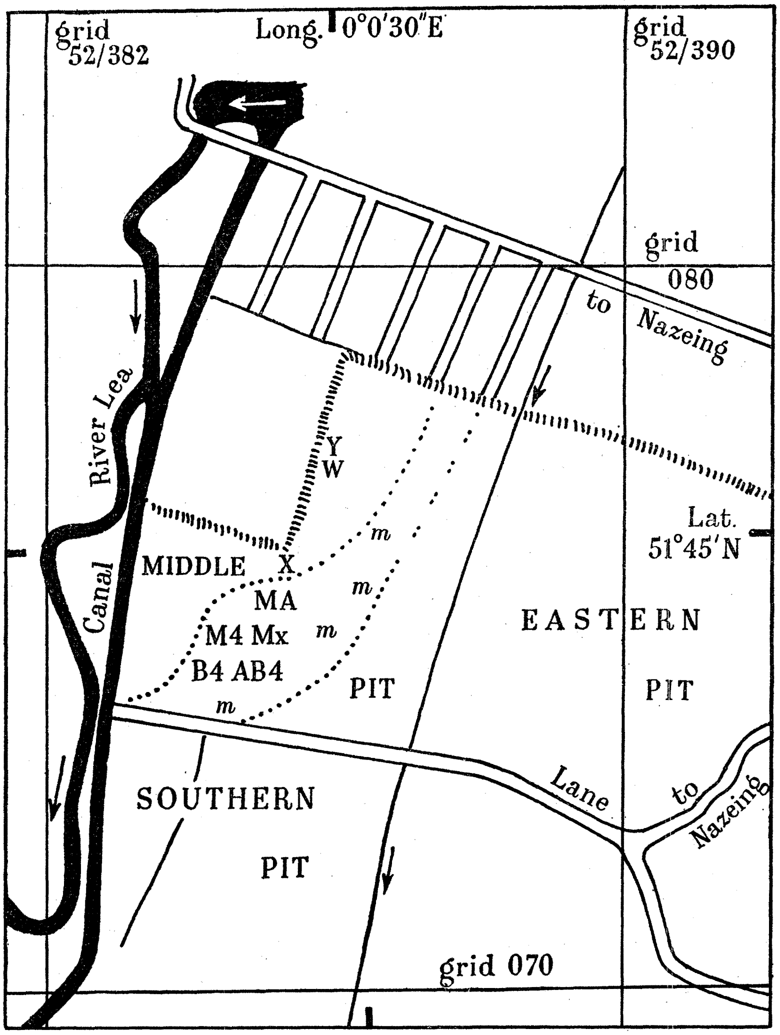

FIGURE 1. Sketch map of the gravel-pits at Nazeing, Essex. Letters indicate the sites of recorded sections, the area within dotted lines is approximately that of the buried channel; *m* indicates minor patches of the deposit 'M' beds. Scale is given by the National Grid references.

In the extreme south-west corner of the pit the channel is swinging to the west, and does not touch the position of the south pit. A little farther down-stream it evidently turns south (which is the direction of the valley), as it occurs again in Rikof's pit (see Warren, Clark, Godwin, H. & M. E., and Macfadyen 1934).

(*b*) The flood-plain gravel

The earliest known deposit of the flood-plain of the River Lea is the gravel of the Ponder's End stage, with its included Late-Glacial plant bed generally referred to as 'The Arctic Bed'. This must originally have spread over the whole floor of the valley, and still occupies considerable areas from Nazeing to Stratford. But through a long period of time the river has wandered over this plain cutting and refilling new channels in different directions, so that there is no general stratigraphical sequence. There may be inliers of gravel on the flood-plain that are earlier than the Ponder's End stage, but none has been proved so far as I know; on the other hand, a considerable proportion of the flood-plain gravel has been proved to be later.

Typical Arctic Bed (Warren 1912, 1916) has been proved in the east and south pits, and in the south-east corner only of the middle pit, but the main part of the middle pit is occupied by gravel which has probably been rearranged in channels later than the Arctic Bed. Remains of *Elephas primigenius* and *Rangifer tarandus* have been dredged from below the water-level of the pit, but these may be from remnants or pockets of the earlier gravel (figure 3, Gr i). *Rhinoceros antiquitatis* is very common in the Ponder's End stage but has not yet been recorded from the gravels that are either presumed, or known, to be later.

To the west of 'M4' on the plan a large and massive antler of *Cervus elaphus* was dredged from the bottom of the gravel, but being below the water-level in the pit the exact circumstances were uncertain. Dr Godwin and Miss Allison in their report comment on the absence of any evidence of the Allerød milder interlude (zone II) between the Late-Glacial zones I and III. It is possible that this find might have been in a channel of zone II date; one can only say that it seemed out of place otherwise, but the explanation is a matter of speculation.

I am indebted to Mr C. P. Caskell of the British Museum (Natural History) for examining a small collection of Mollusca from a patch of Arctic Plant Bed in the south-east corner of the middle pit. Material from the same patch was sent to Chicago for Carbon-14 dating (see §3). The list, with the numbers of each, is as follows:

Succinea oblonga, 5; *Limnaea truncatula*, 1; *Columella columella*, 7; *Pupilla muscorum*, 21; *Oxychilus allianus*, *Pisidium* sp., 1.

The distinctive Nazeing channel species, *Troculus hispidus*, *Planorbis leucostoma*, *Succinea pfeifferi*, were all absent.

(*c*) The early stages of the Nazeing channel

As indicated above, the earlier stages of the Nazeing channel remain obscure. The underlying gravel rests upon an undulating floor of sand belonging to the Reading Beds, at a depth of some 22 to 25 ft. from the surface. But below the visible channel at higher levels, the dredging proved the existence of a deeper channel going down some 5 ft. or more below the general subdrift surface. It seems not improbable that this represents the first stage of the Nazeing channel. At least after partial refilling with gravel the overlying shallower channel was clearly defined.

At the spot marked W–Y on the plan (figure 1) and sections (figure 2) the upper part of the gravel showed a well-marked hollow in the stratification which is occupied by a bed of peaty mud up to about a foot thick in the middle (Peat B); a loamy sand about 2 ft. thick coming between this and the overlying Peat C to be described in the next section. This hollow probably represents a small tributary of the main channel at this stage. As will be found in Dr Godwin's and Miss Allison's investigations Peat B yielded a similar Late-Glacial flora to that of the immediately overlying Peat C; the difference in time represented by the intervening bed of loamy sand may be quite negligible.

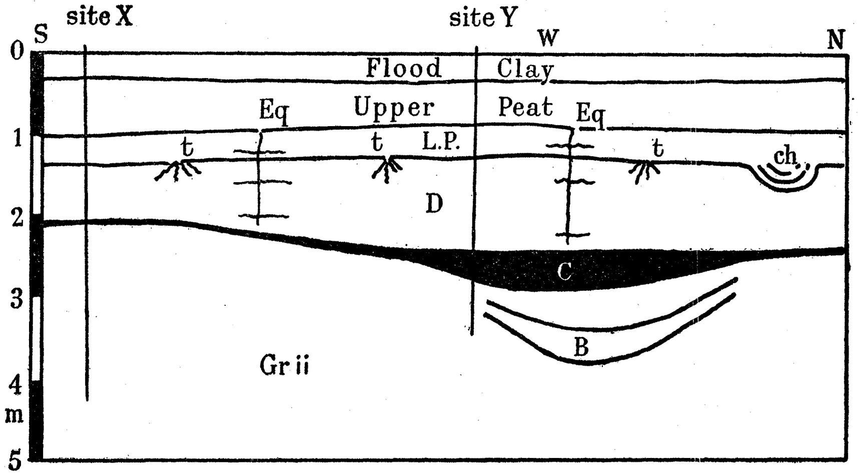

FIGURE 2. Diagrammatic section of the north-east pit face showing calcareous muds (Marl D) of the mere, the surface channelled and penetrated by tree roots during the Pre-Boreal and Boreal period. Above this surface rests the Boreal and Atlantic peat identified by the pollen series taken at X. Lettering of beds as in text.

These deposits were thickest in the middle, and thinned off towards the edges; their accumulation did not obliterate the shallow channel, and the overlying Peat C thickened exceptionally to 18 in. in the middle of this channel. This local thickening was not continued upwards into Marl D or the overlying fen peats.

(*d*) PEATY MUD C UNDERLYING MARL D

These two deposits, though very different in character, are everywhere closely related in sequence. The former is a bed of peaty mud, seldom more than 3 in. thick on the flood-plain (except over Peat B). At a distance of about 200 yd. from the bank of the channel Peaty mud C thins off to a feather-edge and finally disappears; Marl D then rests directly on the gravel, before it in turn disappears.

Dr Godwin's and Miss Allison's work indicates the final Glacial stage as the probable date of Peat C.

(*e*) MARL D, OF THE TEMPORARY MERE

This partly lacustrine, or mere, deposit occurred over all the north-western part of the pit. Over a considerable area it was about 4 ft. thick, which may be taken as its maximum. On the east face of the pit it appeared to be represented by 1 to 2 ft. of sandy loam, below about the same thickness of peat, without shells or other remains. The gravel surface on the east side was slightly higher than on the west, and was evidently not subject to the same prolonged flooding.

Marl D yields an abundant molluscan fauna, and it was through sending a collection of the shells to Mr Kennard that the significance of the site came to be realized. He reported that the Mollusca were a modified survival of the stunted fauna of the Arctic Plant Bed, including the sub-Arctic form *Columella columella.*

The deposit is a true marl, often of a loamy texture, and is a mixture of clay (largely Eocene), chalk, some sand, and much fine silt. Although its continuity suggests a single unbroken sheet of shallow water, it shows local variation; in some places it is practically a clay, in others it passes to a calcareous ooze. This is not surprising, as there would always be some slow current passing through the mere, or 'broad', and this might well result in local grading of the material. There was some rather obscure stratification, but no lamination. It contains small stones, and a few of larger size; there are also chalk pebbles and lumps and pellets of derivative peat and Eocene clay. Small groups of chalk or other material were noted, associated together, and also lenses of sand. Perhaps these may have arisen from the melting of ice-floes drifted from up-stream.

All the deposits of the Nazeing channel contain derivative material to varying degrees, and I found flints up to 4 in. diameter in the upper fen-peats.

(*f*) THE MOLLUSCA OF MARL D

For the study of the Mollusca Marl D was divided into three stages, namely, 'Base', the lowest 3 in.; 'Top', the uppermost 3 in.; and 'Mid', the main middle thickness. Samples were collected from different situations over the area, but these proved almost identical, and so there seemed no useful purpose in keeping them separate. The results are recorded in the table of Mollusca (table 2), and it is of interest to point out that the 'Base' gave 18 % of land shells, the 'Mid' 33 % and the 'Top' 51 %, pointing to an increasing tendency to intermittent desiccation during the accumulation of the marl. Although there was much recent infiltration of land shells from the surface 'D' down root-holes and animal burrows (see subsection (*k*)) every care was used to avoid these, and it seems certain that the percentages must indicate a progressive fall in the water-level.

TABLE 1

	Arctic Plant Bed	Nazeing Channel
Pupilla muscorum	commonest	scarcer
Succinea oblonga	very common	absent
Columella columella	common	scarcer
Planorbis leucostoma	very rare	commonest
Succinea pfeifferi	common	very common
Troculus hispidus	absent	very common

It has already been mentioned that the Mollusca of the Nazeing channel are, as a whole, a survival of those of the Arctic Bed but not without some notable modifications. Table 1 shows the chief diagnostic differences.

(*g*) THE B4 GROUP OF DEPOSITS

The situation of these deposits is indicated on the plan and sections (figures 1, 3); they were very variable in composition, and there was sometimes a foot or two of peaty mud overlaid by marly silt of uncertain original thickness owing to the erosion it suffered.

Apparently marly silt was in larger quantity than peaty mud, with some subordinate peaty sand. There were more included stones than in Marl D; lamination by slowly moving water was frequent, and in places there was evidence of contemporary erosion and resorting.

These deposits occurred as a large number of separate patches included in the gravel, and their position was horizontal longitudinally to the course of the river, but dipping laterally from the bank to mid-channel. The largest patch I saw remaining intact measured 50 yd. in the longitudinal direction near the bank of the river, where it rose laterally to the top of the gravel. The physical conditions were a repetition of those seen in the partial breaking up of the earlier Arctic Bed, of which also large patches remain undisturbed. Here also (at Nazeing) there appears to have been ice-raft action in the breaking up of the soft silts, but in a broad sense they were certainly *in situ*; it would be incorrect and misleading to describe these deposits under a general name of 'rafts'.

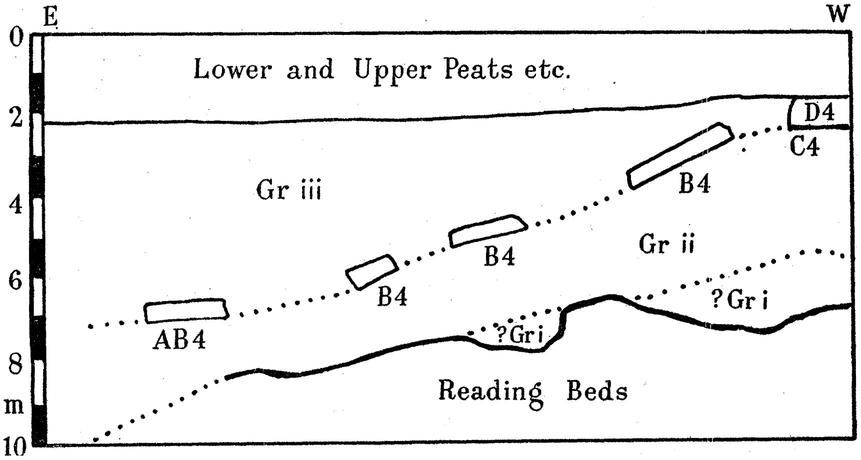

FIGURE 3. Section across the west side of the channel showing on the right the truncated margin of the mere deposits, and the masses of organic silts lying in the gravel of the channel. Lettering of beds as in text.

It is clear that the coarse current-bedded gravel (Gr ii) underlying the B4 beds indicates a time of vigorous, torrential activity in the Nazeing channel, the B4 beds themselves representing a phase of slack water which may well have lasted for a considerable time. This slack-water phase being closed by a return of torrential activity which only partially destroyed the silty deposits, and then preserved the remaining patches under banks of sand and gravel (Gr iii) to a thickness of 10 or 15 ft. in mid-channel. No trace of these B4 beds was observed on the east side of the channel (or elsewhere in the pit), and it may be that their fortunate preservation was the result of the river cutting its channel to the east, that is, round the outer curve of the bend.

It should be explained that the bed AB4 was the first of this group to be found, and I at first thought from its depth in the gravel that it might be Arctic Bed, or not much later, but the Mollusca alone disproved this, and in the light of the subsequent evidences which have been described above, it fell into a natural place in mid-channel with the other B4 beds rising to higher levels towards the bank.

(*h*) THE MOLLUSCA OF THE B4 BEDS

Although these deposits were unsuited to finer subdivisions of dating, no collections, either of Mollusca or plant remains, were made from any smaller pieces which could have been drifted from farther away. At the same time I do not think there was much drifting from a distance, as even the smaller blocks of less than a foot in diameter were restricted in their occurrence to close association with the large patches that could not have been moved. That is to say, these smaller blocks or rafts of the B4 beds were never scattered indiscriminately through the thickness of the gravel, but maintained a well-defined position representing the stream-bed at one particular phase.

Kennard remarked that the Mollusca were very similar to those of Bed D, except that the assemblage suggested rather deeper and less stagnant water, that is to say, a sluggish river. He also remarked that all the shells have a wide northern range, the majority living to-day in Iceland. *Pisidium obtusale* var. *lapponum* occurs in profusion, but now lives only in Lapland; it seems to have lingered here into a very late (possibly Atlantic) stage.

(*i*) THE RELATION OF THE B4 BEDS TO MARL D

Professor King and Dr Godwin have visited the site on numerous occasions, and I owe much to their help. On one of these visits the former, with the assistance of Mr Tallantire, cleared a critical part of the section across the right bank of the channel. I returned later and cleared the section further, with the result shown in figure 4.

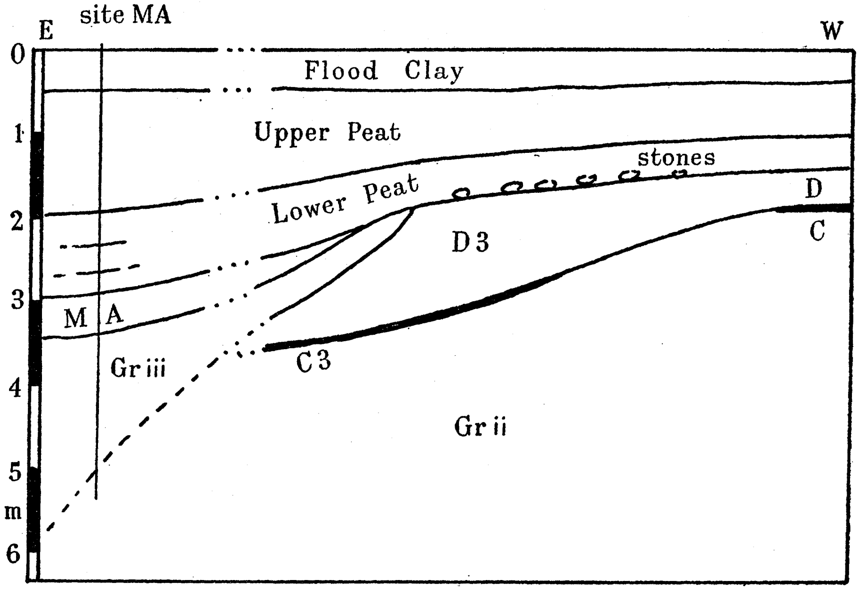

FIGURE 4. Section at site MA showing the channel cutting through the mere deposits (C3 and D3). Within the channel calcareous muds (*Chara* marls) (MA) are succeeded by organic muds and peats. The base of MA was a surface bearing dwarf willow and birch. Lettering of beds as in text.

At the top of the section is the recent flood-loam, or clay, together with the remaining surface soil of which the greater part has been stripped for glasshouse cultivation. Below this there is the upper peat with well-preserved wood, and underneath that the lower (humified) peat with water-laid organic deposits in the channel. D3 is continuous with the main deposit of Marl D where this descends into the bed of the channel at an inclination of 1 in 7. There is a miniature erosion cliff covered by a bank of gravel and sand, Gr iii, which extends a little way over the top of D3, and is represented farther up the slope by a scatter of stones. Overlying this gravel, which includes blocks of derivative peat, may be seen the feather-edge of the M beds (*Chara* marls) of site MA, where the pollen sequence was taken 35 ft. farther to the left of the dotted line.

It will be seen from the section (figure 4) that Marl D substantially increases in thickness as it passes into the channel. The underlying Peat C was eroded away from the top of the bank (? or not deposited there) but reappears, C3, farther down the slope. Where Marl D passes into the channel (D3) it includes more small stones and sand than on the flood-plain, and also becomes practically a clay, stiff and dark coloured, uniform throughout its thickness. But its Mollusca change little and in the main continue to indicate almost stagnant water.

Farther to the left of the section (that is, towards mid-channel) the Beds C3 to D3 were completely cut away by erosion, and replaced by gravel. Down-stream from the site of this section the B4 beds followed the inclination of D3 along the former bed of the channel (figure 3), and had the appearance of having been originally continuous before being partially broken up. Both occupy the same position in the bed of the channel, both contain similar Mollusca and plants, and both indicate a similar sequence of physical events. However, the two have been investigated and recorded separately, so that if any significant difference can be found between the one and the other it will not be lost. It is true that the laminated silts of the B4 beds contained a profusion of leaves of dwarf arctic willows which were absent from Marl D, but I think that can be reasonably explained by the intermittent desiccation, and consequent weathering, of Marl D during its deposition.

I do not think one should infer more than one phase of slack-water conditions (represented jointly by Marl D and the beds AB4 and B4) without some substantial evidence.

(*j*) THE DRAINING OF THE MERE

The phase of high (but slack) water-level indicated by Bed D was closed by a return of vigorous erosion and deposition of much well-washed gravel and sand (Gr iii), already referred to as covering the B4 beds. This is the last phase of vigorous erosion and gravel deposition seen in the Nazeing channel. This was accompanied by a lowering of the water-level, as there is no trace of its effects over the surface of Marl D on the flood-plain, where one saw only small streamlet channels a few feet across with a scatter of stones in their beds (figure 2, ch).

This phase may have been (one does not know) a very brief episode, quickly past, as it does not necessarily take long to sweep 10 or 15 ft. of gravel into a channel. I do not think that the escape of the waters of the mere would be an adequate explanation for this phase; these would not be very much in bulk, and I do not see how they could fill the channel with gravel.

(*k*) THE LAND SURFACE OVER MARL D ('SURFACE D')

After the final draining of the mere, the area occupied by Marl D became a land surface for a relatively long period, from before the end of zone III until the spread of the Boreal peat of zone VI, thus making a break in the sequence of deposits over this part of the then flood-plain (figure 2).

Cumulative evidence points to the conclusion that during some part of this phase the land surface became surprisingly dry for its situation. Among the collection of shells Mr Kennard has found five examples of *Cecilioides acicula*, which is a subterranean mollusc that lives down root-holes in dry soil, but never in a marsh where it would be drowned. It clearly infiltrated into Marl D from the overlying land surface.

Forest trees of considerable size also grew upon the same surface (figure 2, t). Decayed remains of their woody roots, radiating downwards from where the tree stood, were frequently noted. Many of these were to varying degrees surrounded by concretionary material, often reaching a complete tubular form, usually up to about 25 mm. internal diameter. Superficial deposits frequently contain roots coated with thin calcareous or ferruginous encrustations (not unlike the twigs of the so-called 'fossilized' bird's nests of the dripping wells), but I have not previously found tubular concretions so strongly developed. Kindle (1923) has described similar structures.

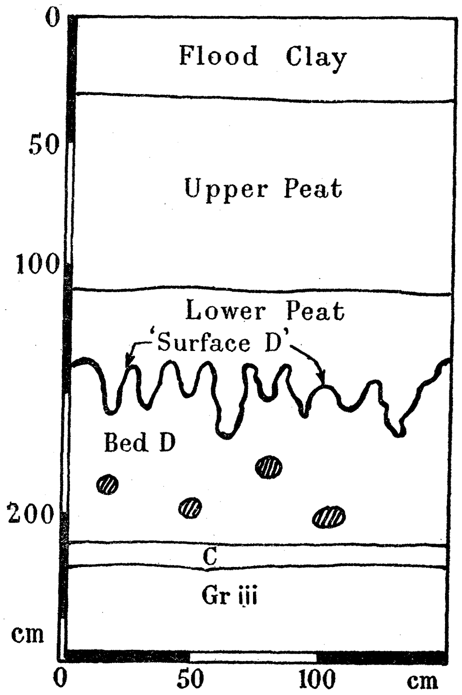

FIGURE 5. Section illustrating the irregular drying surface 'D' above the marl 'D' and organic mud 'C' of the mere. The drying surface was tree-grown and animal burrows extend down from it into the layers beneath. Lettering of beds as in text.

Among the non-woody roots there were numerous deep perpendicular rhizomes with horizontal branches and clusters of small tubers; Dr Godwin has identified these as belonging to *Equisetum palustre*. Some were seen to wrap round the outside of the tubular root casts, thus apparently indicating that the accumulation of the concretionary material was completed before the growth of the *Equisetum*. I traced these rhizomes upwards through the lower fen peat as far as the lower boundary of the overlying wood peat; so the *Equisetum* swamp may have been situated on this boundary line (figure 2, *Eq*).

Helix nemoralis occurs, sometimes in profusion, both below, and also in the lower part of, the Boreal Peat; that is, on the line recorded in table 2 as 'Surface D'. Both Mr Kennard and myself have found this species in Marl D itself, but in most instances (and this may apply to all) I proved that this was due to infiltration from the overlying land surface, through root-holes and animal burrows. I therefore thought it better to omit this species, together with *Cecilioides acicula*, from the fauna of Marl D.

In places (figure 5) there were numerous horizontal animal burrows, usually at about the middle of the marl, filled with darker and more peaty soil than the surrounding deposit. These contained many land shells beside the large *Helix*, similar to those of the overlying surface, together with fresh-water shells obviously derived from the surrounding marl. The commonest shell in the infilling of the burrows was *Vallonia costata*, which is also by far the commonest shell on the overlying surface, but so rare in Bed D that it is possible that its presence there is entirely the result of infiltration. Most of the burrows were infilled with peaty material that was conspicuously different from the surrounding marl, but this difference may not always be obvious, and I may have got some burrow infilling without knowing it.

(*l*) The M beds, with notes on the Mollusca

The local break in the sequence of deposits described in the previous part is bridged by a good series of deposits in the channel that are marked as the M beds (MA, M4, Mx, etc.) on the plan and sections (figures 1, 4, 6). These are the subject of a large part of Dr Godwin's and Miss Allison's investigations, but as I was able to keep the excavations under more continuous observation there are certain supplementary points I may add.

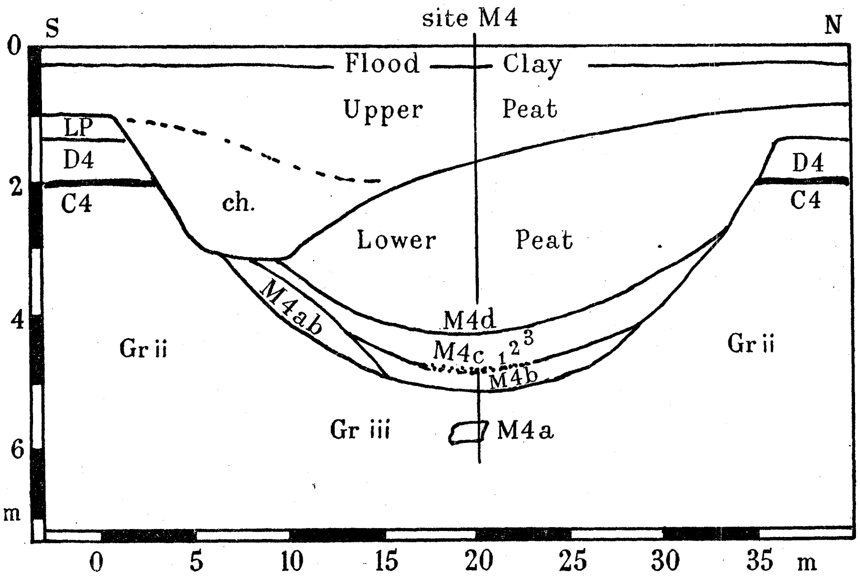

Figure 6. Section through the channel at site M4. The channel cuts through the mere deposits (C4 and D4). The lower deposits of the channel are calcareous muds M4*ab*, *b*, *c* containing abundant plant and animal material; these are dated by the pollen series at the site indicated. Lettering of beds as in text.

The low water-level referred to in subsections (*j*) and (*k*) is further emphasized by the evidences of the M beds. It is clear that the Nazeing channel was now reduced to a chain of pools in which *Chara* marls, organic muds, and plant remains were able quietly to settle and accumulate, with only occasional partings of fine gravel swept in. This is in sharp contrast with the coarse well-washed gravel of the earlier stage (Gr ii).

The MA and M4 sites are dealt with fully in Dr Godwin's and Miss Allison's report, and I have little to add. A minor point might be mentioned, namely, that in the top of bed M4*c* and the overlying M4*d* I collected fifty-seven opercula of *Bithynia tentaculata* but only three small examples of the shell itself, a clear suggestion of grading by a very sluggish current (figure 6). Bed M4*ab* was not seen in the earlier visits to the site; it was a grey marly silt exceptionally rich in shells (see table 2). Judging from its position this was probably deposited before the channel had been cut to its full length. The secondary channel '*ch*' was filled with mixed silting, including lumps of peat, etc., and had been cut through the Lower Peat and covered by the Upper Peat.

The Mollusca of the M beds still continue to be, in the main, the modified survivors of the Ponder's End, or Arctic Bed, fauna, but more change is beginning to appear. In the middle third of the *Chara* marls at the MA site large and well-developed shells of *Limnaea pereger* appear (in contrast with the stunted forms in Bed D) and become dominant in the upper third. This site is not included in table 2, as little other information was obtained. Similarly, at the M4 site there was a sudden dominance of big *L. stagnalis* at about the middle of the *Chara* marls very near to Dr Godwin's 475 cm. line. In both cases these big shells were established below the top of zone III.

At both sites most of the big shells were crushed by the compression of the deposit; the resistance offered by stones and other harder inclusions resulted in a wavy crumpling of the laminae.

In beds M4*b* and M4*c* were found fish-bones, including part of a skeleton, and these were described by the British Museum of Natural History as Percomorph.

The position of some of the minor patches of M beds in the channel is indicated on the plan (*m* in figure 1). These did not offer the same opportunity for detailed investigation.

(*m*) THE FROG AND TOAD BONES MAINLY FROM THE M4 SITE

Dr Malcolm Smith has kindly identified the bones of *Rana* and *Bufo* from the deposits M4*c*3 and M4*b*. They appear to be *Bufo bufo* and *Rana temporaria*. The frog is found within the Arctic Circle and the toad nearly as far north; it is nevertheless of great interest to find them present as early as zone III.

(*n*) THE MX SITE

This represented another separate pool in the channel between the pools of the MA and M4 sites. As seen in the section, the width of the pool was about 50 ft., the deposits thinning off to a feather-edge against a gravel bank at either end. The following is a section taken in the deepest part:

(Original first spit stripped for glass-house cultivation)	ft.
(6) Remaining soil and flood-loam	1
(5) Peat	4¾
(4) 'Surface Mx'	—
(3) Bed Mx, organic mud	2¾
(2) Peat L, peaty mud in place	1¼
(1) Gravel, strongly current-bedded	+

(1) The underlying gravel included broken-up beds of peaty mud and silt of the B4 type which was not understood at the time the section was seen.

(2) The Peaty mud L occupied a similar position to the thinner *Dryas* bed at the MA site, but was a very different deposit, and apparently of later date.

(3) This bed differed from the *Chara* marls of the M beds in the absence of lamination, and in conforming more closely to the sticky type of organic mud. Pollen analyses from the middle and base of this bed reveal abundant derived Tertiary pollen, of *Haploxylon* and *Picea*, but little satisfactory evidence of the contemporary flora. The Mollusca indicate swampy conditions with a few land shells washed in: 442 shells were collected, and these are so fragile that they are not likely to be derivative. I have found a few derivative shells, broken and rolled in the Nazeing channel deposit, but these are rare and cannot be confused with the contemporary fauna. A single hazel nut from the base of this bed is probably also contemporary.

(4) 'Surface Mx.' One could follow an eroded and uneven line of junction between Beds 3 and 5, which I referred to as 'Surface Mx'. This line was characterized by a scatter of small stones, and yielded a large and varied collection of Mollusca, remains of small mammals, and hazel nuts. The Mollusca indicated woodland conditions, moderately dry as a whole, but probably subject to occasional flooding; it being noteworthy that they represented a fully developed Early Holocene assemblage, whereas those of the immediately underlying sticky organic mud continued to be of Pleistocene affinities. The pollen analysis of the stony surface layer is most clearly referable to zone V, that is, to the Early Boreal period, a circumstance of great value in dating the rich fauna. It is of interest to note in passing that the extremely rich Mesolithic culture recently described from Star Carr, Yorkshire (Clark, Godwin, Fraser & King 1949), with its accompanying fauna, is referable to the end of zone IV, very little earlier.

(5) The overlying peat. It was unfortunate that Dr Godwin was unable to visit the site when the Mx deposits were visible, but from the abundance of alder the greater part was evidently of the Atlantic period. I think there was also a little Boreal peat, but my impression was that there had been some local erosion of the earlier peat before the accumulation of the latter. Two clear sections elsewhere showed streamlet channels of this period filled with fresher peat; they had been cut through the older and more humified peat and Marl D into the gravel below in one of the instances, and nearly as far as the gravel in the other.

(*o*) THE MOLLUSCA OF 'SURFACE MX'

It has already been noted that the Mollusca up to the top of the underlying organic mud (Bed 3 of the section) continued to be of Late Pleistocene affinities (a modified survival of the Ponder's End fauna), whilst on the 'Surface Mx' the change to a fully developed Holocene assemblage of Mollusca is complete. Among the more noteworthy species may be mentioned: *Goniodiscus ruderatus* (58 examples), an exclusively woodland form which is extinct in Britian and points to a milder climate than the present; *Ena montana* also indicates scrub or woodland conditions; *Retinella petronella* is extinct in Britain and not previously recorded from any Essex deposit; *Acanthinula aculeata* is also extinct in Essex, and indicates a milder climate than the present.

The collection included 30 % of *Carychium*, 18 % of *Vitrea* and 3 to 4 % of *Clausilia*. This association (often with *Goniodiscus*) is characteristic of a number of Early Holocene British deposits such as those at Lincoln, Copford, Tilekiln Green (Warren & Kennard 1945), and many more. All these are also associated with marl or travertin (also called calcareous tufa), which suggests a milder and drier climate resulting in rapid evaporation of spring water.

There were 13 % of fresh-water shells which were probably washed in during occasional flooding.

'Surface Mx' represented some fraction of the time occupied by the more widely spread 'Surface D'. I sent the best and largest collection from 'Surface D' to Kennard only a very short time before his death, and this could not be traced, so the comparison between the two lists must be taken with reserve as the numbers are so unequal.

(*p*) REMAINS OF SMALL MAMMALS

(BY M. A. C. HINTON, F.R.S.)

In January 1947, Mr S. H. Warren kindly sent me for identification a collection of teeth and bones of small mammals which he had obtained from the Nazeing deposits. These specimens are referred to in this report as belonging to 'Series I'. A note upon them was prepared in the autumn of 1950 and submitted to Mr Warren. He then told me that a further collection had been made and sent to the British Museum (Natural History) for identification. At his request Miss D. M. A. Bate of the Geological Department very kindly forwarded this second collection to me; these specimens are referred to below as forming 'Series II'. Examination showed that it would be well to suppress my first note and to prepare a report on the two collections combined.

In Series I the specimens were in three lots defined by Mr Warren as follows:

A. The main lot marked 'Surface Mx'. This contained remains of four mammals, namely, *Sorex* sp., *Evotomys* sp., *Arvicola* sp. and *Microtus* sp. (a tetramerodont species, i.e. not *M. agrestis*, but possibly a member of the *arvalis* or *ratticeps* groups).

B. A small lot marked 'Mx'. 'These are from the first trial sample collected from Bed Mx; this material was not confined to the top which was subsequently defined as "Surface Mx" but was very little older' (*S.H.W.*) This lot included remains of two species, namely, *Arvicola* sp. and *Ochotona spelaea*.

C. Another lot marked 'DB' came from the neighbouring Broxbourne pit. 'These remains were found in washing out samples of the Bed DB (see subsection (*t*)), but it seems not improbable that they were introduced into this deposit by burrowing animals from the overlying land surface which is sealed under the upper fen-wood peat (see subsections (*k*) and (*n*))' (*S.H.W.*). This lot included remains of two species, namely, *Arvicola* sp. and *Microtus* '*ratticeps*'; but the single specimen at first referred to the latter species is better referred to the *M. nivalis*/*ratticeps* group (see below).

Series II, all from Nazeing, came to me in thirteen packets labelled as follows:

(1) 'Surface Mx small mammals'. This contained remains of seven species, namely, *Apodemus* '*sylvaticus*', *Lemmus* sp.?, *Evotomys* sp., *Arvicola* sp., *Microtus arvalis*/*agrestis* (possibly *M. corneri*), *M. ratticeps* and *Ochotona spelaea*.

(2) 'Surface Mx part jaw with two molars.' *Arvicola* sp.

(3) 'Mid Mx (molars, etc.).' *Microtus* sp.

(4) 'Bed M4*d* Lower Jaw.' *Arvicola* sp.

(5) 'M4*b* several molars etc.' *Arvicola* sp. and *Microtus ratticeps.*

(6) 'Bed M4*c*3 (mammals etc.).' *Dicrostonyx henseli*, *Microtus anglicus* and *Microtus* sp. (allied to *M. malei*).

(7) '*Helix*-bed or surface over D and below Boreal Peat. Lower jaw with molars. Damaged incisor, etc.' *Arvicola* sp. and *Microtus* sp.

(8) 'Found in animal burrows in Bed D.' Fragments of teeth of voles; not determinable.

(9) 'Bed D4, 1 incisor. D4 is definitely below Boreal Peat but probably later than D.' *Arvicola* sp.

(10) 'Mid D.' *Microtus anglicus.*

(11) 'Bed AB4*a*, 2 molars, 1 incisor, lower jaw, etc.' *Lemmus lemmus.*

(12) 'Bed B4, 3 molars.' *Microtus ratticeps.*

(13) 'Bed B.' *Microtus ratticeps*?.

Notes on the species

INSECTIVORA

Sorex sp. In an imperfect left mandibular ramus (Series IA) the articular condyle is formed as in the *S. araneus* group. The specimen is not sufficient for specific determination; but a shrew of the *araneus* group, *S. kennardi* Hinton, was found in the deposit at Ponder's End.

LAGOMORPHA

Ochotona spelaea Owen. Cave pika. Two right upper incisors, one in Series IB (figure 7*a*) the other in Series II, no. 1 (figure 7*b* to *d*), are perhaps the most interesting specimens in the collection. They agree perfectly in size, curvature and section with specimens still implanted in their skulls among the abundant remains of the pika obtained from the Great Doward Cave of the Wye Valley, first by Miss D. M. A. Bate and more recently by the University of Bristol Spelaeological Society. The chief upper incisor is a very characteristic tooth in this genus, and there can be no doubt that the Nazeing specimens represent the same species of pika as that occurring in the Pleistocene of the Wye Valley. Remains of pikas have been found also in the deposits of Kent's Cavern, the Ightham Fissures, and the caves of Bleadon and Brixham.

I have long thought that pikas survived in the British Isles until a very late moment in Pleistocene time. Pikas have a wide distribution in the Himalayas and more northerly ranges of Asiatic mountains, and they also occur in the mountains of western North America. The presence of a species of pika in the late Pleistocene of Europe lends some support to the ingenious suggestion by Miss Bate (whose recent death is deplored) that one of the Lascaux cave paintings represents the chiru (*Pantholops*), now restricted to the Himalayas but possibly once distributed in the mountains as far as western Europe.

RODENTIA: Muridae

Apodemus sylvaticus Linnaeus. Long-tailed field mouse. Represented in Series II, no. I, by two first upper molars (M^1), one old with long roots, the other younger and showing a well-developed third inner tubercle, and by a left first lower molar (M_1), showing the characteristic cusp pattern of that tooth in members of the *A. sylvaticus* group to which these specimens may be referred without hesitation. The group has a long range in time from the Cromerian Upper Fresh-water Bed (at least) to the present day and a very wide distribution from Ireland and Iceland eastwards to Japan.

