DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF BIRMINGHAM

THORNE MOORS: A PALAEOECOLOGICAL STUDY OF A BRONZE AGE SITE

A contribution to the history of the British insect fauna

by

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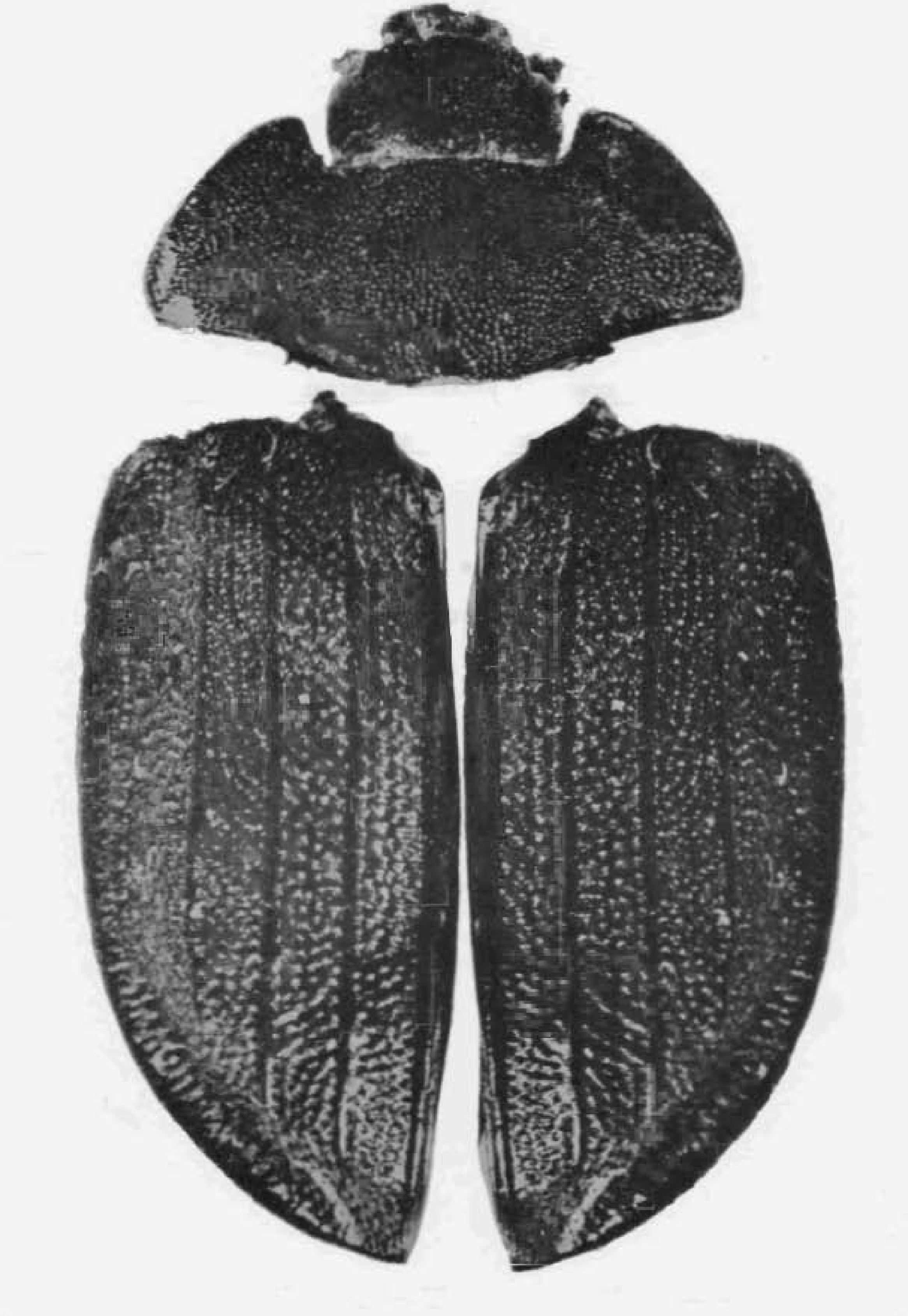

Frontispiece: Peltis grossa from pupal chamber in small birch, Thorne Moors (1972). Age of specimen c. 2,500 B.P.

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"In the Soil of all, or most of which the abovesaid 180,000 Acres of Land, of which 90,000 were drained, even in the bottom of the River of Ouse, in the bottom of the adventitious Soil of all Marshland, and round about by the skirts of the Lincolnshire Woulds unto Gainsburg, Bautry, Doncaster, Baln, Snaith and Holden, are found infinite Millions of the Roots and Bodies of Trees of all bignesses great and little, and of most of the sorts that this famous Island either formerly did, or that at present does produce, as Pitch Trees commonly called Firre, Oaks, Birch, Beech, Yew, Wirethorn, Willow Ash, & c. the Roots of all, or most of which stand in the Soil in their natural postures, as thick as ever they could grow, as the bodies of most of them lye by their proper Roots. Most of the great Trees, by all their length about a yard from their great Roots (unto which they did most evidently belong, both by their situation, and the sameness of the Wood) with their tips commonly North East, the indeed the smaller Trees lye almost every way cross those, some above, some under, a 3d part of all which are Pitch Trees, commonly called Firrs, some of which have been found of 30 yards length and above, and have been sold to make Masts and Keels for Ships of. Oaks have been found of 20, 30 and 35 yards long, yet wanting many yards at the small end".

Abraham de la Pryme, 1701.

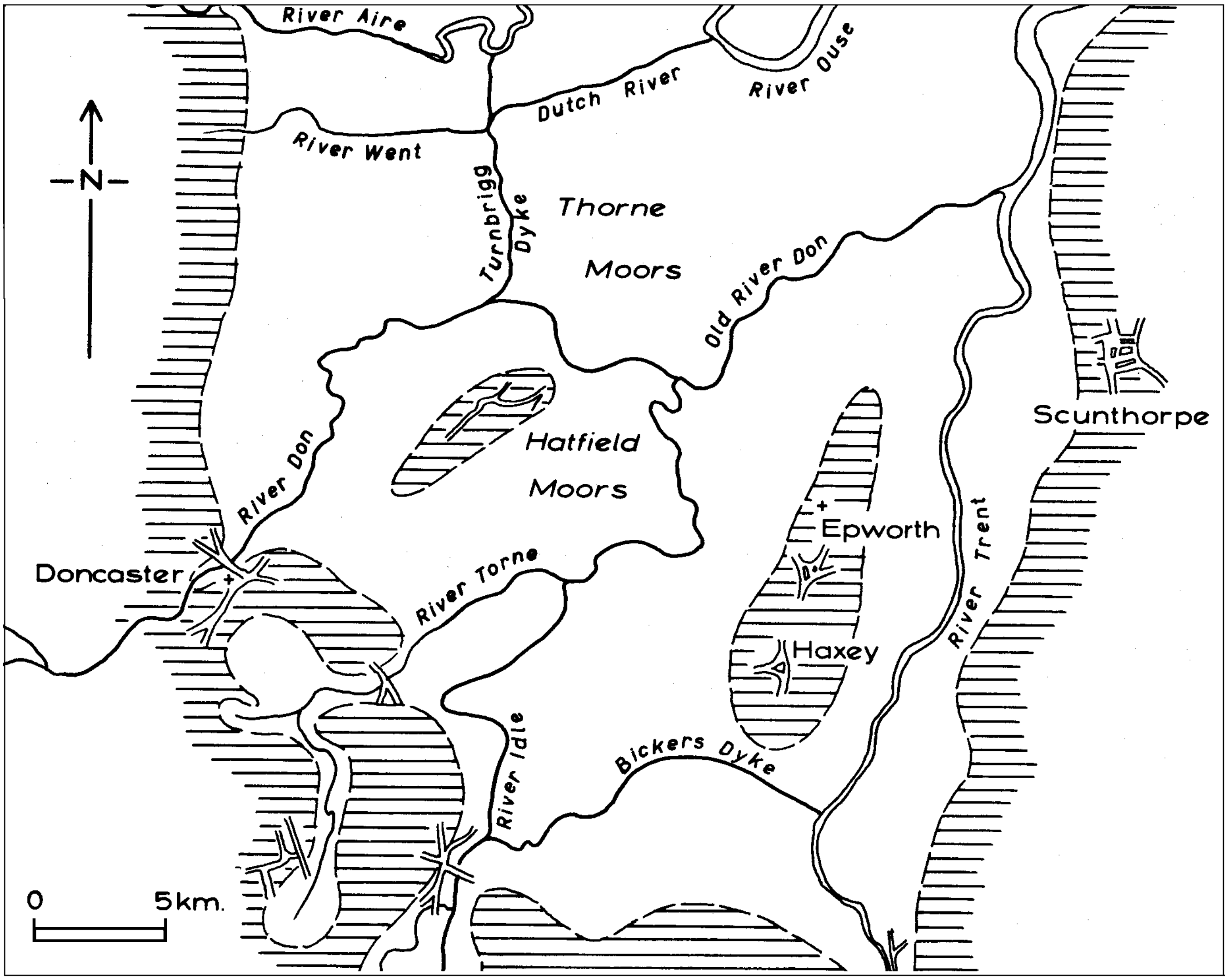

Figure 1: The Humberhead Levels, showing Thorne and Hatfield Moors and the principal rivers.

INTRODUCTION

Thorne Waste, or Moors, lies 15 km. north-east of Doncaster (Fig. 1), 7 km. south of Goole, Yorkshire. Although reduced in area by drainage and warping in the nineteenth century, it still comprises, with the contiguous bogs of Snaith and Cowick, Goole and Crowle Moors, roughly 21 sq. km. of degraded Sphagnum bog, the largest surviving area of lowland ombrophilous mire in Eastern England (Rogers & Bellamy, 1972). To the south and east, the Moors are bounded by the alluvium of the former main channel of the River Don which, until the drainage in the seventeenth century, flowed eastwards to the Trent at Adlingfleet. The alluvium of the Ouse forms the limit to the north, and westwards the deposits of the River Went can be traced beneath the Turnbrigg Dyke, a diversion of the Don of mediaeval or earlier construction (Gaunt, 1975). The present surface of the Moors, after peat cutting, lies at about 2 m. O.D., somewhat below natural high tide level on the surrounding rivers, and, as on much of Hatfield Chase, continuous pumping is necessary to avoid flooding.

Commercial peat cutting operations began in the late nineteenth century and have continued at an increasing rate until the present day, by which time upwards of 4 m. of peat have been removed from the greater part of the surface of the Moors. The primary exploitation by the Dutch used canals and barges to move the peat and these canals, now largely infilled by new growth of Sphagnum have acted as refuges for the plants of the ombrophilous mire complex, in the face of increasing drying out by drainage activities. The canals area, east of the now defunct Thorne Moorends Colliery, thus has a very diverse acid bog flora and several uncommon species from the fen environment survive on the edges of the warplands. The plant list includes such rarities as Osmunda regalis, Viola stagnina, Drosera spp., Salix repens, *Utricularia* spp., and *Andromeda polifolia*, for some of which, Thorne Moors provide the only locality in the Lowland Zone. Amongst the invertebrates the recent addition of the small Carabid *Bembidion humerale* Sturm. to the British insect list from Thorne specimens is of particular note (Crossley and Norris, 1975), but reference should also be made to the Mantis fly, *Ochthera mantis*, a fenland bug, *Anthocoris limbatus*, the Mullein Shark moth, *Cucullia vervasci* and the Erotylid beetle, *Triplax russica* (L.) (Skidmore, 1970).

The present surface of the Moors is largely dominated by birch scrub and bracken in the drier areas and cotton grass in the wetter. Clearance and peat cutting leave a dismal wetland landscape (Figs. 2 and 3) dominated by *Eriphorum* spp. The amount of habitat disturbance and speed of operation of modern, commercial peat exploitation is so great that, unless urgent conservation measures are taken, the rarer plants and animals will be unable to recolonise the cut-over areas and will become extinct. There have also been several proposals to develop the land, ranging from an airfield to the disposal of power station waste.

Figure 2: Thorne Moors : the surface before peat extraction (1975).

Figure 3: Thorne Moors : the same locality after peat cutting (1975).

PREVIOUS RESEARCH

In many ways, the Hatfield Levels provide an ideal area for palaeoecological study. Useful primary references to the flora go back to Leland (1543) and Gerarde (1597). The papers and diaries of the Reverend Abraham de la Pryme (1687-1703), vicar of Hatfield, contain numerous notes on local topography and the peat deposits. Information can also be gleaned from Stovin (1730), Peck (1815), Casson, (1829) and Stonehouse (1839). The ecology of Thorne Moors in particular, as it was and had been, was reviewed by Peacock (1920-21) and, more recently by Skidmore (1970). The threat to the Moors created by the proposed dumping of 32 million tons of pulverised fuel ash by the Central Electricity Generating Board in 1969, spurred local naturalists led by W. Bunting of Thorne, into preparing a detailed list of the flora and fauna of Thorne Moors (Bunting et al., 1969). These lists, with additions made since 1969 by the staff of Doncaster Museum (Crossley et al., 1976), provide a usefully detailed modern background on which to base any palaeoecological study of the peats and other deposits underlying the Moors.

Although Leland (1543) refers to "firre trees overthrown and coverid with bogge and mershe" (Gorham, 1953) on the Isle of Axholme, the first paper devoted to the fossil material and consideration of its origin in the Hatfield Levels was written by de la Pryme and published in the Transactions of the Royal Society in 1701. In much quoted, often misquoted passages (Tomlinson 1882; Rogers and Bellamy 1972), de la Pryme notes the occurrence of 'pitch trees', oak, birch, yew, 'wirethorn', willow, ash and hazel beneath the peat. In a later contribution he suggests that a few 'pitch trees called firre', referring to the Scots pine, lasted into the eleventh century and finally disappeared shortly before the drainage (de la Pryme, 1704).

The destruction of this forest he attributed to the Romans under Ostorius Scapula in the first century A.D. Whilst this hypothesis can now be seen as little more than antiquarian speculation, his reference to the finding of worked wood and metal work with coins of Vespasian during the cutting of a new river, presumably the Dutch River, may, in a circumstantial manner, have some bearing of the date of construction of the Turnbrigg Dike, which lies west of the Moors. As well as de la Pryme's accounts of finds of artifacts in the past and of a preserved body from Thorne Moors, Stovin (1747) records the body of a woman in an upright posture from the peat at Amcotts, near Althorpe on the Trent. Later antiquarian sources, particularly Tomlinson (1882), add little original data and consist largely of plagiaries of de la Pryme and Stovin.

Pollen analysis of the deposits of the Hatfield Levels was first carried out by Erdtman (1928), who concluded that peat formation began late in the Atlantic period (pollen zone VII(a)). His work was expanded by Pigott (1956), although the diagrams were never published. Pigott noted evidence for cereal cultivation going back to the Early Bronze Age (zone VII(b)) from Thorne Moors and equated the silts and clays beneath the peat with the transgressive, Late Neolithic 'Buttery Clay' of the Cambridgeshire Fens (Godwin, 1940). Subsequent research has shown that these deposits belong to the terminal phases of the Last Glaciation (Gaunt, 1974). Pigott, however, was correct in assigning the peats of Thorne Moors to the upper part of pollen zone VII(b) and VIII. The dangers of assuming contemporaneity between two adjacent bogs are illustrated by Rogers and Bellamy's (1972) use of Smith's (1958) data from Hatfield Moors in their discussion of Thorne. Hatfield Moors is separated from Thorne by only 3 km. of alluvium and Late Glacial sands yet peat deposition seems to have begun there considerably earlier, during zone VII(a) (op. cit.). Smith's work provided useful background to the archaeology of the region and his interpretation of the evidence, showing increasing agricultural activity through the Iron Age with a maximum in the Roman period, has been amply confirmed by recent aerial photography and excavations at Dunsville, 5 km. west of Hatfield (Magilton, 1978), and Sandtoft, between the two moors (Samuels and Buckland, 1978) Smith (op. cit.) also refers to unpublished diagrams by Clapham. In a similar doctoral thesis for the University of Cambridge, Turner (1960) prepared detailed diagrams from Thorne Moors and parts of these have been published in her work on forest clearance (Turner, 1962; 1965). The provision of 14_C dates considerably enhanced the value of these pollen diagrams by providing a firm chronological framework. Samples from near the base of the succession gave dates of 3,160±115 B.P. (Q.481) and 2,931±115 B.P. (Q.462) and these correlate well with those obtained during the course of this research. Also relevant to the interpretation of the Thorne Moors sites is the remapping of the Drift deposits of the Doncaster and Goole districts for the Institute of Geological Sciences, principally by Gaunt (Gaunt et al., 1971; Gaunt, 1974; 1975).

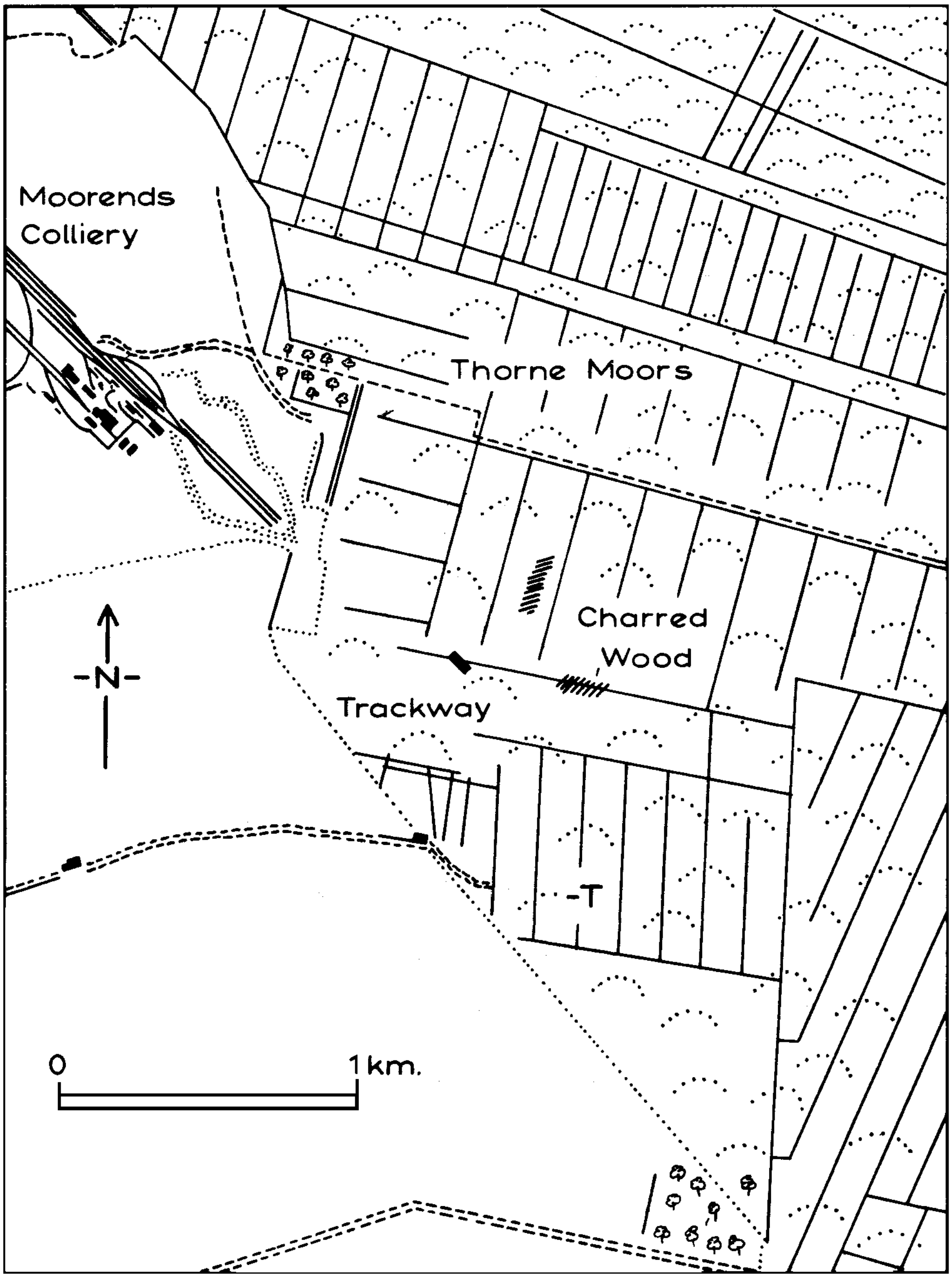

Figure 4: Thorne Moors : location of sites examined.

THE ARCHAEOLOGICAL EVIDENCE

During October 1971, William Bunting, a local naturalist with considerable knowledge of the Moors, reported to both Doncaster Museum and the author that several large trees with charred surfaces had been thrown up during the cutting of a major new drain across the Moors, through the Canals region and draining into Thorne Waste Drain, (Fig. 4) flowing south-eastwards along the eastern edge of the warplands of Tween Bridge Moors, towards Elmhirst Cottage. Bunting had reported similar, more extensive finds around Medge Hall, at the southern tip of the Moors in 1949, but no archaeologist had followed up the finds and they passed unnoticed except in the local press (Yorks. Evening News, 6.1.49). In Doncaster Museum, there exists correspondence with Leslie Armstrong about several rather undiagnostic flints from the region of Elmhirst Cottage, which suggest that these now lost pieces might have been of Bronze Age date. A local farmer, John Birtwhistle, had also recovered a few artifacts, including a mesolithic tranchet axe and a perforated stone battle axe (Dolby, 1969) from the sand ridge on which Whitaker's Plantation stood, between Thorne and Nun Moors. All these finds had apparently come from beneath the peat. In view of this material, de la Pryme's account (1701) and Turner's (1965) pollen analytical evidence from the peat for small, temporary clearances in local woodland during the Late Bronze Age, it was decided that Bunting's findings warranted investigation. The lengths of new drain along which the burnt timbers occurred were recorded and samples taken for both faunal analysis and radiocarbon dating. On a subsequent visit, three large, apparently spilt timbers were noted lying side by side (Fig. 6) close to the base of the peat and a very limited excavation, undertaken principally to recover samples, during June 1972, revealed a short stretch of a rough trackway, constructed of timbers of various sizes, oriented approximately south east to north west (Fig. 5). Since the level of the structure lay largely below that of current peat extraction operations and resources were limited, it was decided that no further field work was warranted on the site and research was restricted to the examination of soil and wood samples and the preparation of an outline pollen diagram.

The principal area in which burnt timbers occurred lay between the second and third canal, c. 400 m. south of the footpath which runs out onto the Moors parallel with Cottage Dike, virtually due east of the end of the spoil heap of Moorends Colliery (site centred on N.G.R. SE 721153). Along this stretch of the new drain, the mechanical grab had torn up many pieces of tree trunks, several of which had the surfaces charred to depths in excess of 1 cm. The bark was missing from these fragments, the largest of which were of the order of 2 m. long and 0.5 m. across. The level of water in the drain made closer examination of the trees in situ difficult and several complete, apparently unburnt trunks, which the grab had failed to cut through, further impounded the drainage. It was apparent, however, that all the large trees lay close to or at the base of the peat, here about 1.75 m. thick, and the upright stumps of several were still clearly rooted in the underlying deposits. Excavation was impractical and, in any case, on a limited scale, liable to yield little additional information since the burnt fragments were scattered over about 50 m. of the length of the dyke. One of the superficially charred pieces of tree was recovered and the charcoal stripped from the surface and submitted for a radiocarbon date. The wood, subsequently identified as oak, provided a date of 3080±90 B.P. (Birm. 336).

The second area with burnt timbers lay in a drain out at right angles to the first area, roughly 400 m. further south (centre of area

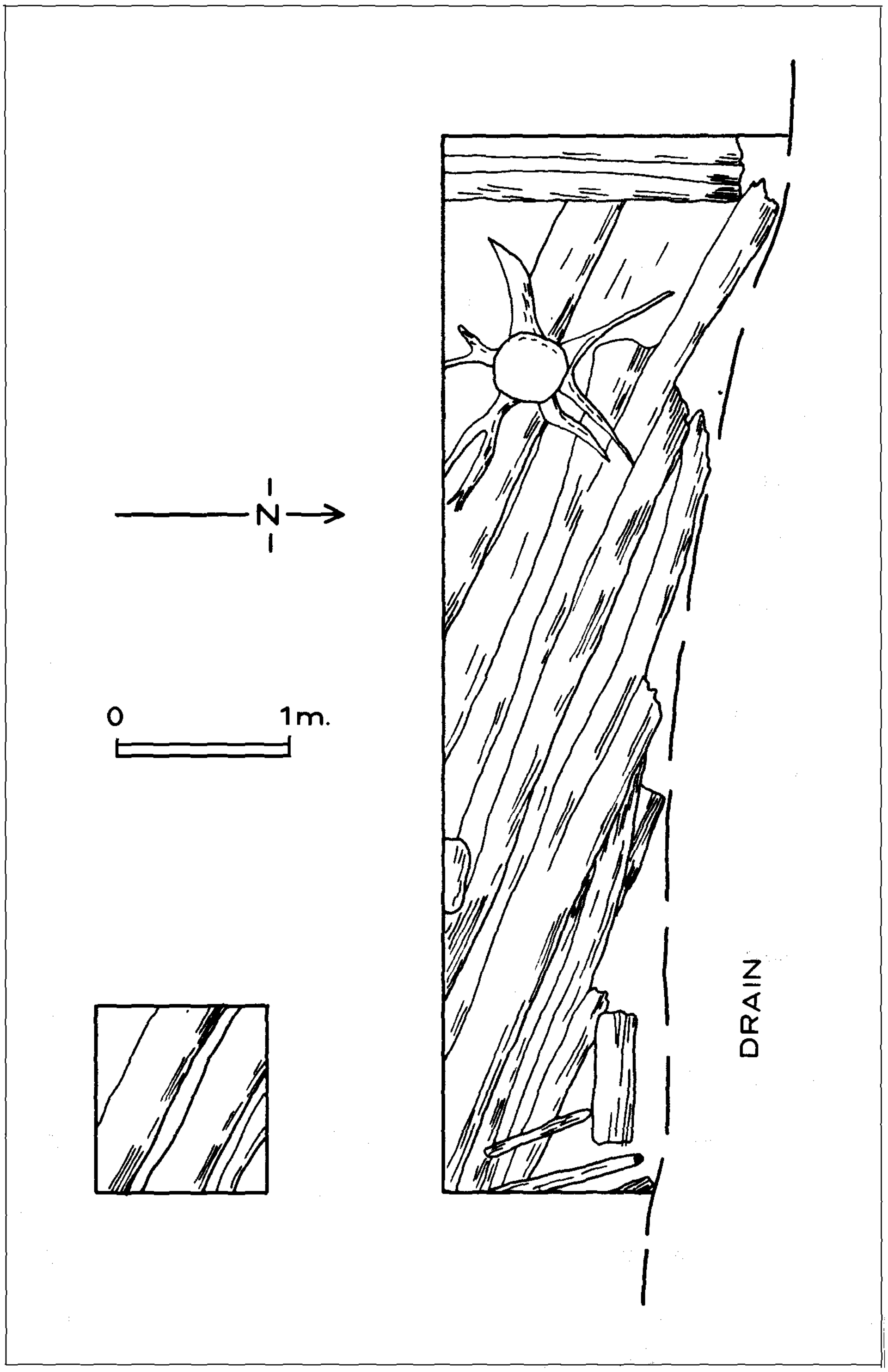

Figure 5:. Thorne Moors : plan of trackway (1972).

at N.G.R. SE 722149). This cut produced fewer obvious fragments of burnt tree trunks and these were dispersed along about 100 m. of drain. Examination of the deposit in situ was again almost impossible but it was evident that the material came from the base of the peat. It seems probable that both areas relate to the same or two closely related episodes but, because of the alignments of the new drain cuts and the disturbance between to a depth of at least 3 m. by one of the late nineteenth century canal cuts, the two sections cannot be directly stratigraphically related. It is tempting to relate these fires to the first of Turner's (1965) landnam horizons, dated to before 3160±115 B.P. or 2931±115 B.P. (Q481-482), but recent work on the incidence of natural forest fires in North America (Brown and Davis, 1973) urges caution. Turner's pollen core site lies less than 800 m. south of the second locality and the sequence may go back sufficiently far to record this event, but the difference in altitude between the two sites can only be a few centimetres and tree growth on both sites must have ceased due to waterlogging at about the same time The preservation of organic deposits must postdate the actual burning since it is improbable that fire would run easily through a moribund forest standing in water and fen peat. It is more probable that Turner's diagram relates to clearance on the marginally higher sand and alluvium on either side of the former course of the River Don across the High Levels towards Sandtoft, south of Thorne Moors. Evans (1975) has commented that there is little evidence for the use of burning for clearances from the British Isles, the only example which he is able to cite being from ApSimon's excavations at Ballynagilly in Country Tyrone, Ireland. Recent 14C dates, however, suggest that Dimbleby's apparently Neolithic clearance phase, represented by charcoal in the soil profile at White Gill on the Yorkshire Moors

(Dimbleby, 1962), is in fact Late Bronze Age (Jacobi, pers. comm.). It may also be questioned whether one would expect charcoal from landnam in the deposits from which pollen diagrams are most frequently constructed since these largely organic, waterlogged deposits would not be suitable for agriculture and charcoal would only arrive there by redeposition, or the chance firing of the bog surface, a not infrequent occurrence at the present day. Smith (1958) obtained charcoal from samples close to the zone VII(a)/(b) boundary on Hatfield Moors.

Westwards along the new drain, at about 400 m. from its confluence with Thorne Waste Drain, the previously mentioned, possible trackway was noted protruding from the south section of the dyke (at N.G.R. SE 7206151). The disturbance of the north bank made it evident that the grab had dragged similar timbers from that side and these lay on the spoil heap. Although timber is frequent at the base of the peat, the attitude of these pieces was suggestive of a man-made structure and it was decided to excavate a short section to investigate this. An area 6 m. long by 1 m. deep was cut back from the ditch side and a further 1 m. square cut beyond it to ascertain any alignment. The peat, here surviving to a maximum depth of 1.0 m., was removed down to the surface of the timbers and these were roughly cleaned up. Seven split timbers were located lying side by side, providing a slightly undulating surface, remaining to a maximum width of about 3 m. (Fig. 5). The surface of the wood was poorly preserved, largely reduced to a soft amorphous structure, and some of the timbers had been split and partially pulled out of place by the drag. Several smaller pieces and thin trunks lay at various angles, in a horizontal position, over the main surface. There was no evidence in the small area examined for the extensive use of coppiced timber which has been shown to have been used in the construction of some of the Somerset trackways

Figure 6. Thorne Moors : trackway timbers exposed in new dyke section (1972).

Figure 7. Thorne Moors : the trackway and peat succession (1977).

(Rackham, 1977) and most of the timbers clearly came from the trunks of trees which were moribund or dead before incorporation in the structure. Although the outer surface of the wood remained, the bark was absent from most and several were obviously extensively bored by insects. Some lengths of birch, however, retained the bark and the bark was removed from a small pine, about 15 cm. in diameter, lying across the larger timbers, to provide the sample for the radiocarbon data of 2980±110 B.P. (Birm. 358). Although several timbers appeared to show oblique chop mark none was sufficiently convincing to be wholly acceptable and no artifacts were recovered from the site. Peat cutting over the area south of this feature had penetrated to within 30 cm. of the horizon but no further timbers were apparent. Despite the absence of corroborative material and the limited nature of the excavation, there can be little doubt that the structure represents part of a crude trackway, orientated roughly north west to south east. The timbers may only represent a minor feature, across a marginally damper area, but, on this alignment, such a track could have connected the slightly higher and drier areas of Pighill Moors, where Moorends Colliery now stands, and Medge Hall, although the actual topography beneath peat and warp is difficult to ascertain. Similar trackways are widely known, particularly in the Somerset Levels (Coles and Hibbert, 1975). The irregular nature of the excavated fragment may, however, be misleading. The Neolithic Sweet Track on the Somerset Levels (op. cit.) has a complex irregular deposit of timbers put down into an open water part of the bog to support a level single plank walkway, and a similar upper structure may not have survived at Thorne. In the Fens, mediaeval roads were kept in repair by means of bundles of rushes and reeds, a method still used into this century to deal with thick, black peat mud (Porter, 1969), and the actual surface may not have been preserved at Thorne, although such material might be expected to be reflected in the insect faunas. The whole structure and concept is reminiscent of how Stephenson coped with Chat Moss in providing a firm footing for the Liverpool and Manchester Railway (Smiles, 1854), and his bundles of brushwood would no doubt look very similar and disordered if excavated. No other trackway has yet been recorded from the Hatfield Levels but a much better constructed one, with squared timbers, is recorded from the Ancholme Valley at Brigg in North Lincolnshire belonging to the end of the late Bronze Age or Early Iron Age (Dudley, 1949; Smith, 1958). The two carbon dates, supplemented by a third of 3260±100 B.P. (Birm. 335) from a rootlet of birch seated on the underlying deposits, fall towards the end of the Middle Bronze Age (Burgess, 1974).

There are few artifacts of the last two phases of the Bronze Age from Hatfield Chase and only a few sherds from a site near Crowle of the succeeding Iron Age. No finds of pottery occur closer than the collared urn from Doncaster (Manby, 1973) and there are, as a result, no proven occupation sites. No securely localised bronze implement can be related to any site catchment orbit which might be drawn to include the trackway site, based upon the 5 km. radius suggested as the mean maximum distance from the settlement site for a sedentary, primitive agricultural community (Chisholm, 1968), but since the feature does not relate directly to land exploitation, the trackway could connect two more distant settlements. Amongst the incompletely localised material, however, an adze palstave comes from the Sandtoft region (Davey, 1973), an area shown to have been extensively cultivated at least by the Roman period (Samuels and Buckland, 1978), and a palstave is recorded from Moorends, 2km. to the west of the site. Other Middle Bronze Age finds from the Chase include a palstave from Misson, a rapier from Austerfield and a looped, socketed spearhead from Hatfield. A gold torc from Low Burnham, on the Isle of Axholme, is in the British Museum. From Finningley come two Late Bronze Age socketed axes and a rivetted, socketed spearhead; a socketed axe is known from Hatfield Woodhouse and a basal looped, socketed spearhead has been found near Hatfield. A hoard of Middle Bronze Age equipment was alleged to have been found in 1747 near Crowle (Dudley, 1949), but a recent re-examination of sources suggests that the hoard in fact comes from Burringham on the otherside of the Trent (Knowles, pers. comm.). A further hoard was found during the construction of Keadby Bridge over the Trent early this century (Davey, 1973). It is evident that much must remain buried beneath the peat.

THE GEOLOGICAL SEQUENCE

In all the sections exposed in the ditch sections, about one metre of peat remained over a gently undulating surface of poorly sorted, light grey sandy silt. Up to 0.5 m. of these silts were exposed in the base of the dykes and, although much disturbed, in some cases by tree roots surviving from the overlying brushwood peat horizon, some traces of thin, horizontal bedding was evident. Occasional pellets of red marl of Permo-Triassic origin occurred and, from one section, a large, angular block of Millstone Grit, weighing c. 15 kg., was recovered. At Sandtoft (SE 734090), a more complete section through these deposits showed a similar leached silt horizon, underlain by chocolate-brown laminated clays, the 'Silt and Clay' of the '25-Foot Drift' of the geological maps (Gaunt et al., 1971). The presence of a block of coal, 15 cm. by 15 cm. by 10 cm. in the layer of Sandtoft, with the gritstone erratic from Thorne Moors, implies transport by ice, probably in icebergs floating in the proglacial Lake Humber, and these strata are interpreted as marking the terminal phase of the lake (op. cit. ; Gaunt, 1976), dated to before 11,100 B.P. The correlation between the two localities, however, is not irrevocable. A thin, compressed peat, overlying the silts at Sandtoft, produced a restricted insect fauna, yet to be examined in detail, which suggested an open *Carex* marsh environment with no trees in the immediate vicinity. This probably belongs to pollen zone I of the Late Glacial (Coope, pers. comm.). Since this layer is cut through by an at least three metre thick succession of silts filling the old bed of the river Idle and is overlain by nearly two metres of thinly bedded sands, it is tempting to relate these beds to the 'Older fluvial depositional phase' of Gaunt et al. (1971) and to correlate the thin bedded sands with similar deposits, mapped as 'older Blown Sand' on the Doncaster sheet, north of the old course of the Don, on the southern margin of Thorne Moors. In support of this interpretation, it can be noted that brown, silty clays were located by augering at the western tip of the Moors, east of the colliery (SE 711161).

The soil horizon which underlies the Flandrian peat deposit is of some interest since rarely do the silts of the '25-Foot Drift' preserve a soil profile at the present surface. To the east, extensive outcrops of Cover Sands, in part derived from these deposits, (Buckland, in press), are strongly podzolised (Straw, 1969) and, from the truncated profiles examined at the surface on the Chase, it is apparent that the more silty parts of the Lake Humber sediments would also bear podzols at the present day and the Thorne Moors substrate, where the organic component has been preserved by waterlogging, shows an incompletely developed podzol. The rising water table, which has resulted in this preservation, however, complicates interpretation. No iron pan or zone of iron deposition occurs in the profile and the interface between peat and silt is represented by a <u>moder</u> rather than a <u>mor</u> humus with some intermixing of silt and organic component, presumably by arthropod rather than worm action. Pollen from the upper few centimetres of silt was poorly preserved but showed a mixing of the woodland spectrum with a few grains of juniper, presumably surviving from initial deposition during the Late Glacial or pollen zone IV. The survival of pollen through the period of afforestation in the early post-Glacial into the Bronze Age is surprising and suggests that the soil, at least in this locality, had always been deficient in bases, leaching perhaps having occurred during a period of heavy snowfall and, consequent high runoff in pollen zone III. Despite the enascent podzol, when peat deposition began, it was in a fen rather than acid bog environment. The terminal phase of the last glaciation was marked by deep incision of water courses towards a sea level of at least - 16m. O.D. (Gaunt & Tooley, 1974), and organic deposits are therefore lacking until the water table became sufficiently high to facilitate preservation. On Hatfield Moors, peat deposition began during pollen zone VII(a) (Smith, 1958) and at Thorne Waterside, sediments in the channel of the old Don have been dated to 4230±100 B.P. (Birm 359). On Thorne Moors, although there may be pockets of slightly earlier deposition, a brushwood peat had begun to form by c. 3260±100 B.P. (Birm 335), with fen peat giving way to more acid *Sphagnum* peat and the inception of the raised bog shortly after the trackway horizon of c. 2980±110 B.P. (Birm. 358). In the section at the trackway site, 30 cm. of brushwood peat and trackway are succeeded by 70 cm. of *Sphagnum* peat, the upper 20 cm. of which is well humified and pollen is not preserved in it.

THE SAMPLES

From an examination of timber fragments thrown out during the cutting of the new ditches and the excavation of the trackway, it became apparent that insect remains were particularly well preserved in the brushwood peat at the base of the succession and several near complete individuals were recovered from within wood samples. 5 kg. samples were taken out of the dark brown, well humified peat from between the timbers of the trackway (Sample 2), and from the rather mixed silt and humified peat horizon below the trackway, which represented the moder humus horizon of the soil (Sample 1). A further 10 kg. were taken from the horizon at the base of the Sphagnum peat, roughly 10 cm. above the trackway (Sample 5). Definition of the primary horizon and collection of uncontaminated samples from the two areas, which produced charred timbers were impractical because of the water level in the dykes, and it was decided that more useful data could be obtained from the examination of the fauna associated with one of the stools of large trees remaining in situ at the base of the peat. A large stool, subsequently identified as oak, was chosen, lying on the west side of the new north-south dyke close to its junction with the east-west one (N.G.R. 725151) between the two areas which produced the burnt wood. This stump, nearly 2 m. in diameter, had well developed buttressing and the peat lying between two of these was cleaned off and sampled in two spits, each weighing c. 5 kg. (the upper, Sample 4 and the lower, Sample 3). Additional material was recovered by splitting wood samples and washing out rot-holes in timbers from various points along the new cut and this material is included in column 6 in the lists of insect remains (table 1). In order to relate the local environment to the more regional picture presented by previous palynological work, pollen counts were prepared by Dr. M. Herbert-Smith utilising samples taken at 10 m. intervals from the present ground surface down through the trackway into the underlying silt deposits, to a total depth of 1.5 m. (pollen samples 1-15), from which the diagram (fig. 8) and tables were drawn up. Sample 1 for insect remains comes from the same horizon as pollen sample 4, the trackway (insect sample 2) is equivalent to pollen sample 6 (fig. 8) and insect sample 5 lies around pollen sample 8.

The samples recovered for insect remains were disaggregated over a 300 micron sieve and the material retained on the sieve placed in a bowl and treated with paraffin (kerosene) (Coope & Osborne, 1968).

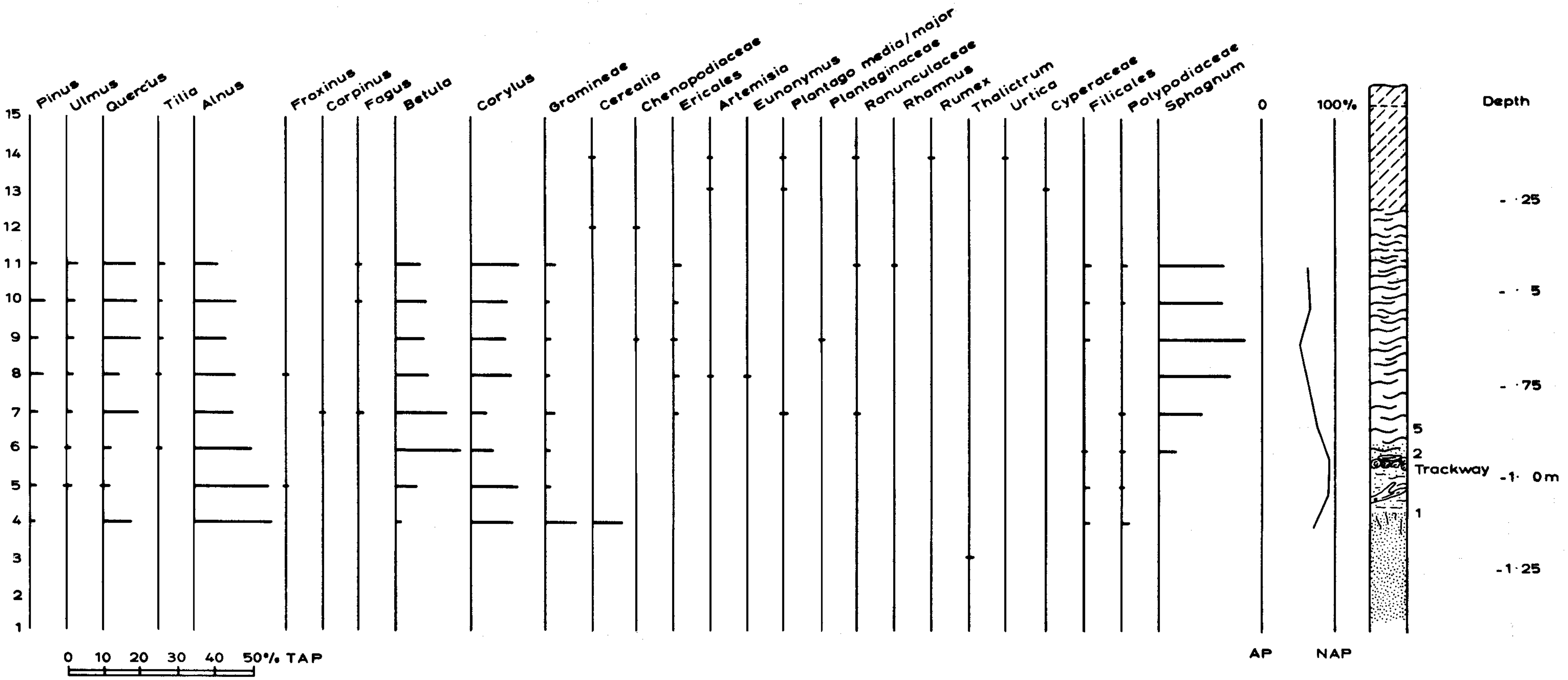

Figure 8: Thorne Moors : outline pollen diagram from the trackway site (counts by M. Herbert-Smith).

Table 1

Insect Remains from Thorne Moors

	1.	2.	3.	4.	5.	6.
Dermaptera						
Forficulidae						
Forficula auricularia L.	-	-	1	-	-	-
Thysanoptera						
Phlaeothripidae						
Megathrips lativentris (Hieg.)	-	-	-	1	-	-
Hemiptera						
Heteroptera						
Cynidae						
Sehirus biguttatus (L.)	-	-	1	-	-	-
Lygaeidae						
Drymus sylvaticus (F.)/*ryei* Doug. & Scott.	-	-	2	5	-	1
D. brunneus (Sahl.)	2	4	2	-	-	-
Drymus sp. (? *latus* Doug. & Scott.)	-	1	2	1	-	-
Tingidae						
Acalypta parvula (Fall.)	-	-	-	1	-	-
Anthocoridae						
Anthocoris sp.	-	-	-	1	-	-
Miridae						
Globiceps sp.	-	-	-	1	-	-
Saldidae						
Saldula sp.	-	-	-	2	-	-
Chartoscirta cocksi (Curt.)	-	-	1	-	-	-
Chartoscirta sp.	-	2	1	-	-	-

	1.	2.	3.	4.	5.	6.
Corixidae						
indet.	not counted					
Homoptera						
indet.	not counted					
Ulopidae						
Ulopa reticulata (F.)	-	-	-	-	1	-
Cixiidae						
Cixius nervosus (L.)	-	-	-	1	-	-
Megaloptera						
Sialidae						
Sialis sp.	-	-	-	1	-	-
Raphidiidae						
Raphidia notata F.	-	1	-	-	-	-
Coleoptera						
Carabidae						
Leistus rufescens (F.)	-	1	1	1	-	-
Nebria salina Fairm. & Lab.	-	-	-	1	-	-
Dyschirius globosus (Hbst.)	1	-	-	-	-	-
Trechus quadristriatus (Schr.)/*obtusus* Er.	-	-	-	1	-	-
T. secalis (Payk.)	-	1	-	-	-	-
Bembidion doris (Panzer)	1	2	1	-	-	-
Bembidion sp.	-	-	1	-	-	-
Stomis pumicatus (Panz.)	-	1	-	-	-	-
Pterostichus minor (Gyll.)	-	13	-	-	-	-
P. nigrita (Payk.)	-	5	2	3	1	-
P. strenuus (Panz.)	-	9	-	-	2	-
Pterostichus sp.	-	-	-	1	-	-

	1.	2.	3.	4.	5.	6.
Agonum fuliginosum (Panz.)	-	11	3	2	-	-
A. gracile (Sturm.)/_thoreyi_ Dej.	-	4	-	-	-	-
A. livens (Gyll.)	-	1	-	-	-	-
A. obscurum (Hbst.)	-	2	-	-	-	-
Agonum sp.	-	-	1	-	-	1
Amara (?) _familiaris_ (Duft.)	-	1	-	-	-	-
Trichocellus cognatus (Gyll.)	-	-	-	1	-	-
T. placidus (Gyll.)	-	1	-	-	-	-
B. harpalinus (Serv.)	-	-	1	2	-	-
Bradycellus ruficollis (Steph.)	-	1	2	14	-	-
Rhysodidae						
*_Rhysodes sulcatus_ F.	-	-	-	1	-	-
Haliplidae						
Haliplus sp.	-	1	-	1	-	-
Dytiscidae						
Hygrotus inaequalis (F.)	-	2	-	-	-	-
Hydroporus dorsalis (F.)	-	1	-	-	-	-
H. memnonius Nic.	-	1	-	2	-	-
H. neglectus Schaum.	-	-	-	2	-	-
H. palustris (L.)	-	1	-	-	-	-
H. rufifrons (Müll.)	-	1	-	-	-	-
H. scalesianus Steph.	-	17	-	-	-	-
Hydroporus spp.	-	51	19	20	2	3
Copelatus haemorrhoidalis (F.)	-	1	1	-	-	-
Agabus bipustulatus (L.)	-	2	1	1	-	-
A. congener (Thun.)	-	-	-	1	-	-
A. paludosus (F.)	-	1	-	-	-	-
A. unguicularis Thoms.	-	2	-	-	-	-

	1.	2.	3.	4.	5.	6.
A. prob. unguicularis Thoms.	-	17	4	2	-	-
Ilybius guttiger (Gyll.)	-	1	-	-	-	-
I. (?) quadriguttatus (Lac. & Bois.)	-	-	-	1	-	-
Ilybius sp.	-	4	-	-	-	-
Rantus sp.	-	-	-	-	-	2
Colymbetes fuscus (L.)	-	1	-	-	-	-
Hydrophilidae						
Hydrochus brevis (Hbst.)	-	6	-	-	-	-
Helophorus aquaticus (L.)/grandis Ill.	-	1	-	-	-	-
H. flavipes (F.)/obscurus Muls.	-	-	-	1	-	-
H. granularis (L.)	-	1	-	-	-	-
H. minutus F.	-	-	-	1	-	-
H. (?) obscurus Muls.	-	-	-	1	-	-
Helophorus sp.	-	1	-	1	-	-
Coelostoma orbiculare (F.)	-	2	1	1	4	-
Cerycon convexiusculus Steph.	-	22	1	1	-	-
Cercyon sp.	1	-	-	-	-	-
Megasternum obscurum (Marsh.)	1	1	13	1	-	-
Hydrobius fuscipes (L.)	-	5	1	1	-	-
Anacaena globulus (Payk.)	-	28	1	9	-	2
Helochares lividus (Forst.)	-	-	1	-	-	-
Enochrus coarctatus (Gredl.)	-	3	6	6	-	-
E. melanocephalus (Ol.)/testaceus (F.)	-	-	1	-	-	-
Enochrus sp.	-	-	1	-	-	1
Hydraenidae						
Ochthebius sp.	-	1	-	2	-	-
Hydraena riparia Kug.	-	3	-	-	-	-

	1.	2.	3.	4.	5.	6.
Limnebius nitidus (Marsh.)	-	-	-	1	-	-
L. truncatellus (Thun.)/*papposus* Muls.	-	1	-	-	-	-
Histeridae						
Abraeus globosus (Hoff.)	-	1	-	-	-	-
Paromalus parallelipipedus (Hbst.)	-	1	-	-	-	-
Ptiliidae						
Ptenidium nitidum (Heer.)	-	-	-	1	-	-
Ptenidium spp.	-	-	3	-	-	-
(?) *Pteryx suturalis* (Heer.)	-	-	1	-	-	-
Acrotrichis prob. *intermedia* (Gill.)	1	1	7	1	-	-
Leiodidae						
Agathidium atrum (Payk.)	-	-	1	1	-	-
A. seminulum (L.)	1	1	-	-	-	-
A. nigrinum Sturm.	-	-	1	-	-	-
Agathidium sp.	-	2	1	-	-	-
Choleva sp.	-	-	4	1	-	-
Catops sp.	-	-	1	-	-	-
Silphidae						
Silpha atrata (L.)	1	2	2	-	-	-
Scydmenidae						
Neuraphes sp.	-	-	1	-	-	-
Stenichnus collaris (Müll.	-	-	-	1	-	-
Stenichnus spp.	-	-	3	1	-	-
Staphylinidae						
Metopsia retusa (Steph.)	-	-	1	-	-	-
Proteinus ovalis Steph.	-	3	1	3	-	-
P. atomarius Erich.	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
Anthobium unicolor (Marsh.)	-	-	1	-	-	-
Olophrum fuscum (Grav.)	-	2	-	-	-	-
O. piceum (Gyll.)	-	9	9	4	-	-
Acidota crenata (F.)	1	1	1	-	-	-
Lesteva heeri Fauv.	-	8	-	5	-	-
Dropephylla ioptera (Steph.)	-	2	1	-	-	-
D. vilis (Erich.)	-	2	2	-	-	-
Xylodromus depressus (Grav.)	-	10	-	-	-	-
Syntomium aeneum (Müll.)	-	-	-	3	-	-
Anotylus rugosus (F.)	-	-	1	-	-	-
A. sculpturatus (Grav.)/*mutator*(Lohse.)	-	1	-	1	-	-
S. boops Ljungh	-	1	-	-	-	-
S. cicindeliodes (Schal.)	-	1	-	-	-	-
S. juno (Payk.)	-	5	-	-	-	-
Stenus nitidiusculus Steph.	-	3	1	1	-	-
Stenus spp.	1	26	3	2	-	-
Euaesthetus ruficapillus Bois. & Lac.	-	1	-	-	-	-
Paederus riparius (L.)	-	1	2	1	-	-
Lathrobium longulum Grav.	2	-	4	1	-	-
L. rufipenne Gyll.	-	-	2	1	-	-
L. terminatus Grav.	-	2	-	1	1	-
Lathrobium spp.	4	25	12	4	1	-
Ochthephilum fracticorne (Payk.)	-	1	-	-	1	-
Medon (?) *brunneus* (Er.)	-	-	2	-	-	-
Rugilus rufipes Germ.	2	-	2	-	-	-
Othius myrmecophilus (Kies.)	2	3	10	2	-	-
O. punctulatus (Goeze)	-	1	3	-	-	-