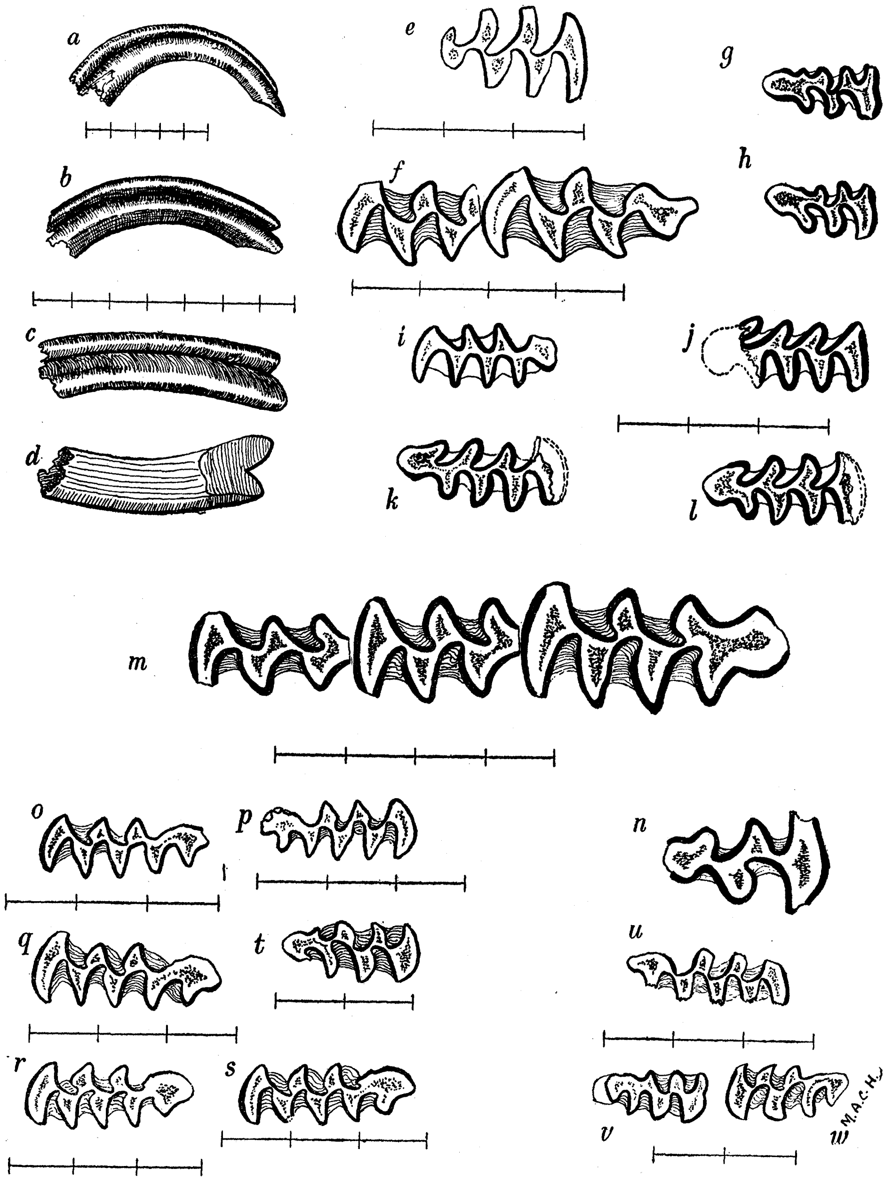

Figure 7. For Legend see opposite.

Dicrostonyx henseli Hinton. Hensel's Arctic lemming. In Series II, no. 6, there is a right M^1 (figure 7*e*), the only trace of this species so far found at Nazeing. It is a characteristic tooth with four inner and four outer salient angles; the reduced posterior pair of prisms are broadly confluent with each other, and the posterior wall of each has lost its concave form and thick enamel, with the result that the posterior walls form together a sort of bow. In the closely allied *D. torquatus* group the hinder end of the tooth is less reduced. As normal in the genus there is no cement in the re-entrant folds.

D. henseli was first described from the fissure deposits of Ightham, Kent. It was abundant in the Third Terrace deposits of the Lea Valley at Ponder's End and Angel Road; quantities of dung accompanied the bones and teeth. The species is known from a good many late Pleistocene deposits in Great Britain, Ireland, the Channel Islands, France and Germany; it is most nearly related to the living *D. hudsonius*, described from Labrador.

Lemmus lemmus Linnaeus. Norwegian lemming. In Series II, no. 11, there is part of a left mandibular ramus, with the incisor and M_1 and M_2. The crown patterns of the two cheek-teeth (figure 7*f*) agree perfectly with those of the Norwegian lemming, to which species the specimen is referred. In Series II, no. 1, there is a fragment of a molar which may also belong to this species.

The genus *Lemmus* has a circumpolar distribution, the species being all very closely related to each other and hardly or not distinguishable by dental characters. In Britain it is first known from the later Middle Terrace deposits of the Thames at Crayford, Kent, and it is commonly found in the later Pleistocene cavern and river deposits.

Evotomys (or *Clethrionomys**) cf. *glareolus* Schreber. Bank vole. In Series I A, the bank vole is represented by part of a palate, with the right M^1 and M^2 in place, and by nine detached cheek-teeth among which are four examples (three left, one right) of the M_1.

FIGURE 7. All scales on this figure are marked in mm. *a*, *Ochotona spelaea* Owen. Right upper incisor; outer view, with scale. From Series IB. *b*, *O. spelaea* Owen. Right upper incisor; outer view, slightly oblique to show cutting edge of tooth; scale below applied also to figure *c* and *d*. From Series II, no. 1—'Surface Mx'. *c*, same specimen. Dorsal view. *d*, same specimen. Ventral view. *e*, *Dicrostonyx henseli* Hinton. Right M^1; crown view of enamel pattern; scale below. From Series II, no. 6; bed M4*c*3. *f*, *Lemmus lemmus* Linnaeus. Crown view of M_1 and M_2 of left mandibular ramus; scale below. From Series II, no. 11; bed AB4*a*. *g*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus* Schreber. Crown view of a right M^3, with short roots, adult. This and the subjects of figures *h* to *l* are from Series II, no. 1—'Surface Mx'. The scale applicable to figures *g* to *l* is shown below figure *j*. *h*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus*. Crown view of a right M^3, adult, with short root. *i*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus*. Crown view of left M_1, young. *j*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus*. Crown view of left M_1, young, cement spaces closed below. *k*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus*. Crown view of right M_1, young adult, very short roots. *l*, *Evotomys* (*Clethrionomys*) sp. cf. *glareolus*. Crown view of right M_1, adult, with short roots. *m*, *Arvicola* sp. Crown view of the three molars of a left mandibular ramus; scale below. From Series II, no. 7; *Helix*-bed or surface over D and below Boreal Peat. *n*, *Arvicola* sp. Crown view of right M^3; same scale as figure *m*. From Series II, no. 5; bed M4*b*. *o*, *Microtus ratticeps* Keyserling and Blasius. Crown view of young left M_1; scale below. From Series II, no. 5; bed M4*b*. *p*, *M. ratticeps*. Right M_1, young, with ephemeral structures in the anterior loop. From Series II, no. 12; bed B4; scale below. *q*, *M. ratticeps*. Left M_1, adult; scale below. From Series II, no. 1—'Surface Mx'. *r*, *M. nivalis/ratticeps* group. Left M_1; scale below. From Series I C; 'DB' Broxbourne Pit. *s*, *Microtus* sp. (allied to *M. malei* Hinton). Left M_1; scale below. From Series II, no. 6. *t*, *M. ratticeps*. Right M^3; scale below. From Series II, no. 5; bed M4*b*. *u*, *M. anglicus* Hinton. Right M_1; scale below. From Series II, no. 6. *v*, *M. ratticeps*. Right M^3; young, with ephemeral characters. From Series II, no. 12; bed B4. *w*, *M. anglicus*?. Left M^3; scale below (applying also to *v*). From Series II, no. 5; bed M4*b*.

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* The substitution of this unknown name, dating from an almost inaccessible publication, on grounds of priority for the well-known name *Evotomys* is to be deplored. *Evotomys* is so well familiar to palaeontologists that it cannot be dropped entirely and both names must be cited together for a long time to come.

In Series II, no. 1, there are a fragment of a left mandibular ramus, with M_2 in place, and fourteen detached cheek-teeth including five examples of the M_1 (all of the right side) and three examples of the M^3 (two right, one left). In enamel pattern (figures 7*g* to *l*) and in the roots, varying in development according to individual age, the teeth agree perfectly with those of living *Evotomys*; but the material is insufficient for precise specific determination.

The genus is a circumpolar one with many living species. Remains attributable to it are found in the Cromer Forest Bed Series, the High Terrace of the Thames, and in all the later deposits.

Arvicola sp. 'Water vole'. This genus is represented in Series I A, B and C, by some fragmentary teeth and limb-bones. In Series II, no. 1, there is a fragment of a left mandibular ramus and about a dozen cheek-teeth, including four (three right, one left) last upper molars, M^3, but no example of the M_1; no. 2 contained part of a left ramus with M_1 and M_2; no. 4 part of a right ramus with M_1; no. 5 a right M^3 (figure 7*n*); no. 7 part of a left ramus with all the cheek-teeth, M_{1-3} in place (figure 7*m*); and no. 9 some scraps. These remains are all clearly referable to *Arvicola*, but they are not sufficient for specific determination.

A. abbotti Hinton is the common 'water vole' of our Late Pleistocene deposits. It is a large member of the *A. scherman* group distinguished from *A. amphibius*, our living water vole, by the extreme fossorial specialization of its skull, smaller teeth and lighter general build. The cheek-teeth from Nazeing are certainly small and light and suggest a reference to *A. abbotti*; but in the absence of the hinder part of the lower jaw or of skull material no definite identification can be made.

Microtus sp. In Series I A, three right second upper molars, M^2, without roots and with only two inner salient angles, represent this genus; they certainly do not belong to *M. agrestis*, the living short-tailed vole of Great Britain; but may indicate a member of either the *arvalis* or *ratticeps* groups. A right M^3, without roots, with an anterior loop, three closed triangles and a long crescentic posterior loop, presenting three outer and four inner salient angles, may also be referred to this genus.

Microtus arvalis/agrestis groups. Series II, no. 1, contains two (one right, one left) first lower molars, M_1, both unfortunately too damaged to be figured; close study shows that these teeth have the pattern characteristic of voles allied to *M. arvalis* and *M. agrestis*. The less damaged left tooth is mutilated at both ends; but enough remains to show six closed triangles in front of the posterior loop and also the outer wall of the anterior loop; the pattern of the tooth closely resembles that of the M_1 in *M. orcadensis*, a fact which suggests that the tooth is really referable to *M. corneri* Hinton, described from the fissure deposits of Ightham, Kent, which is the Late Pleistocene mainland forerunner of *M. orcadensis* and related island forms.

Microtus anglicus Hinton. This species is represented by two examples of the characteristic M_1. In Series II, no. 6, there is a right M_1 (figure 7*u*), which in form, despite a little oblique wear, closely resembles the specimen from Ightham, Kent, shown in figure 68–28 of Hinton (1926); and in no. 10 there is another right M_1 which, although too broken to figure, shows the fourth inner prism closed in front and an anterior loop of quite typical form, resembling that of the tooth from Ightham shown in figure 68–10 of Hinton (1926).

In Series II, no. 5, there is a left M^3 (figure 7*w*) with an anterior loop, three closed triangles and a long posterior loop, presenting three outer and four inner salient angles; this tooth is much like that of the type skull of *M. anglicus* from Ightham, and it may possibly be referred to this species; but it and several similar specimens from Nazeing, not specially noted, might equally well be referred to the *M. arvalis/agrestis* group.

M. anglicus is a member of the Stenocranius group, a section of the *arvalis* group, which is now confined to eastern and central Asia. The species was widely distributed in western Europe in Late Pleistocene times, and for many years palaeontologists referred its remains to *M. gregalis* Pallas, one of the less well-known Asiatic species. Fine skull material collected from the fissure deposits of Ightham, Kent, showed that this species could not possibly be identified with *M. gregalis.* I thought (in 1910) 'the most likely explanation of *M. anglicus* is that one of the species of the *arvalis* group in Pleistocene Europe happened to strike into and proceed along the same path of evolution as many of its Asiatic brethren have done'.

Microtus ratticeps Keyserling and Blasius. Northern vole. This species is represented in Series II: in no. 1 by a left M_1 (figure 7*q*) of typical form, closely resembling in form and structure of the anterior loop the M_1 of a specimen from the Clevedon Cave shown in figure 67–29 of Hinton (1926), and by two mutilated examples of the same tooth; in no. 5 by a young left M_1 (figure 7*o*) and by a right M^3 (figure 7*t*) with four outer and four inner salient angles, the posterior pair being reduced; in no. 12 by a young right M_1 (figure 7*p*) which still shows distinct traces of the youthful and ephemeral complications of the anterior loop, and by a young right M^3 (figure 7*v*) which also retains certain youthful features of interest; and in no. 13 possibly by a right M^3 with three outer and four inner salient angles—but this tooth might belong equally well to one of the other species occurring in the deposit.

In the British Isles *M. ratticeps* characterizes the later Pleistocene deposits appearing first in the later part of the Middle Terrace of the Thames at Crayford and Erith. Dr Godwin tells me that Dr J. Wilfrid Jackson has recently identified a jaw of this species from the peat of the Somerset levels (Huntspill Cut), and it is interesting to find it in these similarly late deposits at Nazeing. The species is often referred to as the northern vole, having a wide distribution from Scandinavia and the Baltic countries eastwards through European and Asiatic Russia; its fossil remains were formerly regarded as one of the proofs of the existence of cold conditions in the Pleistocene period in western Europe. But since Blasius (1857) published his excellent account of the species and its distribution *M. ratticeps* has been discovered living in northern Hungary, north Germany (Brandenburg), northern and central Holland and notably on the island of Texel (Schreuder 1933); it has thus lost its supposed force as a witness for a former cold climate, and it may well have survived in Britain until a quite recent moment.

Microtus nivalis/ratticeps group. In Series I C is a left M_1 (figure 7*r*) which I at first referred to *M. ratticeps*; but the discovery of further and quite typical material representing that species has caused me to reconsider this first specimen. In the slightly less reduced structure of the fourth outer prism, forming the postero-external part of the anterior loop, the tooth is very similar to some of those occurring in the late Middle Terrace of the Thames at Crayford, Kent; these are shown in figures 67–20, 23 and 24 of Hinton (1926) and represent a form transitional in dental characters between *M. nivalis* and *M. ratticeps*. Until good skull material is forthcoming it will not be possible to reach any satisfactory conclusion concerning the status of these forms.

Microtus sp. (allied to *M. malei* Hinton). In Series II, no. 6, is a left M_1 (figure 7*s*) with a posterior loop, four closed triangles, the fifth triangle (fourth inner prism) opening fairly widely into the anterior loop; the latter is rather nivaloid in form, approaching some of the teeth found in the Clevedon Cave (e.g. figure 67–26 of Hinton (1926)), with a well-developed though reduced fourth outer angle at its base. Teeth like this one and like that noticed in the preceding section are very characteristic of deposits of later Middle Terrace age. I regret that their exact systematic status is still uncertain; probably nothing less than good skull material will enable us to go very much further.

Besides the mammalian remains described above the collection in Series II, no. 6, contains some jaws of a small lizard (probably the common lizard) which have not yet been determined with precision.

The collection is a very fragmentary and difficult one and there remains a certain residue of undetermined scraps; but I do not think much of interest is likely to come out of them.

The mammalian fauna is quite rich and the assemblage seems to me to be definitely of Late Pleistocene age. The two last teeth described, referred to *M. nivalis/ratticeps* group and *Microtus* sp. (allied to *M. malei*) indicate late Middle Terrace forms, and I should be tempted to regard them as derived from the break-up of some pre-existing Middle Terrace deposit; but so far as I can see they do not differ in condition from the remainder of the collection.

Comment on provenance (S.H.W.)

Mr Hinton writes: 'In all my experience I have never had such a fragmentary collection to deal with, and never such a rich one in species.' The fragmentary condition and the fact that some of the species are characteristic of the Crayford (Middle Terrace) stage of the Thames valley lead him to think that some at least of the mammalian fossils have been derived from older Pleistocene deposits in the Lea Valley. It is clearly of great importance to determine how far these remains are in their primary position, for if they are contemporary their occurrence in beds dated by pollen analysis proves the survival of several typical Pleistocene species into the early Post-Glacial period.

So far as the material from 'Surface Mx' is concerned, the presence of undoubtedly derived pollen grains in some samples, and also the presence of a scatter of small pebbles seems to support the possibility of derivation of the mammalian remains, but there is nevertheless substantial evidence in a contrary sense for the deposits as a whole. Whilst it appears that the Lea Valley Arctic Bed would be the most likely source of derived fossils, the vast amounts of material washed out from many sites have yielded few species and few individuals apart from the locally abundant remains of *Dicrostonyx henseli* at Angel Road. It is also difficult to see how derived fossils could have been concentrated upon 'Surface Mx' which was a woodland surface subject to occasional flooding. Like 'Bed D' it was densely riddled with small animal burrows, a fact in harmony with the view that the mammal remains are contemporary. Whatever may be said of the abundant material from Mx, that of the second series comes from horizons of different age and different character. The calcareous muds of zone III (see 2[*b*] IV) which contain the remains of frog, toad and lizard along with abundant leaves and fruits of *Potamogeton*, contain little mineral matter, and it is difficult to see how the teeth of *Dicrostonyx henseli*, *Microtus ratticeps* and *M. anglicus* could have been brought into them except in the carcasses of the animals themselves. To a lesser extent the same argument may be applied to the older peaty muds B4 and AB4*a* from which come *Lemmus lemmus* and *Microtus ratticeps*. The *Arvicola* and *Microtus ratticeps* in D may well have been introduced by burrows from the dry marsh surface of zone IV.

Collectively the evidence favours the view that these Late Pleistocene mammals survived in the Lea Valley at least until the very end of the Late-Glacial period (zone III), and that if the remains of Early Boreal age (Surface Mx) are not primary, then they may well have been derived from these immediately preceding deposits.

(*q*) 'OOLITIC' GRANULES FROM THE CHANNEL DEPOSITS

Sand residues from washings of many of the deposits contained quantities of white ovoid granules resembling ooliths. The granules occurred from the base of 'Marl D' (referred to pollen zone III) up to and including the Boreal Peat of zone V or even zone VI. The frequency passes from being higher than the quartz sand down to vanishing point, but I cannot find any average change between the earlier and later stages. Neither is there any difference between inorganic deposits like 'Marl D' (which is mainly composed of a mixture of derivative Eocene Clay and Chalk), and the deposits of organic mud and peat.

There is, however, a notable difference in the position of the deposits. The granules were abundant in seventeen out of eighteen situations which were either in former stagnant pools, or on former swampy land surfaces which would be studded with pools. On the other hand, they occurred rather rarely in only three out of nineteen situations at lower levels in the channel, that is, from below the normal water-level.

I obtained the largest amount of the oolitic granules from the site I defined as 'Surface Mx', which belonged to the Boreal period, but this was because I washed out such a large quantity of material from there in search of small mammal remains. I am indebted to Dr K. P. Oakley of the Department of Geology, British Museum of Natural History, for the following notes:

'The majority of the granules are slightly flattened ovoids varying in longer diameter from 0·5 to 2·0 mm. The larger ones are less regular than those of medium size. Spherical forms occur, but are mostly less than 1 mm. in diameter.

'A sample of these granules was examined by Dr J. D. H. Wiseman in the Department of Mineralogy, who reported that they are made of calcite, some showing a tendency to radial structure, others being aggregates of small calcite rhombs.

'The surfaces of some of the granules are smooth, but others have a rough, corroded appearance. It is improbable that these bodies have been derived from pre-existing oolites, for oolitic rocks are unknown in this region, except in the form of occasional glacial erratics. In view of the wide dispersal of the ooliths in the Nazeing deposits, it would seem more probable that they were formed nearby, perhaps in pools of lime-rich spring water, after the manner of cave-pearls.'

TABLE 2. MOLLUSCA OF THE PONDER'S END AND NAZEING CHANNEL STAGES (PERCENTAGE FREQUENCIES)

			bed D			site M4							
land shells	Ponder's End stage	AB4 and B4	base	mid	top	M4*a* and M4*ab*	M4*b* and M4C1	M4C2 and M4C3	M4*d*	organic mud, Mx	surface Mx (Boreal)	surface D	marsh clay
no. of shells counted		1297	704	1350	262	2058	808	218	54	442	4448	102	857
Ponder's End stage:													
Arion sp.	r.	0·5	2·6	4·7	4·2	.	0·25	.	.	2·3	9·0	5·0	31·0
Columella columella (Benz.)	c.	2·4	4·7	10·1	2·3	0·05	0·6	1·0	.	0·7	0·2	.	.
Limax arborum B.Ch.	c.	.	.	.	.	.	.	.	.	.	0·4	.	.
Limax sp.	r.	.	.	.	.	.	.	0·5	.	.	.	.	0·8
Pupilla muscorum Drap.	v.c.	7·5	0·7	1·2	1·5	0·15	2·6	2·3	.	1·4	0·2	1·0	0·9
Succinea oblonga Drap.	v.c.	.	.	.	.	.	.	.	.	.	.	.	.
Vertigo concinna	r.	.	.	.	.	.	.	.	.	.	.	.	.
Nazeing channel:													
Trochulus hispidus (Linn.)	.	17·0	9·6	16·8	39·0	1·1	13·5	10·0	.	5·4	0·8	8·0	16·0
Vallonia costata (Mull.)	.	0·4	0·4	0·07	1·5	.	.	0·5	.	1·1	5·2	46·0	.
Vallonia excentrica Sterk.	.	0·8	0·3	0·27	1·9	.	0·25	1·8	.	2·5	3·3	.	9·0
Zua lubrica (Mull.)	.	0·5	.	0·07	0·38	.	.	1·4	.	.	0·6	.	8·2
Boreal to Atlantic:													
Acanthinula aculiata (Mull.)	.	.	.	.	.	.	.	.	.	.	3·2	5·0	.
Arianta arbustorum (Linn.)	.	.	.	.	.	.	.	.	.	.	0·02	.	7·0
Carychium minimum Mull.	.	.	.	.	.	.	.	.	.	.	11·0	.	2·1
Carychium tridentatum (Risso)	.	.	.	.	.	.	.	.	.	0·23	19·5	11·0	1·2
Ceciloides acicula (Mull.)	.	.	.	.	.	.	.	.	.	.	.	1·0?	.
Clausilia rugosa (Drap.)	.	.	.	.	.	.	.	.	.	.	3·5	4·0	.
Ena montana (Drap.)	.	.	.	.	.	.	.	.	.	.	0·1	5·0	0·12
Goniodiscus ruderatus (Harkn.)	.	.	.	.	.	.	.	.	.	.	1·3	.	.
Helix nemoralis (Linn.)	.	.	.	.	.	.	.	.	.	.	0·23	1·0	1·2
Helix hortensis (Mull.)	.	.	.	.	.	.	.	.	.	.	0·18	.	.
Limax maximus Linn.	.	.	.	.	.	.	.	.	.	.	0·54	.	.
Punctum pygmoeum (Drap.)	.	.	.	.	.	.	.	.	.	.	2·9	1·0	0·6
Retinella fuloa (Mull.)	.	.	.	.	.	.	.	.	.	.	0·6	.	0·23
Retinella nitidula (Drap.)	.	.	.	.	.	.	.	.	.	.	2·1	.	0·23
Retinella petronella (Pfeif.)	.	.	.	.	.	.	.	.	.	.	0·3	.	.
Retinella radiatula (Alder)	.	.	.	.	.	.	.	.	.	.	.	.	0·6
Succinea putris (Linn.)	.	.	.	.	.	.	.	.	.	.	.	.	2·2
Vertigo artivertigo (Drap.)	.	.	.	.	.	.	.	.	.	.	0·6	.	1·6
Vertigo pusilla Mull.	.	.	.	.	.	.	.	.	.	.	2·1	2·0	.
Vertigo pygmea (Drap.)	.	.	.	.	.	.	.	.	.	.	0·06	.	3·0
Vertigo substriata (Jeff.)	.	.	.	.	.	.	.	.	.	.	0·22	.	.
Vitrea crystallina (Mull.)	.	.	.	.	.	.	.	.	.	.	18·0	8·0	1·0
Zonitoides nitidus (Mull.)	.	.	.	.	.	.	.	.	.	.	1·2	.	.
approx. percentage of land shells (without *Succinea pfeifferi**)		30	18	33	51	1	17	17	0	14	87	98	87

TABLE 2. (*cont.*)

Fresh-water shells (with *S. pfeifferi*)*	Ponder's End stage	AB4 and B4	bed D			site M4				organic mud, Mx	surface Mx (Boreal)	surface D	marsh clay
			base	mid	top	M4*a* and M4*ab*	M4*b* and M4C1	M4C2 and M4C3	M4*d*				
Main habitat water plants:													
Succinea pfeifferi Rossm.*	c.	15·0	25·0	13·0	23·0	14·0	18·5	9·0	.	22·5	1·9	2·0	1·2
Ponder's End stage:													
Limnaea palustris (Mull.)	v.r.	4·4	1·0	3·8	0·38	2·2	1·0	0·5	.	1·1	1·0	.	.
Limnaea peregra (Mull.)	v.r.	1·6	0·4	0·44	.	1·7	0·4	1·4	.	10·0	0·4	.	.
Limnaea stagnalis (Linn.)	v.r.	0·23	.	.	.	.	0·6	27·0	.	.	.	.	.
Limnaea truncatula (Mull.)	c.	7·6	8·0	1·6	2·7	16·0	9·0	4·1	.	0·5	0·5	.	5·7
Limnaea sp.	r.	.	.	.	.	.	.	.	.	.	.	.	.
Pisidium cinereum Alder	v.r.	7·0	12·0	6·7	.	39·0	.	.	.	7·5	0·7	.	0·7
Pisidium henslowanum (Shepp.)	v.r.	.	.	.	.	.	.	.	.	.	.	.	.
Pisidium nitidum Jenyns	r.	.	.	.	.	.	1·0	.	.	.	.	.	.
Pisidium obtusale Pfeif.	r.	.	.	.	.	.	.	.	.	.	.	.	.
Pisidium var. *lapponum*	c.?	9·0	12·0	7·4	.	2·5	.	.	.	.	.	.	1·4
Pisidium pusillum (Gem.)	r.	.	.	.	.	.	.	.	.	.	.	.	.
Pisidium subtruncatum Malm.	v.r.	.	.	.	.	.	.	.	.	.	.	.	.
Planorbis contortus Linn.	v.r.	0·4	.	.	.	0·05		.	.	0·23	.	.	.
Planorbis crista (Linn.)	v.r.	0·4	.	.	.	.	.	3·2	.	0·23	.	.	.
Planorbis leucostoma Mill.	v.r.	19·0	21·0	33·0	22·0	22·0	25·0	11·5	2·0	33·0	2·7	.	3·4
Planorbis leavis Alder	c.	0·5	0·4	.	.	.	.	.	.	0·23	.	.	0·23
Sphaerium corneum (Linn.)	r.	1·0	.	.	.	.	.	1·8	.	0·7	.	.	.
Valvata piscinalis (Mull.)	r.	3·0	0·14	.	.	0·15	0·6	1·0	.	.	.	.	.
Nazeing channel:													
Amphipeplea glutinosa (Mull.)	.	0·08	.	.	.	.	.	.	.	.	.	.	.
Bithynia tentaculata (Linn.)	.	0·23	0·14	.	.	.	.	3·6	96·0	1·1	.	.	.
Pisidium hibernicum (West)	.	.	.	.	.	0·5	.	.	.	.	.	.	.
Pisidium milium Held.	.	.	.	.	.	.	0·7	.	.	.	.	.	.
Pisidium spp.	.	.	.	.	.	.	26·0	6·0	.	7·7	2·3	.	.
Planorbis planorbis (Linn.)	.	0·9	1·0	1·0	1·0	0·5	0·7	6·0	2·0	1·4	0·1	.	.
Boreal to Atlantic:													
Ancylus lacustris (Linn.)	.	.	.	.	.	.	.	1·4	.	.	.	.	.
Aplecta hypnorum (Linn.)	.	.	.	.	.	.	.	.	.	.	3·4	.	0·12
Planorbis complanatus (Linn.)	.	.	.	.	.	.	.	1·4	.	.	.	.	.
Valvata cristata Mull.	.	.	.	.	.	.	.	4·6	.	.	0·1	.	.

* *Succinea pfeifferi*, although not strictly a fresh-water mollusc, has been included here as an indicator of fresh water, since its main habitat is the leaves of water plants.

(*r*) THE ATLANTIC STAGE

It is clear that the final obliteration of the Nazeing channel was not completed until this period (zone VII). Away from the channel the total peat thickness is very often less than 3 ft., but over the channel the fen peats thicken very considerably but to varying degrees; no stated thickness would be true for more than a short distance.

On the western edge of the middle pit, that is, near to the present river, there was little fresher peat, but the lower humified peat was overlaid by a foot or two of marsh clay very rich in shells. Mr Kennard grouped these as Early Holocene, not very much more recent than those of 'Surface Mx'. The list will be found in table 2, among which the most conspicuous form is the high-spired variety of *Arianta arbustorum*.

(*s*) TABLE OF MOLLUSCA (TABLE 2)

For the determination of the Mollusca, with the exception of the *Pisidia*, Kennard is exclusively responsible. For the *Pisidia* we are indebted to the kindness of Mr A. E. Ellis and Mr A. W. Stelfox. The collection is now in the British Museum (Natural History). I have much correspondence from Kennard but this was not intended for publication as it stands, and one cannot know what conclusion he would have reached when finally reviewing the balance of the evidences. I am greatly indebted to Mr A. G. Davis who was in close personal touch with Kennard for valuable help in completing the work.

In arranging the table I have ignored the systematic classification of the Mollusca, but divided them first into land and fresh water. Secondly, I have subdivided these into the fauna of the Ponder's End stage in accordance with Kennard's unpublished revision for which I am also indebted to Davis; next follow the new introductions of the Nazeing channel beds; and lastly the new introductions of the Pre-Boreal to Atlantic stages.

I understand from Kennard that *Pisidium lapponum* (previously referred to in subsection (*h*)) was common in the Ponder's End stage, but it was not recognized by B. B. Woodward who determined the original list of this genus.

During the preliminary stages of the work a general collection of the shells was made from the spoil heaps and the following additional species were not recorded from any precise level: *Vertigo concinna*, *V. moulinsiana*, *Pisidium amnicum* and *P. lilljeborgi*.

In the extreme south-west corner of the pit there was an isolated patch of deposit below a humified peat, which had much resemblance to Marl D but did not seem to be precisely the same. Here a shell that Kennard described as a large variety of *Planorbis planorbis* occurred in profusion, and this was not found elsewhere in the pit. This authority stated that it was a perfectly distinctive race, not living in Britain, but known in Austria and Finland. Davis is not able to throw any further light on this question, even after making many inquiries.

(*t*) BROXBOURNE

A continuation of the Nazeing channel deposits passes through the pit formerly known as Rikof's (Warren *et al.* 1934) but the opportunities for study were not so favourable as in the Nazeing pit. The collection of shells proved the extension of the Marl D stage without doubt, but it was too mixed for publication in detail.

In the extension of the Marl D that is seen in the Broxbourne pit I was fortunate in finding a small flake-blade that was undoubtedly *in situ*, but I have had no further success in the discovery of archaeological evidence. One would expect that it would be of Upper Palaeolithic date, and while one cannot draw any conclusion from a single untrimmed flake, there is nothing in its form and technique to negative the possibility.

(*u*) Comments on the stratigraphical relations

In this study of the Nazeing channel and its deposits I have endeavoured to ascertain its physical history without reference to any theory of wider correlation. It may be that some of the details are the result of local causes related only to the channel itself, but I do not think this can apply to the broad outlines.

My general picture of the conditions during the Nazeing stage is that of a long winter freeze-up of the rivers, together with accumulation of snow on the hills, followed by torrential flood-waters, with ice-jams in the river channels, during the spring thaw. But that alone does not explain the long intervals of slack water of which there is conclusive evidence.

There is so little comparative evidence at present available that I feel that speculation would be premature. Kennard insisted that the only comparable deposit known to him anywhere in the basin of the Thames is represented by a group of Mollusca collected by the late Henry Woodward in the Tottenham Reservoirs (Woodward 1882).

I would, however, like to refer to one or two points of evidence to be taken into consideration.

In the first place, the gradient of the Lea during the Ponder's End (or Arctic Bed) stage was identical with that of the present river, but about 15 to 17 ft. lower. This is true from Nazeing to Stratford, that is, as far as the Arctic Bed is known. The Buried Channel was proved many years ago up the Lea Valley to Tottenham where it goes down to 57 ft. from the surface (Holmes 1902), the Arctic Bed being 40 ft. higher.

Thus it is clear that the Arctic Bed and the Buried Channel cannot be contemporary, and I think the balance of the evidence points to the probability that the Buried Channel is the later. In that case, the Buried Channel would fit very well with the early stages of Nazeing, while the later stages of Nazeing might be associated with the subsequent changes in the emergence and submergence of the land. But the complexities arising from climatic changes, and probable alterations in the river channels, are so great that I feel it better to await further comparative evidences before reaching any conclusion.

2. BOTANICAL INVESTIGATIONS

(H. Godwin and Jean Allison)

(*a*) Introduction

Mr Warren has described the stratigraphy of the remarkable series of deposits exposed at Nazeing on the Essex-Herts border, north of London, in deep excavations of the gravels of the 'flood-plain', the lowest and latest of the terraces which occupy the width of the River Lea Valley.

In these gravels at varying depth from the surface there are sedimentary deposits (lak and channel muds, marls and peat). These include (i) the so-called 'Mere' deposits

(C and D), (ii) the infilling of peaty silts, calcareous muds and peats (M) of a deep channel cut into the gravel across the pit, (iii) a general blanket of peat covering the gravels and channel deposits alike, (iv) discontinuous masses of peat, organic silts, etc. (AB4, B4), embedded at varying depths in the gravel of the channel, all parts of a formerly continuous deposit.

The deepest and oldest of the plant-bearing deposits are the rafts of 'Arctic Bed' which contain the remarkable fauna and flora described in past years from many situations in the Lea Valley.

The botanical investigations to be described make use equally of pollen analysis and of identification of larger plant material, called conveniently 'macroscopic remains', although microscopy is in fact constantly used in their identification. The investigations do not concern the Arctic Bed except by comparison in discussion; they deal, however, with all the other categories of organic deposit, with much the greatest stress upon the layers still in place.

It may be said at once that pollen analysis of the channel infilling shows a continuous sequence of deposition extending back from the Post-Glacial climatic optimum (Atlantic) to the relatively tree-less birch-pine period of the Late-Glacial at which time the base of the channel became filled with silty muds which incorporate not only a striking assemblage of pollen, but a very extensive range of fruits, seeds, leaves and other identifiable macroscopic material. The establishment by this means of the character of Late-Glacial vegetation in this part of south-east England is one of the most important aspects of the investigation, but the pollen analyses of course equally serve to date the faunal remains contained at the various levels of the channel deposits.

The mere deposits (C and D) and the discontinuous masses (AB and B) yield much less precise botanical information; macroscopic remains are scarce in them and the pollen is often sparse or derived from Tertiary or Inter-Glacial sources; in some instances, however, the pollen shows the vegetation to have had a Late-Glacial character undistinguishable from that of the bottom beds of the channel referred to above.

The pollen diagrams have been zoned in terms of the system applied to England and Wales (Godwin 1940) and of the very similar system employed by Jessen (1949) in his recent studies in the Late Quaternary deposits of Ireland. Since the particular interest of the Nazeing deposits lies in the light they cast upon Late-Glacial conditions, it should be made clear that the English zoning system for this period agrees with that used by Jessen for Denmark and Ireland. According to this Late-Glacial time* is divided into three zones, the lowest (I) glacial in climate and with open park-tundra vegetation (corresponding with the last general glaciation in Ireland and the Danish end-moraines), the middle (II) somewhat warmer and characterized by closed birch or pine woods in Denmark and Holstein (corresponding with the Allerød climatic amelioration), the upper (III) again glacial (corresponding with the Athdown mountain glaciation in Ireland) and again characterized by open park-tundra vegetation (see Godwin 1947; Pennington 1947; and Conolly, Godwin & Megaw 1950).

Above these the Post-Glacial time opens with zone IV (Pre-Boreal) in which birch

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* Note that 'Late-Glacial' is here employed in a restricted sense, not necessarily corresponding with that of Mr Warren, who used it from the beginning to include the Arctic Plant Bed of the Ponder's End stage.

woods are dominant and suppress the open tundra-type herbaceous vegetation. In zone V the hazel begins to expand rapidly and pine tends to replace birch as the dominant tree. In zone VI (with V constituting the Boreal period) there is the great expansion of the warmth-demanding trees, particularly elm and oak at the expense of birch and pine, and, towards the end, the initial expansion of the still more exigeant lime and alder. Zone VII*a*, the Atlantic period, opens by a very great expansion of alder and much increase in the lime, whilst pine and birch are practically eclipsed by the mixed oak-alder forest; this is the post-glacial climatic optimum. We are not concerned with subsequent zones.

(*b*) SITE STRATIGRAPHY AND POLLEN ANALYSES

In considering the pollen-zoning of the Nazeing deposits, it is convenient to begin with the most recent and work backwards in time, taking in sequence the upper peats (site X), the channel deposits (sites Z, MA, M4 and Mx), the mere deposits (sites Y and W), and miscellaneous samples of varying age, some as old or older than the mere deposits (AB4, B4).

The Nazeing pollen diagrams fall into four categories:

(i) Those of the deep channel MA and M4, which have arctic plants at their base and show a full and continuous sequence upwards into peat deposits of evidently the Post-Glacial climatic optimum.

(ii) The upper portion of the mere deposits at X, which correspond only with the upper (Boreal) section of the two channel series MA and M4. These peats sit uncomfortably on older mere deposits.

(iii) The lake marls and muds of X, which must predate the base of the channel series MA and M4. Results for their deposits are presented as tables.

(iv) Individual scattered samples from AB4 and B4 incorporated in gravels below the series MA and M4 and from peat B below the mere deposits.

(i) *Site X* (upper peats and mere deposits)

Section exposed by digging: pollen series (see figure 2) through mere deposits of the west face of the middle pit.

cm.	
0–30	Crumbly clay—flood deposit of River Lea.
30–40	Transition.
40–115	Black fen-wood peat with abundant bark and wood fragments. Occasional tree stools of *Alnus* and *Quercus in situ* (as at 50 to 60 cm.). *Carex* rhizome fragments throughout with fruits (cf. *C. binervis* at 73 cm.). Lower 8 cm. transitional and in one place with nuts of *Corylus*.
115	Pronounced discontinuity all along profile, locally sandy.
115–130	Black clay-mud with locally abundant fine silt and some fine sand, pierced from above by rhizomes. Wood fragments and *Equisetum palustre*.
130–195	Pale yellowish brown calcareous lake marl with abundant fine silt and fine sand. Abundant fresh-water Mollusca at 170 to 175 cm. Penetrated from unknown upper level by rhizomes of *Equisetum palustre* with clusters of tubers at nodes; now largely in form of casts.
195–200	Black, greasy homogeneous organic mud; non-calcareous.

The pollen series shown in figure 8 is restricted to that portion of the section which lies over the unconformity; at this level there must have been for some considerable time a dry surface on which trees established themselves, but the *Equisetum palustre* appears to have grown downwards from still higher levels.

It is quite apparent that the upper part of the diagram falls within zone VII*a*, at the opening of the 'Atlantic' period, and beneath it lie the subzones VI*c* and VI*b* and VI*a* of the 'Boreal' displaying characteristics already familiar in East Anglian pollen diagrams. The transition between zones VI and VII is unmistakably indicated by the abrupt rise in *Alnus* slightly preceded by the appearance and expansion of *Tilia* to the customary high values for zone VII. It is less certain where the boundary between subzones VI*a* and VI*b* should fall, but since *Ulmus*, *Quercus* and *Corylus* are present continuously down to the base of the series we may take it that zone V is not represented. It is of particular interest to note the high frequency of *Hedera helix* (ivy) pollen in zones VI*b* and VI*c*. It seems probable that the high willow pollen values found at these levels reflect local development of the genus on the peat surface. The macroscopic discovery of hazel nuts at the lower surface of these peats accords with the allocation of this level to zone VI*a* or the preceding zone V, both widely characterized by high *Corylus* pollen values.