	1.	2.	3.	4.	5.	6.
Othius sp.	-	-	1	1	-	-
Atrecus affinis (Payk.)	2	2	9	2	-	-
Xantholinus linearis (Ol.)/*longiventris* Heer	1	-	2	1	-	-
Erichsonius cinerascens (Grav.)	-	-	-	-	1	-
Philonthus nigrita (Grav.)	-	1	-	-	-	-
Philonthus sp.	2	-	-	-	-	-
Quedius fuliginosus (Grav.)	-	-	2	-	-	-
Quedius sp.	-	4	2	-	1	-
Quedius/*Philonthus* spp.	-	5	-	1	1	-
Habrocerus capillaricornis (Grav.)	-	-	1	-	-	-
Mycetoporus rufescens (Steph.)	-	-	2	-	-	-
M. splendidus (Grav.)	-	-	1	2	-	-
Bolitobius cingulatus (Mann.)	-	-	-	-	1	-
Sepedophilus immaculatus (Steph.)	-	-	1	1	-	-
S. marshami (Steph.)	-	1	1	1	-	-
Tachyporus (?) *pusillus* (Grav.)	-	-	2	-	-	-
Tachyporus sp.	-	1	2	-	1	-
Deinopsis erosa (Steph.)	-	1	-	-	-	-
Gymnusa brevicollis (Payk.)	-	1	-	-	-	-
G. variegata Kies.	-	-	2	-	-	-
Gymnusa sp.	-	-	-	-	1	-
Autalia impressa Ol.	-	1	1	-	-	-
A. rivularis (Grav.)	-	-	1	-	-	-
Drusilla canaliculats (F.)	-	-	1	2	-	-
Ilyobates subopacus Palm.	-	1	2	-	-	-
Aleocharinae indet.	-	17	36	5	8	3
Pselaphidae						
Euplectus sp.	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
Plectophloeus nitidus (Fairm.)	-	-	1	-	-	-
Bryaxis curtisi (Leach)	-	-	2	-	-	-
Bryaxis spp.	1	13	14	3	-	-
Trissemus impressa (Panz.)	-	3	2	-	-	1
Pselaphus heisei (Hbst.)	-	-	1	-	-	-
Geotrupidae						
Geotrupes sp.	1	1	-	-	-	-
Scarabaeidae						
Aphodius luridus (F.)	-	1	-	-	-	-
A. sphacelatus (Panz.)	-	1	-	-	-	-
Aphodius spp.	1	-	4	1	-	-
Phyllopertha horticola (L.)	-	1	-	1	-	-
Dascillidae						
Dascillus cervinus (L.)	-	1	-	-	-	-
Scirtidae						
Microcara testacea (L.)	-	4	2	-	-	-
Gen. et spp. indet. (prob. *Cyphon* spp.)	6	200+	199	68	554	13
Byrrhidae						
Syncalypta striatopunctata Steff.	-	-	-	1	-	-
Heteroceridae						
Heterocerus sp.	-	1	-	-	-	-
Elateridae						
Ampedus balteatus (L.)	-	-	-	2	-	-
A. nigerrimus (Lac.)/*nigrinus* (Hbst.)	-	2	-	-	-	-
A. (?) *pomorum* (Hbst.)	-	1	-	-	-	-
Ampedus sp.	-	1	1	-	-	-
Melanotus erythropus (Gmel.)	-	-	1	-	-	-

	1.	2.	3.	4.	5.	6.
Athous haemorrhoidalis (F.)	-	-	1	-	-	-
A. hirtus (Hbst.)	1	-	-	-	-	-
Agriotes pallidulus (Ill.)	1	-	-	-	-	-
Dolopius marginatus (L.)	-	1	4	2	1	-
Denticollis linearis (L.)	-	1	1	-	-	-
Throscidae						
Trixagus carinifrons (Bonv.)	-	1	2	-	-	-
Eucnemidae						
Eucnemis capucina Ahr.	-	-	-	1	-	-
Melasis buprestoides (L.)	1	1	1	1	-	1
**Isorhipis melasoides* (Lap.)	-	-	-	-	-	7
Cantharidae						
Cantharis paludosa Fall.	-	2	-	-	-	-
Rhagonycha lignosa (Müll.)	-	-	-	1	-	-
R. testacea (L.)	-	2	-	-	-	-
Malthodes sp.	-	2	-	-	-	-
Dermestidae						
Trinodes hirtus (F.)	-	1	-	-	-	-
Anobiidae						
Grynobius planus (F.)	-	2	1	1	-	-
Xestobium rufovillosum (Deg.)	-	1	-	-	-	-
Gastrallus immarginatus (Müll.)	-	1	-	-	-	-
Hemicoelus fulvicorne (Sturm.)	-	1	-	-	-	-
Anobium punctatum (Deg.)/*inexpectum* Lohse.	-	1	3	-	-	1
Hadrobregmus denticolle (Creut.)	-	-	-	1	-	-
Dorcatoma chrysomelina Sturm.	1	5	-	-	-	-
Caenocara sp.	-	2	-	-	-	-

	1.	2.	3.	4.	5.	6.
Ptinidae						
Ptinus fur (L.)	-	2	9	1	-	-
P. palliatus (Pers.)	-	3	-	-	-	-
Peltidae						
**Pelta grossum* (L.)	-	-	-	-	-	1
Thymalus limbatus (F.)	-	2	-	-	-	-
Cleridae						
Thanasimus formicarius (L.)	-	1	-	-	-	-
Melyridae						
Aplocnemus pini Redt.	-	1	-	-	-	-
Dasytes niger (L.)	-	1	-	-	-	-
Nitidulidae						
Brachypterus urticae (F.)	-	-	1	-	-	-
Meligethes sp.	-	-	1	-	-	-
Epuraea guttata (Ol.)	-	1	-	-	-	-
E. pusilla (Ill.)	-	1	1	-	-	-
Epuraea spp.	-	-	2	-	-	-
Soronia punctatissima (Ill.)	-	1	-	-	-	-
Rhyzophagidae						
Rhizophagus parallelocollis Gyll.	-	-	12	1	-	-
R. perforatus Er.	-	-	4	-	-	-
Rhizophagus sp.	-	1	4	2	-	-
Sphindidae						
Aspidiphorus orbiculatus (Gyll.)	-	2	-	-	-	-
Cucujidae						
Silvanus sp.	-	1	-	-	-	-
Psammoecus bipunctatus (F.)	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
**Prostomis mandibularis* (F.)	-	56	5	-	-	4
Cryptophagidae						
Cryptophagus c.f. *dentatus* (Hbst.)	-	1	1	-	-	1
Cryptophagus spp.	-	3	1	1	-	1
Atomaria mesomela (Hbst.)	-	1	-	-	-	-
Atomaria spp.	-	-	4	-	-	-
Phalacridae						
Phalacrus caricis Sturm.	-	-	-	-	-	1
Cerylonidae						
Cerylon histeroides (F.)	-	-	2	-	-	-
C. prob. *histeroides* (F.)	-	-	3	-	-	-
Corylophidae						
Corylophus cassidoides (Marsh.)	1	-	-	-	-	-
Coccinellidae						
Coccidula rufa (Hbst.)	-	1	-	-	-	-
Rhyzobius litura (F.)	-	-	-	1	-	-
Chilocorus renipustulatus (Scrib.)	-	1	-	-	-	-
Coccinella septempunctata L.	-	-	1	1	-	-
Endomychidae						
**Mycetina cruciata* Schall.	-	1	-	-	-	-
Lathridiidae						
Enicmus fungicola Thoms./*rugosus* (Hbst.)	-	-	2	2	-	-
E. histrio Joy & Tom.	-	-	-	1	-	-
Dienerella separanda (Rtt.)	-	-	8	-	-	-
Corticaria punctulata Marsh.	-	2	-	-	-	-
Corticaria spp.	-	1	-	2	-	-
Cortinicara gibbosa (Hbst.)	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
Corticarina spp.	-	1	1	-	-	-
Corticarina/Melanophthalma spp.	-	2	-	-	-	-
Corticaria/Corticarina/Melanophthalma spp.	-	-	6	-	-	-
Ciidae						
Octotemnus glabriculus (Gyll.)	-	-	1	-	-	-
**Rhopalodontus baudeuri* Abeille	-	1	-	-	-	-
Sulcacis sp.	-	-	4	-	-	-
Cis micans (F.)	-	1	-	-	-	-
C. setiger Mel.	-	-	-	1	-	-
Cis spp.	-	3	-	1	-	-
Mycetophagidae						
Litargus connexus (Fourc.)	-	2	-	-	-	-
Mycetophagus piceus (F.)	-	1	-	-	-	-
Colydiidae						
Colydium elongatum (F.)	-	-	1	-	-	1
Teredus cylindricus (Ol.)	-	9	7	3	-	-
Tenebrionidae						
Corticeus (?) *bicolor* (Ol.)	-	-	3	-	-	-
C. fraxini (Kug.)	-	4	-	-	-	-
C. unicolor (Pill. & Mitt.)	-	1	-	-	-	-
Corticeus spp.	-	1	1	-	-	-
Prionychus melanarius (Germ.)	-	1	1	-	-	-
Mycetochara humeralis (F.)	-	-	-	1	-	-
Salpingidae						
Rhinosimus planirostris (F.)	-	1	-	-	-	-
Melandryidae						
Orchesia (?) *micans* (Panz.)	-	-	1	-	-	-

	1.	2.	3.	4.	5.	6.
O. undulata Kraatz.	-	1	-	-	-	-
Phloiotrya vaudoueri Muls.	-	-	1	-	-	-
Hypulus quercinus (Quens.)	-	-	7	3	-	-
Scraptidae						
Anaspis sp.	-	-	1	-	-	-
Aderidae						
Aderus brevicornis (Perr.)	-	1	-	-	-	-
A. oculatus (Payk.)/*pygmaea* (Deg.)	-	4	-	-	-	-
Cerambycidae	-	4	-	-	-	-
Rhagium bifasciatum F.	-	1	1	-	-	-
Rhagium sp.	-	1	-	-	-	-
Grammoptera variegata (Germ.)	-	1	-	-	-	-
Leptura scutellata F.	-	1	-	-	-	-
Anaclyptus mysticus (L.)	-	-	-	-	-	2
Mesosa nebulosa (F.)	-	1	-	-	-	-
Chrysomelidae						
Plateumaris discolor (Panz.)	-	-	1	-	3	-
P. sericea (L.)	-	5	1	3	1	2
Plateumaris sp.	-	1	-	-	-	-
Plagiodera versicolora (Laich.)	-	1	-	-	-	-
Chrysomela aenea L.	-	1	-	-	-	-
Phyllodecta vulgatissima (L.)	-	3	1	-	-	-
Lochmaea caprea (L.)	-	2	1	-	-	-
L. suturalis (Thom.)	-	-	-	2	-	-
Aphthona atrocaerulea (Steph.)	-	-	-	4	-	-
A. lutescens (Gyll.)	-	-	1	1	-	-
Altica (?) *lythri* Aubi.	-	1	-	-	-	-

	1.	2.	3.	4.	5.	6.
Chalcoides fulvicornis (F.)	-	1	-	-	-	-
Chalcoides sp.	-	-	1	-	-	-
Attelabidae						
Deporaus betulae (L.)	-	1	-	-	-	-
Apionidae						
Apion minimum Hbst.	-	1	-	-	-	-
A. simile Kirby	-	1	-	-	-	-
Apion spp.	1	5	4	1	-	-
Curculionidae						
Otiorhynchus sulcatus (F.)	-	-	-	1	-	-
Polydrusus cervinus (L.)	-	-	1	1	-	-
Sitona hispidulus (F.)	-	-	-	2	-	-
Tanysphyrus lemnae (Payk.)	-	6	-	-	-	-
Eremotes ater (L.)	-	2	45	11	-	-
Dryophthorus corticalis (Payk.)	-	-	-	1	-	1
Trachodes hispidus (L.)	-	1	-	-	-	-
Acalles ptinoides (Marsh.)	-	-	2	1	-	-
A. roboris Curt.	-	1	3	-	-	-
**Acalles* sp.	-	-	-	1	-	-
Bagous tempestivus (Hbst.)	-	-	-	1	1	-
Bagous sp.	-	-	-	-	1	-
Notaris acridulus (L.)	-	2	-	-	-	-
Coeliodes rubicundus (Hbst.)	-	1	-	-	-	-
Ceutorhynchus sp.	-	-	2	-	-	-
Ceutorhynchinae indet.	-	4	-	-	-	-
Curculio pyrrhoceras Marsh.	1	1	-	-	-	-
C. salicivorus Payk.	-	-	1	-	-	-
C. villosus F.	-	-	1	-	-	-

	1.	2.	3.	4.	5.	6.
Rhynchaenus avellanae (Don.)	-	1	-	-	-	-
R. pilosus (F.)	1	1	-	-	-	-
R. quercus (L.)	2	2	1	-	-	-
R. rusci (Hbst.)	a	4	1	-	-	-
R. stigma (Germ.)	-	1	-	-	-	-
Rhynchaenus sp.	-	2	1	-	-	-
Ramphus pulicarius (Hbst.)	-	3	-	-	-	-
Scolytidae						
Scolytus intricatus (Ratz.)	-	1	-	-	1	-
S. ratzeburgi Jans.	-	1	-	-	-	-
Hylastes opacus (Er.)	-	1	-	-	-	-
Tomicus piniperda (L.)	-	1	-	-	-	-
Dryocoetinus villosus (F.)	-	15	140	8	-	-
Xyloborus saxesini (Ratz.)	-	-	1	-	-	-
Pityogenes quadridens (Hart.)/bidentatus (Hbst.)		-	1	-	-	-
Pityopththorus (?) lichtensteini (Ratz.)	-	-	1	-	-	-
Platypodidae						
Platypus cylindrus (F.	-	3	1	1	-	-
Hymenoptera						
Xiphydriidae						
Xiphydria prolongata (Geoff. in Fourc.)	-	1	-	-	-	-
X. camelus (L.)	-	1	-	-	-	-
Parasitica						
indet.		not counted				
Formicidae						
Myrmica spp.	-	-	-	1	11	-
Lasius fuliginosus (Lat.)	-	-	-	2	-	-

	1.	2.	3.	4.	5.	6.
<u>L. niger</u> (L.)	-	9	-	-	-	-
<u>Lasius</u> spp.	-	-	-	-	7	-
Diptera						
Bibionidae						
<u>Dilophus</u> sp.	-	-	-	1	-	-
Tipulidae						
indet.	not counted					
Puparia						
indet.	not counted					

<u>Key</u>

1. soil beneath trackway.
2. between the timbers of the trackway.
3. 'tree 1', lower sample.
4. 'tree 1', upper sample.
5. base of Sphagnum peat, c. 10 cm. above trackway.
6. additional material obtained by splitting timber.

ENVIRONMENTAL INTERPRETATION

Although a sample was washed out from the silts beneath Sample 1, it contained very little organic material and no insect remains or recognisable plant macrofossils, other than rootlets. Pollen preparations, however, from 5, 15 and 25cm. into the deposit did produce occasional grains and spores. In the lowest sample, forty-seven traverses of the slide produced a total of thirteen grains and in the second five grains were noted in thirty-three traverses; the sample closest to the gradational interface with the peat which, by its darker colour, clearly included more organic material, produced about one hundred and fifty grains in forty traverses, although only twenty are of tree genera (Table 2).

The occurrence of juniper pollen in these samples is enigmatic. Despite the repeated examination of samples from several localities, no identifiable organic remains have yet been recovered from the laminated silts of pro-glacial Lake Humber (Gaunt, pers. comm.), to which, tentatively and with some circularity of argument, these silts have been related. They would appear, however, to represent the terminal phase of the lake and the pollen may have been incorporated during deposition, possibly during Zone I, when Bartley's (1962) diagram from near Tadcaster, c. 35 km. to the north-west, shows a rise in frequency of juniper to 44% of the total pollen in one sample. Incorporation after the deposition of the silts by invertebrate action is possible and this explains the apparently mixed spectrum from pollen Sample 3, but the Tadcaster diagram (op. cit.) does not show a return to high juniper frequencies late in Zone III and into Zone IV, although such is a common feature of many British diagrams (Godwin, 1975), and it is absent from all diagrams of later date from the Vale of York (Smith, 1958; Turner, 1960). In the south Pennines, Tallis (1964) has

Table 2

Thorne Moors : Trackway site - Pollen and spores from sediments beneath peat and from basal peat sample

	Silts			
	1 (-25 cm)	2 (-15 cm)	3 (-5 cm)	4 (+5 cm)
A.P.				
Betula	-	-	2	7
Pinus	-	-	4	1
Quercus	-	-	-	37
Tilia	-	-	3	-
Alnus	-	-	8	100
Juniperus	1	1	3	-
Corylus	-	-	8	51
N.A.P.				
Gramineae	9	3	70	45
Cerealia	-	-	-	40
Cyperaceae	1	-	1	3
Ericaceae	-	-	-	-
Compositae	-	-	1	-
Thalictrum	-	-	1	-
Sphagnum	2	1	3	-
Filicales	-	-	10	2
Polypodium	-	-	24	10
(*Hystrix*	-	-	3	-)

(for location of samples, see fig. 8)

demonstrated that this shrub was extinguished by the expansion of blanket bog from zone VII(a) onwards but it remains native elsewhere in the Highland Zone and on some calcareous soils, notably on the Chalk in south-east England, where it occasionally appears in later pollen diagrams (e.g. Bradley & Keith-Lucas, 1975). An origin for the Thorne pollen penecontemporaneous with the inception of peat growth towards the end of zone VII(b) would seem improbable, particularly since this would also require either differential preservation, which the state of the grains does not support, or selective resorting by invertebrate action, a process which Dimbleby's (e.g. 1962) work on soil pollen would imply does not occur. The survival of sparse grains of Late Devensian age in the sediment is the most acceptable explanation. More detailed, closer sampling and substantial absolute counts from the silts would be necessary to examine the sequence of Late Glacial pollen preservation followed by a diastema of several thousand years before the deposition of pollen in the mixed Sample 3, but it is apparent that the active layer of the Flandrian soil had been shallow throughout its existence, despite the much lower water-table during most of this period, acidity perhaps inhibiting arthropod and worm sorting and preserving the pollen. Survival of pollen towards the base of the former active layer could have been the result of waterlogging but the absence of hazel and presence of lime amongst the few grains of arboral pollen from the uppermost silt sample suggests a gap between this and the first peat sample, 10 cm. above. If anything can be deduced from the Sample 3 spectrum, the large number of grains of grass pollen would imply a Neolithic or later date, after some clearance, and the apparent break in the sequence may be covered by the soil pollen within the remaining 5 cm. of slightly humic silt, preserved by the incipient podsolization of the profile.

At the level of pollen Sample 4, the gradation from silt stained by humic compounds to a virtually wholly organic peat had progressed to a stage where organic material and amorphous humifaction products had largely replaced silt, the horizon approaching a 'moder humus' inhibited by progressive waterlogging. A bulk sample, taken to 5 cm. either side of the pollen sample, produced a sufficient insect fauna for comparison with the palynological data, although preservation was fitful, with only forty-six identifiable individuals (1 in Table 1). The pollen spectrum is unusual for its high percentage of cereal pollen,[1] reaching 14% of the total pollen (n=284) and, with the Gramineae, amounting to nearly 30%; these high totals are unaccompanied by ruderals (Table 2). The tree pollen sum, including Corylus, is also high at 69% of total, implying fairly closed woodland. Seeds of alder were common in the sample washed out for insect remains and four individuals of oak leaf-mining weevils, Curculio pyrrhoceras, Rhynchaenus quercus and R. pilosus, were also recovered, suggesting the immediate proximity of both oak and alder, perhaps biasing the pollen count. Abstracting the alder pollen as local overweighting reduces the tree pollen the 52% of the sum, still well above the 40% usually accepted as indicating a partially cleared landscape (Pennington, 1969). Omission of hazel, a tree regarded as an undershrub and not counted within the arboral total in many diagrams (Godwin, 1975), further reduces this total to 34%, within the partially cleared landscape figure, but the number of actual grains involved is too small for much significance to be attached to it. It should be noted, however, that hazel does not flower readily under closed canopy conditions and the relatively high count of 26% total tree pollen, including Corylus, is itself indicative of some opening up of the forest.

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[1] B. Smith, currently working on the palynology of Thorne and Hatfield Moors, points out the possibility of confusion with Glyceria pollen, a more probable grass in this environment.

The limited insect fauna gives no definite indication of open ground and the majority of taxa are either eurytopic or associated with woodland or timber. Although Bembidion doris tends to be very hydrophilous (Lindroth, 1974) and Corylophus cassidoides a species of Phragmites litter, true water beetles are entirely absent from the assemblage at this level and there are no indications of the open water and detritus-rich ponds which appear higher in the succession. Much of the fauna would not be out of place in an assemblage recovered by pitfall trapping in woodland, and the one Elaterid, Agriotes pallidulus, is a common species of mixed deciduous woodland (Horion, 1953; Evans, 1969). In addition to the oak leaf-mining weevils, moribund or dead timber is implied by Melasis buprestoides, whose larvae develop in several species of deciduous tree, especially oak and birch (Skidmore, pers. comm.), Dorcatoma chrysomeloides also occurs in wood, particularly oak, attacked by fungi. The two dung beetles, Geotrupes sp. and Aphodius sp., may suggest herbivores in the vicinity but both are active fliers and could be adventitious. The assemblage could relate to a single oak, with its litter, in a forested environment and the pollen record of polypody (Polypodium vulgare) is also consistent with this interpretation.

The amount of available data upon modern insect life and death assemblages is still pitifully small and papers such as those of Evans (1969 (a) & (b) and Kenward (1975) form a slim volume in the entomological literature. The Thorne faunal list is too limited for interpretation of much more than the immediate local environment and only the most exhaustive of faunal lists would contain enough adventitious species to hint at the nature of other, different, adjacent habitats. The character of the less immediate area is therefore only available via the pollen data.. Assuming that the forty grains of cereal pollen do not reflect a single anther, and the equally high count of grasses suggests not, some form of arable farming is clearly implied but its distance from the site of the spectrum is not to be easily ascertained. Smith's (1958) diagram from towards the southern edge of Hatfield Moors, 10 km. south of the Thorne site, shows a peak of nearly 10% of total tree pollen in the cereal curve early in zone VIII, but this sample is from a Sphagnum bog and transport on a more regional basis, perhaps from crops on the sands and gravel island on which the present village of Wroot lies to the south, is probable. This cereal peak is also accompanied by high values for Plantago lanceolata, grasses and ruderals. Since the Thorne spectrum comes from the forest floor, the high percentage of grass and cereal pollen ought to have a very local origin, as movement through the closed environment would be minimal. The insect fauna precludes clearance at the sampling site and it is tempting to relate the non-arboreal component to one of the two limited areas wherein the tree trunks at the base of the peat had charred surfaces, which lay c.400m. to the north-east of the sampling site, and to suggest that both relate to an episode of small temporary clearance within the forest, fossilised by the rising water table. It might be countered that, by the time that plant and insect remains were able to be preserved, the soil would have become too waterlogged to bear a crop. Yet, the process of inundation by small winter increments to the subterranean water table could leave the soil away from the tree cover dry enough in the summer months, or perhaps for several seasons, to obtain a snatch crop or two of cereals. The somewhat moribund trees, injured by the rising water level, may themselves have been attractive to prospective cultivators as areas more easily cleared, although clearance itself would have exacerbated the problem. The cut-off in grass and cereal pollen above this horizon is drastic and, as flooding advanced, birch expanded at the expense of oak (fig. 8) although, in part, this rise may result from the recolonisation of formerly cleared areas. Certainly by the level of the next insect fauna, the change in the environment, over to fen with open water, would have wholly curtailed any farming activity on the area later occupied by Thorne Moors.

The Trackway Horizon (Insect sample 2: pollen sample 6)

That the drastic decline in oak pollen at the trackway level, from over 25% of the tree pollen, excluding hazel, to just over 2% results from progressively wetter conditions rather than direct anthropogenic interference is supported by the insect evidence. From a few individuals of varying preservation in sample 1, the insect fauna rises to more than eight hundred and fifty individuals in sample 2, from between the timbers of the trackway, and of these, nearly one fifth are water beetles. The presence of several species characteristic of open water habitats, particularly the larger Dytiscids, *Agabus* spp., *Ilybius* spp. and *Colymbetes fuscus*, implies a reasonably sized pond and similar conditions, if less pronounced, occur around the base of the moribund oak from which sample 3 was recovered, c. 400 m. away. The majority of the Dytiscids and Hydrophilids in sample 2 belong to what Balfour-Browne (1940; 1950; 1958) has termed the detritus pond community and several, including *Hydroporus dorsalis* and *H. memnonius* are noted from woodland ponds with dead leaves (Balfour-Browne, 1940). *H. scalesianus* has been recorded in its few English localities from thick moss with clear water in fen swamps (op. cit.) but Guignot (1933) says that it prefers woodland pools in France and Girling's (1976) fossil records from throughout the Somerset Levels succession suggests that it may be even more eurytopic; in Norfolk it has been found in the same habitat as *Ilybius guttiger*, also in the Thorne list. A number of species imply some variation in the character of the open water: *Agabus* *unguicularis*, represented by up to nineteen individuals in the trackway, occurs in pools and acid water with *Sphagnum*, usually among the moss at the edges of pools (Balfour-Browne, 1950) and *A. paludosus* prefers shallow streams with thick vegetation, although the solitary individual may be adventitious and Guignot (op. cit.) also notes it from stagnant water. *Anacaena globulus* is equally common in still and moving water but also occurs in the litter layer on the forest floor (Evans, 1969) and a gradation between the two environments is to be envisaged. Thick vegetation around the pond is suggested by *Hydrobius fuscipes* and *Enochrus coarctatus* but this element can give no indication of the plants involved. Open water is also required for the duckweeds, *Lemna* spp., on which the small weevil *Tanysphyrus lemnae* depends. Around the ponds and over the timbers, which formed the trackway, considerable moss growth is indicated by over two hundred Helodids, *Coelostoma orbiculare* and several Staphylinids, which commonly live as predators in wet moss. Spores of *Sphagnum* first enter the pollen diagram at this level and rapidly increase as raised bog takes over from the Fen environment (Fig. 8). Grasses and sedges are indicated by *Plateumaris sericea* and *Notaris acridulus*, whilst *Psammoecus bipunctatus* is frequently associated with *Carex paniculata* (Skidmore, pers. comm.). *Altica lythri* occurs on *Lythrum salicaria*, purple loosestrife, a common flower of marshes and river banks. Sample 3, from a roughly contemporary horizon, adds *Aphthona lutescens*, which is recorded from *Epilobium* spp. in wet places (Mohr, 1966), *Brachypterus urticae* on nettles, and the bug *Sehirus biguttatus* on *Melampyrum* spp., usually the common cow-wheat, *M. pratense*., *Caenocara* spp. occur in *Lycoperdon* spp., the puff-ball fungi, which usually grow on drier sandy soils, although *L. pyriforme* occurs on tree stumps, which would fit this species into the rotten wood community of the trackway.