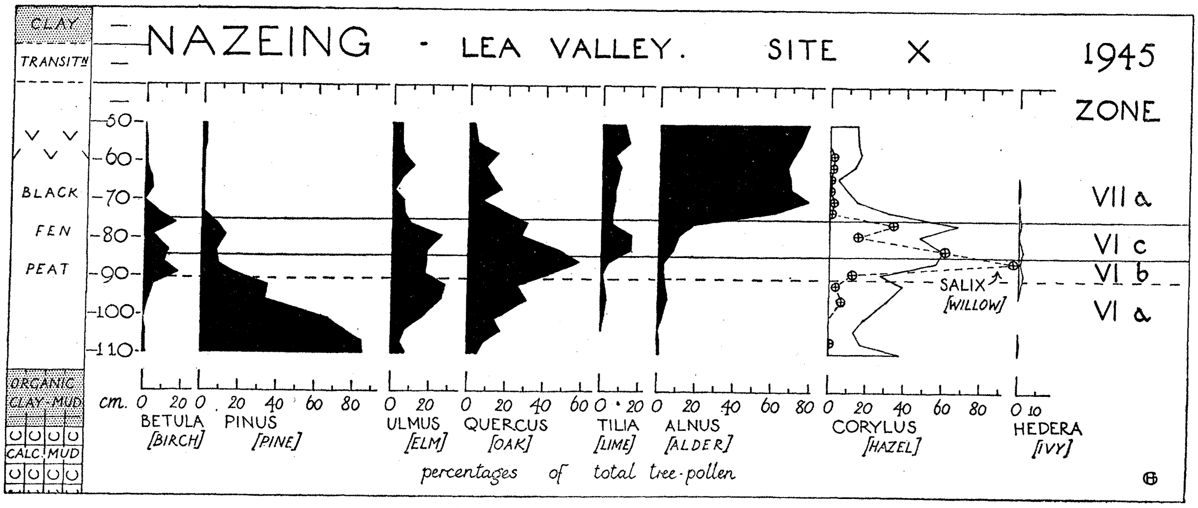

FIGURE 8. Tree-pollen diagram of the fen-peat deposits of Boreal and Atlantic age, which (unconformably) overlie the calcareous marl and clay-muds of the mere.

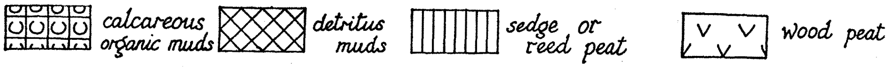

FIGURE 8*a*. Key to stratigraphic symbols employed in figures 8 to 12.

Non-tree pollen/tree-pollen ratio is low throughout, save for the effect of reed-swamp plants growing locally (*Typha*, *Nymphaea* and *Alisma*). There are very high values for fern-spores in the levels 79 to 96 cm., which support the view that there may have been willow-carr upon the fen at this stage.

For pollen analyses of the lower deposits of this section see p. 202.

(ii) *Site Z* (channel)

In November 1945 Mr Warren showed us 150 yd. south of site X, a section of the gravel pit where channel deposits interrupted the spread of the deposits of the mere. It later appeared that this channel was already recognized as crossing the pit in a direction roughly north-east to south-west. The following stratigraphy was noted:

cm.	
0–50	Disturbed flood clay.
50–200	Dark wood peat, including *Alnus*.
200–265	Pale yellow *Phragmites* rootlet peat with abundant rhizomes.
265–275	Greenish grey shell marl with very abundant *Chara* fruits, and penetrated from above by rhizomes of *Equisetum palustre*.
275	Coarse gravel.

(No pollen samples have been analyzed from this section.)

(iii) *Site MA* (channel, figure 4)

In October 1946 the west face of the pit was revisited in company with a small international group of pollen analysts. The face had been cut back to expose a somewhat deeper section of the channel already seen at Z, and along with abundant stems and leaves of willows (cf. *Salix phylicifolia*) on the gravel surface of the channel, a leaf of *Dryas octopetala* was recognized by Professor K. Jessen. This exposure has been termed site MA. On this and return visits pollen samples and large samples of material for washing were secured and these are described below.

The stratigraphical relationship of this channel to the mere deposits is complex, but Mr Warren's investigations leave little doubt that whilst the mere deposits descend into the bed of the channel existing at an older stage, all the organic beds represented in the section above (and in MA) are more recent than the lacustrine beds.

Site MA (channel)

Pollen series from gravel surface upwards for 150 cm.

cm.	
0–50	Disturbed flood clay of River Lea.
50–190	Black much crumbled peat.
190–235	Black much humified peat with frequent wood remains.
235–260	Black wood peat, or coarse detritus peat. Numerous fruits and cone-scales of *Betula alba* and *B. pubescens*. One fruit of *B. nana* at 230 cm. *Salix* wood at 235 and 225 cm.
260–294	Black coarse detritus peat with abundant monocot remains, *Chara* oospores. One fruit of *Betula nana* at 240 cm. Some bark.
294–302	Very pale buff calcareous *Chara* muds, small Mollusca.
302–310	Abundant coarse rhizomes, probably *Typha*.
310–325	Very pale buff calcareous *Chara* mud's, scattered organic debris, small Mollusca.
325–340	Pale buff calcareous *Chara* muds, with shell fragments and Mollusca. Some grey banding somewhat contorted, yielding coarse plant debris.
340–342	Black peat with abundant twigs, stems and leaves of *Salix*.
342–	Coarse gravel penetrated by *Salix* roots.

Much attention has been given to sorting and identifying the abundant plant material of the lower part of this section. The gravel surface was clearly occupied by a growth of dwarf willows *in situ*; their twisted stems and roots lay on and within the uppermost gravel, and abundant leaves, capsules, inflorescence stalks, bud-scales, twigs and pollen were recovered from the peaty layer immediately over the gravel. Thirty-eight samples of wood collected from this level proved upon sectioning all to be of *Salix*, mostly stem wood; no other wood was recognized. It seems probable that *S. phylicifolia* is largely represented in this material, with some *S. repens* and possibly also *S. myrsinites* (see §2(*c*) (ii)).

This layer also proved rich in fruits, leaves and cone-scales of the dwarf birch, *Betula nana* (with occasional bracts from the male cone also). There were frequent calyces and some inflorescences of *Armeria maritima*, and valves of the fruit of *Draba incana*.

A large monolith of the lower channel deposits was broken down and washed in the laboratory for plant remains; the results are recorded in table 8. In terms of the sequence recorded above the segments of the monolith are (*a*) 340 to 335 cm., (*b*) 335 to 312 cm., (*c*) 312 to 294 cm.

The pollen series (shown in figures 9 and 10, for tree pollen and non-tree pollen respectively) does not extend far into the black fen-peat. The uppermost samples, however, are clearly Boreal and confirm the evidence of field observation that at this stage fen-peat formation had become general across the valley sealing in alike deposits of the channel and of the mere. *Tilia* and *Alnus* are absent, and the upper zone with high *Corylus* and rising *Quercus* is probably the early part of VI*b*. Zone VI*a* has high *Ulmus* and *Corylus*, but no *Quercus*, whilst V can be taken as beginning at the 265 cm. level, including the rise of *Corylus* and the *Pinus* maximum. Deposits below 265 cm. probably include zone IV and part of zone III, and if this is a correct interpretation the boundary may be set at 295 cm., where there is a change of stratigraphy to a more organic mud, where the *Pinus* curve begins to rise at the expense of *Betula*, and where there is a substantial decline in the amount of herbaceous pollen types associated with dry land. (Not only are *Typha* and *Sparganium* due to local aquatic stands, but it seems probable that so also is the large peak in pollen of Gramineae.) In the chalk-mud of zone III thus defined

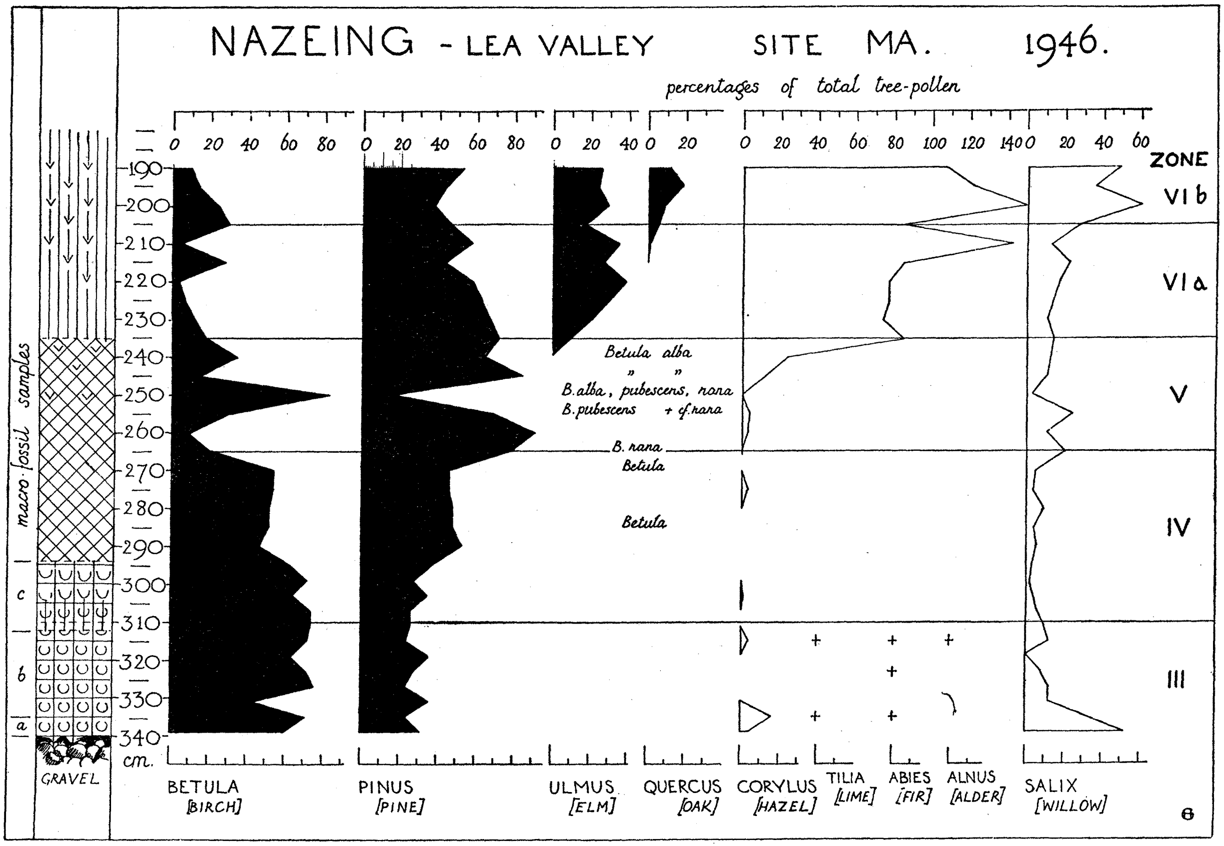

FIGURE 9. Tree-pollen diagram through the channel deposits at site MA. The calcareous muds of zones III and IV were sampled in blocks *a*, *b* and *c* for macroscopic remains (see table 8). Other macroscopic remains of *Betula* were found in the pollen samples of zones IV and V at the levels indicated. Stratigraphic symbols as in figure 8*a*.

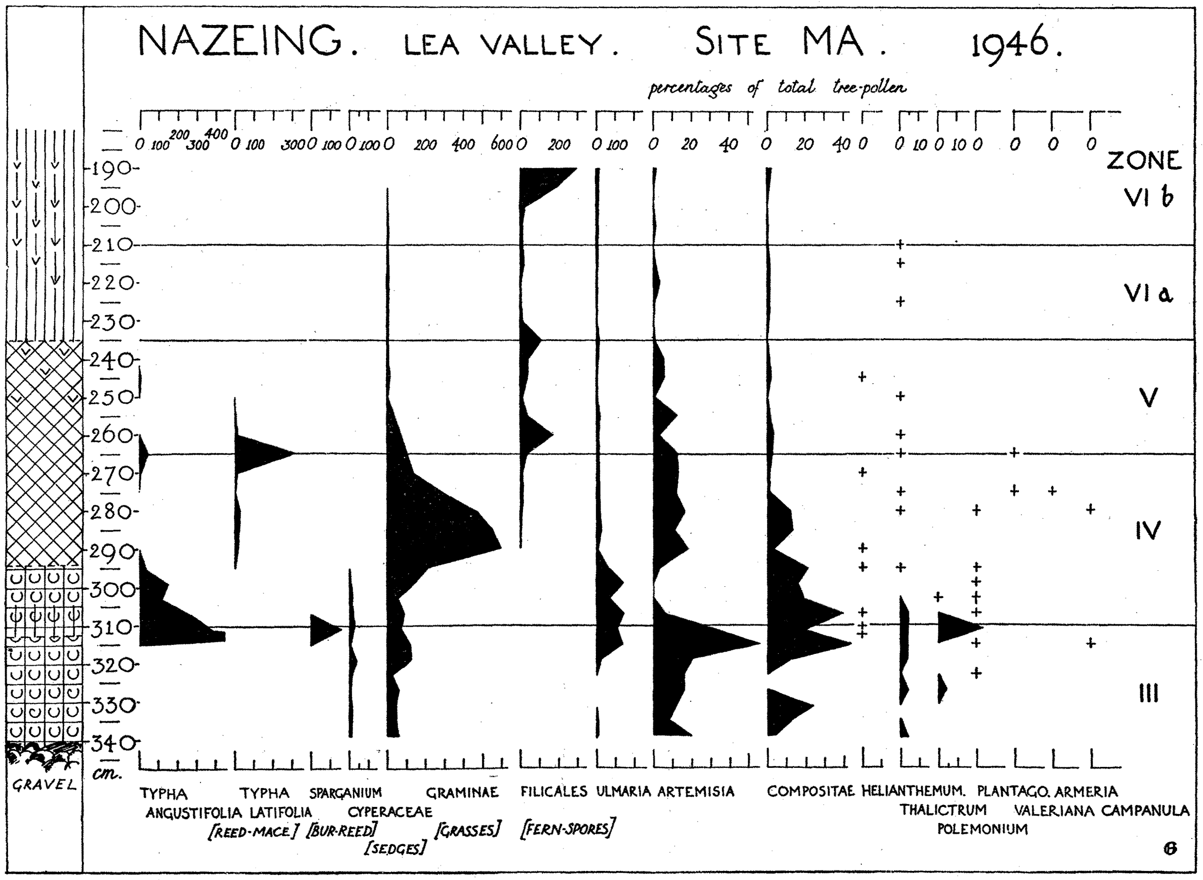

FIGURE 10. Non-tree pollen diagram through the channel deposits at site MA. Stratigraphic symbols as in figure 8*a*.

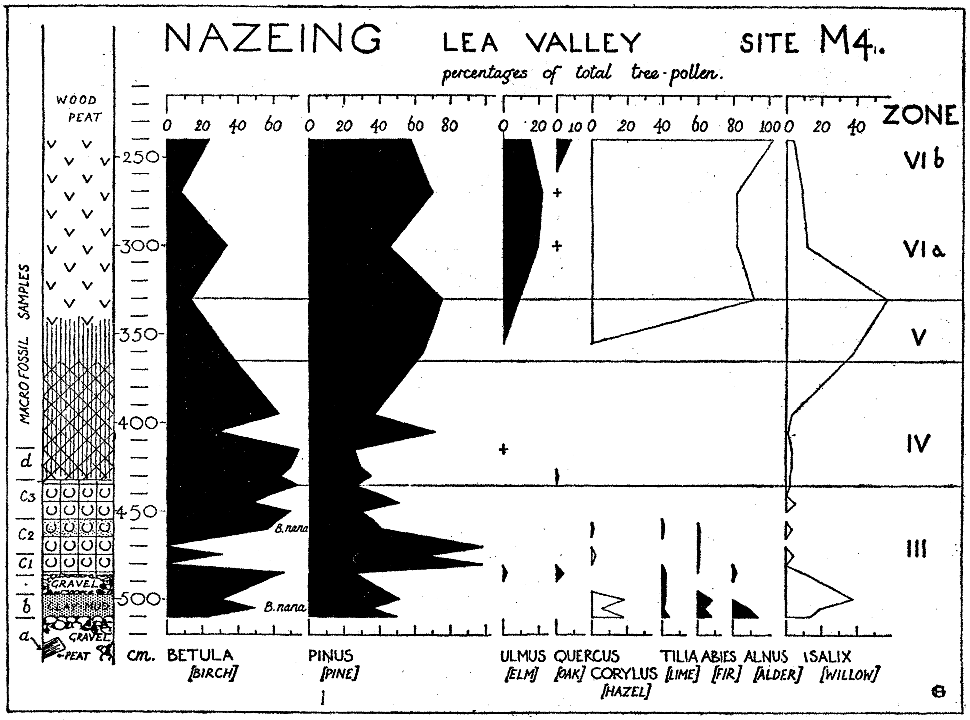

FIGURE 11. Tree-pollen diagram through the channel deposits at site M4. Samples *a* to *d* were taken from zones III and IV for identification of macroscopic plant remains (see table 8). Note contribution of derived pollen (warmth indicating species) in basal clay mud. Stratigraphic symbols as in figure 8*a*.

we have preponderant *Betula*, and a fair density of herbaceous pollen types including substantial amounts of several genera highly typical of Late-Glacial conditions, such as *Artemisia*, *Thalictrum* and *Polemonium*, together with smaller amounts of *Helianthemum* and *Plantago*. (Small amounts of these and others continue into zone IV.) Furthermore, in the zone III muds the tree-pollen diagram shows a certain proportion of the pollen of warmth-demanding trees, *Corylus*, *Tilia* and *Alnus*, which may fairly be supposed to have been derived, along with the *Abies* (not native in the Post-Glacial in Britain), from erosion of older deposits.

It will be noted that not only are both species of tree-birch recorded from macroscopic remains in the pollen samples in zone V, but that *Betula nana* has also persisted to this stage, a fact not out of line with its behaviour recorded elsewhere in western Europe in general and East Anglia in particular.

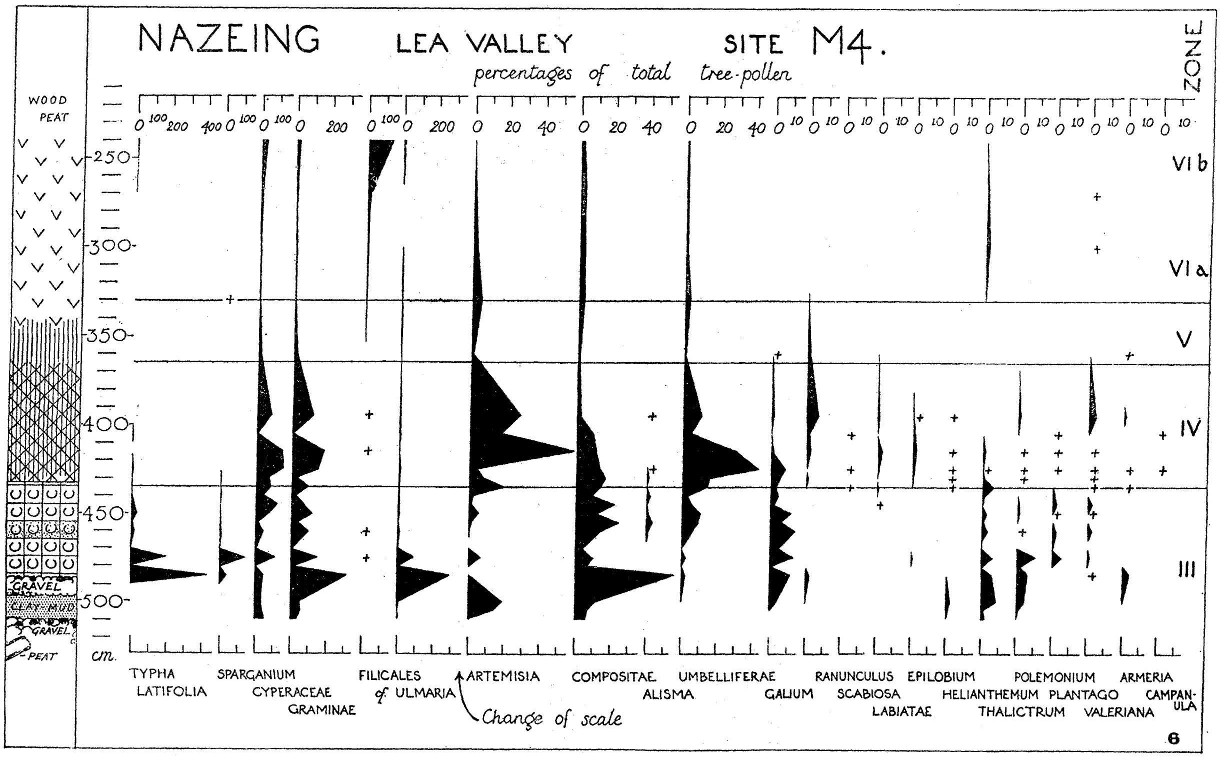

FIGURE 12. Non-tree pollen diagram through the channel deposits at site M4. Stratigraphic symbols as in figure 8*a*.

(iv) *Site M*4 (channel). (See figure 6, and figures 14 to 16, plates 7 and 8.)

This is the deepest exposure seen of the channel; it differs from the section seen at MA in that here there is no trace of dwarf willows growing upon the gravel surface (all the abundant willow remains in the lower layer have drifted) and in the presence of the lens of coarse gravel near the base. It may be that the firmly laminated calcareous muds above this lens are contemporary with the similar muds forming the bottom infilling at site MA.

From the bottom 100 cm. of the channel deposits large samples were secured for washing out of fruits, seeds, etc., in the laboratory; their extent in relation to the stratigraphy and pollen analyses is indicated in figure 6; the results are in table 8.

Here as in MA the analyzed samples extend only part way up into the general peat cover, so that zones VI*b* and VI*a* lie at the top of the diagram. Since samples are widely spaced it is impossible to insert the limits of zone V with any precision, but it is easy to see how the general run of the diagram in this site corresponds with that of site MA. The opening of zone IV may be set when stratigraphy alters, in this instance at 435 cm. Once more we observe that zone III thus delimited is characterized by much derived pollen (*Ulmus*, *Quercus*, *Tilia*, *Corylus*, *Alnus*, *Abies* and *Juglans*), more especially in the lower clay-mud layer, and by substantial amounts of non-tree pollen. The non-tree pollen here includes, besides *Artemisia*, *Thalictrum*, *Helianthemum*, *Polemonium* and *Plantago* already mentioned from MA, the general *Armeria*, *Galium*, *Valeriana*, *Campanula*, *Scabiosa*, *Epilobium*, *Ulmaria* as well as substantial amounts of Compositae (various types outside *Artemisia*) and Umbelliferae. This herbaceous non-tree pollen of characteristic facies persists in diminishing amount through zone IV. It will be noted that the calcareous muds succeed a land of coarse gravel and a bed of clay mud; these latter must certainly also fall within zone III, perhaps somewhat earlier in the zone than the lowest analyzed samples from MA.

Samples for macroscopic remains indicated by indices in brackets.

cm.	
0–60	Fresh-water clay.
60–340	Black fen-wood peat with *Phragmites* and abundant wood, bark, twigs and leaves throughout. Fruits of *Betula* at 300 cm. *Salix* wood at 325 cm., leaves and twigs of *Salix* (cf. *cinerea*) at 340 cm. *Betula* wood at 305 cm. and big *Betula* stem at 275 cm.
340–432	*Magnocaricetum* peat with phases of inclusion of sand or gravel infrequently (415–433 = M4D).
432–437	Transitional green mud layer with abundant leaves, stems and fruits of *Potamogeton natans* with abundant frog bones (M4C3).
437–453	Strikingly laminated greenish organic mud with abundant large flattened shells, very abundant fibres of *Carex* roots and rhizomes—and reed-swamp mud (M4C3).
453–454	Thin discontinuous seams of gravel.
454–457	Five monocotyledonous stems—cf. *Carex*.
457–474	Pale fine-grained calcareous mud at 462 cm. with much fine silt, male flower of *Betula*, *Carex* nut and achene of *Alisma* plantago. At 457 cm. less silt, abundant fruits of *Betula nana* and *Carex* nutlets. Abundant small peat pebbles (M4C2).
474–487	Finely laminated, highly calcareous (*Chara*) marl, pale greenish buff when fresh, but dirty white on drying. Low-density material with abundant *Chara* stems. Some dicotyledonous leaves, with flattened shells and beetle elytra (M4C1).
487–499	Lens of fine gravel.
499–510	Grey calcareous clay-mud with small Mollusca, abundant small twigs and wood (*Salix*) and leaves scattered and in leaf-layers (cf. *S. phylicifolia*). *Betula nana* frequent. Occasional large pebbles. Sample richer in organic matter upwards (M4, B).
510–537	Gravel with derivative blocks of black fibrous peat without silt (M4, A).

(v) *Site X* (mere deposits)

Below the stratigraphic discontinuity in the deposits at site X (p. 195) there are 85 cm. of lake-muds, the upper 15 cm. of which have a high content of black clay and some fine silt, the lower 5 cm. are a black non-calcareous mud, whilst the bulk is a silty calcareous lake-mud with Mollusca.

It proved very troublesome to analyze for pollen; in many samples pollen was too sparse to count, whilst in those where small counts were achieved it is certain that much of the pollen is of secondary origin.

The analyses are given in table 3.

It is at once apparent that these pollen spectra stand quite apart from those hitherto considered. Species characteristic of the Late-Glacial are lacking (with the exception of *Selaginella*, *Botrychium* and *Lycopodium*), all pollen is sparse, and it includes types such as *Abies*, *Tilia*, *Quercus*, *Ulmus* and *Corylus* which cannot be other than derived, most probably from Inter-Glacial sources. In addition, it should be noted that much of the *Pinus* pollen is of the type *Haploxylon* described by Rudolph (1935) from the Tertiary of Bohemia, and later reported as derivative in glacial clays by Iversen (1936). The most probable source of this pollen is the local London clay, and doubtless from the same source come grains of *Juglans* not recognized when the initial counts were made.

These analyses as a whole indicate little beyond the fact that local pollen must have been very sparse during deposition of the mere muds, and local vegetation may have been so too.

TABLE 3. NAZEING. SITE X

Sample depth (cm.) ...	190	180	170	130	125	
	Total number of grains counted					
Betula	1	2(?)	2	7	1	
Pinus (*sylvestris* type)	22	13	6	21	22	
Pinus (*haploxylon* type)	2	5	2			
Abies and/or *Picea*	2	3	.	6	2	presumably derived
Alnus	.	.	1	3		
Ulmus	.	.	.	5	1	
Quercus	.	.	.	.	1	
total tree pollen	27	23	11	42	27	
Corylus	3	4	4	6	4	
Salix	.	.	.	.	.	
Gramineae	.	1	1	5	.	
Compositae	1	1	.	4	3	
Cruciferae	1	.	.	.	.	
Artemisia	.	.	.	7	.	
Chenopodium	1	.	.	.	.	
cf. *Hedera*	1	.	.	.	.	
cf. *Sparganium*	1	.	.	.	.	
Thalictrum	1	.	.	.	.	
Fern spores	2	.	.	20	2	
cf. *Botrychium*	1	.	.	.	.	
cf. *Lycopodium*	1	.	.	.	1	
Selaginella	.	.	2	.	.	
Hynoid moss spores	3	5	5	.	.	
Hystrix	1	8	2	1	3	derived

(Samples between 170 and 130 cm. were too poor in pollen for counting).
Samples 190 to 170 counted by Miss R. Andrew, 130 and 125 by Mrs M. E. Dainty.

(vi) *Site Y* (mere deposits)

Section exposed by digging through mere deposits on west face of pit; 200 yd. north of site X; very close to site W. Pollen samples only from peat layer below the lake-marl.

cm.	
0–30	Flood clay.
30–120	Black fen-wood peat.
120–240	Calcareous silty lake-marl (D) with intercalated pebble bed in middle. Penetrated secondarily by rhizomes of *Equisetum palustre* (as site X).
240–270	Black, compressed peat—a fine detritus lacustrine mud (C1).
270–330	Sand and clayey sand.
330	Coarse gravel.

Pollen analyses by Miss R. Andrew are set out in table 4.

The outstanding features of the results are:

(i) The absolute sparsity of pollen, which allowed only small total counts of tree-pollen.

(ii) The almost total preponderance of *Betula* and *Pinus* in the tree pollen (other genera most probably having a secondary origin).

(iii) The high ratio of non-tree to tree pollen.

(iv) A very long list of genera and pollen types typical of the Late-Glacial cortege in Britain, some such as *Artemisia*, *Galium* and *Thalictrum* in considerable amount, but others not less characteristic, such as *Armeria*, *Helianthemum*, Centaurea, *Scabiosa* and *Valeriana* in much less frequency.

TABLE 4. NAZEING. SITE Y

sample depth (cm.) ...	248	252	256	260	264
	total number of grains counted				
Betula	33	22	45	7	6
Pinus	16	28	5	21	9
Alnus	.	.	.	2	1
Picea	1	.	.	.	.
total tree pollen counted	50	50	50	30	16
Salix	2	6	4	3	1
Cyperaceae	>57	41	222	15	1
Gramineae	18	46	28	21	8
Caryophyllaceae	1	4	.	.	.
Compositae	3	11	1	6	6
Cruciferae	.	1	.	.	.
Umbelliferae	3	11	3	.	.
Armeria	.	.	1	.	.
Artemisia	6	11	6	1	5
cf. *Caltha*	2	3	1	.	.
Centaurea	3	.	.	.	.
Epilobium	.	1	.	.	.
Galium	3	19	.	3	2
Helianthemum	1	2	3	.	.
Myriophyllum vert. or *spic.*	.	.	.	1	.
Plantago med. or *maj.*	1	.	.	.	.
Polemonium	.	.	1	.	.
Polygonum amph.	1	.	.	.	.
Succisa	.	.	1	.	.
Thalictrum	2	10	1	.	1
Ulmaria	29	46	9	3	5
Valeriana offic.	1	.	2	.	.
total non-tree pollen (excluding *Salix*)	131	206	279	50	28
ratio non-tree/tree pollen (%)	262	412	558	167	175

The resemblance of the pollen assemblage of the five samples to that of samples from the base of the channel in the MA and M4 series makes it clear that extraordinarily similar vegetational conditions must have prevailed at the time when the mere was first initiated, and at the time when the lowest channel muds were laid down. If these organic lake-muds do not represent zone III they must be referred to a closely equivalent stage of an earlier zone.

(vii) *Site W* (mere deposits)

From the middle of the west face (see figure 1), Mr S. H. Warren sent a first sample for analysis in July 1945. It consisted of a layer 3·5 cm. thick of black structureless peat

(B) some distance below a pale grey calcareous silty lake-mud (D) from which Mr A. S. Kennard had obtained 'northern pre-Holocene Mollusca'. A block of derived peat was incorporated in this silty lake-mud. Three consecutive samples from the lake-mud were analyzed by Mrs M. E. Dainty, and these formed the starting point of the Nazeing investigation. The results are given in table 5.

Table 5. Nazeing. Site W

(Collected and analyzed 1945)

sample no.	I		II		III	
total tree pollen counted	161	%	145	%	78	%
Betula	136	85	90	62	50	64
Pinus	22	14	49	34	26	33
Ulmus	0	0	1	1	1	1
Quercus	3	2	4	3	1	1
Salix	2	1	0	0	4	5
Cyperaceae and Gramineae	.	*c.* 7000	.	*c.* 12000	.	*c.* 11000
Caryophyllaceae	7	4	4	3	3	4
Compositae: *Carduus* type	8	5	8	6	3	4
Chicoruum type	1	1	1	1	1	1
other	12	7	45	31	34	44
Labiatae cf. *Lycopus*	5	3	1	1	4	5
Alisma	25	15	26	18	8	10
Artemisia	75	47	94	65	51	65
Galium	4	2	3	2	8	10
Rumex	8	5	0	0	0	0
Typha	15	9	18	12	21	27

At this site the upper part of the gravel was more evenly bedded than usual, and showed a broad hollow in the stratification in which occurred the bed of peat above-mentioned. It was a foot or more thick and a few feet of sandy beds separated it from the next overlying peat (C_1), which was in turn overlaid by the Marl D of the mere (see figure 2). When, without attempting a recount, the slides were re-examined in 1950 the full range of characteristic Late-Glacial herbaceous pollen-types was recognized, including *Polemonium, Helianthemum, Thalictrum, Valeriana, Epilobium, Ulmaria* and *Sanguisorba.* The similarity in pollen-composition with that of the peat analyzed from site Y is apparent.

(viii) *Isolated samples* (discontinuous masses, B4 and AB4)

Samples B4 and AB4 are both taken from masses of material incorporated in the gravels forming the bed of the channel at site M4, AB4 coming from a deeper series of marls than B4.

B4 was a dense mass of dark brown peat practically devoid of silt; it contained a mass of rootlets, monocotyledonous leaf-fragments and a few *Carex* fruits. Taken with the evidence of over 600 % of sedge pollen this shows B4 to be a type of sedge peat. Its pollen spectrum (table 6) has *Betula* preponderant over *Pinus*, a high ratio of non-tree to tree pollen, a full and characteristic assemblage of Late-Glacial herbaceous pollen types and only six grains referred to 'cf. *Quercus*' to be reckoned possibly as derivative. Such a spectrum closely matches that of the zone III channel muds just above it, or that of the muds at the base of the mere (site Y).

The evidence of pollen analysis thus confirms the view that the masses of B4 could have been part of the former extension of the mere, but it is insufficient to establish this.

AB4 was a fine grey silty mud with abundant coarse detritus including derived lumps of black organic mud. As is shown in table 6, pollen is scarce in it, and what there is must largely be of secondary origin; some of it, *Pinus haploxylon*, is Pre-Glacial.

(ix) *Site Mx*

Unfortunately the samples from the channel deposit Mx proved devoid of pollen, except for the three instances recorded in table 7. The samples from the middle and base of Mx are full of pollen of *Haploxylon*, *Picea* and other grains strongly suggestive of derivation from much more ancient beds, very probably indicating redeposited London Clay.

The sample from the 'stony layer over Mx' is free from derived material, and quite clearly belongs to zone V, that is, to the Early Boreal period. This accords with the discoveries in it of abundant nuts of *Corylus avellana* and stones of *Cornus sanguinea.*

(x) *Conclusions based upon pollen analyses*

The pollen analyses suggest the following sequence from the time of formation of the mere:

The mere formed when a Late-Glacial vegetation prevailed with scattered birch-pine and characteristic rich and varied herbaceous plant growth; this vegetation was recorded in the pollen catch of the organic muds first formed, but when calcareous silt, silty muds or clay muds were laid down this regional pollen was no longer deposited (or no longer incorporated), and instead a rich derived pollen came in from Inter-Glacial and Pre-Glacial deposits. This would seem to indicate the progress of a general melt bringing water down to accumulate over the valley gravels and later increasing amounts of suspended matter. A sudden drainage episode led to generally lower water-level and created the channels, and some passing flooding which incorporated fragments of the mere deposits in the gravel bed of the channel.

After a brief period in which dwarf willows and birches grew over much of the channel floor, a general rise of water-level (perhaps following decreasing volume of flow and silting-up) led to deposition of calcareous muds. These formed in zone III and at first were strongly banded, possibly a seasonal effect like that established by Welten (1944) for Swiss Lakes. At this stage they incorporated the very extensive and informative aggregation of fruits, seeds and leaves of plants to be described later in this paper. Further amelioration of climate in time caused the formation of more organic muds (zone IV) and then of fen-peats and wood-peats continously through until zone VII. By early zone VI this process of peat accumulation led in zone VI to the extension of peat formation from the channels out over the bed of the former mere, which had meanwhile (since zone III) remained somewhat above the general water-level of the valley and had even carried tree growth. At some time after zone VII*a* the valley peats were sealed in with clay from the River Lea brought from far up-stream, possibly in consequence of disforestation in historic time.

Highly desirable as it certainly is to correlate events in the Lea Valley with the well-substantiated sequence represented by the Allerød oscillation in regions closer to the ice-margin of the last glaciation, adequate evidence for such correlation appears lacking at Nazeing. If we accept the view of Farrington & Mitchell (1951) that the ice-margin of zone I was no nearer than Filey (Yorks), the Cheshire Plain and the Welsh Border, then

TABLE 6. NAZEING B4 AND AB4

sample	B4	AB4
total tree pollen	100	28
Betula	56	0
Pinus	38	8
Corylus	2	4
Salix	4	0
Gramineae	51	2
Cyperaceae	635	2
Caryophyllaceae	5	0
Compositae	2	1
cf. Cruciferae	4	0
Umbelliferae	5	0
Armeria	1	0
Artemisia	1	0
Atriplex	1	0
Galium	18	3
Helianthemum	1	0
Plantago med. or *maj.*	1	0
Ranunculus	1	0
Succisa	1	0
Thalictrum	3	0
Valeriana off.	1	0
Ulmaria	27	0
cf. *Botrychium*	1	0
Abies	0	1
Pinus (*haploxylon*)	0	16
Hystrix	0	1
Tilia	.	2
Alnus	.	1
cf. *Quercus*	6	0

TABLE 7. NAZEING, Mx SITE

sample ...	‘base of Mx’	‘middle of Mx’	‘stony layer over Mx’
total tree pollen	61	71	86
Betula	2	.	8
Pinus (*sylvestris* type)	34	25	77
cf. *Ulmus*	.	.	1
Corylus	.	.	61
Compositae: *Taraxacum* type	.	3	2
Centaurea type	.	1	.
Artemisia type	.	1	.
Umbelliferae	1	1	.
Selaginella	1	.	.
Typha latifolia	1	.	.
cf. *Ulmaria*	1	.	.
Pinus (*haploxylon*)	20	34	.
Picea	1	7	.
cf. *Abies*	.	1	.
cf. *Tsuga*	.	1	.
Alnus	1	1	.
Tilia	3	2	.
Hystrix	7	9	.
Misc. brown spores	9	15	.
Polypodium	.	.	1

surely the amelioration of zone II should have brought birch woodland, or possibly even pine wood to East Anglia, and some corresponding suppression of the herbaceous vegetation. We have seen no botanical evidence for such zone II material, and it may be that extensive melting at this time would have caused erosion rather than deposition to prevail in a valley of this character.

It remains possible of course that faunistic or stratigraphic evidence of climatic oscillation could be adduced to establish correlation where botanical evidence is lacking.

(c) FLORAL LIST

(i) *Recovery and preservation of macroscopic material: nomenclature*

To recover the macroscopic remains samples of material from the various Nazeing deposits were covered with water in a large basin and a few ml. of commercial nitric acid added. The deposit in question was left until digested, the residue was then very gently sieved through a very fine sieve, any silt or other fine residue was washed away by a jet of water, and all macroscopic remains were picked out by a paint brush and kept.

The macroscopic remains after identification are stored in small specimen tubes containing 95 % alcohol, a little glycerine and a few drops of 10 % formalin. A few specimens such as the moss leaves, are mounted on slides in gum chloral.

State of preservation

Except in the few cases specially noted, the sub-fossil macroscopic specimens are well preserved and entire. The assemblage is characterized by a uniform appearance, and this makes it unlikely that any of the specimens are derived. The only exception to this is the state of preservation of *Carex paniculata*, referred to below where however a possible explanation is given.

Nomenclature

Throughout the list the names given are those found in the 'Check-list of British vascular plants' (Clapham 1946).

In addition to these species and genera, given in the floral list of macroscopic identifications (table 8), those in the following list have been identified only by their pollen. They are referred to in the remarks below and in the photographs of plates I–VI.

Alnus glutinosa (L.) Gaertn., *Artemisia* sp., *Atriplex* sp., *Calluna vulgaris* (L.) Hull., *Calystegia* sp., *Campanula* spp., *Centaurea* sp., *Epilobium* sp., *Helianthemum*, *Linum* sp., *Lysimachia* sp., *Matricaria* sp., *Nuphar lutea* (L.) Sm., *Pinus* sp., *Plantago lanceolata* L., *P. major* L. or *P. media* L., *Polemonium caeruleum* L., *Polygonum amphibium* L., *Quercus* sp., cf. *Sanguisorba officinalis* L., cf. *Silene* sp., *Sparganium* sp., *Succisa pratensis* Moench., *Tilia* sp., cf. *Thymus* sp., *Typha angustifolia* L., *Typha latifolia* L., *Ulmus* sp., and *Valeriana officinalis* L.; species of Gramineae; Filicales, including cf. *Botrychium* sp., *Ophioglossum* sp., and *Polypodium* sp., and *Lycopodium* sp. (Derived—*Abies*, *Alnus*, *Juglans*, *Pinus-Haploxylon*, *Tilia*.)