Figure 9:

Thorne Moors : layer of intertwined rhizomes of Vaccinium oxycoccum over trackway (1977).

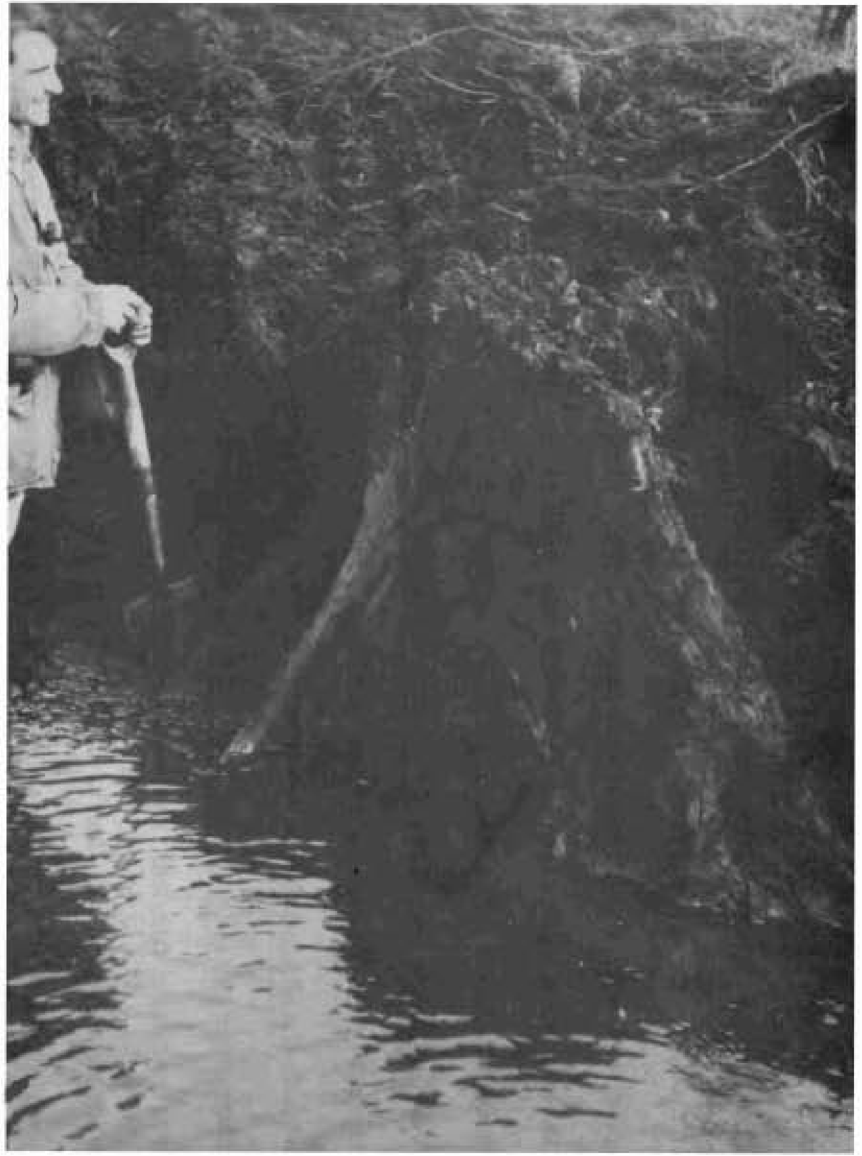


Figure 10:

Thorne Moors : base of large oak in position of growth at the base of the peat (tree 1); samples 3 and 4 were recovered from between the buttresses on the right of the tree.

The palynological data from the trackway level would suggest a co-dominance of birch and alder (Fig. 8), with subsidiary amounts of hazel, although the latter component might include some *Myrica* pollen. Pine and oak appear in sufficient quantity to suggest their presence in the region and elm and lime are represented by single grains. The insect data are more specific in terms of the immediate environment. The macroscopic evidence of a small pine incorporated in the trackway is supplemented by bark beetles, *Tomicus piniperda* and *Hylastes opacus* which, although recorded from other conifers (Chrystal, 1937), would, during most of the Flandrian, be restricted to pine as the only suitable native species. *Pinus sylvestris* is characteristic of the transition phase between fen and raised bog (Godwin, 1975) and its utilisation in the construction of the track need not have involved its portage over any distance. The large numbers of species associated with birch, including *Apion simile*, *Coeliodes rubicundus*, *Rhychaenus rusci*, *Deporaus betulae* and *Scolytus ratzburgi* (Table 3), support the pollen evidence for the presence of this tree around the trackway site and its macrofossils were frequent in the peat. The slightly firmer ground provided by the timbers provided a base upon which a tree birch managed to establish itself after the trackway had fallen into disuse. Whether the indications of the entomological literature (Hoffman, 1954) that the larvae of *A. simile*, *C. rubicundus* and *R. rusci* are to be found upon the leaves of *Betula pendula* rather than *B. pubescens*, more typical of fen (Godwin, 1975), reflect an actual situation or insufficient data cannot be resolved; most British entomologists (e.g. Donisthorpe, 1939) merely refer to the collection of adults by sweeping with a net about oaks, willows and birch. Since there are fewer taxa of Coleoptera which are specific to alder, the evidence for this tree in the insect list is less substantial. *Chrysomela aenea* appears to be restricted to *Alnus*

Table 3

Thorne Moors: Plants indicated by the Insect Record

Taxa		Host
Tomicus piniperda	(2)	Pinus silvestris
Hylastes opacus	(2)	" "
Apion simile	(2)	Betula alba
Coeliodes rubicundus	(2)	" " (rarely Fraxinus)
Rhynchaenus rusci	(2,3)	" " & Populus nigra
Deporaus betulae	(2)	" " & B. pubescens (rarely Alnus. Corylus, etc.)
Scolytus ratzburgi	(2)	Betula spp.
Xiphydria camelus	(2)	" " & Alnus glutinosa
Curculio villosus	(3)	Quercus spp.
C. pyrrhoceras	(1,3)	" "
Rhynchaenus avellanae	(2)	" "
R. quercus	(1,2,3)	" "
R. pilosus	(1,3)	" "
Raphidia notata	(2)	" "
Acalles roboris	(2,3)	Usually Quercus spp.
Chrysomela aenea	(2)	Alnus glutinosa
Curculio salicivorus	(2,3)	Salix vitellina
Chalcoides fulvicornis	(2)	S. caprea, S. atrocinerea, etc.
Plagiodera versicolora	(2)	Salix spp., often S. fragilis, (rarely Populus spp.)
Phyllodecta vulgatissima	(2,3)	Salix spp.
Apion minimum	(2)	" "
Lochmaea capreae	(2,3)	" " Populus spp. & Betula
Chalcoides sp.	(3)	" " " "

Table 3 (Cont.)

Thorne Moors: Plants indicated by the Insect Record

Rhynchaenus stigma	(2)	Salicaceae & Betulaceae
Xiphydria prolongata	(2)	Salix spp. also Populus & Alnus
Sitona hispidulus	(4)	various Cruciferae
Aphthona lutescens	(3,4)	Epilobium spp. in wet plants
Altica lythri	(2)	Lythrum salicaria
Lochmaea suturalis	(4)	Calluna vulgaris
Acalles ptinoides	(3,4)	" " (but also from standing deciduous trees)
Sehirus biguttatus	(3)	Melampyrum pratense (prob. spp.)
Aphthona cyanella	(4)	Euphorbia spp.
Brachypterus urticae	(3)	Urtica spp.
Tanyspyrus lemnae	(2)	Lemna spp.
Bagous tempestivus	(4,5)	Potomageton spp. P. (Groenlandia) densus, P. pectinatus, etc.
Plateumaris discolor	(3,5)	Carex spp.
P. sericea	(2,3,4,5)	" " & Iris pseudocoris Cyperaceae, adults on Glyceria spp. & Polygonum amphibium
Polydrusus cervinus	(3,4)	imagines polyphagous, larvae on roots of Dactylis glomerata
	Fungi:	
Caenocara sp.	(2)	Lycoperdon spp.
Cis micans	(2)	Trametes versicolor (prob. spp.)
C. setiger	(4)	Trametes spp.
Octotemnus glabriculus	(3)	" "

(Mohr, 1966) and Deporaus betulae may occasionally be found upon it (Hoffman, 1954), sufficient with the pollen data to substantiate the picture of a birch-alder fen.

It is unfortunate that the insect evidence goes no way towards resolving the problem of the Coryloid component in the pollen diagram. No feeders upon either hazel or bog myrtle were found and, whilst in the forest floor spectrum Corylus is the more probable, with the development of a more acid fen environment above the trackway, Myrica pollen may become a significant contributor to the Coryloid curve. Smith (1958) does not split the two elements in his Hatfield Moors diagram and Turner (1962) regards the variation in this curve in her Thorne Moors diagram as due to changes in the status of hazel. It should be noted, however, that, when Leland crosses the Chase to Haxey in the 1530's, he remarked upon the preponderence of sweet gale on the peatlands. One major element of the fen flora not represented in the pollen spectrum and consistently under-represented in counts is the willow. Curculio salicivorus, Chalcoides fulvicornis, Plagiodera versicolora, Phyllodecta vulgatissima and Apion minimum all feed upon the leaves of various species of Salix (Table 3). Hoffman (1954) records C. salicivorus from the galls of several species of Tenthredid sawfly on the leaves of white willow, S. alba, and Mohr (1966) notes a preference of P. versicolora for the crack willow, S. fragilis; the sallows are preferred by C. fulvicornis (Allen, 1972). The ladybird Chilocorus renipustulatus preys on scale bugs (Coccidae), usually Chionaspis salicis, on willows but in Scandinavia it is also recorded, intermittently, from aspen, ash, alder (Palm, 1959) and conifers (Kopenen & Nuorteva, 1973). The image must therefore be modified to accommodate a gradation from birch-alder fen, through willow swamp to some open water in the vicinity of the trackway.

The few grains of oak pollen need not imply the presence of this tree close to the sampling locality, but the evidence of the phytophagous beetles is sufficiently strong to show that oaks did exist close to the track and are under-represented in the pollen spectrum. Rhynchaenus avellanae and R. quercus attack the foliage of oaks and, although the imagines may move away from the host - Donisthorpe (1939) records R. quercus from flowers of crab-apple and hawthorn as well as oak - the larvae develop on oak leaves. The trackway evidence for the survival of oaks into the open water phase is expanded by the beetles from the basal sample from between the vanes of an oak stump (sample 3). As well as R. quercus, R. pilosus occurs, with Curculio pyrrhoceras and C. villosus, whose larvae inhabit the galls of the Cynipid wasps, Dryophanta folii and Biorrhiza pallida respectively, on oak leaves (Hoffman, 1954). Quercus is intolerant of flooding (Longman & Coutts, 1974) and the rising water table would have resulted in large numbers of moribund trees more susceptible to insect attack. Acalles roboris would have attacked the thinner shoots of the trees as they died back and a whole range of lignicolous species the more substantial timber. Certainly pollen production would have been drastically curtailed and the oak, or indeed, any other similarly affected tree would be poorly represented in the spectrum. The death and decay of one large oak is documented by the changes in the fauna between samples 3 and 4 where the bark beetles, principally Dryocoetinus villosus, decline from one hundred and forty individuals to eight; the leaf feeders do not reappear in the upper sample.

Into this environment of birch-alder fen with willow swamp and occasional pools, interspersed with numerous dead and moribund large trees, the remains of which were frequent at the base of the peat, the irregular structure of the Middle Bronze Age trackway has to be fitted. Although the reconstruction of the natural habitat is partially governed by the insecure parameters of people's collecting experience and published records, the trackway poses additional problems beyond its own immediate environment. The structure represents a conscious or unconscious selection of timber by man and cannot therefore be regarded as an unbiased sample of the local woodland. Although there is some suggestion of rough working on some of the timbers, it is apparent from the large and diverse xylophagous insect fauna that preference was shown for the more easily obtained dead and partially rotted trees, which were thrown into the mire, here probably a fairly open, if vegetated pool, to form an irregular surface. The accumulation of vegetable litter, small twigs, leaves and moss upon and in this surface was considerable and several taxa can be associated with this habitat, including Megasternum obscurum, Proteinus spp. and Anotylus spp. Donisthorpe (1939) notes Cercyon convexiusculus, in numbers, from under a log in water and in moss in willow swamp at Windsor, and such habitat preference would explain its dominance over the more eurytopic M. obscurum in the trackway sample; the roles are reversed in sample 3, from the base of the oak. This component of the fauna could equally well occur in dung but the few Scarabaeoids, Geotrupes sp., Aphodius luridus and A. sphacelatus do not differ significantly in numbers from the other samples and only suggest the occurrence of herbivores within the general area. The irregular surface of the track, as preserved, may be misleading since the actual walking surface could have been composed of turf sods laid over the timbers. Usage would have reduced this to a composition indistinguishable from the remainder of the peat and it would form a habitat suitable for many of the omnivorous and carnivorous elements in the fauna. There is no evidence of the use of reeds to provide a surface, as practised until recent times in the Fens (Porter, 1969). Fragments of *Phragmites communis* were noted in the peat over the trackway but the true reed forms part of the natural seral succession from open water to wooded fen and, in the limited amount of excavation carried out, there was no evidence for the concentration of these over the timbers. Equally, the employment of twigs, litter and moss over the wood would not have been recognisable by unusual features of the fauna.

The dead wood element in the trackway faunal assemblage is considerable. Over thirty-five species are actual borers in timber in various stages of decay and many more live as predators or commensals in the burrows or under the bark. Several taxa would appear, on the evidence from Britain, to be tied to a particular species of tree but, frequently, Continental sources reveal a much wider range of hosts. In Table 3, therefore, only those species of lignicolous insect have been included which have only one possible native host in Britain, as those recorded only from conifers, or about which British and Continental sources, principally Escherich (1923), Horion (1941 et seq.) and Palm (1951; 1959), are unanimous about the host trees. Thus, the woodboring weevil *Eremotes ater* is only recorded from pine in Britain yet, on the Continent, it is quite catholic in its tastes, taking a whole range of deciduous woods, as well as conifers (Palm, 1959); *Gastrallus immarginatus* occurs in maple in its solitary British haunt, Windsor (Allen, 1956), but is recorded from a considerable range of deciduous woods in Europe (Kaszab, 1969). Duffy (1953) has pointed out that it is not usually the species of timber which is important but the state of the wood, its temperature, humidity, state of decay, etc., and, whilst this is least true of the Scolytids, the more primary of the agents, it becomes progressively more evident through the ecological succession which results in decay and incorporation of the timber in the soil. As Palm's work for the Swedish forestry service has shown (1951; 1959), very few insects are primary pests of living, healthy trees and many require some degree of fungal intervention before they can ingest the intractable cellulose of the wood. Death watch, *Xestobium rufovillosum*, also present in the trackway faunas, in synanthropic situations is a secondary pest after wet or dry rot (Fisher, 1938) and many other species are associated with already rotted wood, feeding on both the broken down timber and the fungal hyphae. *Mycetina cruciata*, *Aspidiphorus orbiculatus*, *Dorcatoma chrysomeloides* and *Ptinus fur* belong to this community, although it has to be remembered that several may occur in many situations where mould and other fungi are to be found. *Rhysodes sulcatus* and *Prostomis mandibularis* also occur in thoroughly rotted wood. The Cisids and several of the Staphylinids are found in the fungal fruiting bodies of bracket and other fungi on trees, the latter largely as predators on fungus gnat larvae. A number of other predators live under bark; the Histerids, *Abraeus globusus* and *Paromalus parallelipipedus*, preying on dipterous larvae or Scolytids (Horion, 1949) and *Atrecus affinis*, *Trinodes hirtus* and *Rhinosimus planirostris* living either as predators or as scavengers in this habitat. The two Rhizophagids are probably to be classed as predatory, although there is some doubt as to whether *Rhizophagus parallelocollis* is not a fungal feeder. Several of the other carnivorous species would exploit the cover provided by the loose bark, decayed wood and thick moss growth on the trees, the latter a feature which pollution has removed from most modern woods. Crowson (1962) notes that *Agonum obscurum* is particularly common in moss on trunks in Scottish oakwoods and several species utilise both moss, thoroughly rotted wood and under bark as hibernation sites.

The succession of lignicolous beetles as they contribute to the decay of a tree is well illustrated by samples 3 and 4, from between the butresses of a large oak stump still in the position of growth (Fig. 10). In the moribund state, the leaf feeders are supplemented by the Scolytids, Dryocoetinus villosus and Xyloborus saxeni, with Platypus cylindrus and, as fungi attack the wood and the bark is loosened, wood-boring species enter, principally the weevil Eremotes ater but also the longhorn Rhagium bifasciatum, the furniture beetle Anobium punctatum, Grynobius planus, Teredus cylindricus, Hypulus quercinus and several Elaterids. The loosened bark and accumulating frass provide habitat for both fungivores and predators and, as the wood begins to split along its annual rings, Prostomis mandibularis moves in. In sample 4, as the timber begins to loose its cohesion and character and frass comes to dominate over wood, the Scolytids and some of the wood-borers decline and are replaced by species which rework this material, Rhysodes sulcatus and Dryophthorus corticalis. The ecological progression which would have finally returned the wood to the soil has been curtailed by peat formation, which precluded all organic activity until the stump was exhumed during drainage. The upper sample shows a considerable decline both in diversity and number of individuals, heralding the transition from fen to raised bog.

The Raised Bog (Insect sample 5: Pollen sample 8)

The invasion of Sphagnum into the fen and willow swamp is evident not only from the rapid rise in the number of spores in the pollen diagram (Fig. 8) but also from the changing character of the peat itself. In the 15cm. between the trackway horizon and sample 5, all wood, other than occasional small birches and some twigs, probably of Calluna, disappears and the deposits assume the aspect of a uniform moss peat with little variation, other than in degree of humification. At the horizon selected for insect sample 5, the rather humified Sphagnum was knitted together by an intertwined mass of rhizomes of Vaccinum oxycoccus (Fig. 9) and several birch trunks appear at a similar level elsewhere along the sections, from one of which the complete example of a male imago of the large Peltid Pelta grossum was recovered (frontis). Although the whole of this part of the succession must lie early in pollen zone VIII and within a few hundred years of the 2980± 110 B.P. (Birm. 358) from the trackway, the irregular nature of the surface of raised bogs and variation in degree of wetness makes it impossible to assume that the age of the specimen of P. grossum is exactly that of the radiocarbon date.

The transition towards more acid conditions is also evident from several changes within sample 4. Although the dead stump of the oak still projected above the surface of the bog, its environment had changed considerably. All the feeders upon the living trees disappear and there are no indications of birch or willow scrub. The phytophages are restricted to dead wood species and a few feeders upon lower plants; Aphthona lutescens on the willow herbs, Epilobium spp. in wet areas, A. cyanella on the spurges, Euphorbia spp. and Sitona hispidulus on various species of Cruciferae. None of these is suggestive of raised bog but the heather beetle, Lochmaea suturalis, usually occurs on ling, Calluna vulgaris, and the weevil Acalles ptinoides bores into the thicker twigs of this plant, although, on the Continent, it is also recorded from deciduous trees away from heath (Palm, 1959), which would account for its appearance in the underlying sample. Several changes occur within the Carabid fauna which also indicate an opening up of the habitat. Both *Bradycellus ruficollis* and *B. harpalinus* often occur on the ground beneath *Calluna* (Lindroth, 1974) and this pair are the most frequent predatory taxa in sample 4, largely replacing the species of *Pterostichus* which favour wetter situations. The predominantly woodland *Trechus secalis* is replaced by the more xerophilous *T. quadristriatus/ obtusus*, although it should be noted that Lindroth (1945) notes the former from under *Calluna* in Denmark. Similarly the deciduous woodland and fen species *Trichocellus placidus* gives way to the dry heath *T. cognatus*, which is also recorded from raised bogs in southern Sweden (op. cit.). A change also occurs in the predatory Lygaeid bugs, from the shade-favouring *Drymus brunneus* to the more xerophilous *D. syvaticus/ryei* (Southwood & Leston, 1959).

Some relatively permanent open water is implied by *Bagous tempestivus*, which is found on various species of pondweed, *Potomogeton* spp. Its more frequent hosts, *P. (Groenlandia) densus* and *P. pectinatus* (Hoffman, 1954), are more characteristic of eutrophic rather than oligotrophic waters, but, since this weevil also appears in the acid bog environment of sample 5, it may be more eurytopic than this French record suggests. The water beetles in sample 4 also include some fen indicators, perhaps a consequence of the arbitrary nature of the division between samples 3 and 4. Both *Hydroporus neglectus* and *H. memnonius* occur in forest pools (Guignot, 1933; Zimmerman, 1931) on the continent and *Enochrus coarctatus*, although a detritus pond insect, is not usually found in acid water (Balfour-Browne, 1958). *Agabus congener*, on the other hand, is largely an upland species of *Sphagnum* pools, with occasional lowland captures including the New Forest and possibly Askham Bog, near York (Balfour-Browne, 1950). This admixture of differing ecotypes may merely reflect differing stages in the hydroseral succession across the few kilometres of enascent raised bog and meandering river courses, flanked by willow swamp and fen. Being efficient fliers, it is not surprising that these water beetles sometimes appear away from their usual habitat.

Sample 5 continues the progression into raised bog. The number of insects declines drastically and only one individual associated with rotten wood occurs, Dolopius marginatus, a species very catholic in its selection of wood, the larvae also appearing as predators in woodland soils (Horion, 1953) and the imago being an active flier. The evidence from other sources, particularly the stratigraphic, is sufficiently strong to preclude the proximity of fresh oak, the principal host of the bark beetle Scolytus intricatus, from the site. The insect is also recorded from beech, hornbeam, elm and hazel and seems less fastidious than most Scolytids in its selection of the state of the host tree (Palm, 1959). As the recent rapid spread of Dutch elm disease has emphasised, members of this genus are usually efficient fliers and the individual is probably adventitious.

Although the occurence of some open water is suggested by the foodplants of Bagous tempestivus, the pondweeds, there are only two water beetles in sample 5, both Hydroporus spp., and the changes in the peat stratigraphy across the sampling horizon, from humified to much less humified Sphagnum peat with leaves and rhizomes of Scheuchzeria palustris, a plant which survived on the Moors in its last lowland station until the 1940's (Bunting, pers. comm.), shows that this level marks a recurrence surface in the raised bog. It is tempting to relate this particularly marked phase of drying followed by swamping to Granlund's RYIII, Weber's original Grenz. of c. 600 B.C., the most extensive of the north European

Grenzhorizont but recent work, particularly that of Schneekloth (1968) on German bogs, urges caution (Moore & Bellamy, 1973). Much more extensive sampling of both macroplant and insect remains, as well as ^{14}C dates, over this surface would be necessary to provide useful comment upon recurrence surfaces. Apart from the almost total disappearance of woodland and aquatic elements and the depleted nature of the fauna, many of the more eurytopic of the wet moss community recur in sample 5; large numbers of Helodids remain, more individuals of Coelostoma orbiculare occur and the few Staphylinids are supplemented by Erichsonius cinerescens. The paucity of the faunal assemblage reflects the depauperate character of raised bogs when compared with fen woodland.

The rise in the oak pollen curve between the trackway and the level of the upper insect sample, at the expense of birch and alder, with a continued decline in the Coryloid component (Fig. 8), may reflect the natural succession in the hydrosere, with the expansion of oak into the drier parts of the bog elsewhere on the Chase but it is apparent from the higher samples and the insect evidence that a much wider, regional component is entering into the pollen rain. Carpinus is represented by a single grain in pollen sample 7 and it is doubtful whether the hornbeam is a native tree outside south-east England (Godwin, 1975), suggesting long distance transport. Fagus presents more of a problem. Although macroscopic records are restricted to south of the Wash (op. cit.), the tree has a low, intermittent, pollen production of low dispersal potential and it is possible that small stands existed as far north as the Lake District by the end of zone VII. Despite the appearance of such insects as Eucnemis capucina, which in this country show a preference for rotting beechwood, there is no conclusive evidence for the tree's presence on the Levels, where the predominantly sandy soils are not suitable without husbanding and the pollen probably represents local stands on the Magnesian Limestone dip-slope, c. 20 km. to the west. The varying amounts of elm and lime pollen presumably also reflect changes further west and Turner (1962) suggests that the variations within her *Tilia* curve record selective clearance events on the limestones, although there is some evidence for the continuance of lime on the Chase. The single grain of *Euonymus europaeus*, the spindle tree, is only the second published record (Godwin, 1975); this shrub today is frequent, if localised, on the Magnesian Limestone.

The fall in frequency of tree pollen in the top 40 cm. of the *Sphagnum* peat (Table II) probably reflects the extensive clearances of the Iron Age and Roman periods, postulated on palynological grounds by both Smith (1958) and Turner (1965) and confirmed by recent aerial survey work over Hatfield Chase and the Permo-Triassic outcrops (Fig.24; Riley, 1973). Pollen of the grasses rises considerably and cereals again appear in the spectrum, together with *Artemisia*, *Plantago*, *Rumex*, *Urtica* and the Chenopodiaceae, probably reflecting agricultural activity on the slightly higher sandy areas between Thorne and Hatfield Moors. The increase in Ericaceae at the top of the column, immediately below the latest peat cutting surface, with the accompanying rise in Gramineae, may correlate with a similar event on Hatfield Moors noted by Smith (1958) and occurring within the Romano-British period but a considerably more detailed diagram would be necessary to uphold this teleconnection. The more recent record of Thorne Moors has now been destroyed by peat extraction.

Table 4

Thorne Moors: Pollen from upper four samples in *Sphagnum* peat

(to current cutting surface)

	12 (+85 cm)	13 (+95 cm)	14 (+105cm)	15 (+115cm)
A.P.				
Betula	14	10	23	16
Pinus	2	6	3	5
Quercus	5	1	3	2
Alnus	14	5	20	16
Fraxinus	-	-	1	-
Corylus (Coryloid)	26	5	20	31
N.A.P.				
Gramineae	7	13	45	53
Cerealia	-	1	-	2
Cyperaceae	-	-	1	-
Ericaceae	5	10	60	79
c.f. *Artemisia*	-	-	2	3
Plantaginaceae	1	4	-	-
Plantago major/media	-	-	1	-
Plantago sp.	-	-	-	2
Chenopodiaceae	1	1	3	1
Compositae	-	1	3	1
Rumex	-	-	-	3
Urtica	-	-	4	1
Ranunculaceae	-	-	-	6
Typha latifolia	-	-	-	2
Potomogeton	-	-	-	1
Sphagnum	58	53	68	180
Filicales	2	2	20	5
Polypodium	-	2	-	-
No. of traverses:	33	35	16	10

(preservation progressively poorer, particularly in 14 & 15)

For location of samples, see Fig. 8.

Discussion : The Flooding Mechanism

The preservation of a complete forested environment beneath peat tends to invite catastrophies in interpretation. From Noah, the deliberate felling by the Roman army invoked by de la Pryme (1701) - a telescoped anthropogenic explanation containing more than a grain of truth - to the more eccentric writings of some modern authors (e.g. Velikovsky, 1958), prone sub-fossil trees, often with a preferred orientation, suggest the events of one or a series of particularly disastrous storms resulting in inundation. In geological terms the events on the Hatfield Levels towards the end of the Middle Bronze Age were rapid but the insect evidence favours a cumulative process of flooding, which would probably have been remembered more in terms of a collective folk memory. The extent of changes associated with the Thorne Moors episode is uncertain. On Hatfield Moors, a few kilometres to the south, established as a Sphagnum bog during the Atlantic period, a phase of increased surface wetness, close to the zone VII(b)/VIII boundary (Smith, 1958), probably correlates with the initiation of the Thorne Moors complex but the initial phase was not noted in the Thorne Waterside succession which straddles the event (Buckland, unpublished). On Thorne Moors, the peat provides no conclusive evidence for actual flooding rather than a rising water-table, but the sediment laden character of the modern rivers entering the lower part of the Vale of York is itself a product of forest clearance and increased erosion. The possibility of the infiltration of relatively silt-free waters into the forest and wetlands therefore cannot be excluded; the rising water-table would ensure that any ponds so created could remain for progressively longer on the forest floor, contributing to the decline of the trees.

The rising base level must relate, at least in part, to the penetration of marine and estuarine conditions into the Humber with the post-Glacial rise in sea level (Gaunt & Tooley, 1974) but, despite the fact that the base of the peat lies over 4 m. below current high water at Goole (+ 4.6 m. O.D.) (Yorkshire River Authority, pers. comm.), 6 km. to the north of the site, no estuarine influence is detectable in the succession. This contrasts with the Ancholme valley, where in a similar situation 13 km. from the Humber, an uninterrupted sequence of estuarine silts was laid down from c. 2,500 B.P. (Buckland, in press) to the building of Ferriby Sluice in the late eighteenth century. The catchment of the river Ancholme, however, the dipslope of the Middle Jurassic and the Chalk scarp, is slight compared with the major rivers draining into the western half of the basin, ultimately from the Pennines. The Ouse and its tributaries drain 8,913 $km.^2$ (3,447 sq. miles), the Trent 10,572 $km.^2$ (4,082 sq. miles) and the Don and other rivers of south Yorkshire and Humberside 5,222 $km.^2$ (2,021 sq. miles), a total of 24,707 $km.^2$ (9,550 sq. miles), over a quarter of the land surface of England. The scale of the current outfall is of the order of 2123×10^7 litres (467×10^7 gallons) per day, rising to 2954×10^8 litres (65×10^9 gallons) per day in flood (Radley and Simms, 1971). The present flow regime is much influenced by the embanked and constrained nature of the river courses and tidal influence reaches up the Ouse for 60 km. from its confluence with the Trent, almost to York, up the Dutch River and Don to Sandal Lock, 26 km. above Goole, and up the Trent to Cromwell Lock, 80 km. from its mouth. As Radley and Simms (op. cit.) note, however, when flooding occurs, the waters of the estuary have a secondary role, backing up the freshwater runoff and increasing the intensity and duration rather than creating an influx of saline conditions. The engineer John Smeaton, writing in 1776, in a report on Hatfield Chase, summarised the problem,

> "the Evil attending the Drainage of these Levels, does not so much consist in this, that the Water cannot be got off from the Surface in dry Seasons, but that the Rains send down so great a Quantity of upland Water, by the Course of the River Torne, during the Winter, which overflowing the Banks thereof, makes its Way over and upon the Surface of the Levels..."

The Torne is a small river draining the Magnesian Limestone dipslope, and its problems are those of a microcosm of the entire basin; the combined effect of several of the major rivers in spate, plus backing up of the outflow by storms in the North Sea, can result in floods as that of 1625, which reached 10.54 m. (34.58 ft.) O.D., drowning the greater part of the Vale of York and Hatfield Chase (Radley & Simms, 1971). If Gaunt and Tooley's (1974) data are sufficient, sea level at c. 3,000 B.P. was oscillating just below O.D. in the North Sea Basin, after a gradual rise over several thousand years from -5 m. O.D. and a similar situation to the present may have pertained. It is apparent that a critical position had been reached between the various regimes, leading to widespread expansion of wetland habitats. Although there are some analogies with the present artificial balance, the effects of forest clearance and the tidal element are difficult to assess. In the Humber Estuary, the operative factor in controlling the tidal pattern is the presence or absence of the sand spit at Spurn. Its absence increases the access of north-easterly gales and these are the most destructive, causing excessively high tides and backing up the outfall. De Boer (1964) has traced the process of construction and breaching of Spurn Point and its precursors back into the Middle Saxon period from documentary sources but it would be unwise to assume its influence any earlier, when the mouth of the Humber would have been several kilometres further east. Certainly by the late Bronze Age, tidal influence extended beyond the gap in the Wolds cuesta at Ferriby (Smith, 1958; Buckland, in press) and increased tidal effects were probably a factor in flooding.

Currently the problems with freshwater runoff are being exacerbated by underdrainage of fields and extensive gripping of upland peat moors, increasing the speed of rainfall runoff (Radley & Simms, 1971). An extensive forest cover acts as a control on flooding, reducing the amount by transpiration, depressing the water-table and slowing the process of feed into the river system. In an extreme case, the effects of uncontrolled and indiscriminate clearance are well illustrated in semi-arid regions where the balance is even more precarious. In the Baringo district of northern Kenya, clear felling and logging operations in the Kamathia Hills have reduced the Ndau river from a permanent stream supplying extensive floodplain agriculture to an intermittent and unpredictable source of flash floods carrying a large volume of sediment. In Temperate Zones, the problems are proportionally less severe but the effects on the geomorphology are often underestimated. The period between upland clearance and the expansion of blanket bog with its compensatory, if less effective, sponge effect would have been one of particular propensity to freshwater flooding in the Humber Basin and this would have been a significant factor in the irreversible progression to fen and raised bog on Hatfield Chase. It is probably the anthropogenic element which gave a fen environment to this area, in contrast with the once extensive estuarine finger which crept up the Ancholme valley. This thesis is, however, difficult to substantiate with the currently available evidence and any correlation between upland and lowland events in the basin requires more absolute dates and stratigraphic examination.

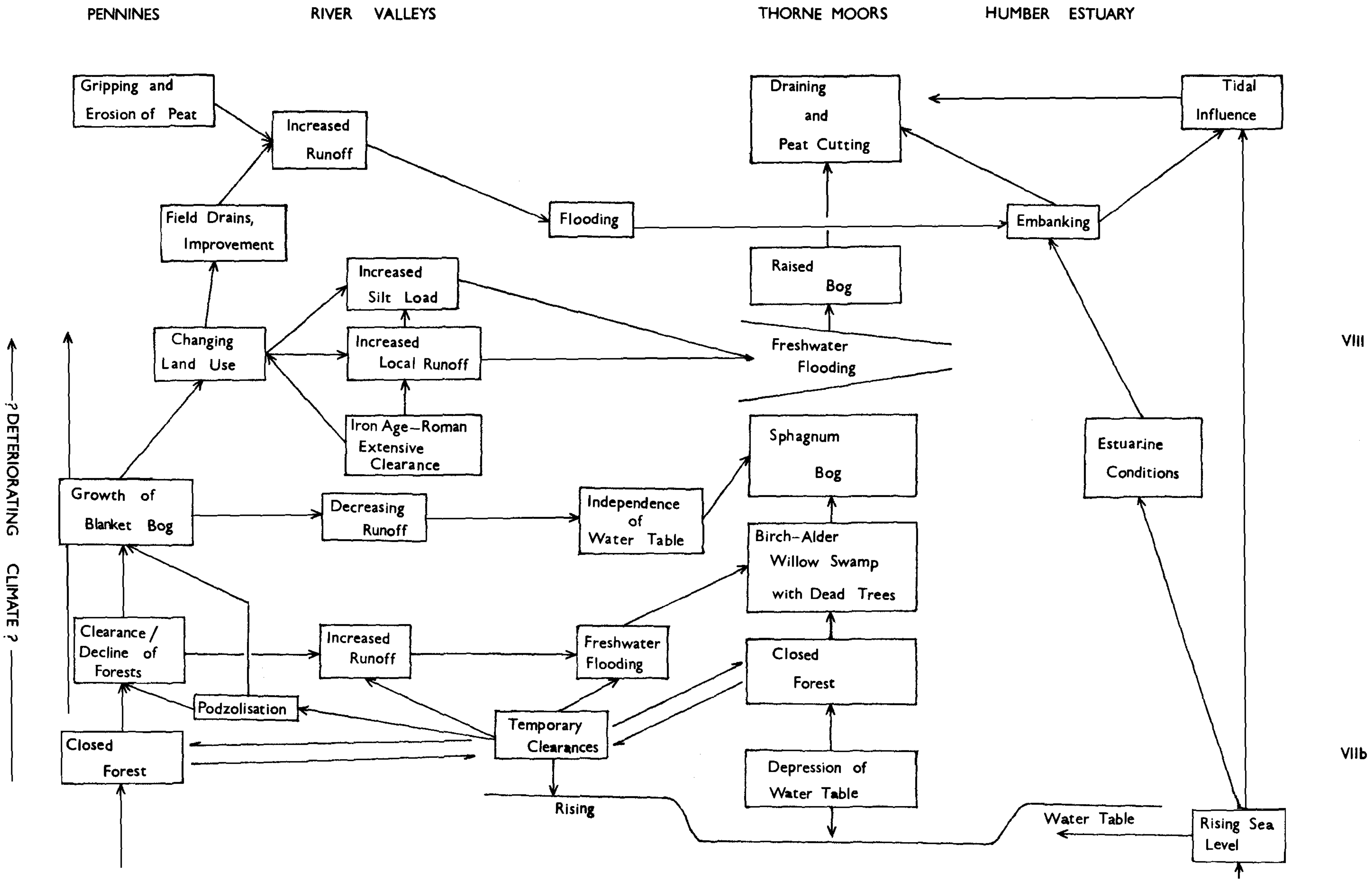
Both palynology (Smith, 1958; Turner, 1965) and aerial photography (Riley, 1973; fig. 22) suggest extensive clearance of the Permo-Triassic outcrop and overlying Drift deposits by the Late

Iron Age but the dearth of stratified finds and the blanket of peat makes the earlier story extremely fragmentary (cf. Buckland & Dolby, 1973). The principal sources of floodwater, however, lie on the Pennine watershed, where, in some shallow basins, peat formation had begun on a large scale by zone VII(a) (Conway, 1954). Generally and particularly on slopes and interfluves blanket bog tends to be a product of the sub-Atlantic, after the demise of the forest cover (Smith, R.T., 1972) and the retention of runoff by peat would be a cumulative process dependant upon depth and degree of saturation, allowing a considerable period over which runoff might have increased to the extent that a tenuous equilibrium with lowland clearance and rising sea level was over-topped, resulting in extensive and frequent intrusion of fresh floodwater into the Humberhead Levels.

Although in the Highland Zone, man may have hastened a naturally occuring progression (Ball, 1975), events in the Lowlands cannot be paralleled under similar temperate conditions in previous inter-glacials, although this may testify to the relative uniqueness of each cycle or the state of research. Hatfield Chase is not alone in experiencing extensive change during the late sub-Boreal, and elsewhere the character of the transition would appear to be much influenced by human pressures. In the valley of the Warwickshire Avon, Shotton (1978) has noted widespread and radical alteration in the character of the alluvium of the floodplain, a rapid transition from grey reduced silts with abundant organic remains to the oxidised deposits of the current depositional regime, which took place during the latter half of the Bronze Age. This change probably relates to a critical point in clearance introducing more soil to the river. A climatic paramater may be sought but Limbrey (1978) has suggested a widespread shift over to the cultivation of winter wheat, leaving large expanses of ground open to erosion. Such a division of the sediment can be traced in many of the river valleys of Britain, including those of the Humber Basin and, had the occurrence been synchronous across the country, it could be invoked, a few kilometres from the actual channels of the rivers, as a contributory mechanism to the initiation of Thorne Moors. At Sandtoft, however, in the former bed of the Don, the change in the alluvium overlies a phase of local coarse sand erosion with Romano-British pottery (Samuels & Buckland, 1978) and, although it may be relevant to post-Roman flooding (Radley & Simms, 1971) and the apparent discontinuity between Roman and later farming activities, the Moors had progressed to blanket bog by this stage. A similar section, at Thorne Waterside, also in the Don, where the transition brought in sediment indistinguishable from recent warp, is undated.

The initial waterlogging of the forest soil by a rising water-table may also have an anthropogenic component. Moore (1973) has discussed the role of man in the spread of upland blanket bog in Wales and it is apparent that some lowland wetlands may have been similarly influenced. The aspects of forest in water conservation and the hydrological cycle are much debated topics (e.g. Molchanov, 1960), but it is established that closed forest results in a considerable depression of the water-table. Even partial felling may be sufficient to bring the table up to the surface (Remezov & Pogrebnyak, 1965) and kill any remaining trees, particularly in areas with a rising base level. Thus the temporary clearances noted at Thorne may themselves have contributed to the succession to a fen environment.

Whilst the discussion has concentrated upon the anthropogenic factors in the development of the Moors, these have to be viewed against the backdrop of an inexorable rise in sea level; man inadvertently deflected the nature of the hydroseres rather than controlled it. The flow diagram (fig. 11) attempts to summarise this mosaic of ideas.


PENNINES
RIVER VALLEYS
THORNE MOORS
HUMBER ESTUARY
Gripping and Erosion of Peat
Increased Runoff
Draining and Peat Cutting
Tidal Influence
Field Drains, Improvement
Flooding
Embanking
Increased Silt Load
Raised Bog
Changing Land Use
Increased Local Runoff
Freshwater Flooding
VIII
Iron Age–Roman Extensive Clearance
? DETERIORATING CLIMATE ?
Sphagnum Bog
Estuarine Conditions
Growth of Blanket Bog
Decreasing Runoff
Independence of Water Table
Birch–Alder Willow Swamp with Dead Trees
Clearance / Decline of Forests
Increased Runoff
Freshwater Flooding
Closed Forest
Podzolisation
Temporary Clearances
Closed Forest
Depression of Water Table
VIIb
Rising
Water Table
Rising Sea Level

THE INSECT FAUNA

Notes on Particular Species

The occurrence of several insects which are no longer found in Britain and of many others, having a very restricted native distribution, in the Thorne Moors samples requires explanation in terms of environmental change, climatic oscillation or both. A uniform interpretation of the changing patterns of all taxa, however, is not possible. Several species show contradictory changes, with retractions both northwards and southwards occurring in the same faunal unit. Frequently, the published distributional data and habitat information are grossly inadequate for the conclusions which have to be based upon them, yet, if any advance is to be made in the study of the development of the insect fauna of Britain during the post-Glacial, the scattered sources have to be collated and reasons for faunal variations through time suggested. More than ten years ago, Osborne (1964) recognised that the effects of man on the insect fauna were as profound as his effects upon the flora. The influence of man and climate become progressively more interwoven and inextricable from the early Neolithic onwards. Hammond (1974) has recently reviewed changes in the beetle fauna, with particular emphasis on variations since more systematic recording began, and he favours anthropogenic agencies for the majority of changes within historic time. Osborne in several papers (1965; 1969; 1972; 1974) has examined the problems of a number of sites and of individual species in deeper perspective, introducing evidence for both climatic and human influence in the Flandrian. With the Thorne identifications, a more adequate amount of data has been accumulated to attempt a more detailed review of events since pollen zone VII (a) and, having set out habitat, distribution and interpretation for individual species, a synthesis is attempted, although Hammond's (1974) caveat has to be considered at all stages:

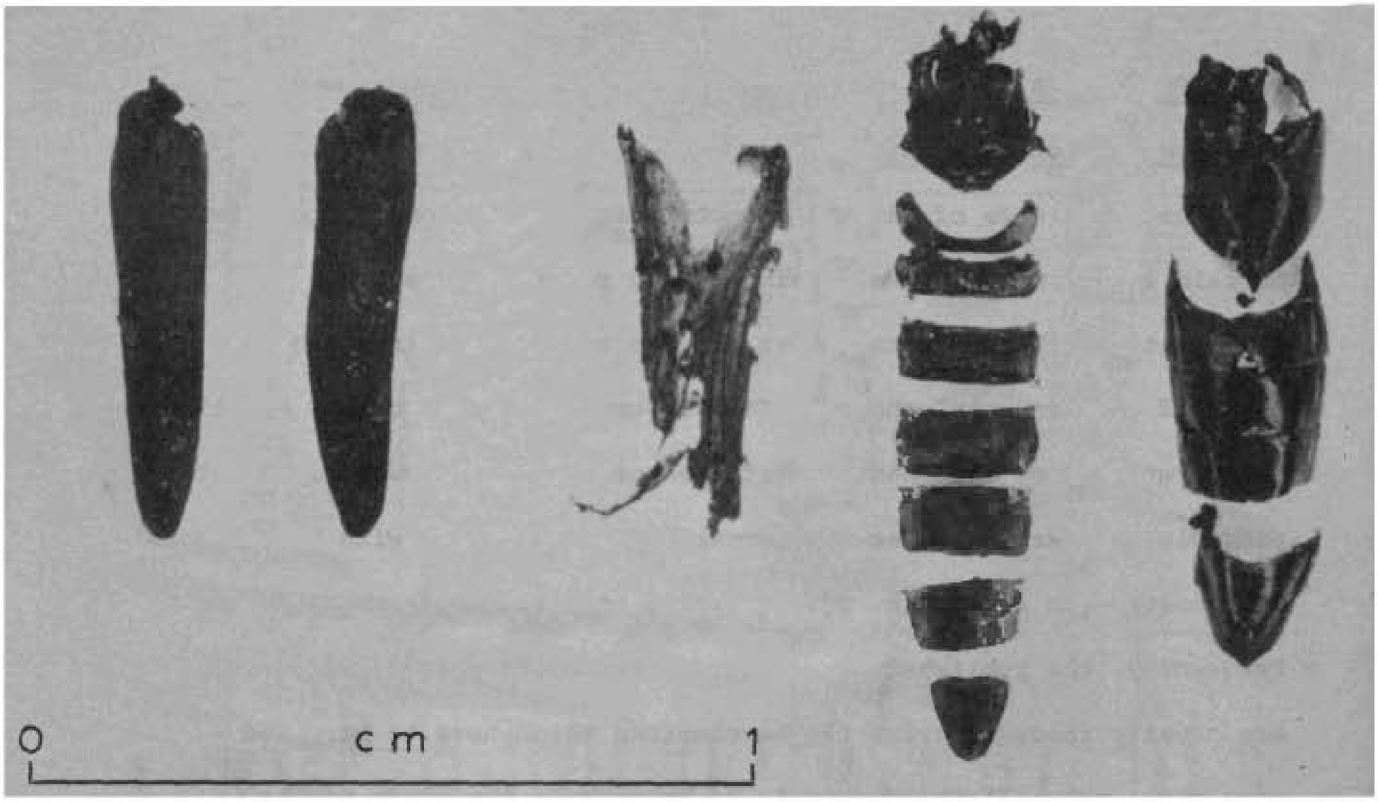


Figure 12: Isorhipis melasoides, an unemerged individual from timber (alder) at the base of the peat. Thorne Moors (1972).

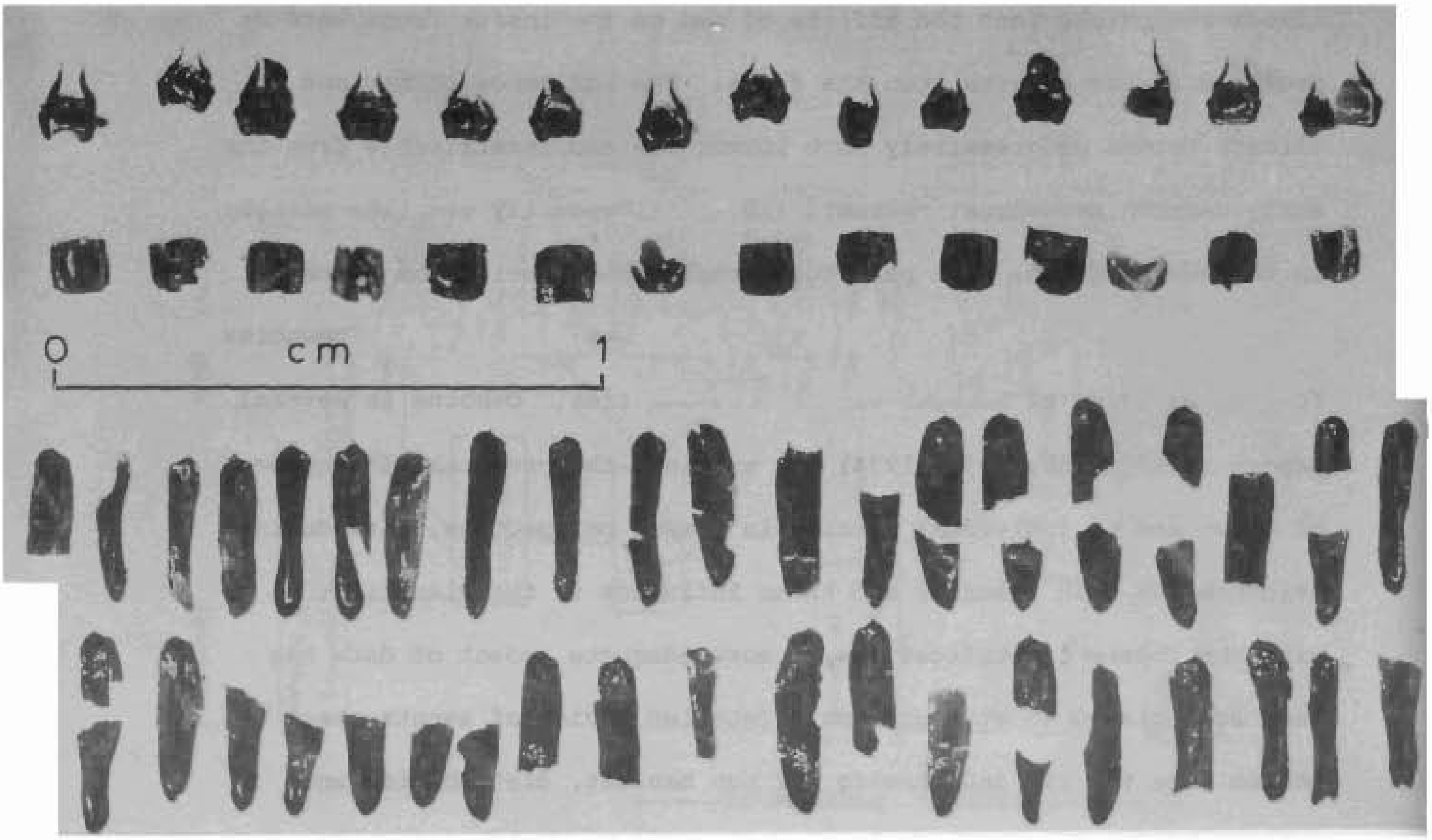


Figure 13: Prostomis mandibularis from between the timbers of the trackway, Thorne Moors (1972).

> "our knowledge of the present-day fauna is an inadequate basis for any discussion of past change".

The specific notes are divided into four sections : the species not presently recorded from Britain, found in the Thorne assemblages, are discussed first; secondly, the more significant of the Thorne insects with restricted British distributions are considered. To consider Thorne Moors in other than a local context without some reference to other finds of non-British species would be parochial, if not misleading, and additional information is provided on published records of pollen zone VII or later finds, as well as notes on two species of dung beetle, which are now probably extinct in this country. Comments on other records of insects with curtailed British distributions with fossil examples known from localities on Hatfield Chase or North Lincolnshire (Buckland, in press) appear in the fourth section.