(ii) *Identifications*

Angiosperms

Alisma plantago-aquatica L. Fruits of *Alisma plantago-aquatica* L. were abundant in the deposit M4C3 and less abundant in M4C2. Pollen was present in the calcareous muds of the M4 section (see figure 11). Thus it may be referred to zone III. *A. plantago-aquatica* has a wide distribution to-day, occurring in North Africa, North America, Asia, Australia, and all parts of Europe and Britain.

The fruits were recorded from the Arctic plant Bed.

Arctostaphylos uva-ursi Spreng. (see figure 19*i*, plate 10). One stone from a drupe of *Arctostaphylos uva-ursi* Spreng. came from M4C3 (i.e. zone III). *A. uva-ursi* grows in heathy rock habitats in Scandinavia, Iceland, Scotland, Ireland, the mountains of England, the Pyrenees, the Alps, northern Italy, central Europe, the Caucasus, Siberia and North America. In this country it has an altitudinal range from near sea-level in Skye, ascending to 3000 ft. in Scotland. It was recorded from the Arctic plant Bed.

Armeria maritima Willd. (see figures 20*r*, plate 11 and 23*e*, *f*, plate 14). Calyx tubes of *Armeria maritima* Willd. were washed out from the deposits M4*b* and MA*b*. The specimens vary slightly in size, relative width and hairiness, but these characters do not place them outside the range of *A. maritima*. Inflorescence bases were found in MA*a*. Pollen grains of *A. maritima* were found in the deposits MA, Y, B4 and M4. Most of the grains have the small reticulate pattern of Iversen's type B pollen grains, but one grain of type A with a coarser reticulation was identified from the deposit Y. These finds all relate to zone III.

A. maritima is found in two distinct regions in Britain to-day, littoral, and inland in mountainous areas in England, Scotland, Wales and Ireland, ascending to 3200 ft. on Ben Lawers and 4200 ft. on Cairntoul. It has a circumpolar distribution which takes in America, Greenland, Iceland, and in Europe, Belgium, Germany, Denmark, Switzerland, France and Scandinavia. The *Armeria* previously recorded from the Lea Valley should probably also be referred to this species, which has been recorded by Jessen from Ireland in zones II, III and IV.

Artemisia sp. (figure 22*b*, plate 13). Pollen grains of the genus *Artemisia* were identified from deposits MA, Y, B4 and M4. No fruits were found. This pollen has become recognized as a primary indicator of open plant communities of the Late-Glacial period and also of regions disforested by prehistoric man. The large frequencies encountered here in zones III and IV correspond well with Late-Glacial records from Ireland and Denmark.

Arenaria ciliata agg. (figure 21*a*, plate 12). Several seeds of *Arenaria ciliata* agg. were washed out from the samples M4*b*, M4C2, M4*d*, AB4 and MA*a*. It appears from examination of recent material that the British subspecies, *A. ciliata* var. *hibernica* and var. *norvegica*, cannot be satisfactorily separated on seed characters. Jessen & Farrington (1938) record seeds of *A. ciliata* agg. from the bogs at Ballybetagh near Dublin (zones II and III). They give a full description and argument which apply fully to the Nazeing seeds, although a few of these are slightly smaller than the Ballybetagh specimens. Mitchell also records seeds of this species from Dunshaughlin (zone III) (Mitchell 1940).

Jessen & Farrington give full details of the distribution of the various subspecies. Suffice it to say here that *A. ciliata* is a very rare plant in Britain, the subspecies *hibernica* growing on the mountains of Co. Sligo, and the subspecies *norvegica* in Sutherlandshire in Scotland, the Orkneys and Shetlands. Outside Britain *A. ciliata* occurs in Arctic Norway, Lapland, Spitzbergen, central Spain, the Pyrenees, Alps, Appennines and Carpathians and in North America.

Barbarea vulgaris agg. (figure 18*j*, plate 9). Throughout the lower deposits AB4, B4, MA*a*, MA*b*, M4*a*, M4*b*, M4C2, there were frequent seeds (zone III) of the characteristic cruciferous campylotropous form with a slightly irregular pitted surface. They could be matched amongst British Cruciferae in the genus *Barbarea*. Within this genus, all the British species of which have a pitted surface, the species *B. intermedia* Bor. and *B. verna* (Mill.) Aschers., can be excluded as having seeds almost as broad as long. The subfossil specimens are always longer than broad often at least twice as long. In this character they agree with both *B. vulgaris* R.Br. and *B. stricta* Andrz., seeds of which cannot be satisfactorily distinguished. These two species can be placed together as *B. vulgaris* agg., and it is to this aggregate species that the Nazeing specimens are therefore referred.

B. vulgaris R.Br. is found in almost all parts of Britain, though it is less common in the north. It grows in open places, especially on ground which has been disturbed by man; it is also found on river banks and on the edges of fen. Outside Britain it is found in all Europe except north Norway, Lapland, Italy, Turkey and Greece; northern, central and western Asia, Abyssinia, Algeria, and it is adventive in North America.

B. stricta Andrz. is also found in waste places and by streams practically all over Britain, but Druce gives it as an alien of north European origin. It occurs in northern and eastern Europe and Asia, and is adventive in North America.

Barbarea sp. was identified from the Lea Valley Arctic Bed.

Betula (figures 19*t*, *n*; 20*o*, *q*; 21*q*, plates 10 to 12). All three British species of *Betula*, *B. nana* L., *B. pendula* Roth. and *B. pubescens* Ehrh., are represented in the Nazeing sites.

Cone scales and fruits of *B. nana* were abundant and small leaves of this species were not infrequent. *B. nana* occurred in the deposits M4*a*, M4*b*, M4C1, M4C2, M4C3, Mx, B4 and MA*a*. Most of the fruits had their wings torn, making it difficult to refer them to a definite species. In the pollen series at MA, *B. nana* extended into zone V (figure 9). Undoubted specimens of fruits of *B. pendula* were obtained from M4*b*, M4C3 and Mx; and of *B. pubescens* from M4C2, M4C3, Mx, MA*a* and B4. Fruits probably of the *B. pendula* × *pubescens* hybrid were found in Mx, M4*b* and M4C3, and in zone V at MA.

B. nana grows in Britain to-day from 800 to 2800 ft. on moors and wet grassy places on Scottish mountains. Outside Britain it is found in north-western and central Europe—in Scandinavia, Switzerland, Austria and Hungary; and in Iceland, Siberia, Greenland and North America. It has been twice recorded from the Late-Glacial in Ireland by Mitchell (1942*a*) and Jessen (1949), in zones II and III, and occurred at Ponder's End in the Lea Valley Arctic Bed.

The hybrid *B. nana* × *pubescens* has been recorded previously in north-western Europe, and Jessen identified it from Ireland in zone III.

It is of interest that both *B. pubescens* and *B. pendula* occur here as early as zone III, for whilst Jessen records the former in Ireland from zone II onwards, the latter is not recorded before zone V.

Calluna vulgaris (L.) Hull. One pollen tetrad of *Calluna* was found in the 95 cm. sample of M4 (zone IV). Jessen has recorded *Calluna* from zones IV to VIII in Ireland, but these were identifications made upon shoots.

Caltha palustris L. (figure 18*i*, plate 9). Fruits of *Caltha palustris* L. occurred in small quantities in M4*b*, M4C1, M4C2, MA*a*, MA*b* and AB4. They are easily recognizable by their somewhat irregular cylindrical shape usually constricted in the middle, and by the surface which is black and smooth, showing a pattern of irregular small rectangular areas.

Pollen, which might possibly be regarded as belonging to this species, was found in samples from MA and Y. All these finds are from zone III.

C. palustris is native in Europe, Caucasus, India, Siberia, North America and Iceland. In Europe it extends north to arctic Russia, but is not found in Spain, Italy, Greece and Turkey. In Britain it is recorded from all the vice-counties. It is found both in lawland and upland regions, ascending to 3500 ft. in Scotland.

Fruits were recorded from the Arctic Plant Bed at Barrowell Green in the Lea Valley, and from Dunshaughlin, Ireland, in zone VIII (Mitchell 1940).

Campanula rotundifolia L. or *C. patula* L. (figures 21*h*, 22*c*, *f*, 23*a*, *b*, plates 12 to 14). A few very small seeds of *Campanula* were obtained from M4*b* and MA*a* (zone III). They are characterized by their small size and roughly ovoid shape. They have a basal circular scar at the more rounded end and taper slightly at the other end to a small neck. The surface is smooth and shiny and is marked into long rectangular strips. These characters are those exhibited by the seeds of both *C. rotundifolia* L. or *C. patula* L., seeds of which are indistinguishable. Pollen grains apparently belonging to two species of *Campanula* were identified from A and M4 (zone III). One agrees most closely with *C. rapunculoides* amongst British species of *Campanula*; the other is too small to be within the annual size range of any British species.

Both *C. rotundifolia* and *C. patula* grow to-day in fairly open vegetation, e.g. dry sunny pastures, banks, waysides, etc. *C. rotundifolia* is found in almost all parts of Britain, whilst *C. patula* occurs more locally, mainly in the south of England. Outside Britain *C. rotundifolia* is found in the Caucasus, Iceland, Siberia and North America, and in all Europe except Spain, Portugal, Greece, Corsica and Turkey, but it is rarer in the south and often montane and alpine. *C. patula* occurs in Scandinavia, Iceland, northern Spain, Germany, northern Italy and central Europe.

No *Campanula* is recorded from the Lea Valley Arctic Bed or from the Late-Quaternary of Ireland.

Carduus sp. (figure 19*c*, plate 10). Fruits of a species of *Carduus* were scattered throughout M4, M4C1, M4C2, M4C3, M4*d* and MA*c* (zones III and IV). They have the oblong compressed shape common to species of *Carduus* and *Cirsium*, but may be distinguished from species of *Cirsium* by the rather indefinite longitudinal striations and the more definite transverse wavy ribbing. These characters are found in the three British species of *Cirsium*, the fruits of which cannot be satisfactorily separated, although those of *C. tenuiflorus* Curt have rather different proportions from the other two species, and the fossil specimens are probably not of this species, but may be referred to either *C. crispus* L. or *C. nutans* L., more probably the former.

Both *C. crispus* and *C. nutans* are plants of waste and open ground in Britain to-day.

Pollen grains belonging to the genus *Cirsium* or to *Carduus* were identified from MA and M4.

Both *C. crispus* and *C. nutans* are common in Britain to-day, occurring in most lowland regions. *C. crispus* is commoner in the south than the north. Outside Britain, *C. crispus* is found in all parts of Europe, except the south, where it is only found in Portugal and in the Caucasus. *C. nutans* is found in Europe, except in the extreme north and parts of the south. It is also found in the Caucasus, Siberia, Turkestan, Asia Minor, the Himalayas and North Africa.

From the Lea Valley Arctic Bed, *C. nutans* and *C. pycnocephalus* were identified.

Carex aquatilis Wahlenb. or *Carex bigelowii* Torr. (syn. *C. rigida* Good.) (figure 20*l*, plate 11). Occurring in the deposits M4*b*, M4C1, MA*a*, MA*b* and AB4 (zone III) were flat nutlets with transparent nerveless utricles which may be referred to either *Carex aquatilis* Wahlenb. or *C. bigelowii* Torr. Either of these identifications would be interesting in view of the northerly distribution of these species at the present day. *C. aquatilis* is found in northern Britain, Scandinavia, Lapland, Finland and northern Russia. In this country it is found from 50 to 3300 ft. It is recorded from Cardiganshire and Merionethshire in Wales; Northumberland, Cumberland and Westmorland in England, and fairly widely from Ireland and Scotland. *C. bigelowii* is native in Britain, Scandinavia, Iceland, the Pyrenees and the Alps. It grows in the north of England, Wales, Scotland and Ireland. Its altitudinal range is from near sea-level to 4350 ft. Jessen reports this *Carex* from zones II and III at Ballybetagh, Ireland, but it is not given in the lists of the Lea Valley Arctic Bed.

Carex cf. *laevigata* Sm. (figure 20*m*, plate 11). Fruits with utricles were recovered in abundance from M4C3, and in smaller amount from M4*d* (zones III and IV). They were of generally uniform character and this strengthened the quality of the determination, although the beak characters were no longer recognizable. Abundant trigonous nutlets present in M4C3 were doubtless referable to this *Carex*, since the other abundant sedge was *C. rostrata* in which the nutlets (also present) are substantially larger.

The species most closely resembling the fossil forms (as far as can be judged in the absence of the intact beak of the utricle) are *C. pseudocyperus* L., *C. acutiformis* Ehrh., *C. binervis* Sm. and *C. laevigata* Sm. *C. pseudocyperus* is excluded by the considerable width of the ribs as against the furrows in that species, and by the continuity of the stout ribs up into the beak where they fuse to form a very much stouter structure than that in the fossil. *C. acutiformis* is excluded by the very generally larger number of ribs in the utricle and a generally shorter and broader form; although a few specimens may be found corresponding closely with the fossil, the substantial bulk of fossil material differs clearly from the main mass of *C. acutiformis*.

C. binervis has the same general size and form as the fossil, but the utricle generally has far too few and too weak ribs. *C. laevigata* appears to correspond closely with the fossil material, but in view of the absence of beak from the latter, final identification is not possible. After comparison of material from several sources however, the authors adhere to the view that this is the closest match possible in the present British flora.*

Not only are the ribs present in proper numbers and of correct proportions but the two marginal ribs which ascend to the beak are stronger than the remainder, exactly as in the fossil. At the present day *C. laevigata* is fairly generally distributed over the British Isles except for the very north of Scotland. It is found in marshes and wet woodland from sea-level to 1050 ft. in Northumberland, and reaches 1350 ft. in Kerry. Outside Britain it has a western distribution, and occurs in Holland, Belgium, France, western Germany, Spain, Portugal, Algeria and Corsica.

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* The authors are greatly indebted to Mr E. Nelmes of the Royal Botanic Gardens, Kew, for the substantial assistance he has given in checking out identifications of the fossil Carices. It should be said that with regard to this particular fossil Mr Nelmes is disinclined to attribute it to *C. laevigata*, and after some hesitation has refused to identify it with any living British species of sedge.

Carex paniculata L. (figure 20*k*, plate 11). Scattered sparsely through the deposits in M4*a*, M4*b*, M4C2, M4C3, AB4, B4, MA*a*, MA*b* and C4 were small carbonized specimens which yielded a small cyperaceous nutlet when the thick outer coat had been dissected away. These may be referred with some doubt to *Carex paniculata* L. Points of similarity with fresh specimens are the size and shape, the ribbing at the base, the nerveless faces, the irregular ventral surface, the groove at the base of the beak, and the shape and conspicuousness of epidermal cells. The group of Carices to which *C. paniculata* belongs is characterized partly by the possession of a coriaceous utricle. This may explain the difference between the texture of these subfossil specimens and those of *C. rostrata*, for example, which has a membranaceous utricle (Nelmes in lit. 4 May 1948).

C. paniculata is a lowland sedge in Britain, growing in practically all the vice-counties and ascending to 1500 ft. in Wales and 1900 ft. in Kerry and Tipperary. In other parts of the world it is found in the Caucasus, Asia Minor, the Canaries, America, and in most of Europe as far north as central Norway and Sweden. It has been recorded by Jessen from Ireland in zones VI, VII*a* and VIII.

Carex rostrata Stokes (figure 20*n*, plate 11). The commonest species of *Carex*, occurring in abundance in the deposits M4C3, M4*d*, AB4, MA*b* and MA*c* (zone III), was *C. rostrata* Stokes, with its small trigonous nutlet and often curved style base, surrounded by the inflated, ribbed utricle. To-day it is a common plant practically all over Britain extending from sea-level to 3000 ft. It is found in Asia, North America and all parts of Europe except the extreme south. Jessen reports *C. rostrata* from Ireland in zones II, IV, VIII and possibly others, and it also occurred in the Lea Valley Arctic Bed.

Centaurea (figure 23*h*, plate 8). Pollen grains which could be referred with certainty to the genus *Centaurea* but not to a given species (the resemblance was close to *C. scabiosa* except for size), were found in M4 (zone IV), MA (zones IV and VI*a*), and Y (zone III or earlier).

Cerastium vulgatum L. (figure 18*l*, plate 9; figure 21*g*, plate 12). Two seeds, from M4C2 and M4C3 (zone III) were identified with fair certainty as *Cerastium vulgatum* L. The identification takes into account the truncate conical shape, size and surface characters. Each cell of the testa projects as a rather diffuse wart, and these are arranged in rows.

This species is very common in Britain at the present time, growing in fields, waste places, road-sides, cultivated ground, by tidal streams, on shingle and sand dunes, all those situations in which the vegetation is open. It shows a preference for well-drained soils. It is found over a wide altitudinal range, ascending to 3030 ft. on Helvellyn and to nearly 4000 ft. in Scotland. It is recorded from all parts of Britain and Europe, also from Asia, India, North Africa, the Canaries and North America.

Fragments of seeds from M4B may doubtfully be referred to the genus *Cerastium*. Seeds referred to this genus have also been found in the Lea Valley Arctic Bed.

Chenopodium cf. *album* L. (figure 19*q*, plate 10; figure 22*q*, plate 13). One or two seeds were found in each of the deposits MA*c*, M4C1, M4C3 (zone III). Taking into account characters of shape, size, surface pattern and texture, the specimens correspond closely with *Chenopodium album*, although in one or two of the subfossil specimens the surface markings are rather more pronounced than is usual in *Chenopodium*.

C. album is found in open habitats (waste places, and cultivated ground) and in all parts of Britain, Europe and the Temperate regions. In Britain it is a lowland plant, ascending to 1000 ft. in Britain and 1250 ft. in Eire.

Pollen grains of the family Chenopodiaceae, some of which resembled *C. album*, were identified from MA and M4 sites (zones III, IV), others with the characters of a species of *Atriplex* from MA, B4 and M4 sites (zones III).

The genus *Chenopodium* has been identified from the Lea Valley Arctic Bed.

Cicuta virosa L. (figure 19*x*, plate 10). The orbicular fruits of this umbellifer were fairly numerous in M4C3 and M4 (zones III and IV). *Cicuta virosa* L. has a local distribution throughout the British Isles. Outside Britain it is native only in northern and central Europe.

It has been recorded by Jessen from zone VI in Ireland.

Cirsium heterophyllum (L.) Hill or *C. palustre* (L.) Scop. (figure 19*f*, plate 10). Of frequent occurrence in M4C1, M4C3, M4*d*, MA*c* and AB4 (zone III) were fruits with the characteristic oblong, compressed shape found in the genera *Carduus* and *Cirsium*. The fruit surface is smooth, longitudinal marking is lacking, or represented only by a median groove or occasionally by one or two faint ribs, and these characters together with size and shape are to be matched in the two species *C. heterophyllum* (L.) Hill and *C. palustre* (L.) Scop. The fruits of these two species are very similar in form, and the size ranges of the fruits of the two species overlap, so that they cannot satisfactorily be separated.

C. heterophyllum has a northern distribution in this country, growing in pastures, grassy hill slopes and other open places in Wales, northern England and Scotland. It is found from 300 ft. in Yorkshire to 3200 ft. on Lochnagar. Outside Britain its range extends over Iceland, Scandinavia, Denmark, France, Germany, Switzerland, northern Italy, Austria, Hungary, Russia and Roumania. *C. palustre* grows in damp habitats, in wet fields, woodlands and hedgerows, and is common all over Britain. It is also found in the Caucasus, Siberia, Algeria and all over Europe except in Spain, Sardinia, Sicily, Greece and Turkey.

C. palustre has been recorded from zone VIII in Ireland, and *C. heterophyllum* from the Lea Valley Arctic Bed.

Comarum palustre L. (figure 19*s*, plate 10). From M4*a*, M4*b*, M4C1, AB4, B4, MA*a* and MA*b* (zone III) achenes of *Comarum palustre* L. were obtained. These are almost pherical, circular in outline except at the position of the gynobasic style scar, and when dry the surface is marked with irregular fine lines.

C. palustre is found in nearly all parts of the British Isles reaching 3000 ft., and has a wide distribution in the northern hemisphere.

Most of these subfossil specimens can be referred with certainty to *C. palustre*, although a few must be regarded with some doubt. The latter are more elongate than the typical round specimens, and it is possible that they are either poorly developed fruits of *C. palustre* or may belong to another species of Potentilla, although they do not agree with material of any other British species.

C. palustre has been recorded from zones IV to VII*b* in Ireland and also from one site in the Lea Valley Arctic Bed.

Cornus sanguinea L. (figure 21*k*, plate 12). Four stones of one whole fruit of *Cornus sanguinea* L. were washed out from Mx (zone V). The stones were spherical with shallow grooves running longitudinally marking the surface into sectors. The whole fruit had the skin and dried fleshy mesocarp surrounding a stone.

C. sanguinea is found in hedges and woodlands of lowland areas, ascending to 1050 ft. in England, Wales, Ireland and the south of Scotland, its frequency occurrence, however, decreasing northwards. Outside Britain it is found in Siberia, and all parts of Europe except northern Scandinavia, Finland and northern Russia. Jessen found it in zones VI and VII*a* in Ireland.

Corylus avellana L. Two fragments of a nut of *Corylus avellana* L. were found in Mx (zone VI).

C. avellana is found all over Britain normally in lowland regions although it ascends to 2050 ft. in Wales. It is found throughout Europe except in northern Scandinavia; in south and central Asia and in North Africa.

Cruciferae. Pollen belonging to the family Cruciferae, not referable to particular genera, was found in samples from M4, B4 and Y (zones III and before).

Cyperaceae. Pollen belonging to the family Cyperaceae was common in all the deposits, but cannot be identified further.

Daucus carota L. (figure 19*b*, plate 10). A single mericarp of *Daucus carota* L., characterized by the rows of spores on its ridges, was identified from Mx (zone V).

This species is widespread in Britain in open habitats, fields, hedgerows, waste places, waysides. It is a lowland plant, ascending to 1325 ft. in Kerry. Outside Britain it is native in all countries of Europe except Norway and Finland; in western and central Asia, North Africa, Abyssinia and the Canaries.

Draba incana L. (figure 21*o*, plate 12). Several pale green, thin 'petal-like' structures, oval in shape were obtained from the deposit AB4. They averaged 5 mm. in length and 2 mm. in breadth, had a definite vein down their centres; some specimens could be seen to be delicately veined. Similar specimens had been frequently found in earlier investigations in the Lea Valley regions, and Clement Reid had identified them as the valves of fruits of *Draba incana* L. They correspond in detail with fresh material of these structures, both in form and size.

D. incana is native in North America and northern and central Europe, occurring in Britain, Norway, Sweden, Finland, Arctic and central Russia, Iceland, Pyrenees, Switzerland and the Tyrol. In Britain it is found in the northern half of England, in Wales, Scotland and Ireland, growing at sea-level in Scotland, but more often on moors and mountains where it occupies dry rocky screes and ledges up to altitudes of 3550 ft.

Dryas octopetala L. (figure 18*o*, plate 9; figure 20*p*, plate 11). Leaf fragments of *Dryas octopetala* L. were obtained from the deposits at the base of the MA channel, in the deposit MA*a* (zone III). In spite of the fragmentary and sparse nature of the material, it could be identified with certainty by the strongly recurved leaf lobes, the densely hairy lower surface and the characteristic venation.

Several fruits were obtained from the deposit MA*b* which may, though with some doubt, be referred tentatively to the species *D. octopetala*. They have an elongate ovoid form, with projecting style, and are hairy, but they are much smaller than achenes from fresh material.

Isolated pollen grains from deposit MA (zone IV) have certain resemblances to a pollen grain of *D. octopetala*, but the determination is rather doubtful.

D. octopetala is found in northern England, Wales, Scotland and Ireland, usually on high land, on mountain ledges on calcareous soils, and open limestone rocky pastures. It ascends to 2800 ft. in Scotland and to 2300 ft. on Helvellyn, and descends nearly to sea-level on the limestone of Sutherland and Clare.

It is also found in Iceland, Spitzbergen, Norway, northern Sweden, Lapland, arctic Russia, the Pyrenees, the Juras, the Alps and in the Balkans; in Asia, Siberia, North America, Canada and the Caucasus.

Whilst looking through material collected some years ago from the Arctic Plant Bed at Broxbourne and mounted by Mrs Reid, a fragment of a leaf of *D. octopetala* was identified which had previously passed unrecognized. No other record has been made from the Arctic Plant Bed, but Mitchell (1942*b*) has recorded it from zone III in Co. Monaghan, Ireland, and of course upon the continent it characterizes the upper and lower Dryas clays which are held to correspond with the British and Irish zones III and I.

Eleocharis palustris (L.) Roem & Schult. (figure 20*h*, plate 11). Two fruits from M4C3 and M4*d* (zones III and IV) were referred to *Eleocharis palustris* (L.) Roem & Schult., on account of their shape, persistent style base, and characters of the cells of the outer coat. The identification has been confirmed by Mr S. M. Walters.

To-day *E. palustris* has a wide distribution, both in the world where it occurs in Africa, America, Asia and all parts of Europe; and in Britain where it is recorded from all the vice-counties (Walters 1949).

Jessen has recorded the species from zones VI, VII*a* and VIII in Ireland, and fossils referable either to *E. palustris* or *E. uniglumis* from zones II and III. It has been recorded from the Lea Valley Arctic Bed.

Empetrum nigrum agg. (figure 20*a*, plate 11). A single stone from a drupe of either *Empetrum nigrum* L. or *E. hermaphroditum* (Lange) Hagerup was washed out from a sample of M4*b* (zone III). The stone is a similar form to that of *Arctostaphylos uva-ursi* (L.) Spreng, but is only half as big.

The aggregate series *Empetrum nigrum* is scattered locally in the south of England, becoming more frequent in the north and in Wales, Scotland and Ireland, ranging from sea-level to 4000 ft. The distribution of the two component species is fully discussed by Jessen, who records *E. nigrum* L. from zones I to V in Ireland, and shows it to have constituted '*Empetrum* heath' in north-west Ireland in Late-Glacial times.

Epilobium sp. (figure 23*m*, plate 14). Single pollen grains and tetrads identified as belonging to the genus *Epilobium* were found in the deposits MA, Y and M4 (figure 11). Jessen has recorded pollen of *Epilobium* from zones II, IV and VII*b* in Ireland.

Erica tetralix L. (figure 12). Three terminal portions of a shoot, each with three leaves, were found in the deposit MA*a* (zone III). Each leaf was small and thick with a distinct midrib but no prominent lateral veins, and with an inrolled leaf margin. On these characters it may be referred, although without complete certainty, to the species *Erica tetralix* L. *E. tetralix* is a species of oceanic western European range occurring throughout Britain, north and central Europe and Ireland. Jessen has recorded it from zones V, VI, VII*a* and VIII in Ireland, but it has not been found in the Lea Valley Arctic Bed.

Filipendula ulmaria (L.) Maxim. (figure 18*n*, plate 9; figure 22*a*, plate 13). Numerous carpels of *Filipendula ulmaria* (L.) Maxim. were found in M4C1, M4C2, M4C3, AB4 and MA*c* (zone III). Each was of an asymmetrical twisted form, crescentic in side view, with a persistent style and a projection from the hollow of the concave side. A few carpels were found complete with outer coat, but more usually this had gone, revealing the irregularities of form described above.

Pollen grains from MA, Y, B4 and M4 were identified with reasonable probability as belonging to *F. ulmaria* (see figure 10 and figure 22*a*, plate 13) (zone III in abundance but also later).

F. ulmaria is found throughout Britain, ascending to 2900 ft. in Scotland. It is generally distributed throughout northern and central Europe, and western Asia. Jessen reports this species from zone II in Ireland, and it has also been found in the Lea Valley Arctic Plant Bed.

Galeopsis tetrahit agg. (figure 19*o*, plate 10). Several nutlets of *Galeopsis tetrahit* agg. were obtained from M4C1, M4C3 and M4*d* (zones III and IV). Each is a large labiate nutlet with pronounced attachment scar, and an angle of about 90° between the two flat contact faces. The surface is shiny and covered with faint tubercular markings. The nutlets of *G. speciosa* Mill. and *G. tetrahit* L. cannot be distinguished.

The aggregate species *G. tetrahit* is generally distributed throughout Britain in waste places, cultivated ground and borders of woods. It is also found in Scandinavia, Iceland, Spain, Belgium, Holland, Germany, Switzerland, the mountains of Italy, eastern Europe and Asia.

Galeopsis sp. has been recorded from one place in the Lea Valley Arctic Bed.

Galium aparine L. (figure 19*c*, plate 10). Two fruits, of *Galium aparine* L., were washed out from M4C1 (zone III). Each is globose with a fairly deep pit in one side and a surface marking of elongated areas. The surface is, however, quite smooth; presumably the hairs found in fresh material have decayed or been rubbed off. Pollen grains of perhaps two species of *Galium* were identified from the deposits of MA, Y, B4, AB4 and M4. They tend to be more frequent in the older layers of the deposit (see figure 12).

G. aparine has a wide distribution to-day, being found in hedges, waste-places, fairly green woodland, and foreshores all over Britain, throughout Europe, and in Siberia, western and central Asia and North Africa.

Geranium sanguineum L. (figure 18*m*, plate 9; figure 21*n*, plate 12). A single seed of *Geranium sanguineum* L. was washed out from D4. Its characteristic features are its large size, dimpled surface, and surface pattern of a fine raised reticulum. Two hairy empty carpels, also of *G. sanguineum*, were found, one in each of the deposits M4*a* and MA*b* (zone III).

In Britain, *G. sanguineum* has a local distribution, being found spasmodically throughout England, Scotland, Ireland and Wales, in pastures, on dry rocky cliffs and on sand dunes. It is a calcicole species, ascending to 1200 ft. near Braemar, and to 1000 ft. in Co. Clare. It is found throughout Europe except in northern Norway, northern Sweden and northern Russia; and it also occurs in western Asia.

Geum sp. (figure 18*p*, plate 9). Achenes of a species of *Geum* were found in the deposits M4*b*, M4C1, MA*b*, MA*c* and AB4 (zone III). These hairy achenes with persistent style might be referred to either *G. rivale* or *G. urbanum* L. as characters such as size, relative breadth and length are similar in both.

The two species have a rather similar world distribution, *G. urbanum* growing in all parts of Europe except in Lapland, Greece and Turkey, extending as far as Scandinavia and Siberia; and present also in western Asia and North Africa, whilst *G. rivale* is found in Europe as far north as Iceland, the Faroes and northernmost Finmark; it is absent from Greece and Turkey but occurs in western Asia, North Africa and North America.

Helianthemum (figures 22*l*, *m*, plate 13). Since the publication of Iversen's work in 1946, pollen of *Helianthemum* has been recognized as an indicator of the 'Park-tundra' vegetation of the Late-Glacial period. Numerous grains of *Helianthemum* pollen were found in deposits MA, Y and M4.

In general they were small (in relation to the size range in British species of the genus), narrow or lemon-shaped, and with a fine reticulation. They thus resembled the *H. oelandicum* pollen described by Iversen, and the closely related *H. canum* found in this country (when *H. oelandicum* is absent).

It is, however, very difficult to distinguish with certainty the grains of the four native British species, *H. guttatum*, *H. canum*, *H. nummularium* (= *H. chamaecistus*) and *H. polifolium*.

Of these species only *H. nummularium* is widespread in Britain.

Helianthemum pollen has recently been found from the Late-Glacial in Ireland (Mitchell unpubl.).

Hippuris vulgaris L. (figure 18*v*, plate 9). Abundant fruits of *Hippuris vulgaris* L. were obtained from M4*b*, M4C3, M4*d*, AB4, B4, MA*a*, and MA*b* (zones III and IV).

H. vulgaris is found in most parts of Britain. It is native in all parts of Europe except Italy, Spain, Greece and Turkey; and occurs in western Asia, Siberia and North America.

It has been recorded by Jessen from zones II, V, VI and VII*a* from Ireland, and occurs at all sites of the Arctic Plant Bed in the Lea Valley.

Linaria vulgaris Mill. (figure 19*k*, plate 10). Three seeds of *Linaria vulgaris* Mill. were washed out from M4C3 (zone III). Each was flat, the surface covered with fine tubercles, and the whole surrounded by a thin wing, circular in form except for a notch, and displaying very clearly a radiating cell pattern.

L. vulgaris grows in waste-places, hedgebanks and similar habitats in almost all parts of Britain, although it becomes less common northwards. In Europe it is found in Germany, Belgium, Holland, the countries of central Europe, and throughout Scandinavia except Lapland and northern Finland. It is also found in northern Asia and the Caucasus region.

This species is so strongly associated with ruderal situations that it is perhaps surprising to find that it has this early native status, but subfossil specimens have also been recovered at Hartford, near Huntingdon, from deposits presumed also to be of Late-Glacial age.

Linum sp. From practically all the site of the Arctic Plant Bed in the Lea Valley, C. Reid recovered seeds of *Linum* which he failed to match with those of existing species. He erected a new species *L. praecursor* Reid for them, but Mrs Reid (1949) casts doubt upon this identification, and points out that the seeds resemble those of *L. anglicum* Mill. very closely, save that the fossils are consistently smaller. Our own examination of Reid's material confirms this view.

No *Linum* seeds were found in the Nazeing beds, but in view of the Arctic Bed finds it is of interest to record that two pollen grains, matching those of *Linum*, were recovered from the sample at 95 cm. in M4 (zone III). They are exceedingly characteristic, but determination of the species was not possible.

Lycopus europaeus L. (figure 19*m*, plate 10). Characteristic fruits of *Lycopus europaeus* L. were common in M4C3, M4*d*, MA*b*, MA*c* and D4 (zones III and IV). Pollen grains which can tentatively be referred to this species were identified from A, Y and M4; they form part of the Labiatae pollen indicated in the non-tree pollen of M4 (figure 12).

L. europaeus is recorded from nearly all British vice-counties. It is found throughout Europe except in northern Scandinavia, but is rare in the east and central region. It also grows in North Africa.

It has been recorded by Jessen from zone VII*a* in Ireland, but not from the Lea Valley Arctic Bed.

Lysimachia sp. (figures 22*g*, *h*, plate 13). In the samples from deposit MA at the level of the *Typha* layer (zone III) pollen grains were found which are referable to the genus *Lysimachia*.

Matricaria type (figure 22*c*, plate 13). Pollen grains of the type found in several genera, including *Matricaria* and *Anthemis*, were identified from all the deposits MA, Y, B4, AB4 and M4 (zones III and IV).

Mentha sp. (figure 19*l*, plate 10). Three nutlets of a species of *Mentha* were found in M4C3 (zone III). The small smooth nutlets are characteristic of the genus *Mentha*, but specific differentiation is not possible.

Mentha has been recorded from Ponder's End in the Arctic Plant Bed.

Menyanthes trifoliata L. (figure 19*j*, plate 10). Seeds of *Menyanthes trifoliata* L. were abundant in the deposits M4*b*, M4C3, M4*c*, AB4, B4, MA*a* and MA*b* (zones III and IV).

This is a common species throughout Britain. In Europe it occurs in Scandinavia, Iceland, northern, central and eastern Spain, northern Portugal, Germany, Switzerland, Italy, and the east European countries. It is also found in Siberia, the Caucasus, Himalayas, Japan and North America.

It is recorded by Jessen from zones II-IV and VIII in Ireland, and from the Arctic Plant Bed at Broxbourne.

Myriophyllum spicatum L., or *verticillatum* L. (figures 18*w*, 21*p*, 22*t*, *u*, plates 9, 12 and 13). Fruits which may be referred to either *Myriophyllum spicatum* L. or *M. verticillatum* L., were fairly common in M4C1, M4C3 and AB4 (zone III). Pollen grains, identified as belonging to one of these species, were found in samples from MA, Y and M4. The fruits of these two species cannot be distinguished, and in these cases the pollen is not good enough for the separation either.

M. spicatum is fairly generally distributed throughout Britain to-day, although it is commoner in the south than the north. It is found in lacustrine habitats in lowland regions, ascending to 1562 ft. in Watendlath. It occurs throughout Europe except Greece and Turkey, extending north to Iceland and Finland. It is also found in Asia Minor, Caucasus, Afghanistan, Siberia, Morocco, the Cape and North America.

M. verticillatum is less widely distributed in Britain, being absent from Scotland, rare in Wales, and present though rather locally in England and Ireland. Outside Britain it is found in all parts of Europe except Lapland, Spain and Turkey, going north as far as mid-Norway and northern Finland; in central and northern Asia, North Africa and North America.

Bracts of a species of *Myriophyllum* (very probably *M. verticillatum*) were washed out from the deposits M4*b*, M4*c*.

Fruits of *M. spicatum* have been recorded from all sites of the Lea Valley Arctic Bed, and there is one doubtful record of *M. verticillatum*. Jessen gives Irish records for *M. alterniflorum* from zones I to VI, *M. spicatum* from zones II to IV, and the genus from zones II to VI.

Naias flexilis (Willd.) Rostk. & Schmidt (figure 20*g*, plate 11). A single fruit of *Naias flexilis* (Willd.) Rostk. & Schmidt was washed out from M4*b* (zone III). It is fusiform in shape, blunt at one end, and pointed at the other, with a characteristic surface marking into regular cells.

In Britain to-day *N. flexilis* is very rare, growing in a very few lakes in Dorset, north-west England, western Scotland and Ireland. Outside Britain it is found in Pomerania, Finland and Scandinavia and North America.

Jessen reports this species from zones V and VI in Ireland, but it was not found in the Lea Valley Arctic Plant Bed.

Nuphar sp. Pollen grains of *Nuphar* were identified from the lowest sample of M4 (zone III). No fruits were obtained.

Pastinaca sativa L. Rather broad Umbellifer pollen grains closely comparable with those of *Pastinaca sativa* were found in M4 (zone IV). Mericarps of this species have been found in the Inter-Glacial at Clacton.

Petroselinum segetum (L.) Koch. (figure 18*y*, plate 9). Two rather poorly preserved mericarps from the deposit MA*b* (zone III) may probably be referred to the species *Petroselinum segetum* (L.) Koch. One of the mericarps is smaller than the second and smaller than fresh material and is probably unripe. Both specimens agree with type material in characters of ribs and shape.

P. segetum is found in hedge-banks, fen dykes and waste-places. It occurs in Wales and in England from Yorkshire southwards, but is absent from Scotland and Ireland. It also occurs in France, Belgium, Spain, Portugal and northern Italy.

Plantago lanceolata L. and *P. major* L. or *P. media* L. (figure 22*p*, plate 13). Two pollen grains of *Plantago lanceolata* L. were identified from deposit M4 (zone III), and of *P. major* L. or *P. media* L. from deposits MA, Y, B4 and M4 (zones III and IV) (see figures 10, 12). No fruits of the genus were obtained.

All three species of *Plantago* are widely distributed in Britain to-day in open habitats and waste ground in lowland areas. *P. lanceolata* and *P. major* are found throughout Britain, *P. media* is less common in the north than the south.

Outside Britain, *P. lanceolata* is found all over Europe except in the extreme north, in western Asia and North Africa. *P. major* occurs in all parts of Europe, in western Asia, Siberia, Cyprus and North Africa. *P. media* grows in most regions of Europe except northern Scandinavia, in Siberia, Persia and the Caucasus.

Pollen of *P. lanceolata* has become an index-fossil to the west European disforestation produced by Neolithic man and his successors, and there is a tendency to regard this species as having been introduced in Neolithic times.

Jessen records pollen of *P. lanceolata* from zones VII *b* and VIII in Ireland.

Polemonium caeruleum L. (figures 22*i*, *j*, *k*, *n*, *o*, plate 13). The deposits MA, Y and M4 yielded pollen grains of *Polemonium caeruleum* L. in substantial frequencies. The grains are exceedingly characteristic and readily identifiable. None of the characteristic fruits was found.

At the present time in Britain, *P. caeruleum* has a very limited and local distribution, and it is often recorded when it is merely an escape from a garden, though it is undoubtedly a native in some places, e.g. Malham Cove. It occurs in northern England, Scotland, the Pyrenees, Scandinavia, Germany, the Juras, central Switzerland, the Tyrol, Austria and Hungary. It is also found in the Caucasus, Siberia, North America and Cuba. The distribution has already been carefully described (Conolly, Godwin & Megaw 1949).

Grains of *Polemonium* have been found in Late-Glacial or early Post-Glacial deposits also in Cornwall and Yorkshire, and it seems probable that in England this species had a widespread distribution at this time, and that it may become a similar indicator to *Thalictrum*, *Helianthemum* and *Artemisia*.

Polygonum aviculare L. agg. (figure 19*r*, plate 10). A nut enclosed in perianth segments from MA*b*, nuts and nut fragments from MA*a* and MA*c* (zone III) were identified as belonging to the aggregate species *Polygonum aviculare* L. Besides characters of size and form, the surface marking of the nut of *P. aviculare* is diagnostic, so that even fragments of a nut can be identified.

P. aviculare is a cosmopolitan plant, occurring throughout Britain, throughout Europe and the world, including arctic regions in cultivated ground, open and wasteland. This is a striking indication of its natural status in England especially when taken with the previous record from the Lea Valley Arctic Bed at four different sites.

Polygonum amphibium L. Pollen grains of *Polygonum amphibium* L. were found in the deposit Y (zone III). This aquatic plant is found throughout Britain and in North temperate and arctic regions.

Populus sp. A single catkin scale of the genus *Populus* was found in Mx (zone VI). From the same deposit, a few bud scales corresponded closely with those from fresh material of *Populus*. Interspecific differentiation is not possible on either bud scales or catkin scales.

Potamogeton spp. Fruits of species of *Potamogeton* were common in the deposits. They were referred with varying degrees of certainty to the species *Potamogeton* cf. *natans* (figures 20*c*, *d*, plate 11). *Potamogeton* cf. *pusillus* L. (figure 20*e*), and *Potamogeton* cf. *filiformis* Pers. (figure 20*f*), from the deposits M4C1, M4C2, M4C3, M4*d*, MA*b* and MA*c* (zones III and IV); M4*b*, M4C1, M4C3 (zone III), and M4*b*, AB4, MA*a* and MA*b* (zone III), respectively.

The present-day distribution of *P. natans* is cosmopolitan; it is found all over Britain and all over Europe except in Spain and Italy. *P. pusillus* occurs in nearly all parts of Britain and Europe, and in Siberia, Arabia, China, Japan, the Azores and North and South America. *P. filiformis* is restricted to northern Britain, is found in north-western and central Europe, in Asia, Africa, Australia, North and South America.

P. natans has been recorded by Jessen from zones II to VII*a* and VIII from Ireland, and it occurred in one of the Arctic Plant Bed sites.

P. pusillus was recorded by Jessen from zones II, VI and VII*b* in Ireland, and is doubtfully recorded also from the Arctic Plant Bed.

P. filiformis was recorded by Jessen from zone II in Ireland, and also from five of the Lea Valley Arctic Plant Bed sites.

Potentilla fruticosa L. (figure 18*r*, plate 9). One achene of *Potentilla fruticosa* L. was found in M4*b* (zone III). Its shape and markings, with a prominent dorsal ridge and three pairs of transverse ridges radiating from the ventral scar of the gynobasic style, make the identification unmistakable.

The species has a fairly wide world distribution, being native in northern Italy, Spain, Russia, Siberia, Himalayas and North America. Within the British Isles, however, it is severely localized, although it grows from near sea-level in Co. Clare, to 1200 ft. in Teesdale. A previous altitudinal record was 2300 ft. on Helvellyn. In each of its present-day localities it is found where the vegetation is kept open, for example, on scree in the lakes, on grazed limestone pavement in Co. Clare, and on basalt rocks in the bed of the river in Teesdale.

Potentilla sterilis (L.) Gaike (figure 18*g*, plate 9). Achenes of *Potentilla sterilis* (L.) Gaike were frequent in B4 and M4*b* (zone III). They can be identified with fair certainty by the pattern of the surface ridges.

P. sterilis is found in practically all parts of Britain, ascending to 2100 ft., but thins out towards the extreme north. It also occurs in all Europe except Norway, Finland, Turkey, Greece, Spain and Portugal; and in Anatolia and North America.

Potentilla sp. (figure 18*t*, *u*, plate 9). Pollen grains and a few achenes belonging to the genus *Potentilla* but of indeterminate species were found, the pollen grains in MA and the achenes in MA*a* and MA*b* (zone III). The latter are very small, and may merely be poorly developed achenes of an otherwise recognizable species.

Prunella vulgaris L. (figure 19*n*, plate 10). Two fruits, which by the characteristic labiate shape and longitudinal grooves may be referred to the species *Prunella vulgaris* L., were found in M4C3 (zone III).

P. vulgaris is found all over Britain to-day, growing in pasture, woodland rides and waste places, ascending to 2400 ft. in Yorkshire and 2500 ft. in Angus. It also grows all over Europe, in Iceland, Asia, North Africa, America and Australia.

Ranunculus cf. *acris* L. (figure 18*g*, plate 9). Achenes of a *Ranunculus* species, which by virtue of shape, size and nature of pits may be identified as *Ranunculus* cf. *acris* L., were found in the deposits M4*b* and M4*d* (zones III and IV).

This species is found all over Britain at the present time, in meadows, pastures, grassy cliffs, dunes and grassy road-sides. It ascends to 4000 ft. in Scotland and 3350 ft. on Snowdon. It also grows in all Europe except Italy, Greece, and Turkey, in Siberia and Morocco.

R. acris is recorded by Jessen from zones II, III, VII*b* and VIII in Ireland, and has been found at four sites in the Lea Valley Arctic Plant Bed.

Ranunculus (*Batrachian* spp.) (=*R. aquatilis* L.) (figure 18*c*, plate 9). Of frequent occurrence throughout M4C1, M4C2, M4C3, AB4, B4, MA*a* and MA*b* (zone III), were achenes belonging to the section *Batrachium* of the genus *Ranunculus*. It is probable from differences in size and marking that more than one species is represented.

Jessen records this fruit type from zones II to VIII from Ireland, and it is abundant throughout the Lea Valley Arctic Plant Bed.

Ranunculus flammula L. (figure 18*c*, plate 9). Characteristic small achenes of *Ranunculus flammula* L. were obtained from M4, M4C3, AB4 and MA*b* (zone III).

At the present time *R. flammula* is found all over Britain, in Europe (except in Italy, Greece and mid-Spain) and in Siberia, Africa and America.

Jessen records *R. flammula* from zones II, IV, VI, VII*a* and VIII from Ireland (and more doubtfully from zone III). It has also been found at four sites in the Arctic Plant Bed.

Ranunculus cf. *lingua* L. (figure 18*f*, plate 9). Achenes, which from their shape, size and surface markings can with fair certainty be referred to *Ranunculus lingua* L., were found in M4*a*, M4C3 and MA*c* (zone III).

R. lingua is rather uncommon to-day in Britain, but its range extends over most of the country. It grows in all parts of Europe except Lapland, Norway, Spain, Portugal, Greece and Turkey; and in India.

Jessen reports this species from zone II in Ireland, but it is not recorded from the Arctic Plant Bed.

Ranunculus cf. *repens* L. (figure 18*h*, plate 9). Achenes which can with fair certainty be distinguished from *Ranunculus acris* L. and referred to *R. repens* L., by differences in shape and surface markings, were obtained from deposits M4C1, M4C2, B4 and Mx (zones III and VI).

In this country to-day *R. repens* is found in waste and open ground and on grassy hills, in all vice-counties. It ascends to 3400 ft. on Snowdon. It is also found throughout Europe (except in Greece), in Iceland, northern and central Asia, North Africa, the Canaries and North America.

Jessen has recorded *R. acris* from zones II, III, VI, VII*b* and VIII in Ireland, and it occurred in most sites of the Arctic Plant Bed.

Ranunculus sceleratus L. (figure 18*d*, plate 9). The characteristic achenes of *Ranunculus sceleratus* L. were found in M4C3 and MA*c* (zone III).

The species is found in most parts of Britain and in all parts of Europe (excepting Spain, Portugal and Greece), in Siberia, Japan, India, Mesopotamia, Asia Minor, Syria, Egypt, North Africa and North America.

It has been identified from Waltham Cross in the Lea Valley Arctic Bed.

Ranunculus sp. A few achenes about the size of those of *Ranunculus acris* or *R. repens* but too badly preserved for identification were obtained from the deposits M4*a* and MA*c*.

Pollen grains referable to the genus *Ranunculus* but not to a particular species were found in the deposit MA; grains particularly comparable with those of *R. lingua* were noted from M4 in the samples at 50, 95 and 120 cm. (zones III and IV); this agrees fairly well with the identifications of achenes of this species in M4C3.

Rorippa islandica (Oeder) Borbas (figure 21*e*, plate 12). Two seeds, one from AB4 and one from MA*a* (zone III), were identified as *Rorippa islandica* (Oeder) Borbas by their shape, size and surface reticulation.

R. islandica is found in most regions of Britain and throughout Europe (except for Spain, Portugal, Greece and Turkey) and in Asia, Egypt, North and South America and New Zealand.

Two seeds unnamed in the Reid collection of material from Waltham Cross Arctic Bed closely resemble seeds of this species.

Rumex acetosa L. (figure 21*l*, plate 12). Two perianths of *Rumex acetosa* L. were found, one from B4 and one from D4 (zone III). The nut had gone from both. The outer perianth segments are small and reflexed whilst the inner are entire, orbicular, with a reticulate venation and characteristic irregular cell pattern.

R. acetosa is found throughout the British Isles, ascending to 4050 ft. in Scotland; throughout Europe although rarer and normally montane in the south, in Iceland, Asia, Greenland, North America and Chile.

Jessen has recorded *R. acetosa* from zones II and VIII in Ireland, and it has been found from one site in the Lea Valley Arctic Bed.

Rumex cf. *aquaticus* L. Murbeck. Two nuts, surrounded by their perianth valves, were obtained from M4D (zone IV). The perianth valves are imperfectly preserved, but their triangular shape with truncate base can be made out. There is no trace of a tubercle on any of the valves. In the venation of each valve, the lower secondary veins make an obtuse angle, and the upper an acute angle with the primary vein. These characters are found in *Rumex aquaticus* L. Murb., but in view of the rather poor condition of the specimens, and the smaller size of the fossils compared with measurements of fresh material (Lousley 1939), the identification cannot be regarded as certain.

R. aquaticus is known only from Stirlingshire in Britain, and is found throughout Europe except in the south of Italy and the Balkan peninsula. It is less frequent in south-western Europe, and also occurs in northern Asia.

Jessen has recorded *R. aquaticus* from un undated bed at Ballybetagh.

Rumex cf. *crispus* L. (figure 21*m*, plate 12). Several nuts surrounded by perianth valves were found in M4C3 (zone III). In each case at least one valve of the three was tubercled. Characters of size and shape point to a tentative identification with *Rumex crispus* L.

R. crispus grows in cultivated ground, waste places and foreshores throughout Britain in lowland areas, ascending to 2000 ft. in Northumberland. It occurs in most parts of Europe excepting northernmost Sweden and Finland; in Asia, North Africa, New Zealand, Australia and America.

R. crispus has been recorded by Jessen from zone II at Ballybetagh, and it came also from three sites of the Lea Valley Arctic Bed.

Rumex sp. (figure 19*s*, plate 10). Nuts belonging to the genus *Rumex*, but with no perianth attached, were found in M4C1 and M4C3 (zone III).

Pollen grains of *Rumex* sp. were identified from MA, 70, 75, 80, 37 and 41 cm. and M4, 120, 95, 85 cm.

Sanguisorba officinalis L. Pollen was found from MA 334. It is a species of European (Arctic) distribution.

Salix phylicifolia L. (figures 13*a* to *m*). Willow leaves were very abundant near the bottom of the channel deposits, in M4*b*, MA*a*, MA*b* and B4. Although the leaves were mostly preserved whole they were very fragile and broke up on drying, and on most attempts to float them free from the surrounding matrix. A few were recovered whole, the rest mainly as leaf apices or bases. The majority of them can be referred to *Salix phylicifolia* L. Leaves were found up to 50 mm. in length. Characteristic features are the often asymmetric acuminate but not apiculate apex, the rather long petiole, varying from 1·5 to 7 mm. in length and often proximally twisted to one side, the rather rhomboidal shape of the lamina, the glabrous surface, the entire or slightly crenate margin, and the reticulate venation with numerous fine vein endings between the parallel laterals. The leaves of

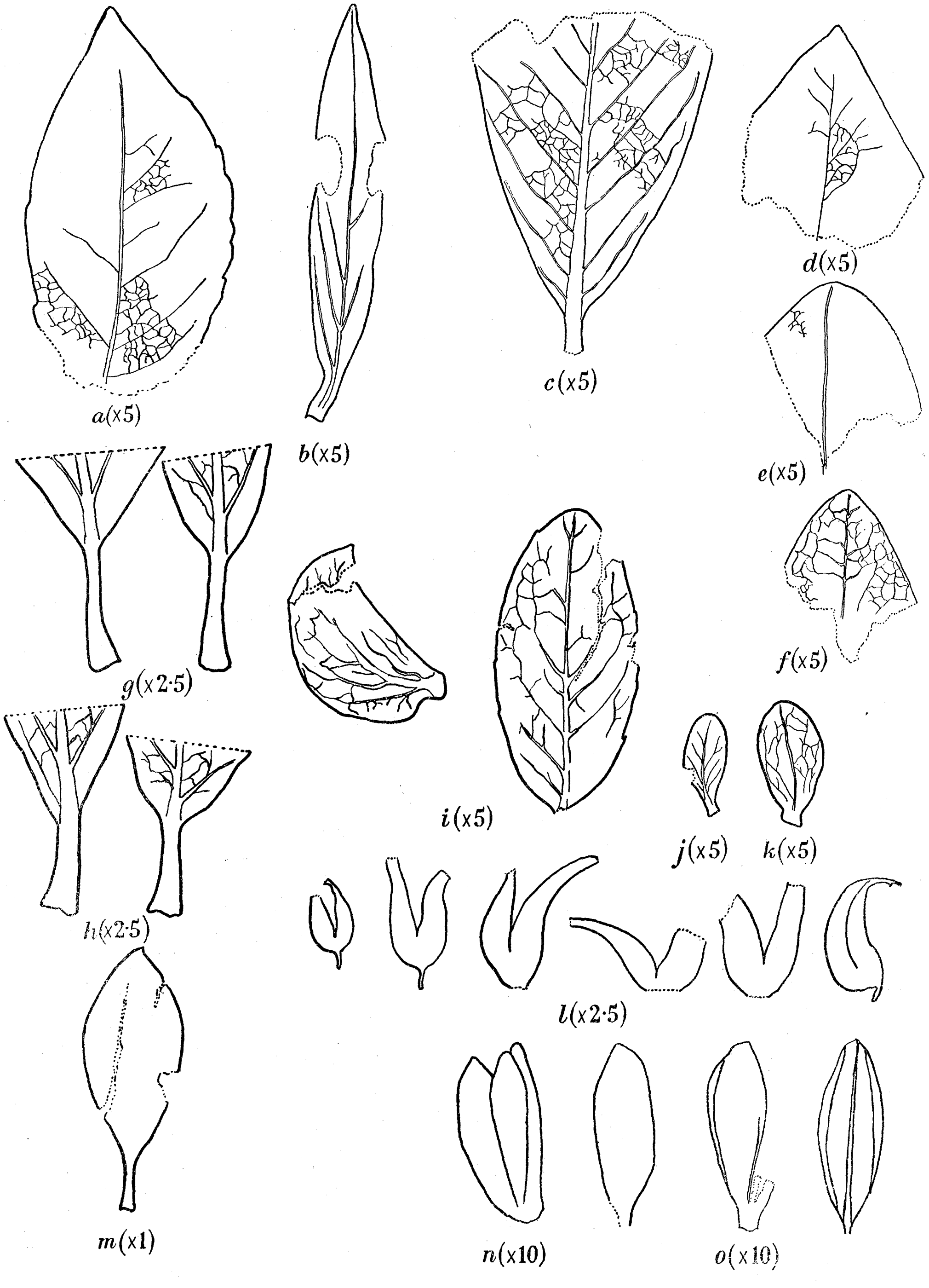

FIGURE 13. *Salix* leaves from the calcareous muds of the Nazeing Channel: most closely resemble *S. phylicifolia.* Four small rounded prophylls are not referable to a species. One narrow leaf (cf. *S. repens*) is shown at the bottom-right, a series of six *Salix* capsules and below small apical shoots closely resembling *Erica tetralix.*

S. atrocinerea Biot. bear some resemblance to the fossil leaves but are apiculate and always have at least some hairs.

Amongst the large number of leaves with these characteristics were one or two others. One has the lanceolate leaf shape of *S. repens* L., another the ovate shape of *S. myrsinites* L., with the greatest leaf width in the middle instead of towards the apex as is more normal in *S. phylicifolia*. However, these variations in leaf shape can all be matched within the species *S. phylicifolia* which is highly variable in this respect. In all instances the venation matched that of *S. phylicifolia*.

In addition a large number of very small leaves were obtained. These are presumed to be prophylls and are similar to those found on flowering shoots and immature axes of several species of *Salix*. Their presence with leaves of *S. phylicifolia* makes it likely that they also belong to this species, and their range of form can be matched with fresh material of this species.

Throughout the Nazeing deposits, buds, bud-scales and small twigs of *Salix* are frequent. Small pieces of wood of *Salix* were also commonly identified (see §2*b* (iii), (iv)).

Capsules of *Salix* were fairly numerous from deposits M4*b*, M4*c*, M4*d*, MA*a* and MA*b*. Most are fragmentary. They are hairy and when not broken at the base are seen to be stalked. Hairs appear to have clothed the capsules quite richly, though many have now been lost. Where they can be seen they are long, stiff and silver in colour. The capsules are flask-shaped; the narrowing of the neck begins about half-way along the total length with a change from convexity to concavity of outline. All specimens save one have lost their stigmas. The dimensions of three fossil capsules from M4B, M4C and LMA of length to stigma base, breadth at widest point and length of stalk are, respectively, 4·0, 1·7, 1·0 mm.; 4·2, 1·9, 0·6 (incomplete) mm.; and 5·5, 2·5 (missing) mm.

Some or all of these characters are to be found in all the fossil capsules which have such general similarity that it is assumed they all belong to one species. Of the British species of *Salix*, the capsules of *S. phylicifolia* agree most closely with the fossil specimens. *S. myrsinites* has a similar range of size and shape, but much softer hairs. The hairiness of the capsules favours *S. phylicifolia* as against *S. nigricans*.

It is reasonable to suppose that the numerous capsules and leaves found in close proximity belong to the same species.

To-day *S. phylicifolia* is native in Scandinavia, northern Britain, Faroes, Iceland, Denmark, Germany, France, central Europe, the Pyrenees, Russia and Asia from Siberia to northern China. In Britain it is found in Scotland; in England north from Lancashire and Yorkshire, and is very rare in Ireland. It ascends to 2300 ft. in Scotland.

Pollen belonging to the genus *Salix* was found throughout the deposits MA, Y, B4 and M4, and was generally most abundant before the onset of zone VI.

Jessen has recorded leaves of *S. phylicifolia* from zones II and V at Ballybetagh in Ireland, but it has not been found in the Lea Valley Arctic Bed. It is noteworthy that the *S. herbacea* which so strongly characterizes zones I and III in Ireland, is not recorded from these Nazeing deposits, although it occurs abundantly at three sites in the Lea Valley Arctic Bed.

Saxifraga cf. *hypnoides* agg. (figure 21*f*, plate 12). A single tiny seed from M4C1 (zone III) may be referred to the genus *Saxifraga* and probably, taking into account the arrangement of the blunt spines into roughly longitudinal rows, to the aggregate species *S. hypnoides*.

S. hypnoides is found in rocky and grassy alpine habitats in Britain, ascending from near sea-level near Belfast to 4400 ft. on Ben Nevis. Outside Britain it is found in Iceland and the Faroes, and in western Europe from Portugal and Spain to the Vosges, Belgium and Holland and southern Norway.

From the deposit MA (base of zone IV) three pollen grains were very tentatively referred to *S. oppositifolia* L.

Scirpus lacustris L. (figure 20*i*, plate 11). Fruits belonging to the *Scirpus lacustris* L. were abundant in the deposits M4*a*, M4*b*, M4C1, M4C3, M4*d*, AB4, B4, MA*a*, MA*b* and MA*c* (zones III and IV).

S. lacustris has an almost world-wide distribution and is found all over Britain and in all parts of Europe except arctic Norway.

Jessen has recorded it from zones VI, VII*a* and VIII in Ireland, and it has been found at those localities in the Lea Valley Arctic Bed.

Scirpus sp. (figure 20*j*, plate 11). Two fruits from M4*b* (zone III) outside the normal range of variation found in *Scirpus lacustris* are probably partially ripe fruits of *S. pauciflorus* Lightf. or *S. caespitosus* L. Both species are found in most parts of Britain. Outside Britain *S. pauciflorus* is found in Scandinavia, Iceland, Spain, France, Belgium, Holland, Switzerland, Germany, Italy and eastern Europe; in Asia and North America. *S. caespitosus* has a very similar European range and is also found in the Himalayas, North America, Greenland and Jamaica.

Jessen has reported *S. caespitosus* from zones VII*a*, VII*b* and VIII in Ireland; this is the evidence of the characteristic stem bases found in peat bogs.

Sium erectum Huds. (figure 19*a*, plate 10). Mericarps of *Sium erectum* Huds. were frequent in the deposits M4C3 and M4*d* (zones III and IV). The species is found to-day in most parts of Britain, decreasing in frequency northwards. It grows in all parts of Europe except mid- and northern Norway and Sweden, and northern Russia; in Asia, North America and Australia.

Sonchus arvensis L. (figure 19*h*, plate 10). Four fruits of *Sonchus arvensis* L. were identified from M4C3 (zone III). Each has prominent longitudinal ribs and transverse wrinkling. Pollen of the '*Sonchus*-type' is produced by several Compositae. It was found in M4 (zone III).

In Britain to-day *S. arvensis* is recorded from all over the country, growing in cultivated ground, fen dykes and river-sides. It is a lowland plant reaching 1250 ft. in Wales. It has a wide distribution outside Britain, and is found all over Europe except in Spain, Sicily, Corsica, Greece and Turkey; in Siberia, Japan, the Caucasus, Armenia and North Africa.

An undetermined species of *Sonchus* has been recorded from the Lea Valley Arctic Bed at Barrowell Green.

cf. *Sorbus* sp. (figure 21*j*, plate 12). Two seeds of a rather irregular thick ovoid shape were washed out from the deposit M4*b* (zone III). Their average measurements are: length 5·6 mm. × breadth 2·8 mm. One specimen has a thin, transparent, folder outer coat (presumed to be part of the fruit). They lack any obvious structural feature such as grooves or scars. Taking into account characters of size and shape they have been identified tentatively as seeds from the fruit of a species of *Sorbus*.

Jessen has identified a seed of *S. aucuparia* from zone VII*a* in Ireland.

Sparganium sp. Pollen grains probably belonging to a species of *Sparganium* were identified from the deposits M4 and MA, in each case practically restricted to the calcareous muds of zone III (see figures 10, 12).

Jessen has reported the fruit-stones of these species of *Sparganium* from zones II to VII*a* in Ireland, and two or three species have also been found in the Lea Valley Arctic Bed.

cf. *Stellaria alsine* Grimm. (=*S. uliginosa* Murr.) (figure 21*b*, plate 12). Two caryophyllaceous seeds and a fragment of a third were washed out from AB4 (zone III). Amongst British caryophyllaceous seeds they correspond most closely in size, shape and surface pattern with *Stellaria alsine* Grimm., although as the fossil specimens were rather larger than the fresh material seen, the identification cannot be regarded as certain.

S. alsine is recorded from all vice-counties in Britain. It ascends from sea-level to 3000ft. in Tipperary, and in Scotland. It is found in all parts of Europe except Turkey, Greece and Italy; and in the Caucasus, Siberia, India, Japan, Morocco and North America.

It has been recorded from one site in the Lea Valley Arctic Bed.

Succisa pratensis (figure 23*n*, *o*, plate 14). In Y (zone III) and M4 (zone IV) were found the characteristic pollen grains of *Succisa* and it may also have been present in MA (see figure 12).

Taraxacum officinale Weber (figure 19*g*, plate 10). Three fruits of *Taraxacum officinale* Weber were obtained from the deposits M4C1, MA*a* and MA*c* (zone III). Pollen grains of '*Taraxacum* type' were found in deposits MA, Y, B4 and M4, but this type is produced by a great range of composite genera and species. The species grows in fields, cultivated ground, heaths, corries and waste places in all parts of Britain, all parts of Europe, in Siberia, western and central Asia, North Africa and North America. In Britain it is found from sea-level to 3850 ft. on Ben Lawers.

This species has been found at four sites in the Lea Valley Arctic Bed.

Teucrium scordium L. (figure 19*p*, plate 10). A single nutlet identified on size, shape and characters of surface pitting as *Teucrium scordium* L., was washed out from the deposit MA*c* (zone III). This species is very rare in Britain to-day growing in a few wet localities scattered over England and Ireland. It is also found in Denmark, Germany, Belgium, Holland, France, Italy, Switzerland, eastern Europe; and in Siberia.

Thalictrum alpinum L. (figure 18*g*, plate 9). The deposits AB4, MA*b* and M4*b* (zone III) yielded four achenes of *Thalictrum alpinum* L.

This species has a northern distribution in Britain occurring in a few localities in northern Wales and northern England, in most parts of Scotland, and a few places in western Ireland (see Conolly, Godwin & Megaw 1949). Outside the British Isles it is found in Scandinavia, Iceland, the Pyrenees, the Alps, Austria and northern Italy.

Jessen has recorded *T. alpinum* from zones II and III in Ireland, and it has been found at three sites in the Lea Valley Arctic Bed.

Thalictrum flavum L. (figure 18*b*, plate 9). Three achenes of *Thalictrum flavum* L. were obtained from deposits AB4, B4 and MA*a* (zone III). These fruits are of a characteristic, cylindrical shape with about eight longitudinal ribs separated from one another by deep grooves, and with a stigma and attachment scar.

T. flavum is found in most parts of Britain except the north of Scotland. It occurs in all parts of Europe except Spain, Portugal, Sicily, Sardinia and Greece; and in Asia Minor, the Caucasus, Siberia and Algeria.

Pollen of *Thalictrum* was identified from deposits MA, Y, B4 and M4; in MA and M4 it is restricted to the calcareous muds of zone III. This pollen type has been commonly found with that of *Artemisia*, *Helianthemum*, etc., in Late-Glacial deposits. Achenes of *Thalictrum flavum* occurred in all sites of the Lea Valley Arctic Bed.

cf. *Thymus* (figure 22*d*, plate 13). Pollen of a member of the Labiatae, resembling that of the genus *Thymus* was found in the deposit MA (zone III).

Typha spp. (figures 21*c*, 23*g*, plates 12 and 14). Pollen grains of both *Typha angustifolia* L. and *T. latifolia* L. were identified from deposits MA and M4. In MA pollen of *T. angustifolia* occurs in the calcareous muds of zone III and shows enormous frequencies at the level when large monocotyledonous rhizome and leaf remains occur; presumably this was a local *Typha* swamp. Pollen of *T. latifolia* at this site occurs at higher levels, in the peaty muds of zone IV.

It is rather remarkable that in their channel site, M4, there should be no pollen of *T. angustifolia* whilst that of *T. latifolia* occurs in substantial amounts in the calcareous muds (zone IV). A few fruits of *Typha* were found in the deposits MA*c*, but the two species cannot be separated on fruit characters alone. The fruits were preserved without the thin outer coat, leaving a tiny fusiform specimen with a black pointed end and a conspicuous cell pattern.

T. angustifolia is found in most parts of Britain except the north of Scotland. It is also found in Spain, Portugal, France, southern Scandinavia, Germany, Switzerland, Italy, eastern Europe, Syria, Africa and North America. *T. latifolia* is found nearly all over Britain, although it thins out towards the north. It also occurs in Spain, Portugal, southern Scandinavia, Germany, Switzerland, Italy, eastern Europe; in Asia, Africa and North America.

Jessen records the pollen of *T. latifolia* from zones IV to VIII in Ireland.

Umbelliferae. Pollen, identifiable as belonging to the family Umbelliferae, but not to any particular genus, was obtained from the deposits MA, Y, B4 and M4.

Urtica dioica L. (figure 21*d*, plate 12). Small flat fruits with a truncate base and pointed apex, identified as *Urtica dioica* L., were found in the deposits M4*b*, M4C1, AB4 and MA*a* (zone III).

To-day *U. dioica* is found all over Britain, in all parts of Europe, and in Asia, Africa and North America (see Grieg-Smith 1948).

Mitchell (1940) has found the fruit of this species from one site in zone VIII in Ireland, and it is recorded from two sites in the Lea Valley Arctic Bed.

Valeriana dioica L. (figure 19*d*, plate 10). Fruits of *Valeriana dioica* L. were found in the deposits M4C1, M4C2, M4C3 and MA*b* (zone III). The fruit is flat and ovate in form, with a truncate tip. One side has a median longitudinal rib whilst the other has three equidistant longitudinal ribs.

V. dioica grows in most lowland regions of Britain, although it is rare in Scotland. It is found also in Europe, in southern Sweden, Denmark, France, Spain, Belgium, Holland, Germany, Switzerland, western and mid-Russia.

There is one record of this species from the Lea Valley Arctic Bed.

TABLE 8. NAZEING. FLO

species and illustration	type of remains	MA*a*	MA*b*	MA*c*	Mx	M4*a*
		III		IV	V	? before
†*Alisma plantago-aquatica* L. (figure 20*b*, plate 11)	*fr*	.	.	.	.	.
†*Arctostaphylos uva-ursi* (L.) Spreng. (figure 19*i*, plate 10)	*st*	.	.	.	.	.
Arenaria ciliata agg. (figure 21*a*, plate 12)	*s*	×	.	.	.	.
†*Armeria maritima* Willd. (figure 20*r*, plate 11)	*ct*	.	× ×	.	.	.
†*Barbarea vulgaris* agg. (figure 18*j*, plate 9)	*s*	× ×	× ×	.	.	× ×
†*Betula nana* L. (figure 19*u*, plate 10; figure 20*o*, *q*, plate 11; figure 21*q*, plate 12) (see also figure 9)	*cs+fr+l+sm*	× × × ×	× × × × ×	.	.	× × ×
Betula cf. *pendula* Roth. (figure 19*t*, plate 10)	*cs+fr*	.	.	.	×	.
Betula cf. *pubescens* Ehrh. (figure 19*t*, plate 10)	*cs+fr*	×	.	.	×	.
Betula cf. *pendula* × *pubescens* (figure 19*t*, plate 10)	*cs+fr*	.	.	.	×	.
†*Caltha palustris* L. (figure 18*i*, plate 9)	*fr*	× ×	× ×	.	.	.
Campanula rotundifolia L. or *C. patula* L. (figure 21*h*, plate 12)	*s*	× ×	.	.	.	.
Carduus sp. (figure 19*e*, plate 10)	*fr*	.	.	× ×	.	.
Carex aquatilis Wahlenb. or *C. bigelowii* Torr. (figure 20*l*, plate 11)	*n+u*	× × × ×	× × × ×	.	.	.
Carex cf. *laevigata* Sm. (figure 20*m*, plate 11)	*n+u*	.	.	.	.	.
Carex paniculata L. (figure 20*k*, plate 11)	*n+u*	× × × ×	× ×	.	.	× ×
†*Carex rostrata* Stokes (figure 20*n*, plate 11)	*n+u*	× × × × ×	× × × × ×	× ×	× × × ×	.
Cerastium vulgatum L. (figure 18*l*, plate 9; figure 21*g*, plate 12)	*s*	.	.	.	.	.
†*Cerastium* sp.	*s*	.	.	.	.	.
†*Chenopodium* cf. *album* L. (figure 19*q*, plate 10)	*s*	.	.	×	.	.
Cicuta virosa L. (figure 18*x*, plate 9)	*fr*	.	.	.	.	.
†*Cirsium heterophyllum* (L.) Hill or *C. palustre* (L.) Scop. (figure 19*f*, plate 10)	*fr*	.	.	× × ×	.	.
†*Comarum palustre* L. (figure 18*s*, plate 9)	*fr*	× × ×	× × ×	.	.	× × ×
Corylus avellana L.	*n*	.	.	.	×	.
Cornus sanguinea L. (figure 21*k*, plate 12)	*fr+st*	.	.	.	× × ×	.
Daucus carota L. (figure 19*b*, plate 10)	*fr*	.	.	.	×	.
†*Draba incana* L. (figure 21*a*, plate 12)	*r*	.	.	.	.	.
†*Dryas octopetala* L. (figure 18*o*, plate 9; figure 20*p*, plate 11)	*l+cf.fr*	×	×	.	.	.
Eleocharis palustris (L.) Roem & Schult. (figure 20*h*, plate 11)	*fr*	.	.	.	.	.
Empetrum nigrum agg. (figure 20*a*, plate 11)	*st*	.	.	.	.	.
Erica tetralix L.	*l*	× ×	.	.	.	.
†*Filipendula ulmaria* (L.) Maxim (figure 18*n*, plate 9)	*fr*	.	.	×	.	.
†*Galeopsis tetrahit* agg. (figure 19*o*, plate 10)	*fr*	.	.	.	.	.
Galium cf. *aparine* L. (figure 19*c*, plate 10)	*fr*	.	.	.	.	.
Geranium sanguineum L. (figure 18*m*, plate 9; figure 21*n*, plate 12)	*s+cp*	.	×	.	.	×
Geum rivale L. or *G. urbanum* L. (figure 18*p*, plate 9)	*fr*	×	×	×	.	.
†*Hippuris vulgaris* L. (figure 18*v*, plate 9)	*fr*	×	× ×	×	.	.
Linaria vulgaris Mill. (figure 19*k*, plate 10)	*s*	.	.	.	.	.
Lycopus europaeus L. (figure 19*m*, plate 10)	*fr*	.	× ×	×	.	.
†*Mentha* sp. (figure 19*l*, plate 10)	*fr*	.	.	.	.	.
†*Menyathnes trifoliata* L. (figure 19*j*, plate 10)	*s*	× ×	× ×	.	.	.
†*Myriophyllum spicatum* L. or *M. verticillatum* L. (figure 18*w*, plate 9; figure 21*p*, plate 12)	*fr+sh*	.	.	.	.	.
Naias flexilis (Willd.) Rostk. & Schmidt (figure 20*g*, plate 11)	*fr*	.	.	.	.	.
Petroselinum segetum (L.) Koch. (figure 18*y*, plate 9)	*fr*	.	×	.	.	.
†*Polygonum aviculare* agg. (figure 19*r*, plate 10)	*n+p*	×	×	×	.	.
cf. *Populus*	*b+cs*	.	.	.	×	.
†*Potamogeton* cf. *filiformis* Pers. (figure 20*f*, plate 11)	*fr*	× ×	× ×	.	.	.
†*Potamogeton* cf. *natans* L. (figure 20*c*, *d*, plate 11)	*fr*	.	× ×	× × × ×	.	.
†*Potamogeton* cf. *pusillus* L. (figure 20*e*, plate 11)	*fr*	.	.	.	.	.
Potentilla fruticosa L. (figure 18*r*, plate 9)	*fr*	.	.	.	.	.
Potentilla sterilis (L.) Garcke (figure 18*q*, plate 9)	*fr*	.	.	.	.	.
Potentilla spp. (figure 18*t*, *u*, plate 9)	*fr*	× × ×	× ×	.	.	.
Prunella vulgaris L. (figure 19*n*, plate 10)	*fr*	.	.	.	.	.
†*Ranunculus* cf. *acris* L. (figure 18*g*, plate 9)	*fr*	.	.	.	.	.
†*Ranunculus-Batrachian* sp. (figure 18*c*, plate 9)	*fr*	× × × ×	× × ×	.	.	.
†*Ranunculus flammula* L. (figure 18*e*, plate 9)	*fr*	.	× ×	.	.	.
Ranunculus lingua L. (figure 18*f*, plate 9)	*fr*	.	.	×	.	×
†*Ranunculus* cf. *repens* L. (figure 18*h*, plate 9)	*fr*	.	.	.	×	.
†*Ranunculus sceleratus* L. (figure 18*d*, plate 9)	*fr*	.	.	×	.	.
†*Rorippa islandica* (Oeder) Borbas (figure 21*e*, plate 12)	*s*	×	.	.	.	.
†*Rumex acetosa* L. (figure 21*l*, plate 12)	*p*	.	.	.	.	.
Rumex cf. *aquaticus* L.	*n+p*	.	.	.	.	.
Rumex cf. *crispus* L. (figure 21*m*, plate 12)	*n+p*	.	.	.	.	.
†*Rumex* sp. (figure 19*s*, plate 10)	*n*	.	.	.	.	.
Salix phylicifolia L. (figure 13)	*b+c+a+l*	× × × × ×	× × × × ×	.	.	.
Saxifraga cf. *hypnoides* agg. (figure 21*f*, plate 12)	*s*	.	.	.	.	.
†*Scirpus lacustris* L. (figure 20*i*, plate 11)	*fr*	×	× ×	× × × ×	×	.
Scirpus sp. (figure 20*j*, plate 11)	*fr*	.	.	.	.	.
Sium erectum Huds. (figure 19*a*, plate 10)	*fr*	.	.	.	.	.
†*Sonchus arvensis* L. (figure 19*h*, plate 10)	*fr*	.	.	.	.	.
cf. *Sorbus* sp. (figure 21*j*, plate 12)	*s*	.	.	.	.	.
†cf. *Stellaria alsine* Grimm. (figure 21*b*, plate 12)	*s*	.	.	.	.	.
†*Taraxacum officinale* Weber (figure 19*g*, plate 10)	*fr*	×	.	×	.	.
Teucrium scordium L. (figure 19*p*, plate 10)	*fr*	.	.	×	.	.
†*Thalictrum alpinum* L. (figure 18*a*, plate 9)	*fr*	.	× ×	.	.	.
†*Thalictrum flavum* L. (figure 18*b*, plate 9)	*fr*	× ×	.	.	.	.
Typha angustifolia L. or *T. latifolia* L. (figure 21*c*, plate 12)						

FLORAL LIST

Deposit

Zones

M4*a*	M4*b*	M4C1	M4C2	M4C3	M4*d*	AB4	B4	C4	D4
? before III	III				IV	? before III			
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† *Taraxacum officinale* Weber (figure 19*g*, plate 10)	*fr*	×	.	×	.	.
Teucrium scordium L. (figure 19*p*, plate 10)	*fr*	.	.	×	.	.
† *Thalictrum alpinum* L. (figure 18*a*, plate 9)	*fr*	.	× ×	.	.	.
† *Thalictrum flavum* L. (figure 18*b*, plate 9)	*fr*	× ×	.	.	.	.
Typha angustifolia L. or *T. latifolia* L. (figure 21*c*, plate 12)	*s*	.	.	× × ×	.	.
† *Urtica dioica* L. (figure 21*d*, plate 12)	*fr*	× ×	.	.	.	.
† *Valeriana dioica* L. (figure 19*d*, plate 10)	*fr*	.	× ×	.	.	.
† *Viola* sp. (figure 18*k*, plate 9)	*s*	.	.	.	×	.
Selaginella selaginoides (L.) Link. (figure 21*i*, plate 12)	*m*	×	×	.	.	.
† Characeae	*o*	× × ×	× × × ×	× × × × ×	×	.
Cristatella sp.	*bl*	.	.	.	.	.
Daphnia sp.	*eph*	×	.	.	.	.