Species not recorded from Britain

Rhysodes sulcatus F. (Fig. 14)

A single thorax of this species was recovered from Sample 3. It has previously been recorded from a somewhat older deposit at Shustoke in Warwickshire (Kelly & Osborne, 1963), dated to 4830±100 B.P. (NPL 39) and a site at Alcester in the same county, dated by pollen analysis to zone VII (c. 7,500 - 2,500 B.P.) (Osborne, 1965). Blair (1935) also recovered a specimen from 'Moorlog', washed up on the coast at Caister-by-Yarmouth. The species is now extremely rare. Absent from Britain, it was recorded last century from the southern tip of Sweden in Blekinge province and possible also from eastern Smaland, immediately to the north, but is now regarded as extinct there (Palm, 1959). The few German records are also old; from Sollinger Wald in southern Hanover (1848) and around Munich in southern Bavaria (1851); in 1919 Novotny noted it, sometimes in large

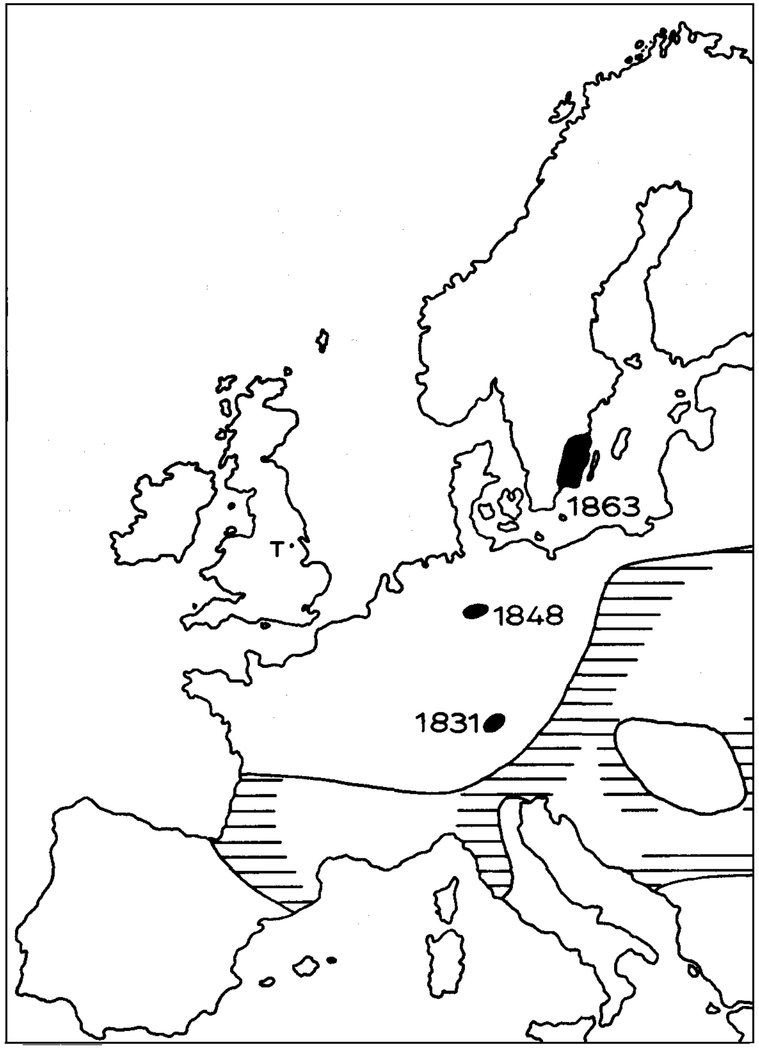


Figure 14:

Present distribution in W. Europe : Rhysodes sulcatus.
T = Thorne Moors.

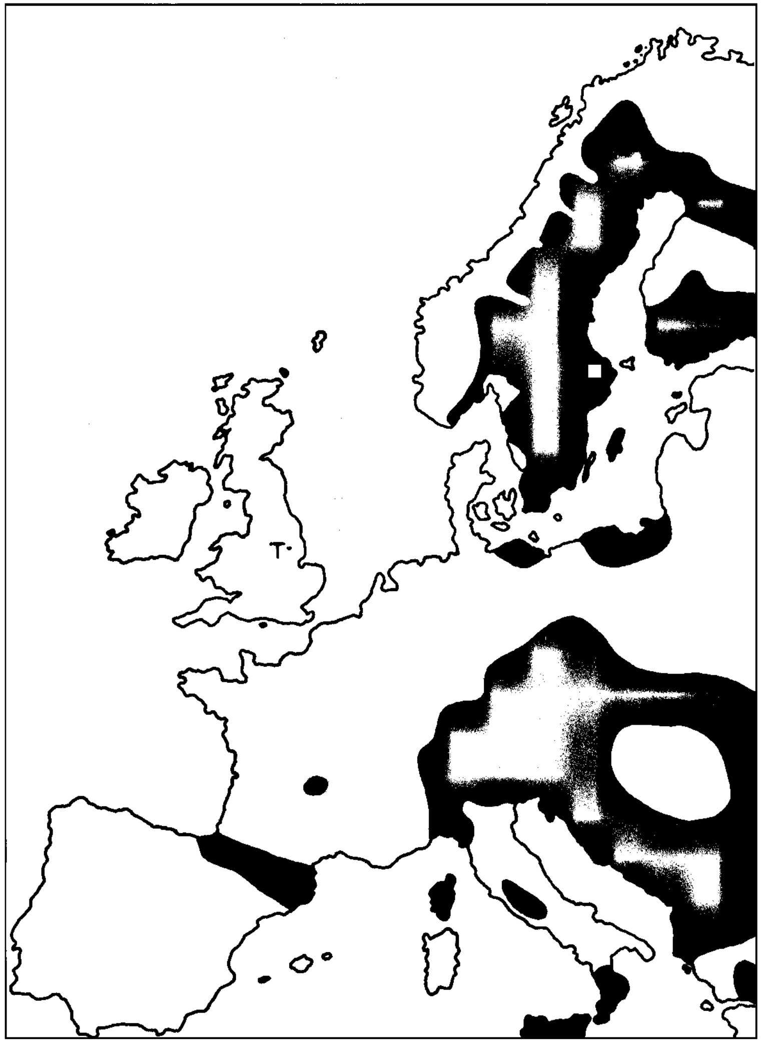


Figure 15:

Present distribution in W. Europe : Pelta grossum.
T = Thorne Moors.

numbers, beneath bark in Upper Silesia (Horion, 1941). R. sulcatus is now largely a south-east Central European species, known from south-west Russia, Poland, Transylvania, Slovakia and the north Balkans, extending in a few scattered localities westwards to Lombardy, Tuscany, southern France and the Pyrenees and eastwards to Anatolia and the Caucasus. The ecology of the animal is poorly known but it appears to prefer beech woodland (Horion, 1935) and lives in thoroughly rotted wood. Novotny's records were from under damp bark on old rotted copper beech, although Palm (1959) notes old records from spruce and Auber (1960) notes it in the Pyrenees from rotted fir. The closely related and equally rare R. germani Ganglb. has also been found associated with beech (op. cit.). The beetle has been variously regarded as a predator or a fungal feeder, the latter being the more generally accepted (Crowson, pers. comm.). The insect may not be as stenotopic as the records from beech imply and the loose association at Thorne is with oak.

Belonging to a small family of only two genera, species of Rhysodes have a worldwide distribution, occurring, as well as in Europe and Western Asia, in India and Burma (Arrow, 1942), Japan (Winkler, 1932), Australasia (Broun, 1881), South Africa (Arrow, 1942), Madagascar (Fairmaire, 1868), Brazil (Guerin 1953) and North America (Arrow, 1942). K. Dorn first proposed the term 'Urwaldrelikt' for this species in present day Europe (Horion, 1935). An apparently primitive group amongst the Adephaga, this family gives the impression of being itself a relict in the Quaternary. When the material for study is finally forthcoming, it is probable that it will be shown to have had a long history in the warmer, more species rich forests of the Tertiary.

Pelta grossum (frontispiece & Fig. 15)

A single complete male of this large Peltid was found, still in its pupal chamber, in a small decayed birch, less than 100 m. in diameter, at an horizon a few centimetres above that of the trackway but 500 m. further east in the dyke section. Several other birches were noted in the fresh ditch sections at roughly the same level and they seem to represent a slightly drier phase in the development of the bog, allowing the spread of trees onto the surface, somewhat like the birch scrub which occupies the Moor at the present day, a result of increased drainage activity. Pelta grossum has a boreo-montane distribution ranging across Europe from Scandinavia and East Germany to the region of Lake Baikal in Russia. Another species, P. gigantea, distinct on the aedeagus, appears in Siberia. Horion (1960) records the species living in Central Europe beneath the bark of rotted spruce and fir, although there are also records from Upper Silesia and Banat from under rotten beech bark. The beetle is likewise not recorded from birch in Finland but in Sweden it occurs in thick, dry birches with soft rot, which develops particularly after felling in trunks and stumps exposed to the sun (Palm, 1951). The association of this insect with Urwald damaged by forest fires is interesting in the light of the evidence for slash and burn agriculture at Thorne and the suggested widespread use of this method of clearance (e.g. Bender, 1975), which would have provided abundant habitats for this and several other species which are attracted to burnt ground. With the spread of more permanent methods of land utilisation, these habitats would have been gradually curtailed.

Isorhipis melasoides (Figs. 12 & 16)

As well as the seven well preserved individuals of this Eucnemid recovered by splitting wood samples from the brushwood peat, the characteristic workings and larval head capsules were noted in several other pieces of timber, implying that the insect was, at least locally, abundant in the Middle Bronze Age on the Hatfield Levels. An undated example, younger than the Early Bronze Age, was also recovered from the Misterton Carr succession (Osborne, pers. comm.). The beetle usually develops in beech (Reitter, 1911) but also recorded from other deciduous timber (Escherich, 1923). It is unfortunate that no wood identifications were done amongst the additional samples from Thorne[1] but beech does not appear in the pollen diagram (Fig. 8) until above the trackway horizon and then only as single grains, perhaps of distant origin. Godwin (1975) notes that macrofossils of beech occur as far north as a line from the Wash to the Lower Severn during pollen zone VII(b) and pollen evidence implies local presence as far north as the Lake District in zone VIII. As a tree more characteristic of drier, more calcareous substrates, *Fagus sylvatica* is unlikely to have thrived during the period of rising water table and flooding represented by the Thorne faunas and, although other predominantly beech feeders, like *Eucnemis capucina*, are present, it is probable that they were living in other hosts. Auber (1960) records *I. melasoides* in France from oak and poplar, as well as beech. If this Eucnemid does prefer beech, its retraction may predate the large scale expansion of beech forest in such areas as the Chilterns, although failure of continuity of habitat due to clearance and the intensive management of these woods during the mediaeval period could have been equally critical. *E. capucina* survives not in the Chiltern beechwoods but in the New Forest, where there has been less disturbance. The continental distribution, however, suggests that *I. melasoides* is relatively thermophilous. It is absent from Scandinavia, rare in France (Auber, 1960), avoiding the western seaboard and the Mediterranean (Horion, 1953). Germany (Horion 1953), it is known from the Baltic coast, Brandenburg and Silesia, and in the Rhineland, Hesse and the Alpine foreland.

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[1] This wood has now been identified as alder (Limbrey, pers. comm.)

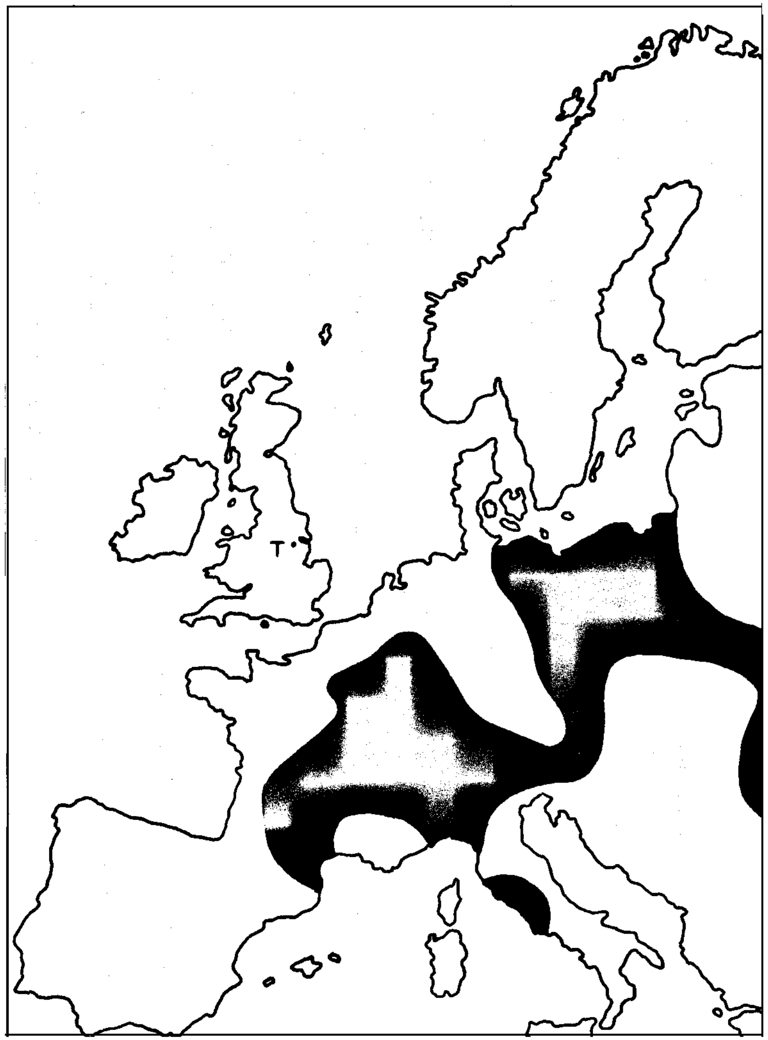

Figure 16:

Present distribution in W. Europe : Isorhipis melasoides.
T = Thorne Moors.

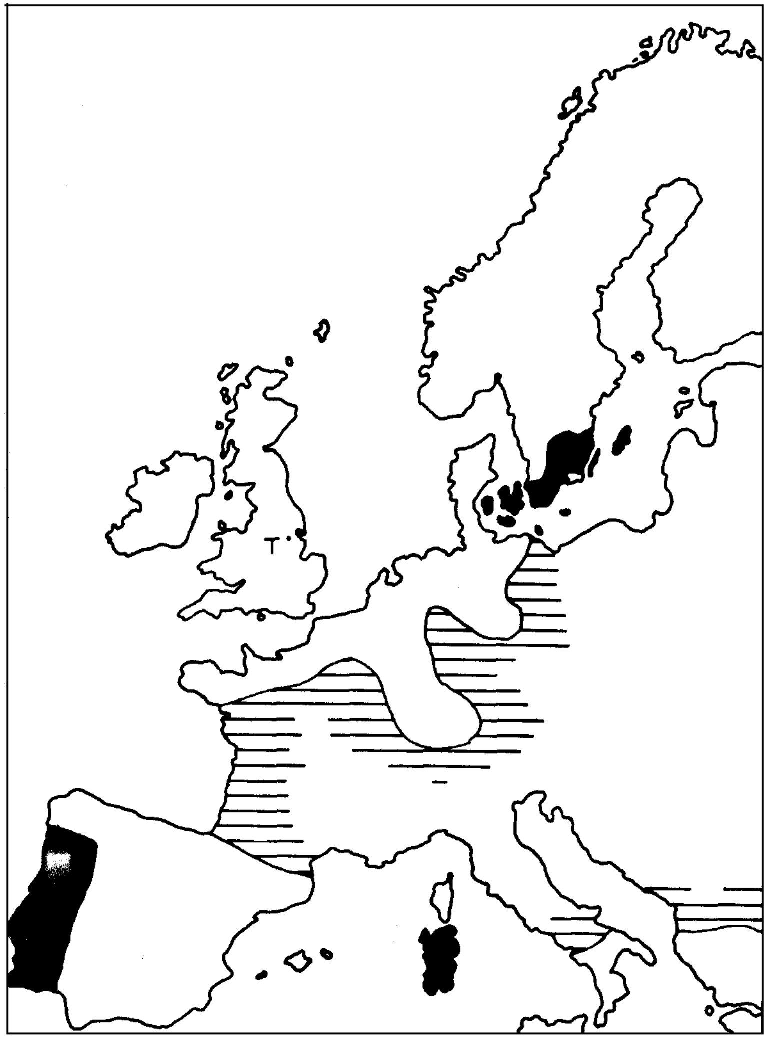

Figure 17:

Present distribution in W. Europe : Prostomis mandibularis.
T = Thorne Moors.

The absence from a broad strip across central Germany implies that its distribution may not be simply climatic and old, established forests would also appear to be essential for its survival.

Prostomis mandibularis (Fig. 13 & 17)

Amongst the species no longer found in Britain, P. mandibularis is the most frequent, with a total of fifty-six individuals from the trackway horizon. It has yet to be recorded from any other site in Britain. Both Horion (1960) and Palm (1959) use the term Urwaldrelikt for this beetle and, although primarily recorded from damp, rotten oak, it is very much an animal of the Urwald, the primary, undisturbed natural forest, and is virtually restricted to only a few isolated strongholds in the remnants of Central European sub-natural forest, from which it is rapidly being ousted by tidier forestry practice. Horion (1960) expected that this rare Cucujid would disappear completely from Central Europe within a few years and that it already seemed to be on the verge of extinction from the Harz, Thuringia, Saxony and the Palatinate. The species has a holarctic distribution, occurring in Europe from the southern part of Sweden southwards with a few localities in Denmark, through Germany into Central Europe; westwards it is known from Portugal and France, particularly in the south of the country, to Switzerland, Sardinia and Italy, south to the Bay of Naples.

Mycetina cruciata (Fig. 18)

A single thorax of this Endomycid was recovered from between the timbers of the trackway. It does not occur in Britain at the present day and there are no other fossil records. In Scandinavia, the species is very southern in distribution, avoiding the wet, oceanic west and south coasts of Norway and the mountains but occurring as far north as Dalarna and Helsingfors province in the

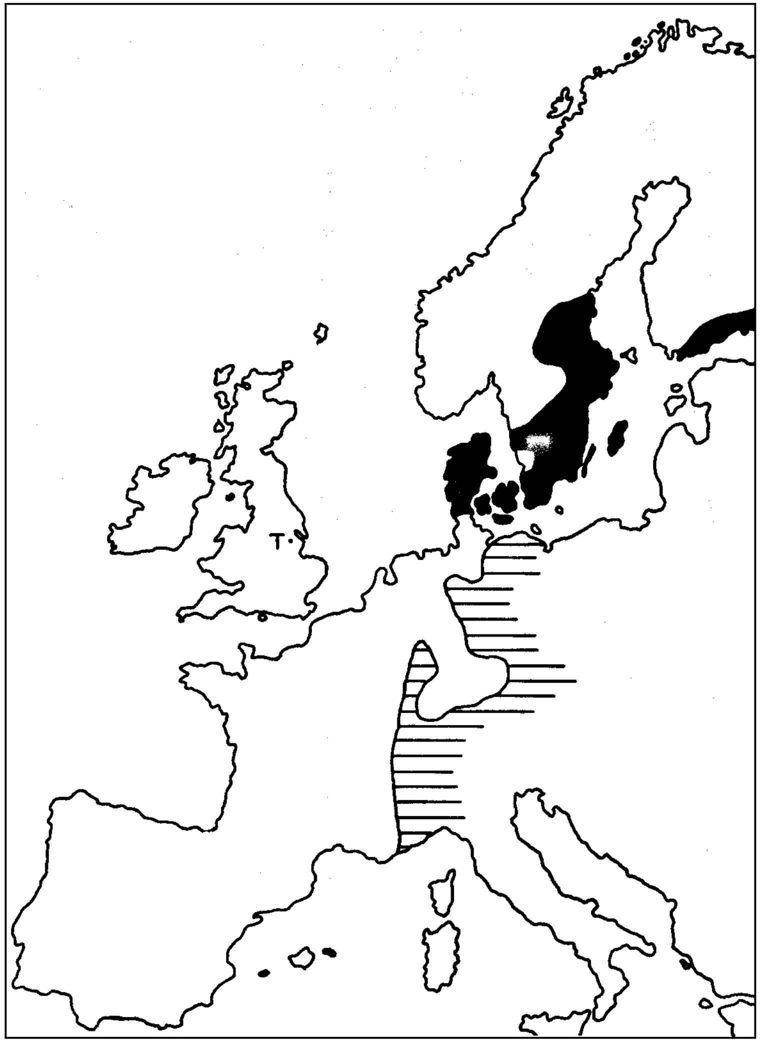

Figure 18:

Present distribution in W. Europe : Mycetina cruciata.
T = Thorne Moors.

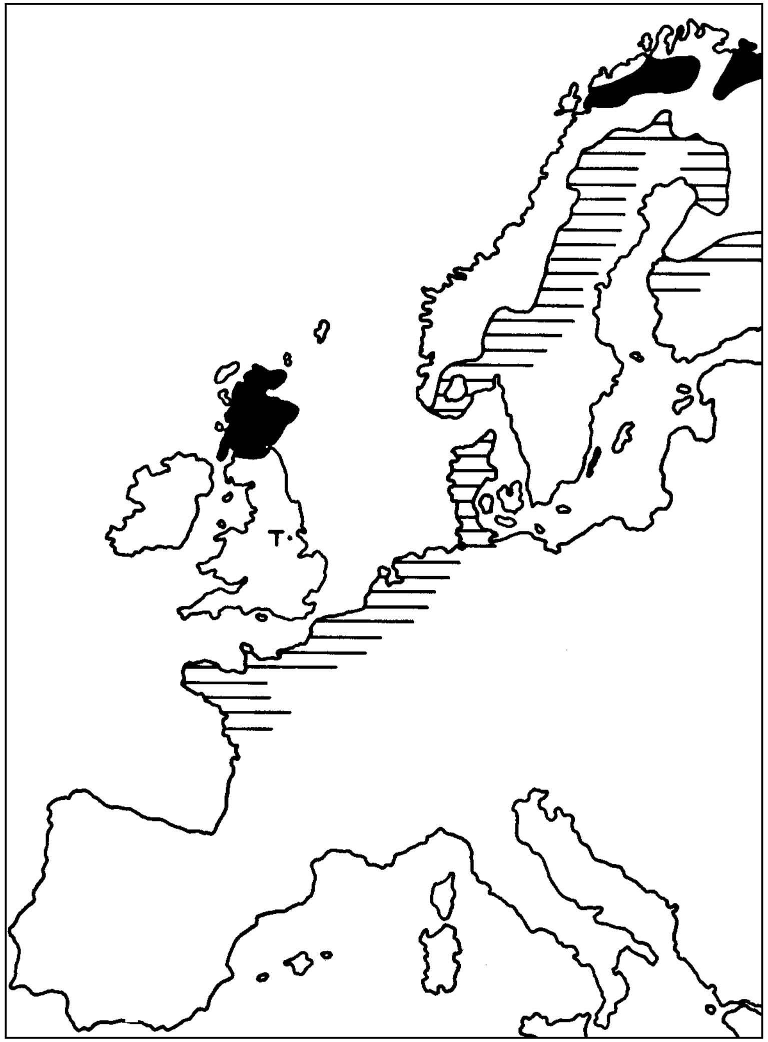

Figure 19:

Present distribution in W. Europe : Scolytus ratzeburgi.
T = Thorne Moors.

more sheltered, continental eastern part of Sweden; in Finland, it is restricted to the southern coast strip (Hansen et al., 1960). In Germany, this beetle tends to be eastern and southern, occurring in Prussia, Silesia, Baden and Bavaria, as well as Austria; there are also old records for Mecklenburg, Hanover, Hess, Thuringia and the Harz (Horion, 1951). Reitter (1911) notes the species from rotting wood in mountain regions. Despite its avoidance of climatically damp areas, this fungal feeder prefers very moist to wet wood in shaded localities in forests, with the wood being in such an advanced state of decay that it is rapidly crumbling into the litter on the forest floor (Palm, 1951). The insect prefers conifers but has been recorded from most types of tree. Horion (1961) notes it to be locally common under the bark of both deciduous and coniferous trees, associated with _Polyporus_ species.

Rhopalodontus bauderi

Distinguishable from _R. perforatus_, known from Scotland (Massee, 1967), by its larger, deeper puncturation on the elytra, _R. bauderi_ is not recorded from either Britain or Scandinavia and Lohse (1967) notes the species from Slovakia, southern and western Europe. The Cisids are not directly associated with rotten wood but with the fungal fruiting bodies appearing thereon. In the British Museum collection, there are three specimens of _R. bauderi_ labelled 'bred in Cambridge Forestry School (1924) from _Fomes fomentarius_ from a beech tree in the Landes, France'. As Paviour-Smith (1968) notes, however, in discussing _R. perforatus_, there has been confusion between _F. fomentarius_, which, in Britain, is restricted to birches in the Scottish Highlands, and _Ganoderma applanatum_, which is more characteristic of old beeches, and it is possible that the latter is intended on the British Museum label.

Acalles sp.

A single head, close to A. roboris but more heavily punctured on the rostrum, could not be matched by specimens in the British Museum collection, but there are several species in this part of the genus in Europe (Hoffman, 1954) and identification will have to await the recovery of more fossil material.

Comments on Species Recorded from Britain

Agonum livens

Although another species of this genus, A.obscurum, from the Thorne samples, is perhaps a more characteristic carabid of deciduous woodland (Lindroth, 1974), its occurrence as far north as southern Scotland often among the moss on the bark of old oaks (Crowson, 1962), makes it less useful from an interpretative point of view than the rather restricted A. livens. This species reaches its present northern limit in Britain on Thorne Moors and at about 20 km. due west, where it is recorded from both Denaby and Edderthorpe Ings in the Dearne Valley (Skidmore, 1966; 1970). To the south, it is recorded from the Trent bank at Rampton (Carr, 1916) but, throughout the country, it is a rare and localised species (Lindroth, 1974) and its relative abundance at its present northern limit is surprising. In Scandinavia, it is largely restricted to the more continental eastern part of the oak zone (Lindroth, 1945) being absent from Norway, although there are occasional records in Finland from as far north as the northern end of the Gulf of Bothnia (Hansen et al., 1960). In Germany it occurs throughout the country but is, on the whole, rather rare and scattered, becoming rarer to the South (Horion, 1941). The species is strongly hygrophilous and Lindroth, in both Scandinavia (1945) and England (1974), records it from 'marshy deciduous forests, often alder, among leaves and Sphagnum moss'. The association with alder or birch in swampy areas (Lindroth, 1945) is not, however, maintained in the South Yorkshire localities. On Thorne Moor, the species was taken from Phragmites litter (Crossley, pers. comm.). Denaby Ings lies at the foot of the scarp slope of the Magnesian Limestone, sandwiched between a disused railway embankment and open, largely arable farmland. There is no woodland on the valley floor and the insect is closely associated with old willows, usually under the loose bark of rotten trees (Skidmore, 1966) on the edges of wet, frequently flooded ings; a similar habitat is found at Edderthorpe Ings; further up the Dearne Valley. On the available evidence, it is difficult to ascertain whether this represents actual variations in habitat between Scandinavia and England, perhaps implying slight physiological adaptation, or an increased specificity in habitat towards the limits of its range, a feature noted with certain of the xylophagous species from Thorne. It is probable that the microclimate in reed swamp litter and beneath willow bark in a relatively open habitat in South Yorkshire is analogous to that in shaded fen woodland in Scandinavia, although clearly other factors may be involved and the available data are insufficient.

Hydroporus scalesianus

The drainage of the East Anglian Fens, largely completed with the disappearance of Whittlesea Mere in 1851, marked the virtual end of the series of interrelated habitats, which had once been ubiquitous in Lowland Britain. The extinction of the British sub-species of the Large Copper butterfly, Lycaena dispar L. which was restricted to the Fens, is widely known (Heath, 1974), but the radical decline in several species of Dytiscid and Hydrophilid water beetle is less frequently referred to. Stephens described H. scalesianus in 1838 from an unlocalised Norfolk specimen and it was not taken again until 1856, when it was found in Chaloner's Whin, near York (Balfour-Browne, 1940). All specimens in British collections came from this locality until it was last taken there 1894, overcollection and decline in the habitat contributing to its demise. Balfour-Browne (op. cit.) took the species in eastern Norfolk in 1904-6 but there are few subsequent records. It must, however, have once been much more widespread since, during pollen zone VII(b), it is recorded from Thorne Moors, the Somerset Levels (Girling, 1976) and Church Stretton, Shropshire (Osborne, 1972). As Balfour-Browne notes, its preference for swamps with thick moss and clear water probably means that it has been overlooked in many suitable localities but French records (Guignot, 1933) suggest an association with woodland pools and it is this aspect of the Fens which had been most seriously depleted long before drainage (e.g. Rackham, 1974) and the few records of this insect may well refer to relict populations precariously surviving in an environment marginal to its normal.

Hydroporous neglectus and H. rufifrons

H. neglectus is also recorded in France from forest pools in stagnant water with dead leaves (Guignot, 1933), although, in England, Balfour-Browne (1940) collected it, occasionally in large numbers, from shallow ditches with much vegetation. This Hydroporine is slightly more widely recorded than the previous species and is known from as far north as north-east Yorkshire and, in the west, from Flint but it has only been taken with any frequency in eastern Norfolk and Surrey (op. cit.)

Balfour-Browne (op. cit.) notes that, despite its wide range and occasional frequency, H. rufifrons belongs to a declining element in our fauna, that of true fen species. It has been recorded as common at Chaloner's Whin near York (op. cit.)

Oxytelus fulvipes

Although there are records of this small Staphylinid from as close to Thorne Moors site as Sherwood Forest (Allen, 1964), c. 25 km. to the south-west, and Askham Bog, adjoining Chaloner's Whin, near York (Kenward, 1978), it is sufficiently uncommon for some comment to be required. Allen (1964) was only able to record captures from four other, scattered localities in England : Ormesby Broad, E. Norfolk, Needwood and Sutton Park, Staffordshire, and Tonbridge, Kent. O. fulvipes has been taken from among dead leaves and other litter in wet situations and may have been overlooked in more northern localities but its Scandinavian distribution, absent from Norway except the Oslo-district (Hansen et al., 1960), suggests a preference for a more continental regime and it may be regarded as having a relict status in England.

Ilyobates subopacus

Specimens of this species in museum collections in Britain were labelled as I. nigricollis (Payk.) until Johnson (1968) pointed out that virtually all the British examples which he and A.A. Allen had examined were of I. subopacus; there are few authentic British records of the true I. nigriocollis. Comparison of the Thorne examples, represented by thoraces and elytra, with a range of both species in the British Museum shows that they belong to the smaller one with closer puncturation on the thorax - I. subopacus Palm. Both species are found in leaf litter but that found in the Thorne samples is the more characteristic of marshy places (Johnson, pers. comm.)

Plectophloeus nitidus

This small Pselaphid is extremely rare and is only known from four British localities : Sherwood Forest, Windsor Forest, Blenheim Park, Oxford, and Moccas Park, Herefordshire (Pearce, 1957). All records of this insect in England are from old, rotting oak stumps and trunks (op. cit.); Donisthorpe (1939) also found it associated with the ant Lasius brunneus in a felled oak in Windsor Forest, although the beetle need not be myrmecophilous. The Thorne specimen is closely associated with an old oak but, in Sweden, where it has only be recorded from Stromsholm, Vastermannland in central, southern Sweden, it has also been taken from limes, in company with L. brunneus (Palm, 1959). The species, perhaps in part due to its small size and cryptic habitat, is also rare in the remainder of Europe and, in Germany, is only recorded from the Rhineland, Wurtemburg, Bavaria, Brandenburg and Silesia, with old records (pre-1910) for Mecklenburg (Horion, 1951).

Paromalus parallelepipedus

Allen (1971) regards this minute Histerid as one of our rarest insects and, apart from old, somewhat vague records from the New Forest, it has only been taken once, in 1952, near Canterbury. The species is not referred to by Joy (1932) but it was included in Kloet and Hincks' checklist (1945). In England, as would be expected with such an uncommon animal, there is little habitat data; one was collected by sweeping in the New Forest, probably around the turn of the century, and the Kent example probably came from beneath the bark of a chestnut, an introduced tree (Allen, 1971). In Sweden, it is recorded from oak and sycamore but is more characteristically found beneath conifer bark on trees attacked by Scolytids (Ips. spp.) (Palm, 1959) and Reitter (1909) notes a similar preference in Germany; French records (Auber, 1960) are from beech and pine. The Thorne specimen, which includes both elytra with abdomen and aedeagus, came from between timbers of the trackway and cannot therefore be associated with any particular species of tree. The beetle occurs throughout Germany but is rare (Horion, 1951) and in

Scandinavia it is found from the Oslo region eastwards, on both sides of the Baltic as far north as 62^0N. (Hansen et al., 1961).

Aplocnemus pini

In Britain, this Dasytid is associated with old pine forest and it is largely known from occasional examples taken in the pinewoods of the Scottish Highlands (Hunter, 1977). Buck (1955) records single examples of the other British species, A. nigricornis (F) from rotten birch in Epping Forest and, in the index to this volume of Entomologists' monthly magazine, this is corrected to A. pini. It has also been found under pine bark in Sweden (Palm, 1959) but it is not an insect of the northern coniferous zone. In Norway, it has only been found in the Oslo region and, in Sweden, it does not occur north and west of the line from Vastergotland to Upland; in Finland, the only records are from the province of Nylandia, on the south coast (Hansen et al., 1961). The restriction to a pine pabulum only occurs in the northern part of its range and, in Central Europe, its more catholic tastes are shared by another British pine feeder, the weevil, Eremotes ater, also in the Thorne faunas. Palm (1959) has taken A. pini by sweeping in a wooded valley with moribund oaks, limes and other deciduous trees in southern Sweden and Horion (1953) notes it frequently from oak in Central Europe, where it becomes rarer towards the north (Horion, 1951). The apparent curtailment of the British distribution almost completely to the Highland pinewoods seems most satisfactorily explained by invoking anthropogenic causes - the disruption and dispersal of its habitat - but such a hypothesis carries the important corolary that either the insect has always been restricted to pine in northern Britain or that the factors which created this increased host specificity, possibly a thermal decline, only became effective after the Middle Bronze Age, when the Thorne specimen shows that A. pini was endemic at least as far south as the Humberhead Levels. Although the distribution on the European mainland would imply that this beetle prefers a fairly warm continental climate, the Scottish Highland localities are far more oceanic than much of the intervening areas of England and Norway and, like two other Thorne species, Eremotes ater and Scolytus ratzburgi, towards the edge of its range, it is perhaps more the long term continuity of specific habitat rather than climatic regime which is most significant.

Dasytes niger

The larvae of this species have been recorded under bark and in rotting wood of various deciduous and coniferous trees and are apparently predaceous, probably on the larvae of Diptera (Palm, 1959). Easton (1965) took the adults, in some number, on rain drenched flowers of the common rockrose (Helianthemum chamaecistus) in southern Hampshire but the beetle is both rare and of restricted distribution in England, with records from the New Forest, Surrey, Windsor, Savernake Forest, Wiltshire (Holford, 1968) and West Sussex (Cooter, 1969). In Windsor Forest, Donisthorpe (1939) was only able to repeat Stephen's records of a capture by Leach, prior to 1830. In contrast, the species occurs throughout most of Scandinavia, including the far north, where it occurs in birch (Palm, 1951), and coastal, montane provinces of Norway (Hansen et al., 1961). It is also widespread in Central Europe (Horion, 1953). The distribution of this insect is the most contradictory amongst those of the Thorne faunas; eurythermal on the Continent yet a very southern, apparent Urwaldtier element in the British fauna. The French distribution, however, also avoids the north-west and it is absent from Iberia (op. cit.), suggesting an avoidance of the influence of the Atlantic on the climate.

Eucnemis capucina

In Britain, this species is only known from Windsor and the New

Forest, whence there are a few records from decaying beeches (Appleton, 1972). Donisthorpe (1939) also took a small series from an old ash tree in Windsor Forest. In Scandinavia, the species ranges north of the limit of both of these trees in Vastmanland, Sweden, and Savonia and Karelia, Finland (Hansen et al., 1960), where it is associated with elm and sycamore (Palm, 1959), in Germany, it is recorded from all species of deciduous tree (Horion, 1953). The species is regarded as a rare Urwaldrelikt by Palm, who studied its biology intensively in Stromsholm district, Sweden. The larvae develop inside the hard surface of the rotting timber, pupating in autumn, and the adults emerge the following spring but remain within the pupal chamber until stable, warm summer weather appears (op. cit.). Such a species would therefore be particularly susceptible to a spell of early warmth followed by late spring frosts.

Trinodes hirtus

This small Dermestid is recorded from Windsor Forest (Donisthorpe, 1939), where both imagines and larvae were taken from cobwebs under oak bark. The species was not uncommon and adults also occurred on ledges by deep pens, in hollow trees and on oak branches. In Scandinavia, it has been recorded from most species of coniferous tree, as well as oak, elm and hornbeam (Palm, 1959). The beetle is a general scavenger of insect remains in trees, being attracted by these to spider's webs. T. hirtus is generally distributed in Central and Southern Europe but rare, occurring also in the Caucasus and east of the Caspian Sea (Horion, 1955). Its northern limit lies at the southern tip of Sweden, occurring in Skäne, Blekinge, Holland, on Öland and Zealand, and on the Danish peninsula (Hansen et al., 1961). Despite its occurrence in synanthropic situations in Germany (Horion, 1955), unlike other Dermestids, T. hirtus seems to have been unable to exploit the artifically cushioned habitats created by man to maintain or increase its range.

Rhizophagus parallelocollis

Apparently distributed throughout Britain, this species forms one of an interesting group of possibly basically forest species, which also includes Cryptolestes ferrugineus and Xestobium rufovillosum, discussed below, which have been able to adopt, to varying degrees, synanthropic habitats. R. parallelocollis is found occasionally, if rarely, both behind damp bark and at sap on deciduous trees (Horion, 1960) but it is most frequently taken from graveyards. Johnson (1963) records it, with R. perforatus, also in the Thorne samples, from compost heaps and vegetable debris as well as in fungi and on carcasses. It has been found in fossil contexts in a medieval burial from London (Stafford, 1970), in the tomb of Archbishop Greenfield (ob. 1316) (Buckland, 1974) and on the Anglo-Danish site at Lloyds Bank, York (Kenward, pers. comm.). All three principal biotopes recorded by modern authors are therefore represented, although the Thorne specimens could have been in rotting plant debris in the trackway and at the base of tree 1, rather than behind bark. There is some discrepancy in the suggested food cources for this beetle. Megnin (1894) noted it preying on Phorid larvae in corpses less than two years old, Palm (1959) thought that it lived on the fatty tissue, whilst Horion (1960) regards it as a mould feeder; Blair (1922) regards it as a predator. It is both difficult and hazardous to argue from the fossil evidence but the closed system provided by the Greenfield tomb is of some significance. Kraats and Heyden (1888) (quoted by Horion, 1960) were of the opinion that R. parallelocollis lived on the mouldy wood of the coffin and not the corpse. Greenfield, however, interred in his robes in a lead coffin inside a stone sarcophagus, had very little associated wood. The tomb allowed the body to dehydrate slowly, reducing everything, except some of the bones and some fabric, to a black organic residue on the base of the lead coffin; the burial, however, was sufficiently sealed and anaerobic to preserve perfectly the insect remains and drying out probably occurred through the pores of the limestone coffin. It would have been virtually impossible for the included insect fauna to have entered the coffin after interment, although Blair's (1922) evidence suggests that newly hatched larvae could enter coffins, and moulds, which would grow on the decaying body, might also be expected to attack the insect remains. Although it should be noted that a few individuals of a known mycetophage, Mycetaea hirta, occurred, it seems unlikely that there was sufficient mould growth within the coffin, whose lead lining would in any case inhibit this, to support the very large numbers of Rhisophagus which occurred in the Greenfield samples. This entire fauna, dominated in the preserved remains by R. parallelocollis and the carnivore/omnivore Quedius mesomelinus, must stem from eggs laid on the corpse whilst the Archbishop lay in state, when there would also have been some opportunity for mould growth. The system, phorid eggs plus those of predators on these flies, seems the most probable, the predators utilising the fatty tissue secondarily by consuming the maggots. It may be significant that the Greenfield samples suggest that few coffin flies reached the pupal stage, although the deposit was packed with adult Rhizophagus and Quedius, this could however, be a factor of preservation. The change from either a predatory of mycetophagous vegetable debris and behind bark to the direct utilisation of putrefying fatty tissue implies physiological change, or at least a specialisation in this species which isolates it from the remainder of the genus. In view of the proven morphological stability of many species during the Post-glacial and earlier (c.f. Coope, 1970) and the general concordance between modern and fossil habitat data this seems an improbable, if interesting possibility. It is more probable that the beetle is able to find the same food source behind bark, in plant debris and in corpses. The mould flora of plant decay differs from those associated with animal putrefaction and although a generalised mould feeding is possible, the available evidence would best support predation on larvae; more research, by direct observation, is needed. The specimens from the Roman sewer at York (Buckland, 1976), seem to have formed part of the resident subterranean fauna and are associated with large numbers of Psychodid fly puparia (*Telmatoscopus* spp.); predation on these seems probable, although mould feeding cannot again be wholly ruled out.

It is interesting to note that there are no recent records of *R. parallelocollis* from South Yorkshire, although it is recorded from old hawthorn stumps at West Ayton in North Yorkshire (Walsh, 1956). Although the more natural habitats remain freely available, more rigorous requirements from the Department of Health for burial grounds has severely affected churchyard populations.

Dienerella separanda

Until 1966, when Allen published a key to separate them, this species was largely confused with *D. elongata* Curt. and all the Donisthorpe and British Museum specimens of the latter were found to be *D. separanda* by Allen. In several sources, including Kloet and Hincks (1945), the two species are synonymised but both Allen and Lohse (1959) describe significant differences in the aedeagi and the curvilinear form of the sutural margin over the elytral declevity in *D. separanda* is a useful diagnostic character for fossil examples, although one of the Thorne specimens is supplemented by an aedeagus. Because of the confusion of these two species, it is difficult to obtain distributional data. Hansen et al. (1961) records *D. separanda* in Scandinavia only from around Oslo and Blekinge province in south east Sweden but Strand (in Allen, 1966) noted that the two were mixed in his Norwegian collection. In England, D. separanda would appear to be more common, although the relative frequency of specimens may well reflect its more gregarious nature. Allen's (1966) list of localities records both species as far north as Sherwood Forest, although there is a gap of nearly 150 km. between these occurrences in this relict forest region and the nearest other localities in the South-east, where the species recovered in the sample from the base of the oak (tree 1) has been taken in scattered localities north into Hertfordshire. Isolated findspots occur further west, in the New Forest and at Bovey Tracey, Devon. In part, this distribution must relate to the relative frequency of collectors but it is surprising to note that the few examples in the Doncaster Museum collection belong to the other species, D. elongata.

Colydium elongatum

A predator in the galleries of wood-boring insects, C. elongatum is only known in Britain from scattered records for the New Forest (Joy, 1932). In Scandinavia, it is only known from southern Sweden (Hansen et al., 1961), where Palm (1959) records it from beech and spruce. Its apparent preference for these trees, as that of its congener, C. filiforme F., as yet not recorded from Britain and noted in Sweden exclusively from old oaks, may be more a factor of its relative rarity than actual and, in France, (Auber, 1960) and Germany (Vogt, 1967), it may occur under the bark and in borings in any species of tree.

Teredus cylindricus

This Colydiid had only been recorded from Sherwood Forest, Nottinghamshire, until Donisthorpe (1939) took it in Windsor Forest, where it appeared to be not uncommon. On the Continent its distribution is equally disjunct, occurring on the Swedish island of

Öland, on Bornholm (Hansen et al., 1961), in southern Germany and Austria with old records from the Lower Rhineland, Thuringia and Bavaria (Horion, 1951). Usually found in old oaks, it is also recorded from old beeches (Reitter, 1911) and lives as a predator in the galleries of Xestobium rufovillosum, Anobium punctatum and Dryocoetinus villosus, all species found in the Thorne samples, as well as in those of Ptilinus pectinicornis and associated with the ant Lasius brunneus. The Sherwood finds were all associated with D. villosus (Carr, 1916). Donisthorpe (1939) also records it from burrows of the longhorn Phymatodes testaceus (L.) in a felled chestnut. Palm (1959) again describes this species as an Urwaldrelikt.

Hadrobregmus denticollis

Distributed as far north as Worcestershire, H. denticollis is very rare in Britain and is recorded from old oaks and hawthorns (Hickin, 1968). The species is absent from Scandinavia and reaches its northern limit on the Danish island of Zealand (Hansen et al., 1961). It is absent from northern Germany and there are only old records for the lower Rhineland (Horion, 1951) and much of eastern Europe (Lohse, 1969). In Central Europe (op. cit.), this Anobiid occurs in most types of deciduous timber and, in winter, under moss on trees and under loose bark. In the western part of its range, it is also known from synanthropic situations, in barns and similar buildings.

Xestobium rufovillosum

The death watch beetle, notorious for its damage to structural timbers in old buildings, is found principally in oak and willow in the open. In Central Europe, it is one of the commonest Anobiids (Lohse, 1969), occurring in wood which has already been subject to fungal attack. In Britain, it is found in the same habitats at least as far north as Oxfordshire, where Fisher (1940) was able to obtain it in large numbers from old willows for his studies on its biology. Northwards, however, outdoor records become progressively rarer and, in Scotland, it is apparently absent from synanthropic habitats also (Hickin, 1968). The insect has not been observed to fly in England, although it has fully developed wings and has been taken from flowers in Central Europe (Lohse, 1969). As Fisher (1940) has shown that the species is significantly less active at temperatures below 17^{0}C; the lack of flight records for England probably results from a paucity of days on which the necessary threshold temperature is attained. The ability of this old forest insect to exploit a man-made habitat can perhaps best be parallelled by such species as Cryptolestes ferrugineus and Aglenus bruneus. Whilst the initial infestation in a building probably came from the utilisation of a piece of infested oak, it should be remembered that, until the eighteenth century at least, most towns and cities in Lowland Britain were almost wholly of timber-framed houses, constructed closely together, usually with ample opportunity for dry and wet rot, and the death watch, driven out of the wild by either human interference and/or climatic change, was able to maintain itself in the man-made forests of houses and church roofs in our medieval towns. It is, however, certain that few, if any, new infestations now occur and the species is gradually being eradicated from north of its present natural range (Hickin, 1968).

If drastic curtailments in native populations of Xestobium rufovillosum took place in the pre-Roman Iron Age, there are problems of continuity. Towns and cities in Britain and, therefore the necessary synanthropic habitats, did not exist until the Roman period and, on most sites, there is some doubt as to whether any major buildings in timber or stone and timber survived into the Saxon period. In York, the death watch was established in at least one Anglo-Danish tenement by the tenth century A.D. (Buckland, 1975), and present populations - it was present in at least threee redundant churches examined in 1973 in the city (Buckland, 1975) - probably stem from this and other similar primary infestations. The problem remains, in part confused by the possibilities of imports of infected timbers from areas where the species remained endemic in the wild, as to when infestation from local natural timber become virtually impossible and populations became isolated in largely man-made thermal regimes. Relict populations in the open may have survived until the early post-medieval "Little Ice Age". A late sixteenth or early seventeenth century yeoman's farmhouse examined (1974) at Stockbridge near Arksey, 18 km. south-west of the Thorne site, showed evidence of active death watch in structural timbers and oak panelling, which had been subjected to repeated flood damage and therefore had rotted. This infestation has probably been in the building, probably once a timber-framed house, rebuilt in stone, since its construction, but many existing timbers have evidently been reused from an earlier structure and initial introduction from the wild could have taken place at any time during the later medieval period. Examination of eighteenth and nineteenth century buildings in South Yorkshire has only revealed evidence of death watch attack where there is obvious reuse of older timbers. There are, however, a number of isolated outdoor records from Yorkshire, from a dry oak stump at Tadcaster (Walsh, 1949) and on an unidentified hardwoood lacking bark at Scotton (Walsh, 1953). Until many more sub-fossil records are available this discussion can be carried no further.

Gastrallus immarginatus

In 1936 Donisthorpe and Allen added the species *G. laevigatus* (Ol.) to the British list from captures made in Windsor Forest. From further captures and re-examination of the specimens in the British Museum, Allen (1954 & 1956) was able to show that the individuals captured in fact belonged to the other continental species of *Gastrallus* (s. str.), *G. immarginatus* (Mull.). In Windsor Great Park and Forest, the only British locality, this insect appears to be consistently associated with old trees of the field maple (*Acer campestris* L.) apparently in dry twigs, although on the Continent there is no such close association. Palm (1959) records it from oak and lime and Lohse (1969) principally from oak and, more rarely, from other deciduous woods. Unlike the more well known other common tree of the genus Acer, the sycamore, A. pseudoplanatus, introduced in the sixteenth century (Godwin, 1975), the field maple is a native species and may have formed part of the primary forest flora at Thorne. G. immarginatus, under Urwald conditions, however, could easily have been more catholic in its choice of deciduous woods. Allen (1956) suggested that the apparent restriction to a single host tree pointed to the species being relict in the British insect fauna and not a recent introduction, a fact confirmed by the Thorne specimen. Palm (1954) also records this Anobiid from the dry branches of decaying maples in the Stromholm district of Sweden, west of Stockholm, again close to the northern limit of its present distribution, although he does not include this reference in his later discussion of the species (Palm, 1959). It is unfortunate that the Thorne specimen, an elytron and thorax from the Trackway, cannot be associated with any particular tree. The other species of Gastrallus, G. laevigatus is recorded from Central and Southern Europe in mistletoe (Viscum album) and, more rarely, old deciduous trees (Lohse, 1969).

Ptinus fur L.

Although generally a synanthropic species, this omnivorous beetle is also recorded from rotten wood and old birds' nests (Palm, 1959). Northwards it becomes progressively rarer outdoors and is only found in synanthropic habitats in Scotland (Crowson, 1966). As a domestic and stores product pest, it has become cosmopolitan, although it is now probably less common in Britain than the recently introduced Australasian species P. tectus.

Ptinus palliatus

In Britain this species is recorded only from the East Sussex coast, Windsor (Allen, 1957) and near Ipswich, Suffolk (Nash, 1972), although it is generally distributed throughout Continental Europe as far north as Central Sweden and is one of the commonest ptinids in the open in Central Europe (Freude, 1969). Unlike the other species in the genus, which feed on animal and vegetable debris, the larvae of this species are active borers, principally in old dry, fungally rotted wood, usually oak but also recorded from lime, elm, beech, willow, hazel and ivy (Palm, 1959). Both in Sussex and on the Continent P. palliatus has been recorded from old fencing posts. At Windsor the species was found by Allen (1957) in company with another of the rare species on the Thorne list, Teredus cylindrus.

Aderus oculatus/pygamaeus and A. brevicornis

It is unfortunate that the pair of species A. oculatus Panz. and A. pygamaeus Deg. cannot be separated on the fossil elytra from the Thorne trackway sample, since Allen (1969) has reaffirmed that A. oculatus is the species to be found in England, although the other may occur. Many authors (e.g. Horion, 1956; Hansen et al., 1961) have regarded the two as merely forms of the same species, although Kaszab (1968) lists them as distinct, and it is therefore difficult to derive distributional data. In Britain, A. oculatus occurs in most old forest areas, sometimes in numbers (Allen, 1969), as far north as Sherwood (Carr, 1916), and Skidmore (pers. comm.) has recently taken it in some numbers at Temple Newsham, near Leeds. It is frequently associated with oak, although Allen (op. cit.) notes that it occurs in any deciduous tree with red-rot and he has taken it from oak, lime, beech, chestnut and hawthorn. Palm's (1959) records from Sweden were particularly from hollow oaks, where it was associated with Dorcatoma and Anitys spp. A pygmaeus is also largely recorded from oak (Kaszab, 1969) but extends north of the oak zone in Sweden (Palm, 1959).

A.brevicornis is one of the rarest of British Coleoptera with only about a score of recorded captures - from the Weald and Chanctonbury Rings in Sussex, the New Forest and Windsor Forest (Allen, 1969). Both the Chanctonbury (op. cit.) and one Windsor specimen (Donisthorpe, 1939) were associated with beech, although a later Windsor record is from elm (Allen, 1969). Allen (op. cit.) also notes that this species occurs in Denmark and Sweden, wrongfully equated with A. pentatomus of Thomson. Under this name, Palm (1959) notes the beetle particularly from rotten aspens, although he includes a record from a 'Polyporus' on oak. A. brevicornis is distributed from southern France through Holland (Kaszab, 1969) to Denmark, southern Sweden and, if the synonomy is the same, South Finland (Hansen et al., 1960) but is rare to extremely rare throughout its range, and absent from Central Europe (Horion, 1956).