Abbreviations: *a*, cone axis; *b*, bud or bud scar; *bl*, statoblast of polyzoan; *c*, capsule; *cp*, carpel; *cs*, cone scale; *ct*, calyx tube; *eph*,
cruciferous pod; *s*, seed; *sh*, shoot apex; *sm*, scale from male cone of *Betula*; *st*, stone of fleshy fruit; *u*, utricle of *Carex*. Frequency of o
to species = recorded from Lea Valley arctic beds.

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ıbe; *eph*, ephippium of crustacean; *fr*, fruit; *l*, leaf; *m*, megaspore; *n*, nutlet; *o*, oospore; *p*, perianth; *r*, replum of
ıency of occurrence: × × × × × abundant; × × × × frequent; × × × occasional; × × rare; × very rare; † as prefix

(*To face p.* 228)

Valeriana officinalis L. (figures 23*i*, *j*, *k*, *l*, plate 14). Pollen grains of a species of *Valeriana* were identified from deposits MA, Y, B4 and M4 (zones III and IV, see figures 10, 12). They did not, however, correspond with type specimens of *V. dioica* L. but approached closely those of *V. officinalis* L. *V. officinalis* occurs throughout Britain and ascends to 2650 ft. in Kerry.

V. officinalis is unrecorded from Ireland or the Arctic Plant Bed.

Viola sp. (figure 18*k*, plate 9). Seeds of a species of *Viola* were frequent in the deposits M4*b*, M4C1, M4C3, AB4 and B4 (zone III). It is not possible to distinguish the various species within this genus on seed characters alone with any degree of certainty.

Jessen records *V. palustris* from zones II, III, VI to VIII in Ireland, and *Viola* seeds, some referred to *V. tricolor* and to *V. canina*, have been recorded from most of the Lea Valley Arctic Bed sites.

Bryophyta

Moss leaves and small shoots were washed out from some of the deposits, generally in a good state of preservation. Those marked with an asterisk in the list below were kindly identified by Dr R. Tuomikoski (Helsinki), and the remainder by Dr P. W. Richards, who has also supplied us with comments on present distribution of these species.

TABLE 9

	Deposits					
	MA*a*	MA*c*	M4*b*	M4C1	AB4	B4
Camptothecium lutescens (Hedw.) B. & S.	.	.	.	×	.	.
Campylium stellatum (Hedw.) J. Lange & C. Jens	×	.	.	.	.	.
**Calliergon giganteum* (Schimp.) Kindb.	× ×	.	.	.	.	.
**Cinclidium stygium* Swartz.	.	.	.	.	×	×
**Drepanocladus aduncus* (Hedw.) Monkm.	×	.	.	.	.	.
**Drepanocladus capillifolius* (Warnst.) Warnst.	× ×	×	× ×	×	.	.
**Meesia uliginosa* Hedw.	×	.	.	.	.	.

These were all identified from leafy shoots, and all the occurrences are from layers we refer to zone III.

Four of the moss species here identified have a general distribution throughout the British Isles although they may also extend far north into the Arctic Circle. Of the rest, *Cinclidium stygium* and *Meesia uliginosa* have a strongly northern distribution in Britain. The former is scattered through Europe (chiefly in northern latitudes), North America, and Kamtschatka: the latter is also scattered through Europe, North America, the Himalayas, etc. Both are species with a wide and broken range, so that they appear to be relict from a previous cold period of more continuous distribution, along with such species as *Meesia triquetra* (Hook and Tayl.) Aongstr. (see Godwin & Richards 1946).

Drepanocladus capillifolius Warnst. is regarded as a forma of *D. aduncus* by Moenkmeyer & Jensen, but not by Gams. Although not recorded from Britain as a living plant it has been recorded from Glacial or Post-Glacial deposits along with other arctic species of mosses and flowering plants, and it was found at every level in the Ponder's End deposits of the Arctic Plant Bed as well as at Angel Row.

Other groups

Selaginella selaginoides (L.) Link. (figure 21*i*, plate 12). Four megaspores of *Selaginella selaginoides* (L.) Link. were found in the deposits B4, MA*a* and MA*b* (zone III). Two microspores were found on the slides prepared for pollen analysis from the two lowest samples of M4. This species is of interest as indicative of an open type of vegetation. It is found to-day in northern England, Wales, Scotland and Ireland, ascending to 3300 ft. in the Highlands.

Jessen records this species from zones II, III and VI in Ireland.

Pediastrum. In slides prepared for pollen analysis of deposits MA and M4 were found skeletons of *Pediastrum.*

Fresh-water fauna. The deposit AB4 yielded several statoblasts of a species of the fresh-water polyzoan *Cristatella.*

Ephippia of a species of *Daphnia* were found in washings from the deposit MA*a* (zone III).

(iii) *Range and status of the Nazeing flora*

A consideration of the origins of the samples from which these macroscopic remains and pollen grains were derived will show that apart from Mx they can be referred to zone III or some stage only slightly younger, and may be considered on this basis as one Late-Glacial or early Post-Glacial aggregate.

Species found nowhere but Mx are *Cornus sanguinea*, *Daucus carota*, *Corylus avellana*, together with the genus *Populus.*

Geographical range

For the purpose of analyzing the implications of the Nazeing assemblage it is convenient to assess their geographical ranges by some common standard, and we have employed for this purpose the groupings devised by Matthews (1937).

In Matthews' paper flowering plants with a wide general distribution in Europe, comprising *ca.* 55 % of the present British flora, are not considered. These comprise the general European element, the Eurasian element and the northern hemisphere species. The endemics are also omitted.

The remaining 45 % of the flora, species showing 'some noteworthy feature in their geographical connexions', are divided by Matthews into eleven groups or elements.

None of the plants found at Nazeing falls into Matthews' Mediterranean, oceanic southern, continental southern, or continental elements. The other seven elements contain representatives as follows:

Oceanic west European: species found almost exclusively in western Europe, apparently favoured by an 'atlantic' climate; *Erica tetralix* (cf.), *Petroselinum segetum.*

Oceanic northern: species characteristic of north-western Europe; *Naias flexilis.*

Continental northern: species whose main area of distribution in Europe is central and north, decreasing or becoming montane southwards; *Cicuta virosa*, *Cirsium heterophyllum* (cf.), *Comarum palustre*, *Menyanthes trifoliata*, *Potamogeton filiformis* (cf.), *Scirpus pauciflora* or *caespitosus*, *Teucrium scordium.*

Northern montane: species of northern Europe, generally absent from the low-lying plains but reappearing in montane or subalpine situations in central or southern Europe; *Polemonium caeruleum*, *Potentilla fruticosa*, *Salix phylicifolia.*

Arctic-subarctic: species which in Europe are exclusively northern, being absent from central Europe, the majority extending into arctic or subarctic regions of the northern hemisphere; *Arenaria ciliata* (*A. norvegica*), *Carex aquatilis* (cf.).

Arctic-alpine: species frequently circumpolar whose chief area of distribution lies in the arctic, that is north of the tree boundary, or in subarctic regions, reappearing farther south at relatively high altitudes in the mountains of Europe, Asia, and/or America; *Arctostaphylos uva-ursi*, *Betula nana*, *Carex bigelowii* (cf.), *Draba incana*, *Dryas octopetala*, *Thalictrum alpinum*.

Alpine: species of mountain areas in central Europe, absent from northern Europe and the Arctic; *Saxifraga hypnoides* (cf.).

	% proportion in British Flora	% proportion at Nazeing
Mediterranean	2·5	0
Oceanic southern	5	0
Oceanic west European	5	3
Oceanic northern	1	1
Continental southern	8·5	0
Continental	5·5	0
Continental northern	6	7
Northern montane	2	3
Arctic-subarctic	2	2
Arctic-alpine	5	6
Alpine	0·6	1 (?)

It will be seen that whilst the geographical elements of northern or alpine character are presented at Nazeing in proportions corresponding to those which they hold in the present British flora as a whole, the elements of southern and 'continental' character are totally unrepresented.

Of the species within the northern and alpine elements many are now highly restricted in occurrence in the British Isles, and are generally not now found in the south and east of Britain.

It is evident also that the bulk of the Nazeing flora must be referable to the species of wide general distribution in Matthews' classification.

Status

Considered from standpoints other than that of geographical range, the Nazeing flora will be recognized as including certain groups of characteristic status.

Forest trees, excepting *Betula pendula*, *B. pubescens* and cf. *Sorbus*, are absent, but nanophanerophytes and chamaephytes are naturally represented in the northern and alpine geographic elements by species such as *Betula nana*, *Potentilla fruticosa*, *Empetrum nigrum*, *Arctostaphylos uva-ursi* and *Salix phylicifolia* (though the latter is often a microphanerophyte).

A substantial proportion of the flora is composed of aquatic and marsh plants, as would be expected from the conditions of incorporation and preservation: these include several of the species with northern and alpine ranges.

Between 30 and 40 % of the Nazeing flora consists of species recognizably intolerant of woodland shade conditions or the competition of closed communities. Some of these are in the northern and alpine geographical range, such as the annuals *Arenaria ciliata*, *Thalictrum alpinum*, *Draba incana*, as well as the dwarf shrubs of the *Betula nana* type.

There remains, however, a large number of species which to-day are generally given (though not necessarily exclusively) the status of ruderals or weeds. We may note the following:

Artemisia sp.
Atriplex sp.
Carduus sp.
Centaurea sp.
Cerastium vulgatum
Chenopodium cf. *album*
Galeopsis tetrahit
Galium aparine
Linaria vulgaris
Plantago lanceolata
Plantago major or *media*
Polygonum aviculare
Ranunculus acris
Ranunculus repens
Rumex acetosa
Rumex crispus
Sonchus arvensis
Taraxacum officinale
Urtica dioica

Some of these species, such as *Linaria vulgaris*, *Galeopsis tetrahit*, *Sonchus arvensis* and *Taraxacum officinale* are so closely associated with the weed and ruderal habit that they are generally supposed to have been introduced by prehistoric man with his early crops. There is here clear evidence of their early and natural status in the country. It seems apparent that, were climatic conditions suitable, the great spreads of fresh gravel, sand and silt in the Lea Valley at this pre-forestal stage would have afforded extremely suitable circumstances for the widespread distribution and establishment of such species. The openness of the vegetation in Late-Glacial times is of course not only recognized very widely in studies of Irish and western European vegetational history, but is attested strongly at Nazeing by the usual Late-Glacial macrofossils and assemblages of non-arboreal pollen. We may note:

Macrofossils	Pollen
Armeria maritima	*Artemisia* sp.
Betula nana	*Centaurea* sp.
Carex aquatilis or *bigelowii*	*Helianthemum* sp.
Dryas octopetala	*Polemonium* sp.
Empetrum nigrum	*Thalictrum* sp.
Thalictrum alpinum	Gramineae
Selaginella selaginoides	Filicales (spores).

Other species less generally familiar but occurring in the Nazeing deposits and also indicative of unforested conditions include:

Arctostaphylos uva-ursi
Arenaria ciliata
Calluna vulgaris
Campanula rotundifolia or *C. patula*
Cerastium vulgatum
Draba incana
cf. *Erica tetralix*
Geranium sanguineum
Linum sp.
Potentilla fruticosa
Succisa pratensis

Comparison with the Broxbourne Arctic Bed

Some thirty species are recorded from the Broxbourne Arctic Bed (Reid 1949). These represent material collected and identified by Clement Reid and Mrs Reid. Through the kindness of Mrs Reid we were able to examine these specimens.

A small amount of material collected near the railway station at Broxbourne in 1948 was also digested, sieved and the macroscopic remains identified. The small number of species in this sample were similar to those found previously.

species recorded by Reid from Arctic Bed, Broxbourne

Thalictrum flavum
Ranunculus heterophyllus
Ranunculus Batrachian spp.
Ranunculus acris
Ranunculus repens
Ranunculus spp.
Viola tricolor
Viola canina
Silene maritima
Stellaria palustris
Linum praecursor
Filipendula ulmaria
Hippuris vulgaris
Myriophyllum spicatum
Menyanthes trifoliata
Polygonum aviculare
Rumex maritimus
Betula sp.
Potamogeton densus
Potamogeton filiformis
Potamogeton sp.
Scirpus lacustris
Carex maritima
Carex punctata
Carex rostrata
Carex spp.
Festuca halleri

Add *Dryas octopetala* (see 'Remarks on Floral List', p. 214).

species from 'Presumed Arctic Bed', 1948

Carex cf. *rostrata*
Hippuris vulgaris
Linum praecursor
Polygonum aviculare
Potamogeton cf. *filiformis*
Stellaria alsine

It is of interest to note the general similarity between this assemblage of species and that found in the Nazeing deposits. Comment has already been made on *Linum praecursor* of the Arctic Bed (Remarks on Floral List, p. 217) and its absence at Nazeing. The other species found in the Broxbourne arctic bed but not at Nazeing are *Viola tricolor*, *V. canina*, *Silene maritima*, *Stellaria palustris*, *Rumex maritima*, *Potamogeton densus*, *Carex maritima*, *C. punctata* and *Festuca halleri*. It may be noted that both these species of *Carex* were present as nutlets only.

3. CONCLUSIONS ON CORRELATION AND BIOTIC HISTORY

The sequence of events recognized in the Lea Valley at Nazeing has been summarized in Table 10.

The coarse gravels of the present flood-plain appear to have been arranged during some part of the last glaciation; within them are the masses of the Arctic Plant Bed, embedded when frozen and containing a characteristic fauna and flora described previously. Hitherto we have had no evidence of conditions between those of the Arctic Plant Bed and those of the peats which overlie the gravel surface throughout the Valley and which have been shown at Broxbourne to be of Boreal Age (Warren *et al.* 1934). The significance of the deposits now described is that they bridge this gap. The earliest of the series are black organic peaty muds (B and C) formed at the opening of a lacustrine stage on the surface of the gravel and in the Nazeing river channel during its earliest stage; they are of Late-Glacial age with Mollusca of the same type as those of the Arctic Plant Bed, a pollen content indicative of grass-sedge tundra or park-tundra, and remains of small mammals equally characteristic of the late Pleistocene. After the deposition of local sandy beds, lacustrine conditions became general over a large area and lake Marl D (calcareous nekron mud) was deposited in some thickness; locally it contains clay derived from the London Clay. Its Mollusca still have the general character of the Ponder's End assemblage.

This lacustrine stage was succeeded by a vigorous second erosion stage which removed most of the lake Marl D from the channel. For a short while thereafter part of the channel bed became dry, was colonized by dwarf willows and then in slack water a banded calcareous mud began to fill in the deeper pools; into these muds was incorporated an extremely rich collection of plant microfossils. Remains of dwarf birch are abundant and the categories of arctic-alpine, marsh and ruderal species are well represented; the assemblage has a general resemblance to the flora of the Arctic Plant Bed. The pollen spectrum indicates general unwooded conditions and includes many genera of herbaceous plants typical of the Late-Glacial period in western Europe. The Mollusca are well-grown specimens of the Ponder's End type, and in the uppermost part occur the abundant remains of frog and toad together with lizard. Along with these the calcareous muds contained remains of the small Pleistocene mammals, very probably in primary position. These channel marls have been attributed to zone III, the last phase of the Late-Glacial period in western Europe, where not uncommonly this zone is represented by the Upper Dryas Clay. This formation of organic muds was now apparently restricted to the channel, and the former mere became a dried-out marsh surface, remaining thus until the whole valley became a fen in the Middle Boreal period.

The calcareous channel muds gave place to more humic detritus muds, whilst the general vegetation became a closed birch woodland from which the rich herbaceous flora of the earlier time was excluded; nevertheless, mollusca of the Ponder's End type persisted. These are the deposits of zone IV, the Pre-Boreal period, in the latter part of which falls the newly described Mesolithic culture of Star Carr, Yorkshire.

As the channel grew shallower the accumulating muds were replaced by sedge- or reed-peats in the ameliorating climate of the early Boreal (zone V), during which hazel became abundant in the birch-pine forest. Finally the channels became almost dry at the 'Surface Mx' which certainly fell within the Boreal period. This surface has also yielded mammalian remains including those of the pika. After a minor third phase of channel erosion the whole width of the Lea Valley became waterlogged, and fen peats began to form alike over the channel and the ancient dried surface of the mere. This alteration is in zone VI, during which mixed-oak-forest with hazel dominated the countryside. At this time the eustatic rise in sea-level which restored the North Sea was reaching its conclusion, so that we may confidently set the buried channel stage of the Thames at some time not later than this. The Mollusca of the Lea Valley had now assumed a characteristically Holocene facies.

Fen peat formation across the whole Lea Valley continued from this time and well into the Atlantic period, and alder fen-woods grew locally upon it. At some undetermined date the exposure of the upland forest soils to erosion led to the sealing in of all the organic muds and peats by a fresh-water clay laid down by flood water.

So much of the history of the deposits seems clear, and the correlations not open to serious question. The beds described clearly carry back our knowledge of fauna, flora and climate from the climatic optimum to Late-Glacial times in both the restricted modern sense of the latter term and also its older wider sense. It would therefore be extremely desirable to seek correlation between the Late-Glacial deposits here and those recognized elsewhere in Britain and the north-western continental countries. More especially it would be desirable to recognize the Late-Glacial climatic Allerød oscillation which has recently become so striking a guide to Late-Glacial correlation (see Godwin 1947; Jessen 1949; Mitchell 1951).

Table 10. Nazeing correlation schema

deposits and processes	zones and periods			fauna		flora and vegetation	external correlations
(present surface) Marsh clay							
Fen wood peat	VII*a*	Atlantic				alder-mixed-oak forest	North Sea refilled
[mere] [channel] third channel erosion and surface Mx	VI V	Boreal	Post-Glacial	*Sorex*, *Evotomys*, *Arvicola*, *Microtus anglicus* *Ochotona spelaea*	characteristic Holocene Mollusca	mixed-oak, hazel (*Cornus sanguinea*) birch-pine-hazel	Broxbourne Mesolithic ←buried channel stage of Thames
Dry marsh surface Fen peat M Organic muds	IV	Pre-Boreal		*Arvicola*	some surviving Mollusca of Ponder's End type	closed birch woodland	Star Carr Mesolithic
M Calcareous muds	III		Late-Glacial	*Rana*, *Bufo*, *Lacerta vivipara* Percomorph fish *Dicrostonyx henseli* *Microtus ratticeps* *M. anglicus*	Ponder's End type Mollusca	park-tundra (dwarf birch and willow)*	Upper Dryas Clays
second erosion of channel D Lake marl					ditto (stunted)	tundra	Ahrensburg culture of north-west Germany
C Peaty muds AB4, B4				*Microtus ratticeps* *Lemmus lemmus*			
first erosion of channel Coarse gravel A Arctic plant bed Coarse gravel				*Elephas primigenius* *Rangifer tarandus* *Dicrostonyx henseli* *Rhinoceros tichorhinus* *Equus*, etc.	abt. Mollusca with *Columella columella* *Succinea oblonga*, etc.	dwarf willows, arctic plants, ruderals, etc.	(C14 dating > 20,000 years) Barnwell Station beds

* Horizon of main fruit and seed collection.

The evidence unfortunately seems not to allow this, and we are especially handicapped by the difficulty of knowing how the climatic conditions of the Late-Glacial might be expected to express themselves in a wide gravel-filled valley so far from the decaying ice-front as was the Lea Valley. It is certain, however, that the Arctic Plant Bed is of greater age than the mild Allerød period (zone II). The flora includes no trees. The mammalian fauna includes species such as the mammoth not known to have persisted so late as the Allerød, and a radio-carbon dating of a sample of plant material collected from the Arctic-bed at Nazeing by Mr Warren was placed at more than 20,000 years by Dr W. F. Libby. This appears to be substantially older than any dated Allerød deposit. A deposit of closely similar character is the Barnwell Station Plant Bed, Cambs. It seems probable that both deposits belong to some pre-Allerød period, associated nevertheless with some stage of the 'New Drift'.

It will be recognized that there are in all three stages of the Late-Glacial represented here by the formation of shallow-water lake or channel deposits; the Arctic Plant Bed, the lacustrine deposits, and the lowest channel deposits. The first two were succeeded by massive movements of coarse gravel and by erosion. There thus appears some element of a cyclic repetition in the physiographic history: this suggests a corresponding causal climatic alteration, and we can point to the known existence of the Allerød mild period isolated by cold periods from the succeeding Post-Glacial amelioration, and also from the preceding oscillation, the Brøndmyr or Bølling stage. Nevertheless, if the lower channel muds are referred to zone III, this represents the cold post-Allerød climate, and we may wonder what evidence there is of the closed birch (or birch-pine) woodland one would expect to have occurred here in the Allerød period itself. No trace of tree-birch or pine occurs at any suitable level of the Nazeing deposits, although it is conceivable that the warm conditions produced severe floods which prevented mud- or peat-formation and caused the gravel movements. In the face of these uncertainties it has seemed best to us not to attempt any more detailed correlation than that exhibited in the table. Whilst it is possible that further evidence may be forthcoming, this seems unlikely at Nazeing itself, where gravel working has ceased and the pits are now deeply flooded.

Whatever may be the truth of the detailed correlation of the Nazeing deposits with established west European sequences, it is beyond question that they belong to the closing stages of the last glaciation, and that the latest of them certainly embrace the transition from the Late-Glacial to the Post-Glacial period. They have provided very comprehensive evidence of the fauna and flora of this transitional period, and the evidence from the different groups of organisms concerned is remarkably concordant.

It will be found that a substantial proportion of the Nazeing Mollusca described as of 'Ponder's End type' have been already recorded from Late-Glacial deposits (*sensu stricto*) in Ireland (Mitchell 1951), Denmark (Jessen 1928; Iversen 1946) and Germany (Rust 1943).

When we consider the mammalian remains it will be found more difficult to match the Nazeing collection in European Late-Glacial sites. Thus in the very comprehensive investigations of Late-Glacial deposits at Meiendorf and Stellmoor in Holstein (Rust *et al.* 1937, 1943), only one of the Nazeing mammals (*Lemmus lemmus*) was identified, although it will be noted that this was accompanied by other species of similar character such as

Citellus rufescens, *Lynx lynx*, *Gulo gulo*, *Desmana moschata* together with *Cervus tarandus*, *Equus*, and *Bos bonasus*. *Rana* was found and unidentified Microtinea were also present. We have not found at Nazeing any remains of the large mammals such as horse, bison, reindeer, giant Irish deer which have elsewhere proved so characteristic of the west European Late-Glacial, but it will be noted that in the older Arctic Plant Bed in the same valley horse, reindeer and mammoth were identified along with Hensel's lemming. Whether we consider plants, Mollusca or Mammalia the conclusion is broadly similar; that much of the biota present in the Arctic Plant Bed and characteristic of Late-Glacial tundra persisted in the Lea Valley through the Late-Glacial in the narrow sense and into the early Post-Glacial. We may note *Betula nana*, *Pisidium obtusale* var. *lapponum* and *Ochotona spelaea* as such survivors. This survival into the Pre-Boreal period with its closed birch woodland we may possibly attribute to the special local conditions of the valley, where erosion, unstable soil and periodic flooding no doubt maintained, at least locally, forest-free stretches of country.

The results as a whole seem to suggest that the conditions during formation of the Nazeing beds (i.e. the Late-Glacial period in the narrow sense) must, in the London area, have had much in common with those of formation of the preceding Arctic Plant Bed (i.e. the Late-Glacial period in the original wider sense). In this region at least it seems probable that for a considerable period during the end of the last glaciation, there existed in south-east England a rather rich tundra biota, much of which persisted until the spread of deciduous woodland in the Post-Glacial time. No doubt the ameliorating conditions in the final part of the Late-Glacial period favoured the rapid multiplication and spread of some of the species of this biota, but it must also naturally have been the time of introduction and expansion of many others. Later came the warm period in which dense deciduous forest cover and peat formation reduced to very small remnants the areas where such fauna and flora might survive.

Our best thanks are due to the management of the St Alban's Sand Co. at Nazeing for giving us every facility and encouragement in carrying out the work, to the many authorities mentioned in the text who have so willingly collaborated in the scientific investigation, and also to numerous friends who gave us willing and skilled assistance in the field.

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Description of Plates 7 to 14

Plate 7

Figure 14. Nazeing channel seen at its deepest point, M4, S. H. Warren holding a 3 m. staff. Note light calcareous muds in bottom of channel and cracked layer of flood-plain clay sealing the surface of the peat. For chief beds see figure 6.

Figure 15. Leaves of willow (cf. *Salix phylicifolia*) from the grey calcareous clay-mud (M4, B) at the base of the channel at M4.

Plate 8

Figure 16. Lowermost channel deposits at M4 with metric scale (see § 2*b*).

Figure 17. Key to figure 16.

Plate 9

Figure 18. *a*, *Thalictrum alpinum* (2 fr.); *b*, *T. flavum* (2 fr.); *c*, *Ranunculus Batrachian* sp. (3 fr.); *d*, *R. sceleratus* (1 fr.); *e*, *R. flammula* (1 fr.); *f*, *R. lingua* (2 fr.); *g*, *Ranunculus* cf. *acris* (2 fr.); *h*, *Ranunculus* cf. *repens* (2 fr.); *i*, *Caltha palustris* (3 fr.); *j*, *Barbarea vulgaris* (3 fr.); *k*, *Viola* sp. (2 s.); *l*, *Cerastium vulgatum* (1 s.); *m*, *Geranium sanguineum* (1 s.); *n*, *Filipendula ulmaria* (2 fr.); *o*, cf. *Dryas octopetala* (1 fr.); *p*, *Geum* sp. (2 fr.); *q*, *Potentilla sterilis* (4 fr.); *r*, *P. fruticosa* (1 fr., 3 views); *s*, *Comarum palustre* (2 fr.); *t*, *u*, *Potentilla* spp. (3 fr.); *v*, *Hippuris vulgaris* (3 fr.); *w*, *Myriophyllum spicatum* or *M. verticillatum* (4 fr.); *x*, *Cicuta virosa* ($1\frac{1}{2}$ fr.); *y*, *Petroselinum segetum* ($\frac{1}{2}$ fr.). (Magnifications of *a* to *y* × 14.)

Plate 10

Figure 19. *a*, *Sium erectum* (2 fr.); *b*, *Daucus carota* ($\frac{1}{2}$ fr.); *c*, *Galium* cf. *aparine* (2 fr., 2 views); *d*, *Valeriana dioica* (3 fr.); *e*, *Carduus* sp. (3 fr.); *f*, *Cirsium heterophyllum* or *C. palustris* (3 fr.); *e*, *Carduus* sp. (3 fr.); *f*, *Cirsium heterophyllum* or *C. palustris* (3 fr.); *g*, *Taraxacum officinale* (1 fr.); *h*, *Sonchus arvensis* (2 fr.); *i*, *Arctostaphylos uva-ursi* (1 st.); *j*, *Menyanthes trifoliata* (2 s.); *k*, *Linaria vulgaris* (3 s.); *l*, *Mentha* sp. (3 fr.); *m*, *Lycopus europaeus* (2 fr.); *n*, *Prunella vulgaris* (2 fr.); *o*, *Galeopsis tetrahit* (2 fr.); *p*, *Teucrium scordium* (1 fr., 2 views); *q*, *Chenopodium* cf. *album* (2 s.); *r*, *Polygonum aviculare* (1 n., 1 n. enclosed in p.); *s*, *Rumex* sp. (1 n.); *t*, *Betula*, tree spp. (3 fr.); *u*, *B. nana* (5 fr.). (Magnifications of *a* to *u* × 14.)

Plate 11

Figure 20. *a*, *Empetrum nigrum* (1 st.); *b*, *Alisma plantago-aquatica* (2 fr.); *c*, *d*, *Potamogeton natans* (3 fr., *c*, with and *d*, without outer skin); *e*, *Potamogeton* cf. *pusillus* (3 fr.); *f*, *Potamogeton* cf. *filiformis* (2 fr.); *g*, *Naias flexilis* (1 fr.); *h*, *Eleocharis palustris* (1 fr.); *i*, *Scirpus lacustris* (2 fr.); *j*, *Scirpus* sp. (1 fr.); *k*, *Carex paniculata* (4 u.); *l*, *C. aquatilis* or *bigelowii* (2 n. + u., 1 n.); *m*, *Carex* cf. *laevigata* (3 n. + u.); *n*, *C. rostrata* (3 n. + u., 1 n.); *o*, *Betula nana* (3 cs.); *p*, *Dryas octopetala* (1 fragment); *q*, *Betula nana* (1) showing perithecia of ?*Venturia* sp.; *r*, *Armeria maritima* (5 ct.). (Magnifications of *a* to *r* × 14.)

Plate 12

Figure 21. *a*, *Arenaria ciliata* (5 s.); *b*, cf. *Stellaria alsine* (1 s.); *c*, *Typha* sp. (2 s.); *d*, *Urtica dioica* (2 fr.); *e*, *Rorippa islandica* (1 s.); *f*, *Saxifraga* cf. *hypnoides* (1 s.); *g*, *Cerastium vulgatum* (1 s.); *h*, *Campanula patula* or *C. rotundifolia* (2 s.); *i*, *Selaginella selaginoides* (1 m.). (Magnifications of *a* to *i*, × 26.) *j*, cf. *Sorbus* (2 fr.); *k*, *Cornus sanguinea* (3 st.); *l*, *Rumex acetosa* (1 p.); *m*, *Rumex* cf. *crispus* (1 p. + n.); *n*, *Geranium sanguineum* (1 cp.). (Magnifications of *j* to *n*, × 10.) *o*, *Draba incana* (3 r.); *p*, *Myriophyllum* sp. (5 sh.); *q*, *Betula nana* (2 l.). (Magnifications of *o* to *q*, × 7.)

Abbreviations used in legends to plates 9 to 12. cp. carpel; cs. cone-scale; ct. calyx tube; fr. fruit; gr. pollen grain; l. leaf; m. megaspore; n. nut; p. perianth; r. replum of Cruciferous pod; s. seed; sh. shoot; st. stone of fleshy fruit; u. utricle.

PLATE 13

FIGURE 22. *a*, cf. *Filipendula* (1 gr.); *b*, *Artemisia* (1 gr.); *c*, *Matricaria* type (1 gr.); *d*, *Labiate* cf. *Thymus* (1 gr.); *e*, *f*, *Campanula* (same gr., 2 planes of focus); *g*, *h*, cf. *Lysimachia* (2 gr., 2 planes of focus); *i*, *j*, *k*, *Polemonium* (same gr., 3 planes of focus); *l*, *m*, *Helianthemum* (same gr., 2 planes of focus); *n*, *o*, *Polemonium* (same gr., 2 planes of focus); *p*, *Plantago* cf. *media* (1 gr.); *q*, *Chenopodium* (1 gr.); *r*, *s*, *Thalictrum* (same gr., 2 planes of focus); *t*, *u*, *Myriophyllum* cf. *verticillatum* (2 gr., 2 planes of focus). (Magnifications of *i* to *m* × 520; *a*, *b*, *g*, *h*, *q*, *r*, *s* × 740; *c*, *d*, *e*, *f*, *p*, *t*, *u* × 820).

PLATE 14

FIGURE 23. *a*, *b*, *Campanula* cf. *rapunculoides* (1 gr., 2 planes of focus); *c*, *Silene* type (1 gr.); *d*, *Sonchus* type (1 gr.); *e*, *f*, *Armeria vulgaris*, type A (1 gr., 2 planes of focus); *g*, *Typha latifolia* (tetrad of 4 gr.); *h*, *Centaurea* cf. *scabiosa* (1 gr.); *i*, *j*, *k*, *l*, *Valeriana officinalis* (1 gr., 4 planes of focus); *m*, *Epilobium* (1 gr.); *n*, *o*, *Succisa pratensis* (1 gr., 2 planes of focus). (Magnifications of *a* to *h* × 740; *i* to *m* × 820; *n*, *o* × 660).

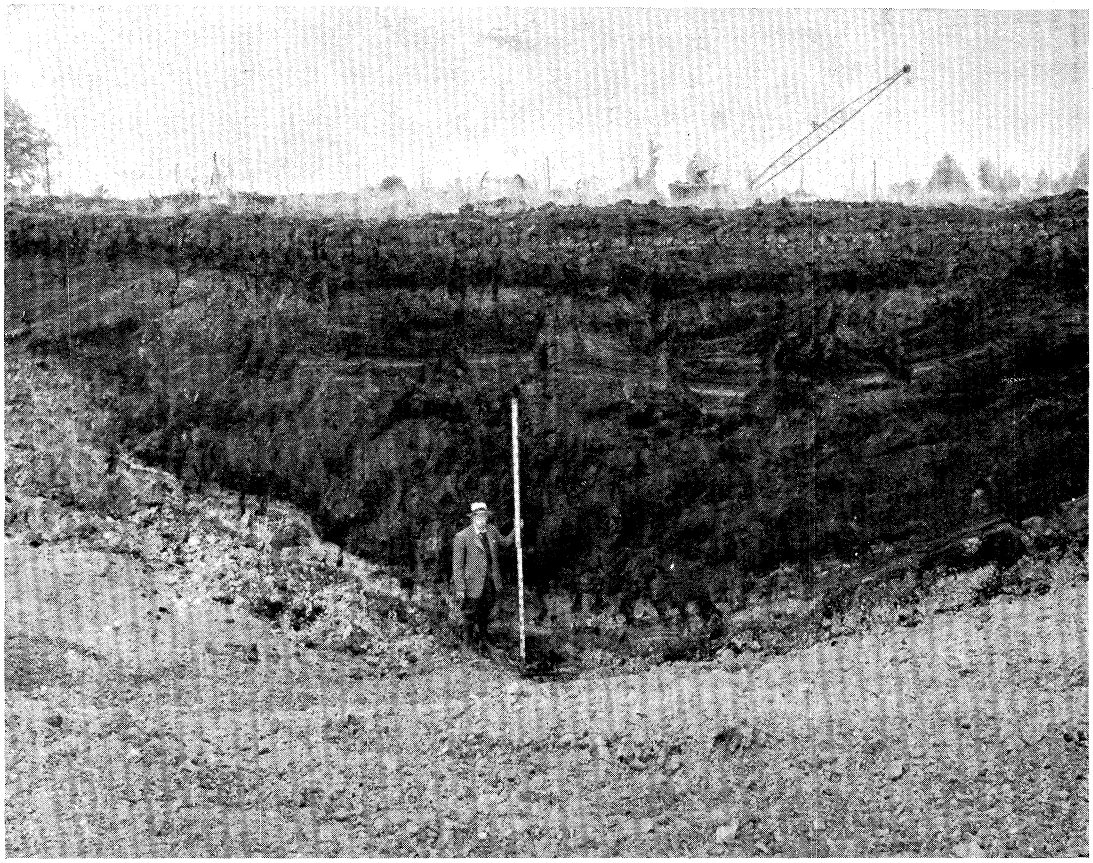

FIGURE 14

FIGURE 15

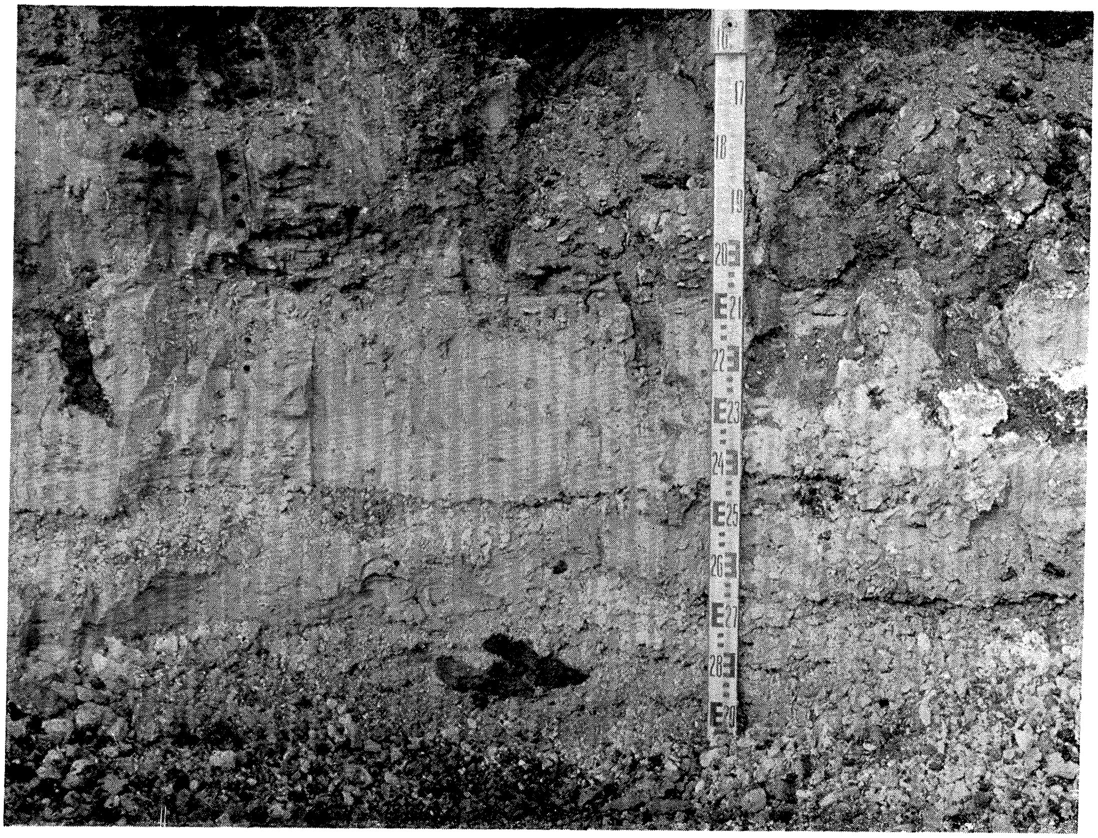

Figure 16

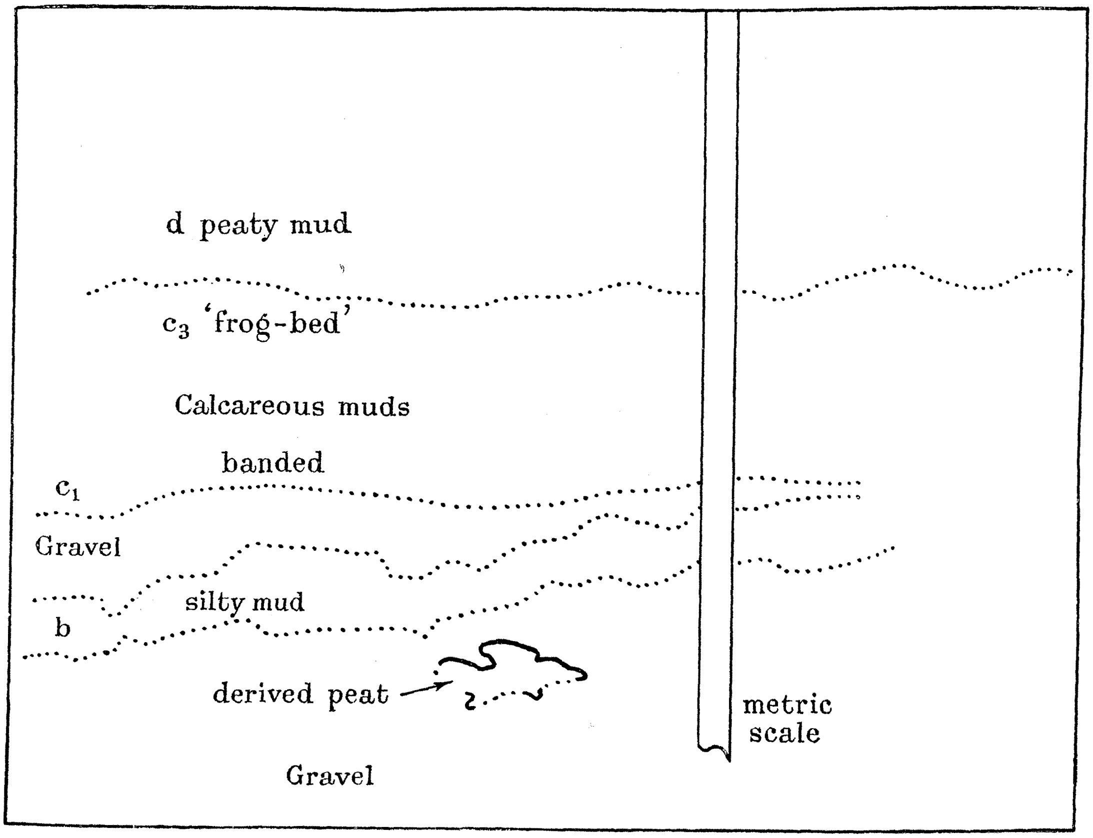

Figure 17

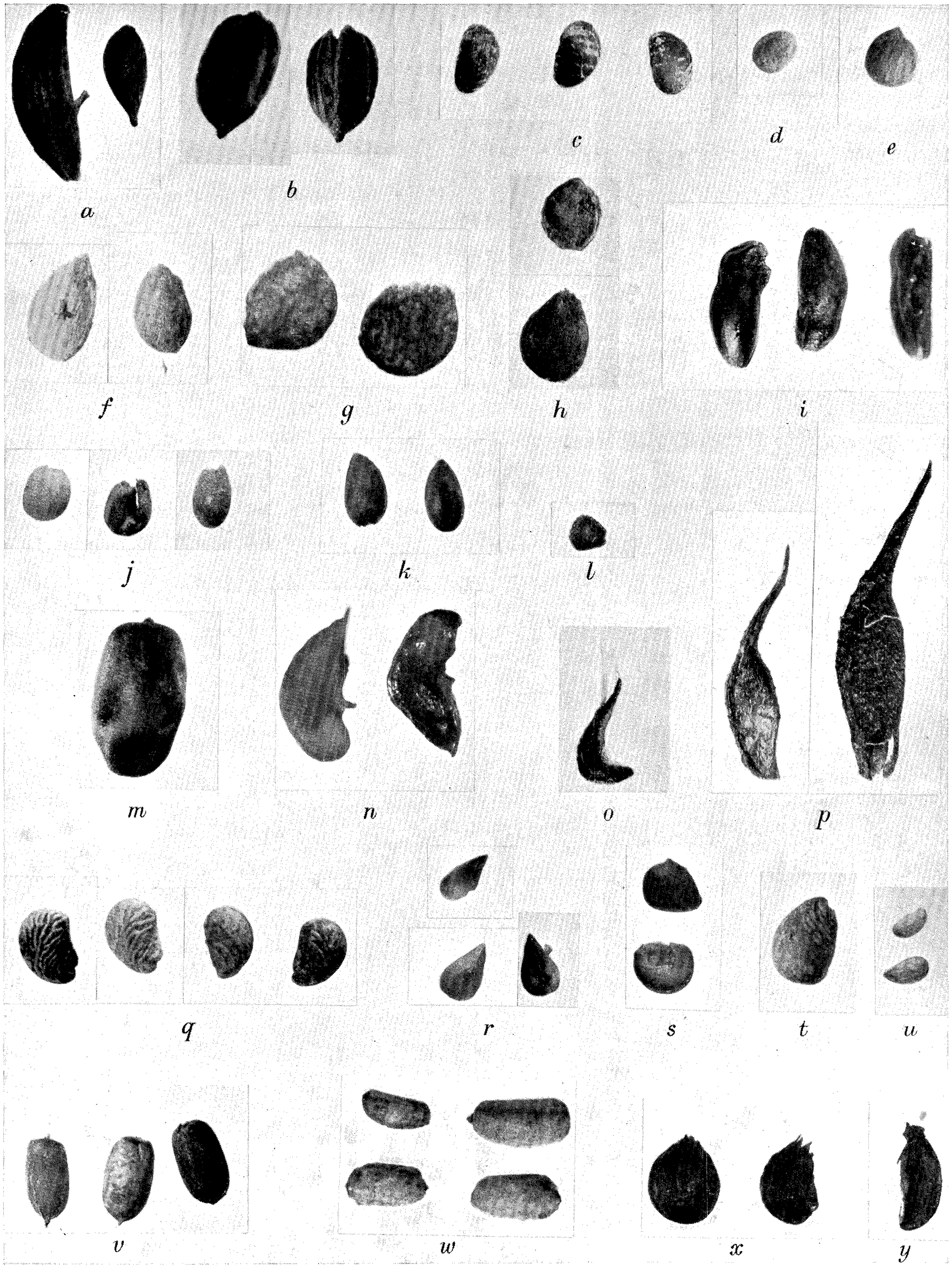

FIGURE 18

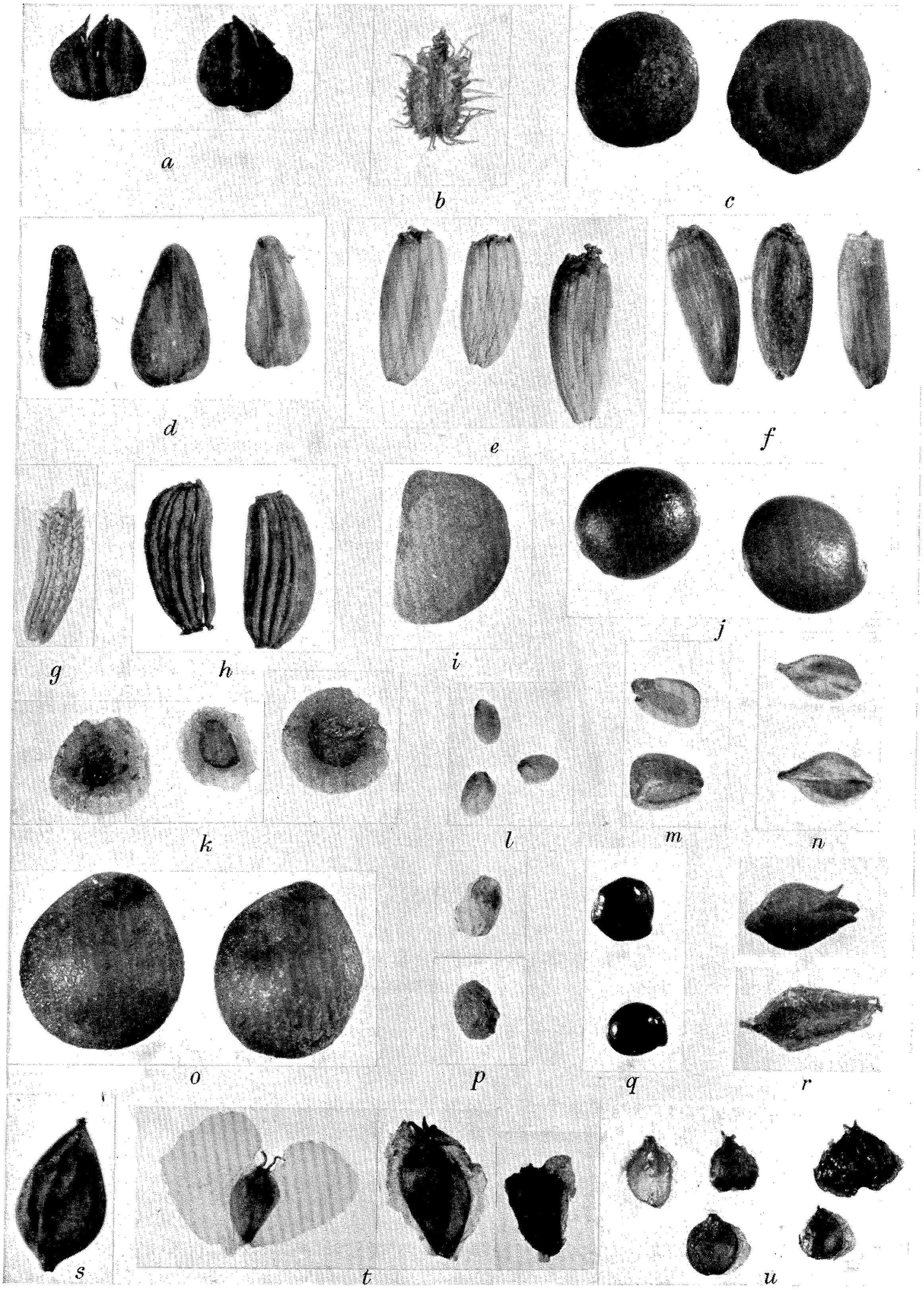

FIGURE 19

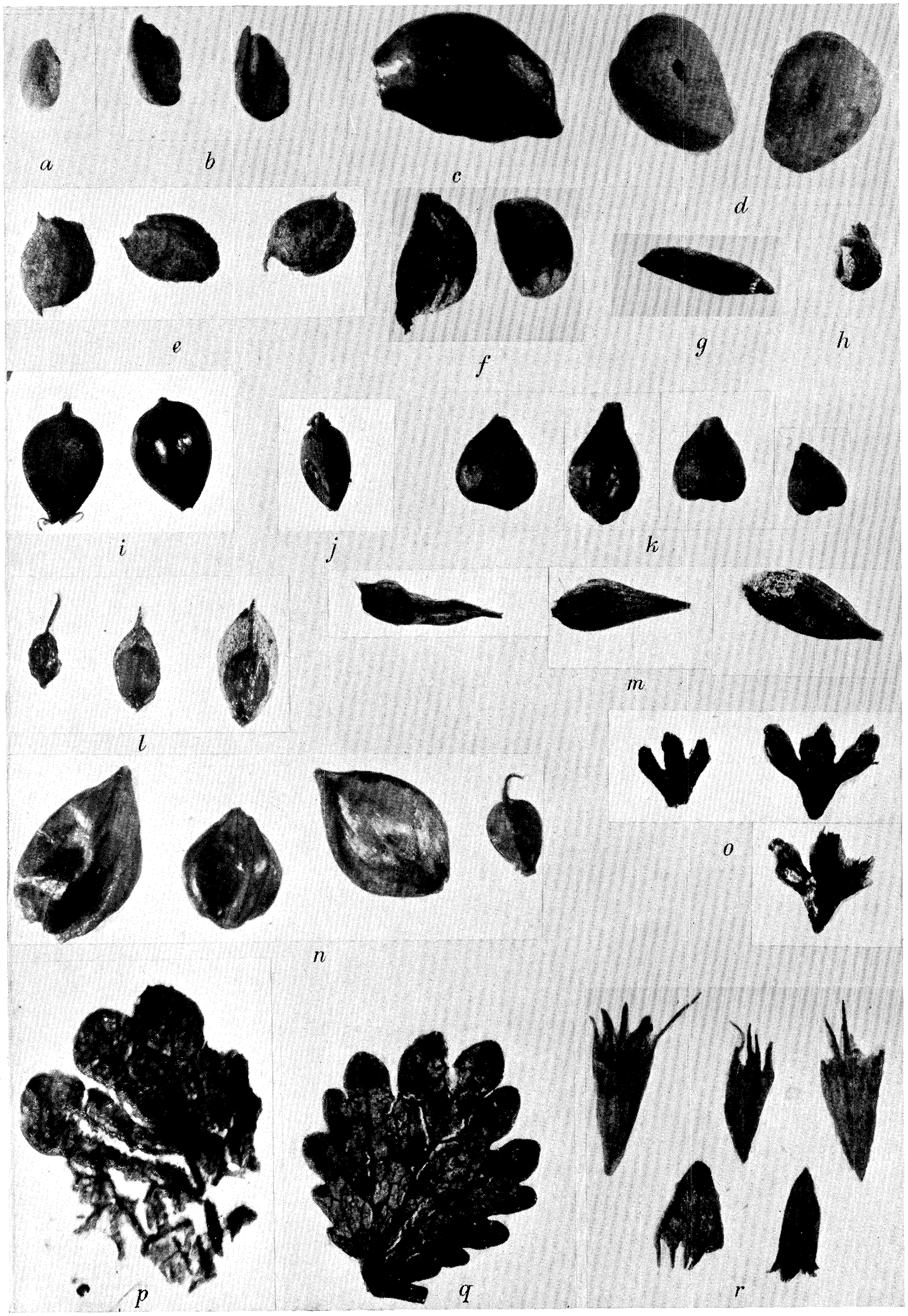

FIGURE 20

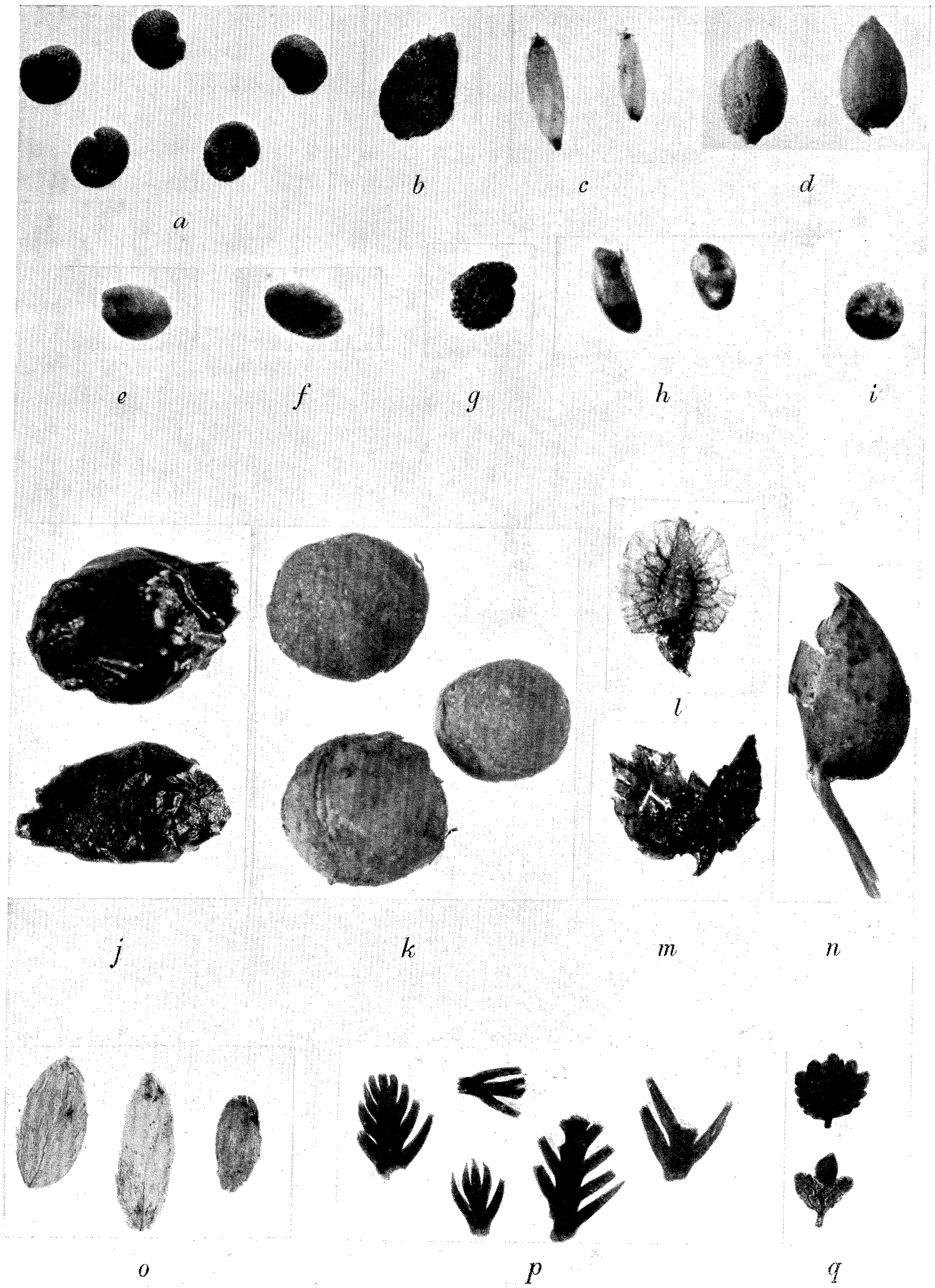

FIGURE 21

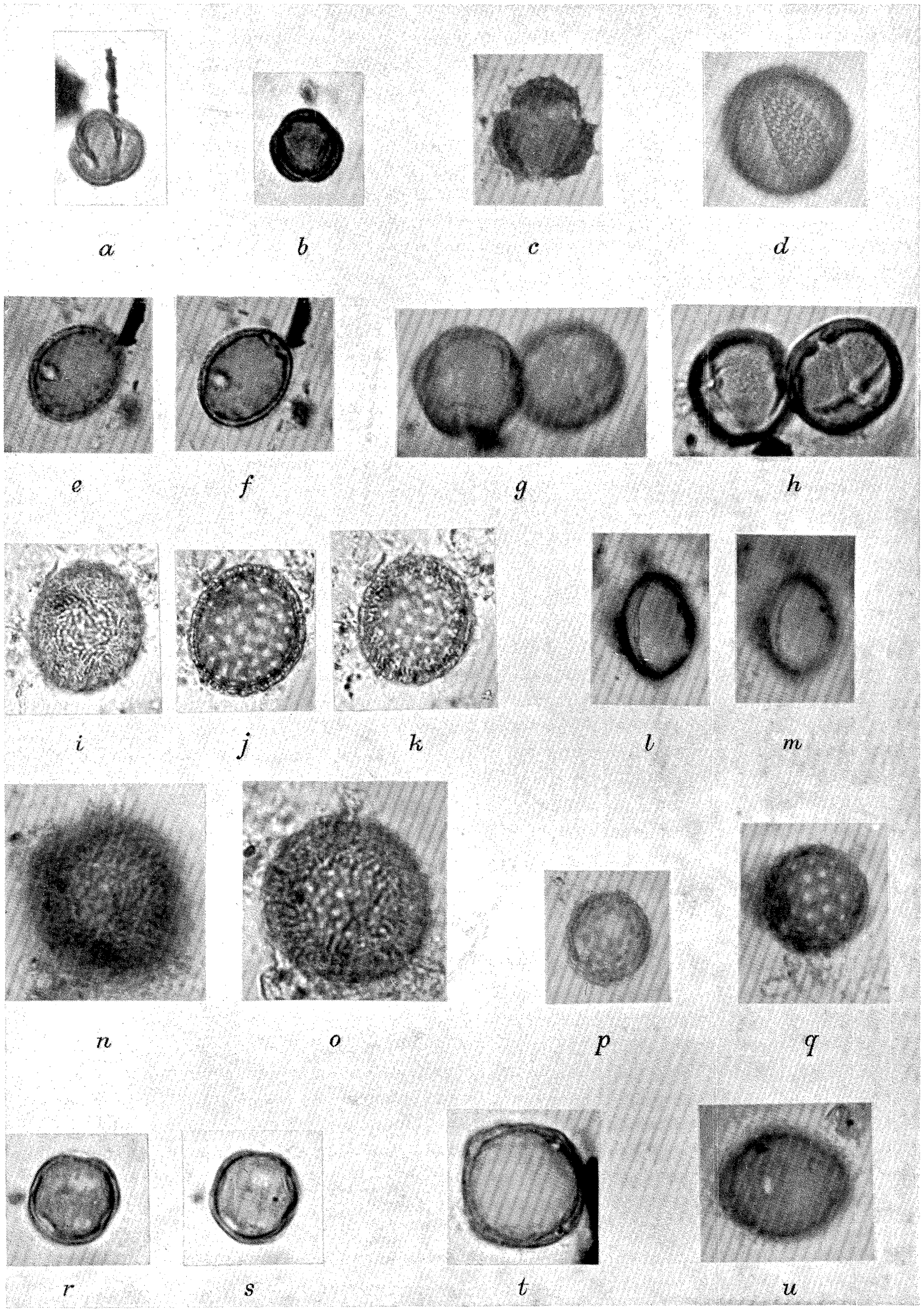

FIGURE 22

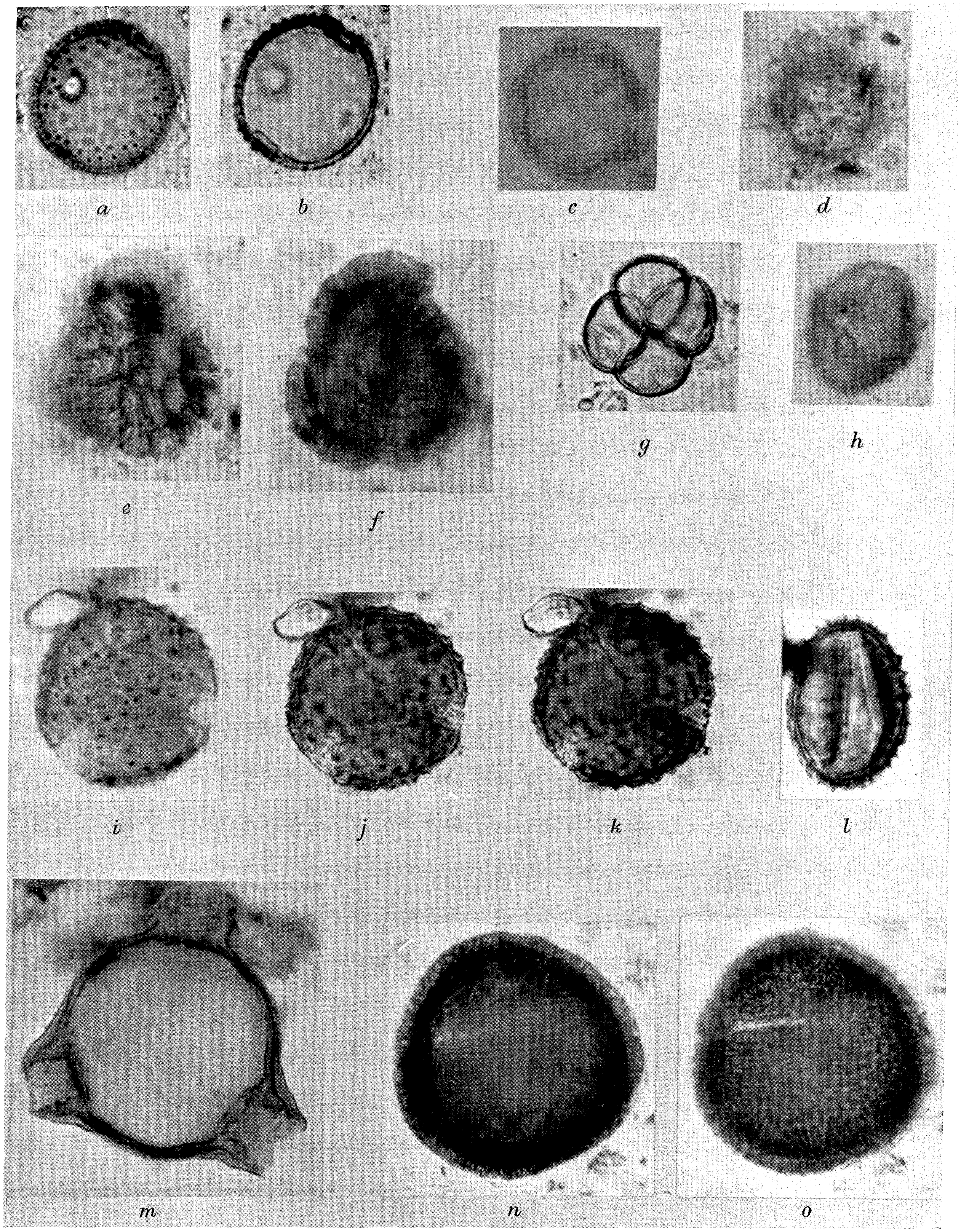

FIGURE 23

TABLE 8. NAZEING. FLORAL LIST

species and illustration	type of remains	Deposit													
		MA*a*	MA*b*	MA*c*	Mx	M4*a*	M4*b*	M4C1	M4C2	M4C3	M4*d*	AB4	B4	C4	D4
		Zones													
		III		IV	V	? before III	III				IV	? before III			
†*Alisma plantago-aquatica* L. (figure 20*b*, plate 11)	*fr*	.	.	.	.	.	.	.	×	× × × × ×	.	.	.	.	.
†*Arctostaphylos uva-ursi* (L.) Spreng. (figure 19*i*, plate 10)	*st*	.	.	.	.	.	.	.	.	×	.	.	.	.	.
Arenaria ciliata agg. (figure 21*a*, plate 12)	*s*	×	.	.	.	.	× ×	.	× ×	.	× × ×	× ×	.	.	.
†*Armeria maritima* Willd. (figure 20*r*, plate 11)	*ct*	.	× ×	.	.	.	× × × ×	.	.	.	.	.	.	.	.
†*Barbarea vulgaris* agg. (figure 18*j*, plate 9)	*s*	× ×	× ×	.	.	× ×	× ×	.	× ×	.	.	×	×	.	.
†*Betula nana* L. (figure 19*u*, plate 10; figure 20*o*, *q*, plate 11; figure 21*q*, plate 12) (see also figure 9)	*cs*+*fr*+*l*+*sm*	× × × ×	× × × × ×	.	.	× × ×	× × × × ×	× ×	×	× ×	.	× ×	× ×	.	.
Betula cf. *pendula* Roth. (figure 19*t*, plate 10)	*cs*+*fr*	.	.	.	×	.	×	.	.	×	.	.	.	.	.
Betula cf. *pubescens* Ehrh. (figure 19*t*, plate 10)	*cs*+*fr*	×	.	.	×	.	.	.	×	×	.	.	×	.	.
Betula cf. *pendula* × *pubescens* (figure 19*t*, plate 10)	*cs*+*fr*	.	.	.	×	.	×	.	.	×	.	.	.	.	.
†*Caltha palustris* L. (figure 18*i*, plate 9)	*fr*	× ×	× ×	.	.	.	× × ×	×	×	.	.	× ×	.	.	.
Campanula rotundifolia L. or *C. patula* L. (figure 21*h*, plate 12)	*s*	× ×	.	.	.	.	× × ×	.	.	.	.	.	.	.	.
Carduus sp. (figure 19*e*, plate 10)	*fr*	.	.	× ×	.	.	×	× × × ×	× × ×	× × ×	× ×	.	.	.	.
Carex aquatilis Wahlenb. or *C. bigelowii* Torr. (figure 20*l*, plate 11)	*n*+*u*	× × × ×	× × × ×	.	.	.	× × × ×	× × × ×	.	.	.	× × ×	.	.	.
Carex cf. *laevigata* Sm. (figure 20*m*, plate 11)	*n*+*u*	.	.	.	.	.	.	.	.	× × × × ×	× × ×	.	.	.	.
Carex paniculata L. (figure 20*k*, plate 11)	*n*+*u*	× × × ×	× ×	.	.	× ×	×	.	× ×	× × ×	.	× × × ×	× ×	× ×	.
†*Carex rostrata* Stokes (figure 20*n*, plate 11)	*n*+*u*	× × × × ×	× × × × ×	× ×	× × × ×	.	× × ×	× × ×	.	× × × × ×	× × × ×	× × × × ×	× × × × ×	× ×	.
Cerastium vulgatum L. (figure 18*l*, plate 9; figure 21*g*, plate 12)	*s*	.	.	.	.	.	.	.	×	×	.	.	.	.	.
†*Cerastium* sp.	*s*	.	.	.	.	.	×	.	.	.	.	.	.	.	.
†*Chenopodium* cf. *album* L. (figure 19*g*, plate 10)	*s*	.	.	×	.	.	.	× ×	.	×	.	.	.	.	.
Cicuta virosa L. (figure 18*x*, plate 9)	*fr*	.	.	.	.	.	.	.	.	× × ×	× ×	.	.	.	.
†*Cirsium heterophyllum* (L.) Hill or *C. palustre* (L.) Scop. (figure 19*f*, plate 10)	*fr*	.	.	× × ×	.	.	.	× × × ×	.	× × ×	× ×	× ×	.	.	.
†*Comarum palustre* L. (figure 18*s*, plate 9)	*fr*	× × ×	× × ×	.	.	× × ×	× × ×	× ×	.	.	× ×	× × ×	× ×	.	.
Corylus avellana L.	*n*	.	.	.	×	.	.	.	.	.	.	.	.	.	.
Cornus sanguinea L. (figure 21*k*, plate 12)	*fr*+*st*	.	.	.	× × ×	.	.	.	.	.	.	.	.	.	.
Daucus carota L. (figure 19*b*, plate 10)	*fr*	.	.	.	×	.	.	.	.	.	.	.	.	.	.
†*Draba incana* L. (figure 21*a*, plate 12)	*r*	.	.	.	.	.	.	.	.	.	.	× × ×	.	.	.
†*Dryas octopetala* L. (figure 18*o*, plate 9; figure 20*p*, plate 11)	*l*+cf. *fr*	×	×	.	.	.	.	.	.	.	.	.	.	.	.
Eleocharis palustris (L.) Roem & Schult. (figure 20*h*, plate 11)	*fr*	.	.	.	.	.	.	.	.	×	×	.	.	.	.
Empetrum nigrum agg. (figure 20*a*, plate 11)	*st*	.	.	.	.	.	×	.	.	.	.	.	.	.	.
Erica tetralix L.	*l*	× ×	.	.	.	.	.	.	.	.	.	.	.	.	.
†*Filipendula ulmaria* (L.) Maxim (figure 18*n*, plate 9)	*fr*	.	.	×	.	.	.	× × × ×	× × × ×	× × ×	.	× ×	.	.	.
†*Galeopsis tetrahit* agg. (figure 19*o*, plate 10)	*fr*	.	.	.	.	.	.	× × × ×	.	× ×	× × ×	.	.	.	.
Galium cf. *aparine* L. (figure 19*c*, plate 10)	*fr*	.	.	.	.	.	.	× ×	.	.	.	.	.	.	.
Geranium sanguineum L. (figure 18*m*, plate 9; figure 21*n*, plate 12)	*s*+*cp*	.	×	.	.	×	.	.	.	.	.	.	.	.	×
Geum rivale L. or *G. urbanum* L. (figure 18*p*, plate 9)	*fr*	×	×	×	.	.	× ×	× × ×	.	.	.	×	.	.	.
†*Hippuris vulgaris* L. (figure 18*v*, plate 9)	*fr*	×	× ×	×	.	.	× × ×	.	.	×	× ×	× × × × ×	×	.	.
Linaria vulgaris Mill. (figure 19*k*, plate 10)	*s*	.	.	.	.	.	.	.	.	× ×	.	.	.	.	.
Lycopus europaeus L. (figure 19*m*, plate 10)	*fr*	.	× ×	×	.	.	.	.	.	× × ×	× × ×	.	.	.	×
†*Mentha* sp. (figure 19*l*, plate 10)	*fr*	.	.	.	.	.	.	.	.	× ×	.	.	.	.	.
†*Menyathnes trifoliata* L. (figure 19*j*, plate 10)	*s*	× ×	× ×	.	.	.	× ×	.	.	× ×	× ×	× × × × ×	×	.	.
†*Myriophyllum spicatum* L. or *M. verticillatum* L. (figure 18*w*, plate 9; figure 21*p*, plate 12)	*fr*+*sh*	.	.	.	.	.	× ×	× × ×	× ×	×	.	×	.	.	.
Naias flexilis (Willd.) Rostk. & Schmidt (figure 20*g*, plate 11)	*fr*	.	.	.	.	.	×	.	.	.	.	.	.	.	.
Petroselinum segetum (L.) Koch. (figure 18*y*, plate 9)	*fr*	.	×	.	.	.	.	.	.	.	.	.	.	.	.
†*Polygonum aviculare* agg. (figure 19*r*, plate 10)	*n*+*p*	×	×	×	.	.	.	.	.	.	.	.	.	.	.
cf. *Populus*	*b*+*cs*	.	.	.	×	.	.	.	.	.	.	.	.	.	.
†*Potamogeton* cf. *filiformis* Pers. (figure 20*f*, plate 11)	*fr*	× ×	× ×	.	.	.	×	.	.	.	.	× × × ×	.	.	.
†*Potamogeton* cf. *natans* L. (figure 20*c*, *d*, plate 11)	*fr*	.	× ×	× × × ×	.	.	.	× × × ×	× × × ×	× × × × ×	× × × ×	.	.	.	.
†*Potamogeton* cf. *pusillus* L. (figure 20*e*, plate 11)	*fr*	.	.	.	.	.	× ×	× × × ×	.	×	.	.	.	.	.
Potentilla fruticosa L. (figure 18*r*, plate 9)	*fr*	.	.	.	.	.	×	.	.	.	.	.	.	.	.
Potentilla sterilis (L.) Garcke (figure 18*q*, plate 9)	*fr*	.	.	.	.	.	×	.	.	.	.	.	× × × ×	.	.
Potentilla spp. (figure 18*t*, *u*, plate 9)	*fr*	× × ×	× ×	.	.	.	.	.	.	.	.	.	.	.	.
Prunella vulgaris L. (figure 19*n*, plate 10)	*fr*	.	.	.	.	.	.	.	.	× ×	.	.	.	.	.
†*Ranunculus* cf. *acris* L. (figure 18*q*, plate 9)	*fr*	.	.	.	.	.	× × × ×	.	.	.	×	.	.	.	.
†*Ranunculus-Batrachian* sp. (figure 18*c*, plate 9)	*fr*	× × × ×	× × ×	.	.	.	.	× × × ×	× ×	× × ×	.	× × ×	× × ×	.	.
†*Ranunculus flammula* L. (figure 18*e*, plate 9)	*fr*	.	× ×	.	.	.	× ×	.	.	× ×	.	×	.	.	.
Ranunculus lingua L. (figure 18*f*, plate 9)	*fr*	.	.	×	.	×	.	.	.	× × ×	.	.	.	.	.
†*Ranunculus* cf. *repens* L. (figure 18*h*, plate 9)	*fr*	.	.	.	×	.	.	× ×	×	.	.	.	×	.	.
†*Ranunculus sceleratus* L. (figure 18*d*, plate 9)	*fr*	.	.	×	.	.	.	.	.	×	.	.	.	.	.
†*Rorippa islandica* (Oeder) Borbas (figure 21*e*, plate 12)	*s*	×	.	.	.	.	.	.	.	.	.	×	.	.	.
†*Rumex acetosa* L. (figure 21*l*, plate 12)	*p*	.	.	.	.	.	.	.	.	.	.	.	×	.	×
Rumex cf. *aquaticus* L.	*n*+*p*	.	.	.	.	.	.	.	.	.	×	.	.	.	.
Rumex cf. *crispus* L. (figure 21*m*, plate 12)	*n*+*p*	.	.	.	.	.	.	.	.	×	.	.	.	.	.
†*Rumex* sp. (figure 19*s*, plate 10)	*n*	.	.	.	.	.	.	×	.	×	.	.	.	.	.
Salix phylicifolia L. (figure 13)	*b*+*c*+*a*+*l*	× × × × ×	× × × × ×	.	.	.	× × × × ×	× × ×	.	.	×	×	× × × ×	.	.
Saxifraga cf. *hypnoides* agg. (figure 21*f*, plate 12)	*s*	.	.	.	.	.	.	×	.	.	.	.	.	.	.
†*Scirpus lacustris* L. (figure 20*i*, plate 11)	*fr*	×	× ×	× × × ×	×	.	× ×	× × × ×	.	× × × × ×	× ×	× × × × ×	× × × ×	.	.
Scirpus sp. (figure 20*j*, plate 11)	*fr*	.	.	.	.	.	× ×	.	.	.	.	.	.	.	.
Sium erectum Huds. (figure 19*a*, plate 10)	*fr*	.	.	.	.	.	.	.	.	× × ×	× ×	.	.	.	.
†*Sonchus arvensis* L. (figure 19*h*, plate 10)	*fr*	.	.	.	.	.	.	.	.	× ×	.	.	.	.	.
cf. *Sorbus* sp. (figure 21*j*, plate 12)	*s*	.	.	.	.	.	× ×	.	.	.	.	.	.	.	.
†cf. *Stellaria alsine* Grimm. (figure 21*b*, plate 12)	*s*	.	.	.	.	.	.	.	.	.	.	× ×	.	.	.
†*Taraxacum officinale* Weber (figure 19*g*, plate 10)	*fr*	×	.	×	.	.	.	×	.	.	.	.	.	.	.
Teucrium scordium L. (figure 19*p*, plate 10)	*fr*	.	.	×	.	.	.	.	.	.	.	.	.	.	.
†*Thalictrum alpinum* L. (figure 18*a*, plate 9)	*fr*	.	× ×	.	.	.	×	.	.	.	.	×	.	.	.
†*Thalictrum flavum* L. (figure 18*b*, plate 9)	*fr*	× ×	.	.	.	.	.	.	.	.	.	× ×	×	.	.
Typha angustifolia L. or *T. latifolia* L. (figure 21*c*, plate 12)	*s*	.	.	× × ×	.	.	.	.	.	.	.	.	.	.	.
†*Urtica dioica* L. (figure 21*d*, plate 12)	*fr*	× ×	.	.	.	.	× ×	× × ×	.	.	.	×	.	.	.
†*Valeriana dioica* L. (figure 19*d*, plate 10)	*fr*	.	× ×	.	.	.	.	× × × ×	× ×	× × ×	.	.	.	.	.
†*Viola* sp. (figure 18*k*, plate 9)	*s*	.	.	.	×	.	×	× × × ×	× ×	× × ×	.	×	× ×	.	.
Selaginella selaginoides (L.) Link. (figure 21*i*, plate 12)	*m*	×	×	.	.	.	.	.	.	.	.	.	× ×	.	.
†Characeae	*o*	× × ×	× × × ×	× × × × ×	×	.	× × ×	× × × × ×	× × × × ×	× × ×	.	× ×	.	.	.
Cristatella sp.	*bl*	.	.	.	.	.	.	.	.	.	.	×	.	.	.
Daphnia sp.	*eph*	×	.	.	.	.	.	.	.	.	.	.	.	.	.

Abbreviations: *a*, cone axis; *b*, bud or bud scar; *bl*, statoblast of polyzoan; *c*, capsule; *cp*, carpel; *cs*, cone scale; *ct*, calyx tube; *eph*, ephippium of crustacean; *fr*, fruit; *l*, leaf; *m*, megaspore; *n*, nutlet; *o*, oospore; *p*, perianth; *r*, replum of cruciferous pod; *s*, seed; *sh*, shoot apex; *sm*, scale from male cone of *Betula*; *st*, stone of fleshy fruit; *u*, utricle of *Carex*. Frequency of occurrence: × × × × × abundant; × × × × frequent; × × × occasional; × × rare; × very rare; † as prefix to species = recorded from Lea Valley arctic beds.

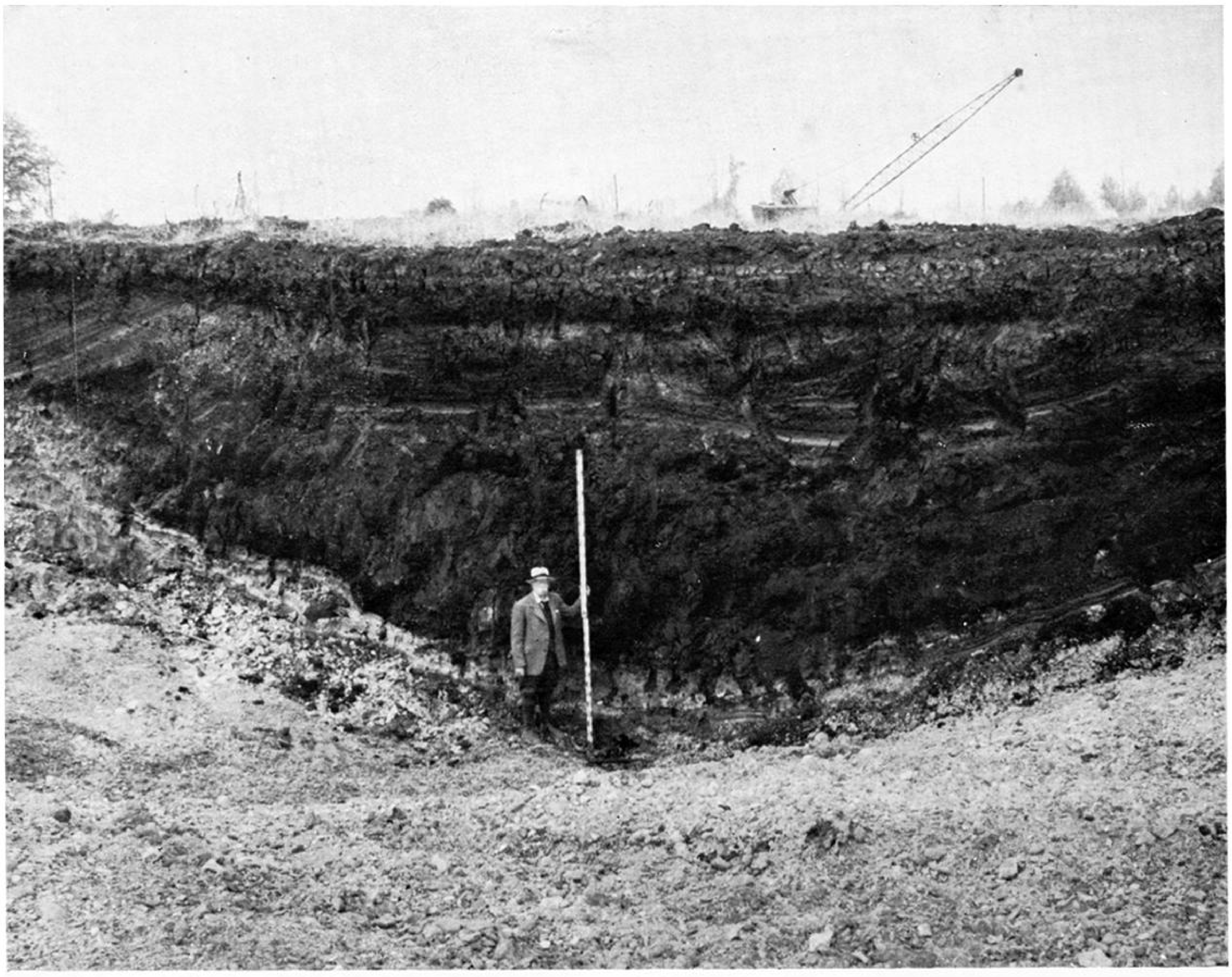

Figure 14

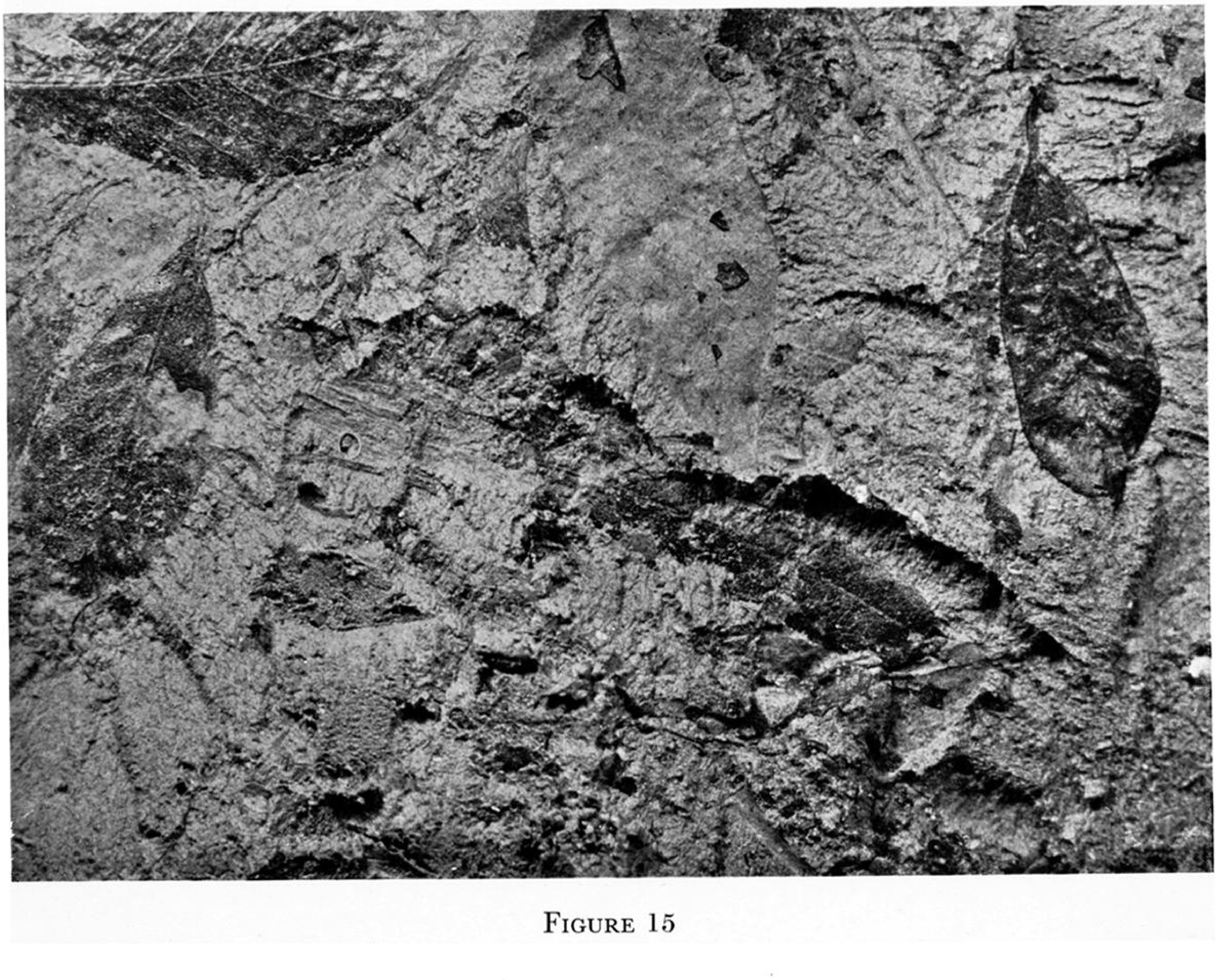

Figure 15

Plate 7

Figure 14. Nazeing channel seen at its deepest point, M4, S. H. Warren holding a 3 m. staff. Note light calcareous muds in bottom of channel and cracked layer of flood-plain clay sealing the surface of the peat. For chief beds see figure 6.

Figure 15. Leaves of willow (cf. *Salix phylicifolia*) from the grey calcareous clay-mud (M4, B) at the base of the channel at M4.

FIGURE 16

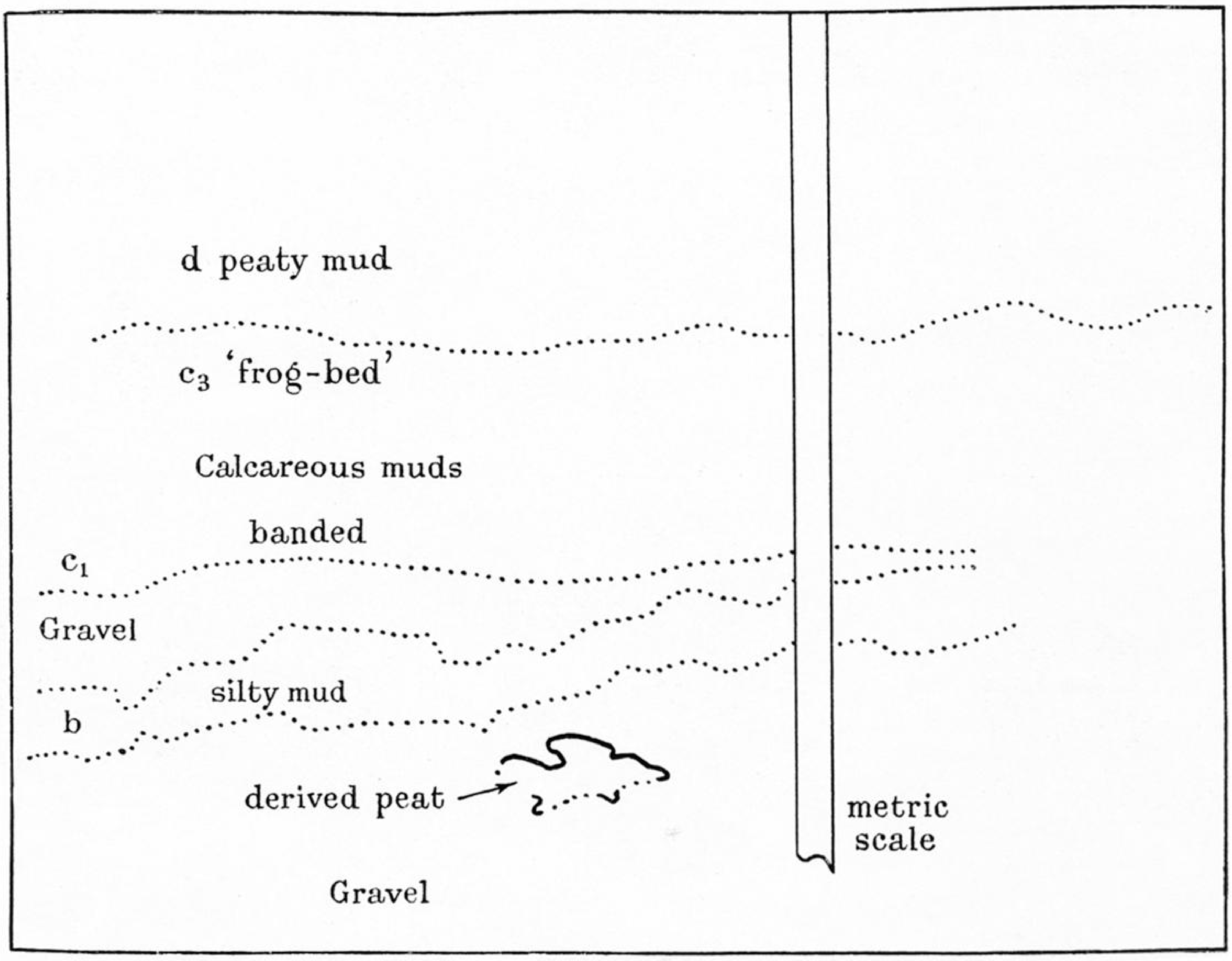

FIGURE 17

PLATE 8

FIGURE 16. Lowermost channel deposits at M4 with metric scale (see § 2*b*).

FIGURE 17. Key to figure 16.

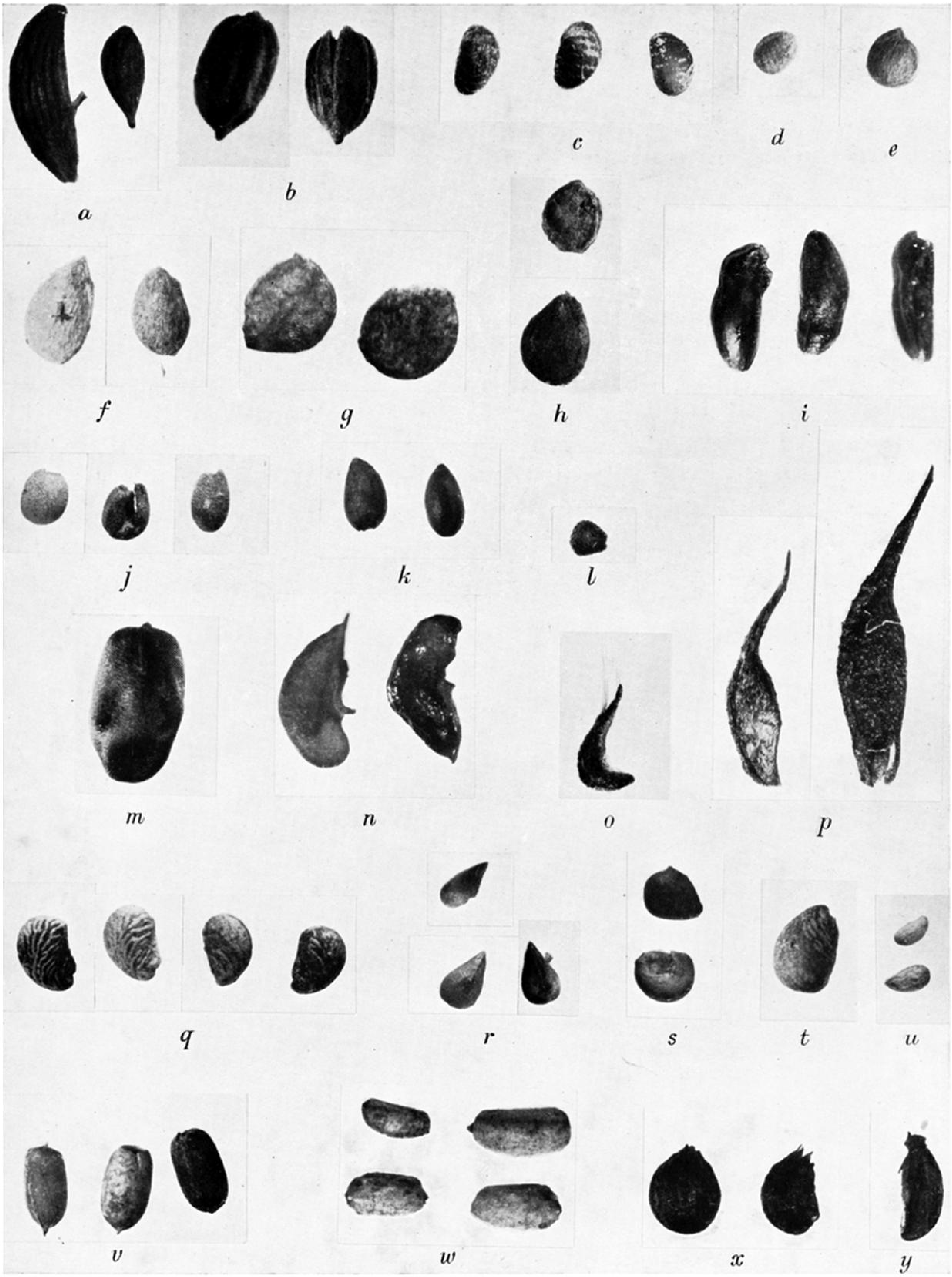

FIGURE 18

PLATE 9

FIGURE 18. *a*, *Thalictrum alpinum* (2 fr.); *b*, *T. flavum* (2 fr.); *c*, *Ranunculus Batrachian* sp. (3 fr.); *d*, *R. sceleratus* (1 fr.); *e*, *R. flammula* (1 fr.); *f*, *R. lingua* (2 fr.); *g*, *Ranunculus* cf. *acris* (2 fr.); *h*, *Ranunculus* cf. *repens* (2 fr.); *i*, *Caltha palustris* (3 fr.); *j*, *Barbarea vulgaris* (3 fr.); *k*, *Viola* sp. (2 s.); *l*, *Cerastium vulgatum* (1 s.); *m*, *Geranium sanguineum* (1 s.); *n*, *Filipendula ulmaria* (2 fr.); *o*, cf. *Dryas octopetala* (1 fr.); *p*, *Geum* sp. (2 fr.); *q*, *Potentilla sterilis* (4 fr.); *r*, *P. fruticosa* (1 fr., 3 views); *s*, *Comarum palustre* (2 fr.); *t*, *u*, *Potentilla* spp. (3 fr.); *v*, *Hippuris vulgaris* (3 fr.); *w*, *Myriophyllum spicatum* or *M. verticillatum* (4 fr.); *x*, *Cicuta virosa* ($1\frac{1}{2}$ fr.); *y*, *Petroselinum segetum* ($\frac{1}{2}$ fr.). (Magnifications of *a* to *y* ×14.)

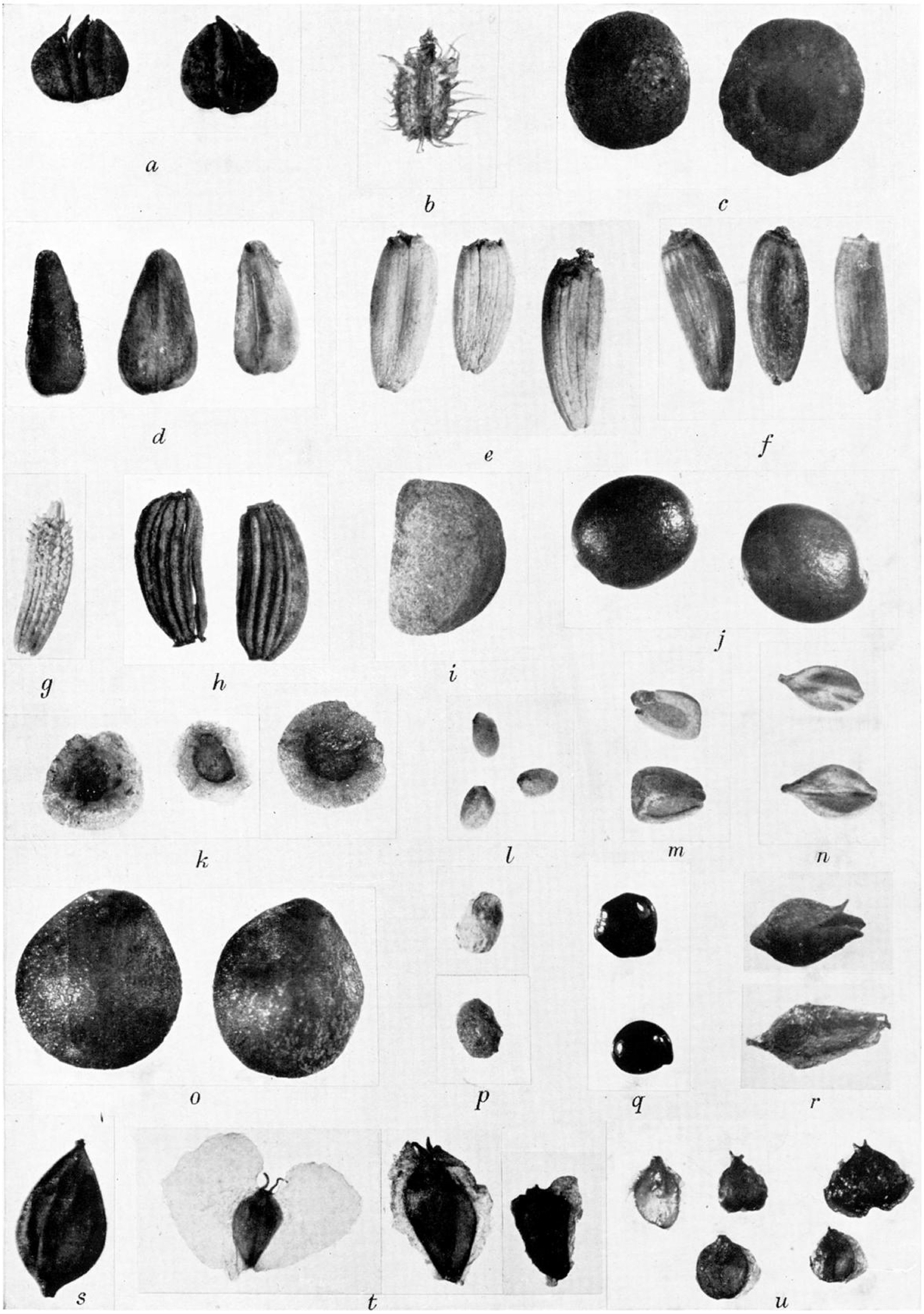

FIGURE 19

PLATE 10

FIGURE 19. *a*, *Sium erectum* (2 fr.); *b*, *Daucus carota* ($\frac{1}{2}$ fr.); *c*, *Galium* cf. *aparine* (2 fr., 2 views); *d*, *Valeriana dioica* (3 fr.); *e*, *Carduus* sp. (3 fr.); *f*, *Cirsium heterophyllum* or *C. palustris* (3 fr.); *e*, *Carduus* sp. (3 fr.); *f*, *Cirsium heterophyllum* or *C. palustris* (3 fr.); *g*, *Taraxacum officinale* (1 fr.); *h*, *Sonchus arvensis* (2 fr.); *i*, *Arctostaphylos uva-ursi* (1 st.); *j*, *Menyanthes trifoliata* (2 s.); *k*, *Linaria vulgaris* (3 s.); *l*, *Mentha* sp. (3 fr.); *m*, *Lycopus europaeus* (2 fr.); *n*, *Prunella vulgaris* (2 fr.); *o*, *Galeopsis tetrahit* (2 fr.); *p*, *Teucrium scordium* (1 fr., 2 views); *q*, *Chenopodium* cf. *album* (2 s.); *r*, *Polygonum aviculare* (1 n., 1 n. enclosed in p.); *s*, *Rumex* sp. (1 n.); *t*, *Betula*, tree spp. (3 fr.); *u*, *B. nana* (5 fr.). (Magnifications of *a* to *u* × 14.)

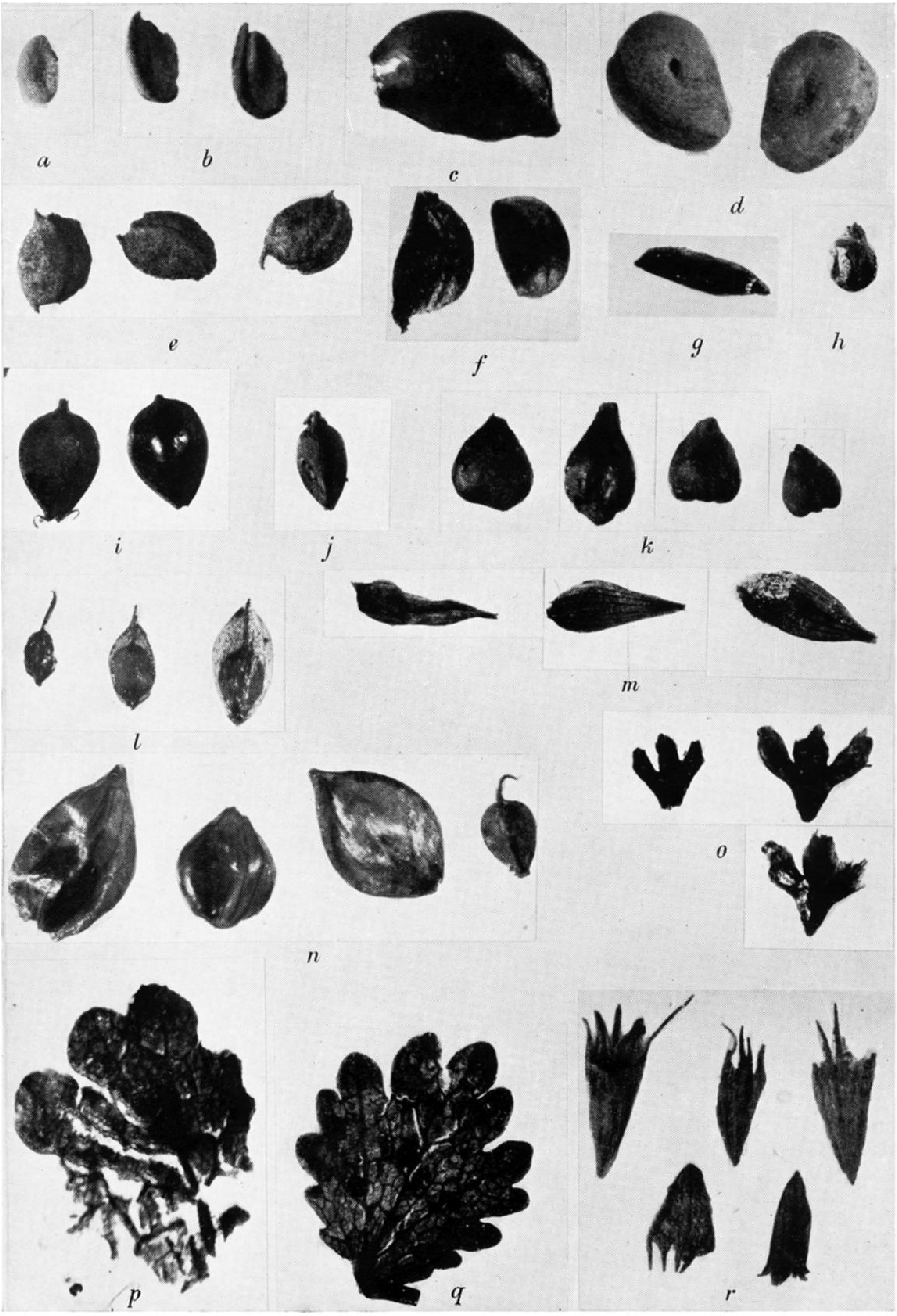

FIGURE 20

PLATE 11

FIGURE 20. *a*, *Empetrum nigrum* (1 st.); *b*, *Alisma plantago-aquatica* (2 fr.); *c*, *d*, *Potamogeton natans* (3 fr., *c*, with and *d*, without outer skin); *e*, *Potamogeton* cf. *pusillus* (3 fr.); *f*, *Potamogeton* cf. *filiformis* (2 fr.); *g*, *Naias flexilis* (1 fr.); *h*, *Eleocharis palustris* (1 fr.); *i*, *Scirpus lacustris* (2 fr.); *j*, *Scirpus* sp. (1 fr.); *k*, *Carex paniculata* (4 u.); *l*, *C. aquatilis* or *bigelowii* (2 n. + u., 1 n.); *m*, *Carex* cf. *laevigata* (3 n. + u.); *n*, *C. rostrata* (3 n. + u., 1 n.); *o*, *Betula nana* (3 cs.); *p*, *Dryas octopetala* (1 fragment); *q*, *Betula nana* (1) showing perithecia of ? *Venturia* sp.; *r*, *Armeria maritima* (5 ct.). (Magnifications of *a* to *r* × 14.)

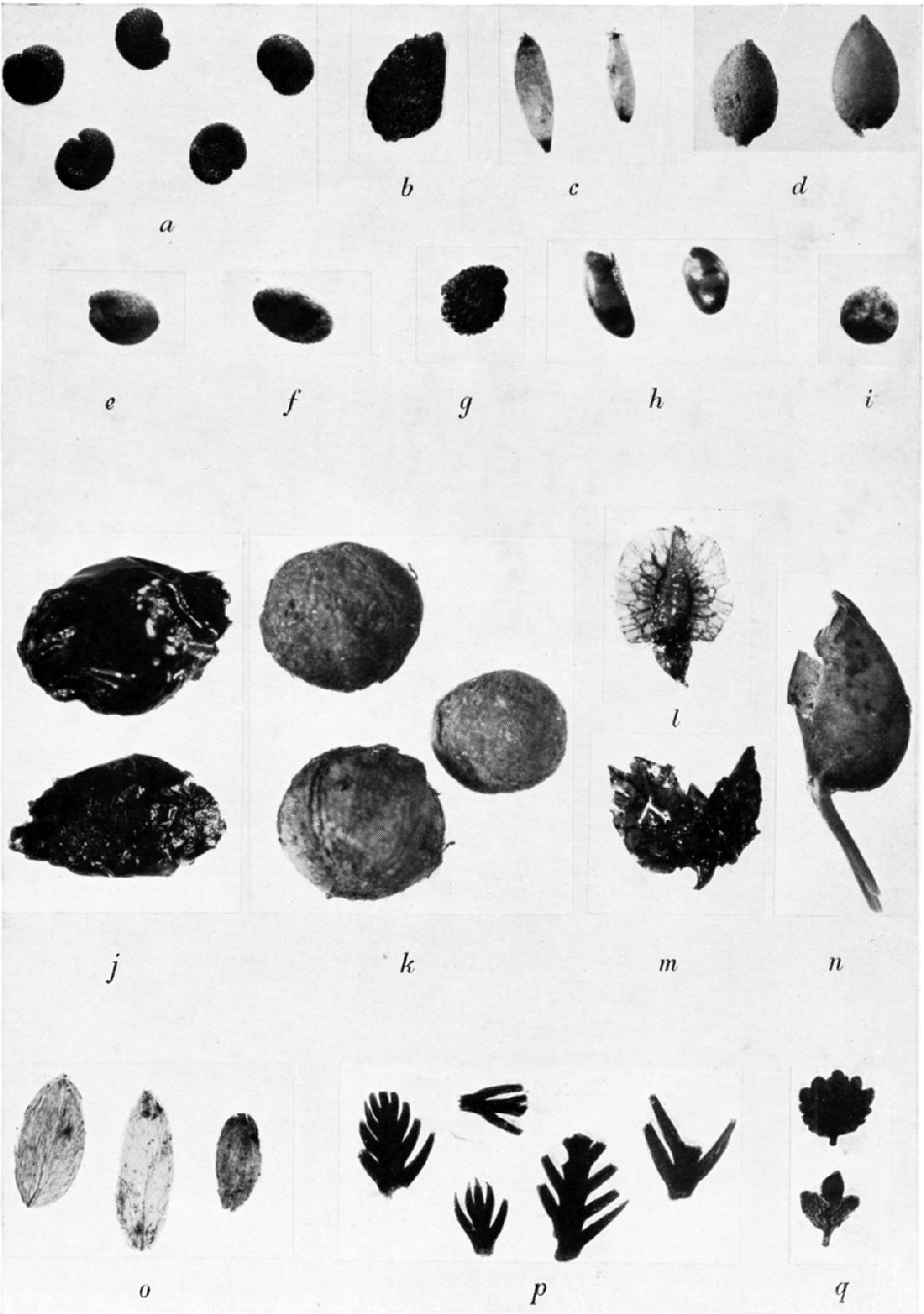

FIGURE 21

PLATE 12

FIGURE 21. *a*, *Arenaria ciliata* (5 s.); *b*, cf. *Stellaria alsine* (1 s.); *c*, *Typha* sp. (2 s.); *d*, *Urtica dioica* (2 fr.); *e*, *Rorippa islandica* (1 s.); *f*, *Saxifraga* cf. *hypnoides* (1 s.); *g*, *Cerastium vulgatum* (1 s.); *h*, *Campanula patula* or *C. rotundifolia* (2 s.); *i*, *Selaginella selaginoides* (1 m.). (Magnifications of *a* to *i*, ×26.) *j*, cf. *Sorbus* (2 fr.); *k*, *Cornus sanguinea* (3 st.); *l*, *Rumex acetosa* (1 p.); *m*, *Rumex* cf. *crispus* (1 p. + n.); *n*, *Geranium sanguineum* (1 cp.). (Magnifications of *j* to *n*, ×10.) *o*, *Draba incana* (3 r.); *p*, *Myriophyllum* sp. (5 sh.); *q*, *Betula nana* (2 l.). (Magnifications of *o* to *q*, ×7.)

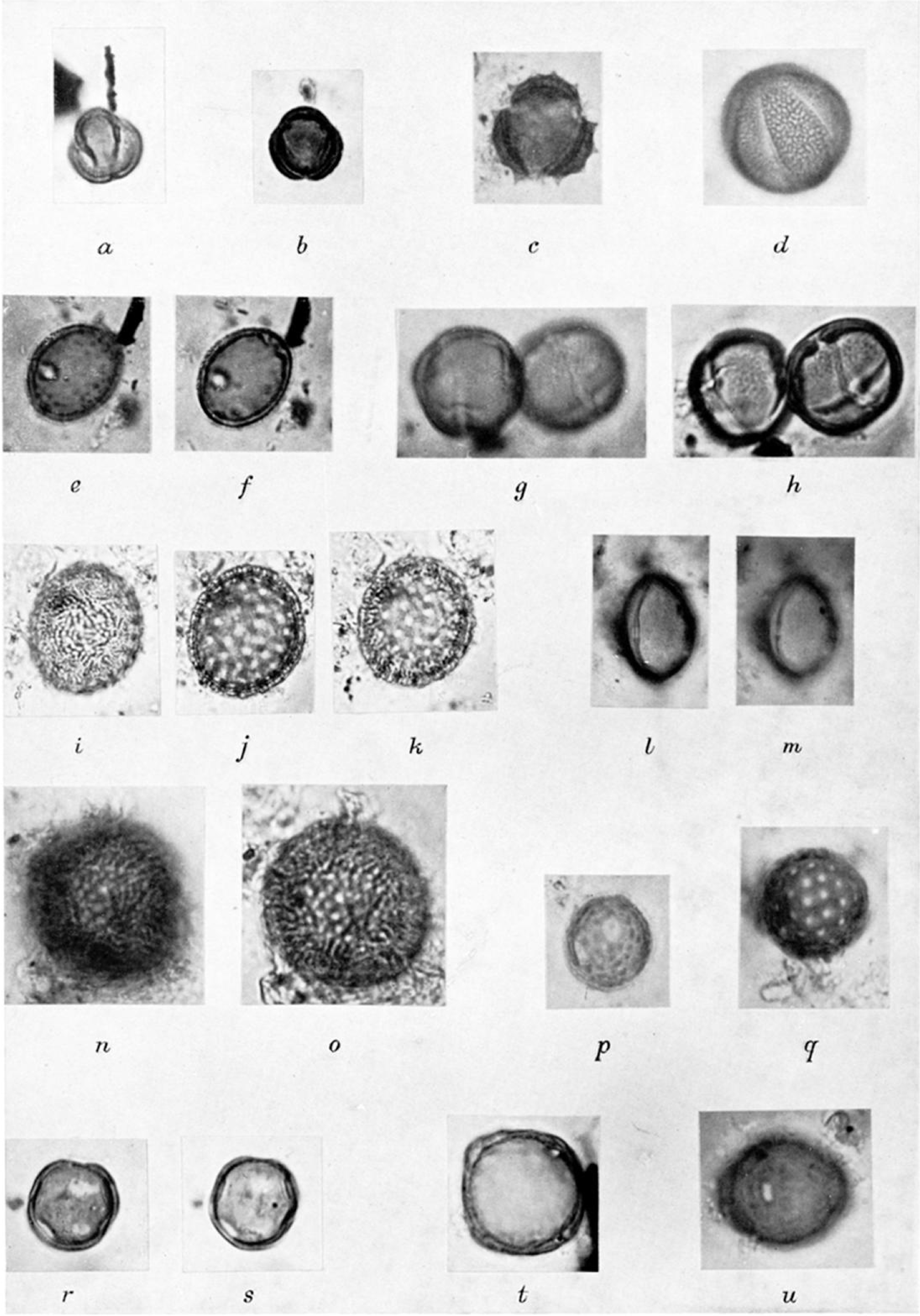

Figure 22

Plate 13

Figure 22. *a*, cf. *Filipendula* (1 gr.); *b*, *Artemisia* (1 gr.); *c*, *Matricaria* type (1 gr.); *d*, *Labiate* cf. *Thymus* (1 gr.); *e*, *f*, *Campanula* (same gr., 2 planes of focus); *g*, *h*, cf. *Lysimachia* (2 gr., 2 planes of focus); *i*, *j*, *k*, *Polemonium* (same gr., 3 planes of focus); *l*, *m*, *Helianthemum* (same gr., 2 planes of focus); *n*, *o*, *Polemonium* (same gr., 2 planes of focus); *p*, *Plantago* cf. *media* (1 gr.); *q*, *Chenopodium* (1 gr.); *r*, *s*, *Thalictrum* (same gr., 2 planes of focus); *t*, *u*, *Myriophyllum* cf. *verticillatum* (2 gr., 2 planes of focus). (Magnifications of *i* to *m* × 520; *a*, *b*, *g*, *h*, *q*, *r*, *s* × 740; *c*, *d*, *e*, *f*, *p*, *t*, *u* × 820).

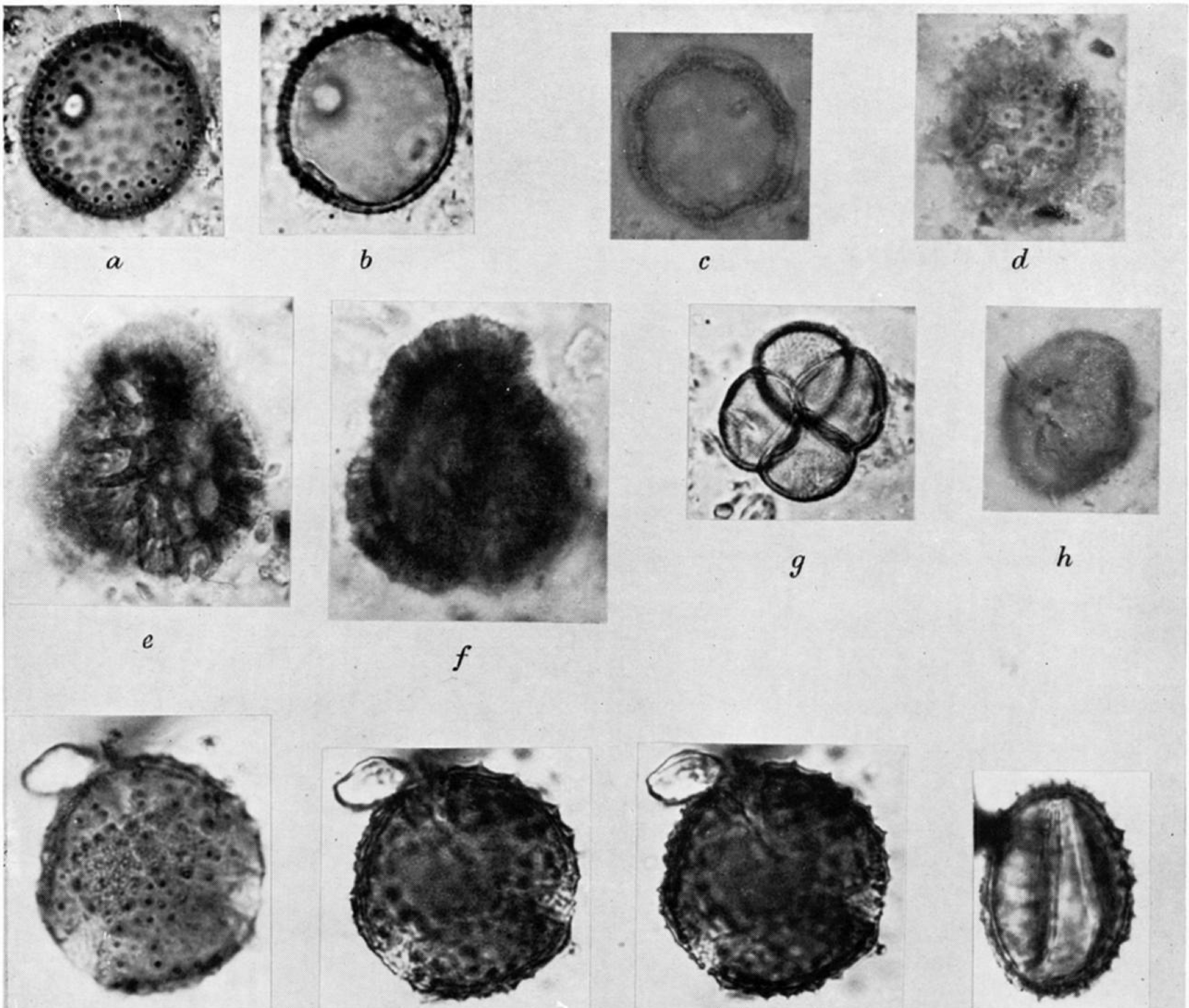

FIGURE 23

PLATE 14

FIGURE 23. *a*, *b*, *Campanula* cf. *rapunculoides* (1 gr., 2 planes of focus); *c*, *Silene* type (1 gr.); *d*, *Sonchus* type (1 gr.); *e*, *f*, *Armeria vulgaris*, type A (1 gr., 2 planes of focus); *g*, *Typha latifolia* (tetrad of 4 gr.); *h*, *Centaurea* cf. *scabiosa* (1 gr.); *i*, *j*, *k*, *l*, *Valeriana officinalis* (1 gr., 4 planes of focus); *m*, *Epilobium* (1 gr.); *n*, *o*, *Succisa pratensis* (1 gr., 2 planes of focus). (Magnifications of *a* to *h* × 740; *i* to *m* × 820; *n*, *o* × 660).