Phloeotrya vaudoueri

As Allen (1970) has recently reaffirmed, the P. rufipes of British authors is, in fact, P. vaudoueri Muls. of Continental workers. Distributed from southern England north to Yorkshire (Buck, 1954), it was found in Dunham Park, near Altringham, Cheshire, by Johnson (1964) in a small,dead beech branch, nearly one hundred years after the last previous capture in the county; a record from Cusworth Park, Doncaster, is also from beech (Walsh, 1955). It has also been taken in the New Forest (Johnson, 1962), Sherwood (Carr, 1916) and Windsor, where Donisthorpe (1939) found it to be not uncommon under bark and in oak, beech and ash. Buck (1954) also records the species from hornbeam, although Continental sources (e.g. Horion, 1956) suggest that oak is the preferred host. P. vaudoueri is apparently absent from Scandinavia (Hansen et al., 1960), provided that it is not there confused with P. rufipes, and sporadic and rare in the rest of western and southern Europe

Hypulus quercinus

This distinctively patterned Melandryid has been recorded from a number of scattered localities in southern England as far north as Huntingdonshire (Buck, 1954). The only record this century was from Devon in 1917 and it was presumed extinct until Allen swept two examples in Darenth Wood, Kent, in 1947. Absent from Finland and only recorded from near Oslo in Norway, the species occurs in Sweden north to about 60^{0}N. (Hansen et al., 1960), in eastern France and the Paris region (Auber, 1960) and in Central Europe it is both sporadic and rare, being restricted to old forest areas (Kaszab, 1969). As its specific name would imply, H. quercinus develops principally in oak, although Buck (1954) also records it from hazel and it appears in chestnut on the Continent (Horion, 1956). The larvae prefer damp wood, either shaded or on the ground, and sometimes occur in decaying roots below the surface. The imagines emerge in late summer, remaining in the pupal chamber to hibernate through the winter (Palm, 1959).

Prionychus melanarius

Johnson (1976) has recently re-examined the British specimens atributed to P. fairmairei Reiche and concluded that all are referable to P. melanarius (Germ.). First recorded in this country in Sherwood Forest by Donisthorpe in 1908, although previously noted as P. ater F. (Carr, 1916), it has also been taken in Arundel Park, Sussex. In both localities, it is associated with old, rotted oaks (op. cit.) although Buck (1954) merely refers to its habitat as 'under bark'. In Scandinavia and Central Europe, as in England, the species is less common than its congener, P. ater (F.) but there is also found in the decayed wood of other deciduous trees, including beech (Palm, 1959) and conifers (Horion, 1956). Occurring in much of Central and south-east Europe (Horion, 1956), this large Tenebrionid reaches its northern limit in Uppland, Sweden, and apart from the English records, is absent further west, an avoidance of Atlantic influence shared with *Dasytes niger*.

Corticeus fraxini

In both Britain and Scandinavia, *C. fraxini* is recorded only from coniferous trees, either under the bark or in Scolytid galleries. Brendell (1975) gives its habitat 'under pine bark, usually in the burrows of *Ips sexdentatus* Boer, more rarely in those of *Orthotomicus suturalis* Gyll. or *O. laricis* (F.)'. In Central Europe, Kaszab (1969) notes that it occurs most frequently in the galleries of *I. sexdentatus* and *I. typographus* (L.), both conifer species, but Horion (1956) also records it from oak, ash and elm. The Thorne association is with oak. The insect, probably a predator on the immature stages of bark beetles (Brendell, 1975), is widely distributed from central and northern Europe eastwards to Transbaikalia. In Scandinavia, it ranges as far north as northern Lapland, within the Arctic circle, but is absent from Norway and Denmark, apart from the Oslo region (Hansen et al., 1960), avoiding the oceanic regions of northern Europe. It is of rare and very sporadic occurrence in Germany (Kaszab, 1969), being largely restricted to the eastern half of the county (Horion, 1951) and, in England, is only known from west Surrey, east Berkshire, north-east Hampshire, west Gloucestershire (Brendell, 1975) and south Staffordshire (Collingwood, 1954); in Wales, the only record is from imported pine in Glamorgan in c. 1923 (Brendell, 1975). It has been suggested that *C. fraxini* is a recent introduction imported with pine pit-props from France earlier in this century (Hammond, 1974; Brendell, 1975). The specimens from Thorne, which have been confirmed by Brendell, show that the species was endemic three thousand years ago, although subsequent extinction during a colder phase of climate and re-introduction during the amelioration of the first half of this century remains a possibility.

Its British distribution, including Windsor Forest (Donisthorpe, 1939) and the Surrey heathlands, remote from both railheads and coalfields, however, suggests that, like several other species, including Ostoma ferrungineum (L.) and Simplocaria maculosa Er. (Hammond, 1974), it has been overlooked and belongs to the Urwaldrelikt group. There remains the problem of continuity of suitable habitats, a factor which influenced Allen (1963) into regarding it as an introduction. Although the most southerly macrofossil evidence during pollen zone VIII comes from the East Anglian Fens, there is good palynological evidence for the continued presence of pine in the Hampshire Basin but it is less probable that it survived in Windsor through to the present day, although continuity on the Surrey heaths and the Weald (Godwin, 1975) is possible. C. fraxini would appear to belong to the same ecological group as Gastrallus immarginatus and Eremotes ater, which become increasingly more host-specific towards the limits of their distribution. If the limiting factor in the present distribution of this Tenebrionid was the climatic deterioration of the post-Medieval period, then it may have been more catholic in the trees in which it would breed until this period, which is sufficiently late for introduced pines to have been planted and to have matured in the Royal Parks, wherein it could have survived the 'Little Ice Age'.

Corticeus bicolor and C. unicolor

In considering the current distribution of C. fraxini, it is necessary to provide some background information on its two congeners in the Thorne assemblage, C. bicolor and C. unicolor. The former is fairly common and widespread in England as far north as Yorkshire (Brendell, 1975), occurring, probably as a commensal rather than a predator, with Scolytids (Beaver, 1966). In Scandinavia, it is less widely distributed than C. fraxini, if more abundant, and is not recorded from the northern part of Finland. It is absent from Denmark and most of Norway but, surprisingly, it has been recorded from the strongly oceanic, mountainous area of Norland (Hansen et al., 1960), although this record may relate to one of the more rain-shadowed and continental valleys. In the northern part of its range it occurs in birch, in the galleries of *Scolytus ratzeburgi* (Palm, 1951) but, further south, it is frequently taken with *S. scolytus* F., under elm bark, as well as in bracket fungi (Brendell, 1975) and other deciduous trees (Kaszab, 1969). The Thorne record, with *Dryocoetinus villosus* on oak, is parallelled by Donisthorpe's (1939) similar record from Windsor Forest.

Both *C. bicolor* and *C. unicolor* are regarded as sporadic in occurrence and uncommon in Central Europe (Kaszab, 1969) but the distribution of the latter is far more restricted in Scandinavia than any of the other species of Tenebrionid from Thorne, occurring in the Oslo region, Denmark and the southerly provinces of Sweden, north to Ostergotland. In England, *C. unicolor* occurs as far north as Skipwith Common, 20 km. north of Thorne Moors (Aubrook, 1967), and has been taken from beneath birch bark on Thorne Moors (Skidmore, 1970) and from a similar situation in the remnants of Bawtry Forest, the northern tip of Sherwood (Skidmore, 1966). In this country, it has also been recorded from beneath the rotting bark of beech and oak (Brendell, 1975). Swedish records are largely from beech and also, rarely, from birch and bracket fungi, the beetle perhaps being polyphagous rather than predatory (Palm, 1959). Further south in Europe, it has been found on other deciduous trees (Kaszab, 1969) and, in Carinthia, Slavonia and southern Italy, the species is also known from conifers; it thus shows increased catholicity with increasingly favourable environment.

Leptura scutellata

This longhorn is closely associated with the remnants of older woodland in England, in which it may be locally common, and is restricted to Windsor, Epping, Hainault, Sherwood (Kaufmann, 1948) and the New Forest (Johnson, 1962); in view of the almost total disafforestation of Ireland, it is surprising to note that there is also a record from northern Galway (Kaufmann, 1948). Adults have been swept from flowers of brambles, hawthorn and Oenanthe, but the larvae have been recorded principally from beech and birch (Donisthorpe, 1939) and also from hornbeam and oak (Duffy, 1953). In Sweden, the species is much more restricted in its choice of suitable timber and has only been found in areas of old, undisturbed beech forest where it occurs in dry, dead beechwood of various sizes sometimes on still living trees (Palm, 1959). In Scandinavia, it is a rare beetle, recorded only from the four most southerly provinces of Sweden and from Denmark (Hansen et al., 1960); it is more common and widely distributed in Central Europe (Horion, 1951). If the records of pabula are regarded as complete, the species displays a relationship which is contrary to that of the majority of species discussed; Allen (1956) suggested that, as a general rule, a species became more host specific towards the limits of its range. L. scutellata would appear to follow this in Sweden but is more catholic in Britain. This could be interpreted to imply that the species shows a preference for a more oceanic climatic regime, yet it is also less stenotopic in Central Europe (Palm, 1959).

Mesosa nebulosa

This fairly large longhorn is now restricted in Britain to south of the Wash (Kaufmann, 1948), principally the New Forest, but with modern records also from Surrey, (Duffy, 1953), Windsor Forest (Donisthorpe, 1939) and Kent (Massee, 1958). In Scandinavia, it is

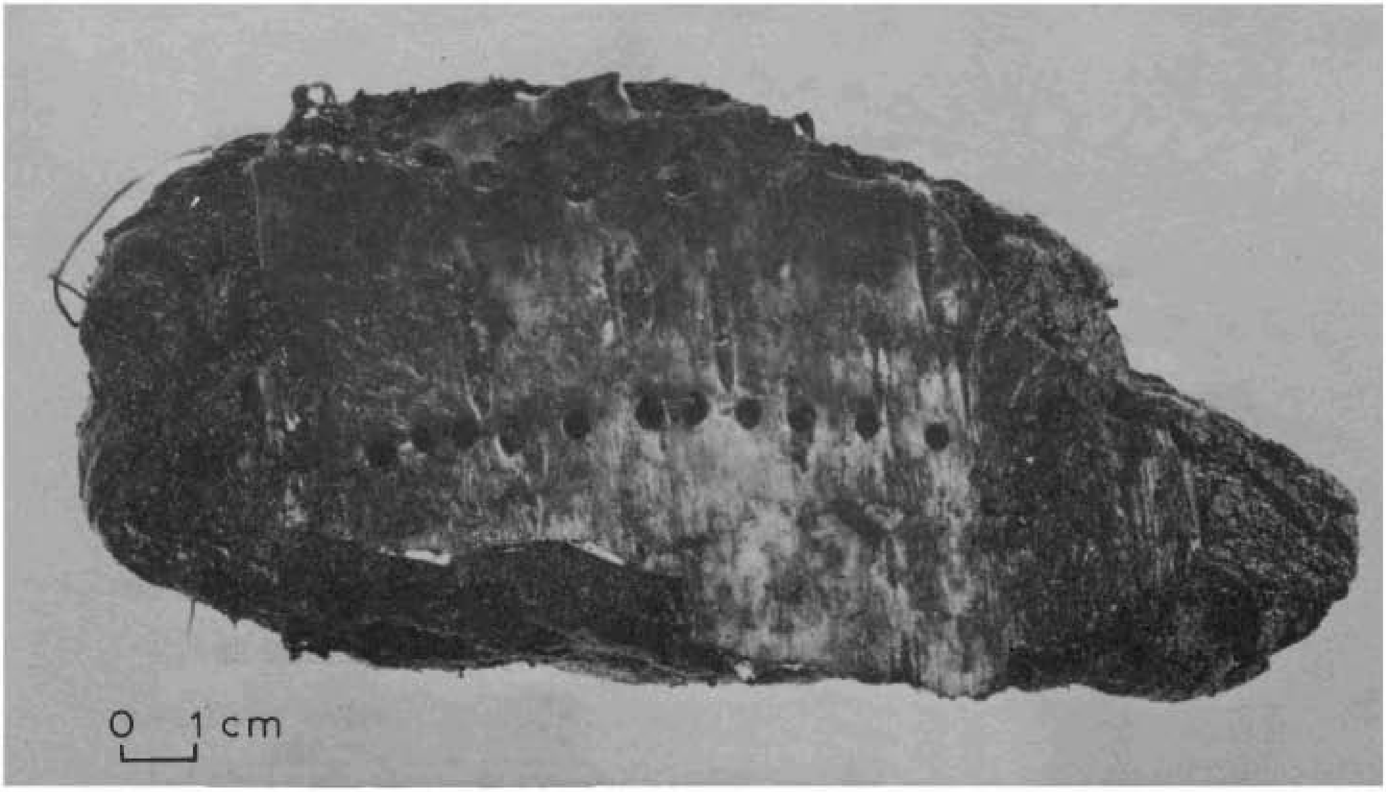

Figure 20: Flight-holes of *Scolytus ratzeburgi* in a birch from the trackway, Thorne Moors (1977).

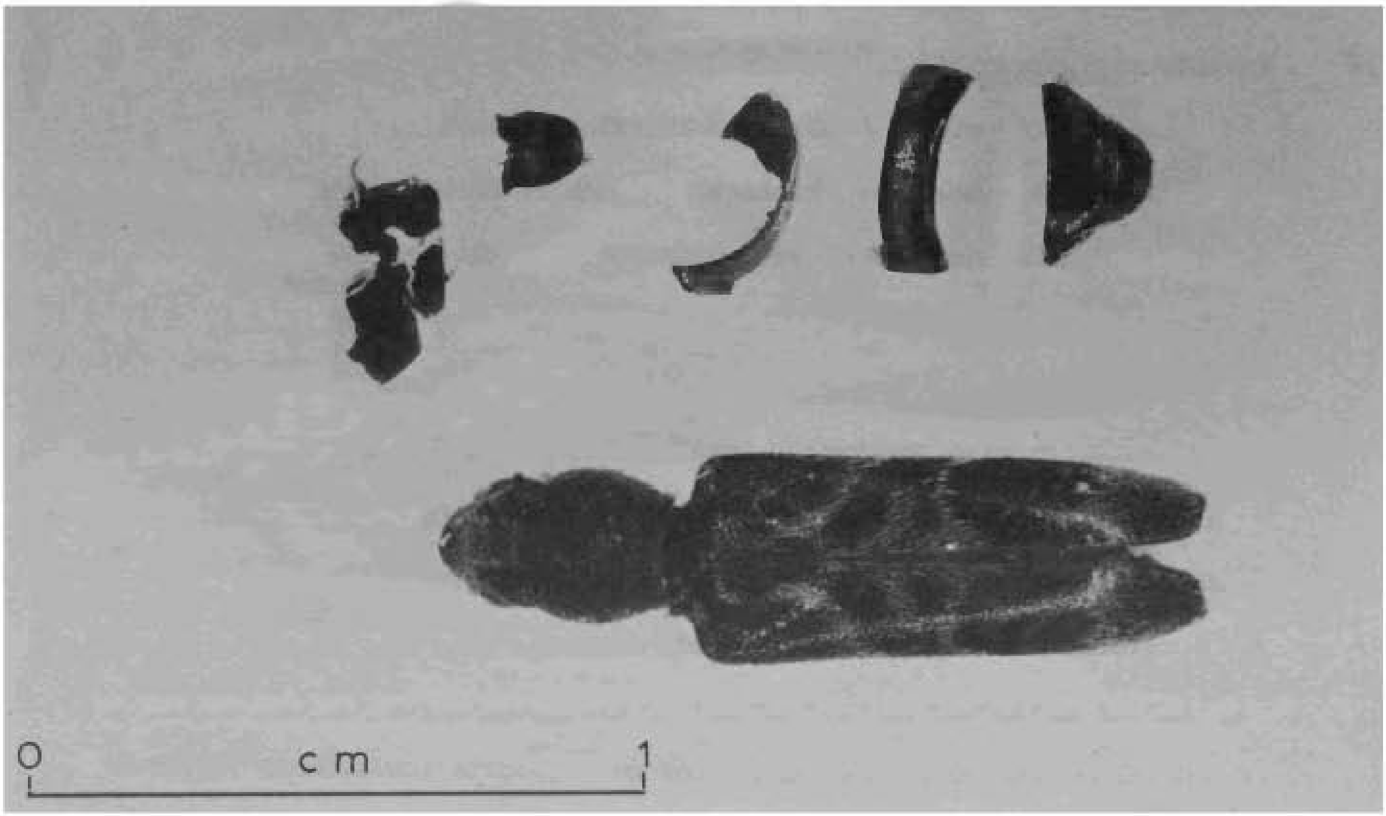

Figure 21: *Anaglyptus mysticus*, an unemerged individual from timber (?oak) at the base of the peat, Thorne Moors (1972).

present in Denmark but absent from Norway and Finland and in Sweden is restricted to south of the 59^{0}N. line of latitude (Hansen et al., 1960). There are records from most species of deciduous tree, including oak, chestnut, willow, poplar, alder, beech, lime, hornbeam, hazel, birch, apple, holly (Duffy, 1953) and buckthorn (Palm, 1959) yet, despite this apparent catholicity, the preferred host is undoubtledly oak. Donisthorpe took the adults by beating hawthorn trees at Windsor (1939). Oviposition takes place both on the higher branches of moribund or recently dead trees (Duffy, 1953) and in trunks and branches of the forest floor, in trees still retaining the bark (Palm, 1959). The larvae, after developing in the sapwood, pupate in the outer part of it during July and August and the imagines over winter in the pupal chambers (op. cit.), a development factor which makes them particularly prone to premature activity in relatively warm oceanic winters.

Plagiodera versicolora

Since the hosts of this Chrysomelid are various species of willow, notably Salix fragilis L. (Auber, 1960), the crack willow, which is widespread beside rivers in lowland Britain, it is difficult to account for its present restriction to south of Worcestershire (Joy, 1932) in terms other than climatic. In Scandinavia, it avoids the more oceanic west coastal provinces of Norway, being restricted to the Oslo region, but further east it is generally distributed in Sweden and Finland, ranging northwards into the taiga and tundra in Lapland and eastern Finland (Hansen et al., 1961), implying a preference for a more continental rather than merely a warmer regime. The larvae develop on the leaves of the willows and, in France, Auber (1960) notes that two to three generations a year may appear under particularly favourable conditions.

Dryophthorus corticalis

This weevil was added to the British faunal list as recently as 1925 when Donisthorpe (1939) found several examples in damp wood inside an old oak tree infested with the ant Lasius brunneus in Windsor Forest, Berkshire. Although there are now many individuals from the Forest, largely from oaks in the same condition, this remains the only British locality. On the Continent, the species occurs throughout France being more common in the Midi, and has been recorded from pine, willow, oak and ivy (Hoffman, 1954). In Fennoscandia, it ranges as far north as Lat. 62^0N. but avoids the mountainous areas and the west and south coasts of Norway with their more oceanic climates. It would appear to be attracted to the timber of any dead tree, provided that it has reached a suitable moist but still firm state of decay, a condition which is also preferred by the ants; the weevil is therefore not strictly a myrmecophile (Donisthorpe, 1927). As well as examples from Piilonsuo, Finland (Koponen and Nuorteva, 1973), fossil specimens are known from Shustoke, Warwickshire (4830±100 B.P. (N.P.L. 39) (Kelly and Osborne, 1965) and two other sites in the Midlands which fall within pollen zone VII, Alcester, Warwickshire (Osborne, 1964) and Church Stretton, Shropshire (Osborne, 1972). The single Thorne specimen was associated with the decayed oak of tree 1.

Eremotes ater

Unlike the majority of the species with restricted distributions here discussed, E. ater belongs to a group, previously noted by Osborne (1972; Kelly and Osborne, 1965), which has retreated northwards with the pine forests. It has recently been able to expand southwards with the massive expansion of available conifer habitat created by the Forestry Commission, although, up to 1972, there were only two Yorkshire records (Aubrook, 1972) and populations must stem from accidental transport by man. In the face of many cases of southward retraction in this fauna, it is unlikely that this wood-boring weevil's withdrawal to north of the Forth-Clyde line can be explained in simple climatic terms and, although there is some evidence locally for the persistence of native pinewoods in such areas as the Hampshire Basin and the Weald (Godwin, 1975), it would seem probable that the effects of man, felling and dispersal of habitat, were decisive factors in limiting its distribution. If we accept uncritically de la Pryme's (1703) statement that the last standing pines, "remnants of the great old forest which covered the whole Humberhead Levels, sank into the morass" in the late sixteenth century, as Rogers and Bellamy (1972) do, suitable habitats for this insect remained locally until the Little Ice Age. Records from Sherwood Forest (Carr, 1916) might imply continuity of suitable pine habitat, although it has to be remembered that landscape and planting of alien trees began early around the group of large country houses in the Dukeries.

The available ecological data on this beetle from the Continent, however, shows the situation to be far more complex. Although conifers are preferred (Palm, 1951), it is almost as frequent in deciduous woods, particularly birch, but also the oak, beech, chestnut and cork-oak (Hoffman, 1954). In the north of Europe it has also been recorded from the timbers of old buildings (Koponen and Nuorteva, 1973), a situation occasionally met with in this country (Hickin, 1968). It is difficult to invoke Allen's (1956) point about increased host specificity towards the limit of a species' range, as has been suggested for some of the insects discussed, particularly since some of the Thorne specimens are closely associated with an oak tree, unless the deterioration which led to its restriction to pine in The north of Scotland took place after c. 3,000 B.P. and the disruption of more southerly habitats was a subsequent phenomenon. Fossil evidence shows that, at some time within pollen zone VII(b), Eremotes ater extended at least as far south and west as Church Stretton in Shropshire (Osborne, 1972). One possibility which can be entertained is the existence of two overlapping clines of the same species, one southern and more catholic, the other northern and tied to pinewood. This hypothesis gains a little credibility in Britain from Godwin's (1975) contention of a separate origin for the Caledonian pine forests, the Thorne Eremotes ater belonging to a southern race which has since become extinct in this country; the confusion of two almost identical species is also a possible explanation. Interpretation, however, must take account of the several other species which have withdrawn northwards.

Scolytus ratzeburgi (Figs. 19 and 20)

S. ratzeburgi is one species in the Thorne Moors assemblage whose present distribution is difficult to provide any explanation for, since it lives exclusively on the bark and sapwood of one of our commonest trees, the birch. The species was first described from specimens collected at Rannoch in Perthshire in 1856 and has subsequently been taken at several scattered localities, largely in the Highlands, the most southerly being near Hawick in Peebleshire (Carlisle and Crooke, 1951). This bark beetle might appear to prefer an oceanic climatic regime, particularly since it occurs around Fort William (Glenfinnan) (Skidmore, pers. comm.), which, as Poore and McVean (1957) show in their vegetational survey, is one of the most oceanic parts of Scotland. The Scandinavian evidence, however, clearly contradicts this proposition since it is not recorded from any of the more oceanic coastal provinces of Norway but is present throughout most of Sweden, Finland and Denmark, except the tundra in the far north (Hansen et al., 1960). Southwards, it is widespread but sporadic in occurrence in Central Europe and extends eastwards through the Caucasus and Siberia to Japan (Horion, 1951). In Sweden, the species is sufficiently common to be a major pest of birch, although it only attacks trees which have been damaged in some way, either by leaf-feeding Lepidoptera, by fire or physical injury, (Palm, 1959). Solitary trees, left for seeding a cleared area within the forest after felling, are also attacked and, occasionally, so are felled birches left lying on the forest floor (Palm, 1951). That the beetle assumes pest proportions in the Baltic region and is somewhat rare in Scotland - after the initial captures, it was not taken again until 1923 at Hawick (Carlisle and Crooke, 1951) - would imply that the latter is the more marginal population, perhaps of relict status. The absence of a correlation between distribution and winter isotherms is matched by a similar disparity with summer temperatures suggesting that the insect is eurythermal; its absence from England, however, has to be explained. It has to be accepted that detailed knowledge of the physiological requirements of all the species discussed is slight and some factors with which we are wholly unfamiliar may be involved. S. ratzeburgi is not restricted to pure stands of birch, occurring in mixed birch and conifer woodland in norther Sweden (Palm, 1951) but it seems significant that, in Scotland, the natural climax vegetation for much of the higher parts of the glens, from which it has been recorded, would be birch forest (McVean, 1964) and this tree has formed an important element in all the forest regions of Scotland through from the end of th last glaciation (Godwin, 1975). S. ratzeburgi appears to show a predilection for old established birch forests with a minimum of human disturbance, rather than mixed, secondary deciduous woodland. Although the frequency of birch in pollen diagrams covering zone VIII in eastern England is far less than in Scotland, by the Middle Bronze Age when the Thorne specimens shows S. ratzeburgi to be endemic at least as far south as the Vale of York, birch scrub would again have been on the increase as a factor in forest regeneration after clearance. In the absence of accountable natural parameters governing this beetle's distribution one is thrown back upon the possible anthropogenic influences and the differing patterns of forest and woodland exploitation between the Highlands and the rest of Britain. There can be little doubt that the chances of extensive stands of birch reaching maturity and senescence in the Lowlands would have been less than in the less densely populated uplands. Grazing pressures in the Scottish Highlands only became important with the eighteenth and nineteenth century Clearances in favour of sheep; in the remainder of Britain grazing would have reduced regeneration and, as a tree with little value as timber, birch would have been extensively utilised as firewood. The frequency ofmature birch woods in much of Britain by the early post-medieval period was probably relatively low and available habitats for the birch bark beetle relatively dispersed. Its absence from Ireland may be the result of the almost total deforestation, completed by the late seventeenth century (Smith, 1975); in Britain, continual habitat disturbance and dispersal may have been themost important factor. Only on the least accessible mountain sides in the Highlands has S. ratzeburgi found sufficient continuity of habitat to survive. If this is the explanation for its curiously disjunct distribution, it does not explain the record from near Hawick. The pattern is also followed by a moth, Zygaena achillae Esp., which is widespread in Europe from the Mediterranean littoral to Central Europe, is absent from England and Lowland Scotland and reoccurs in the Highlands and Islands (Crewdson, 1962). As the more obvious case of the pine weevil E. ater, human interference in the habitat appears the most acceptable hypothesis, yet climatic and historic factors, like the Carse Clay transgression which virtually divided Scotland during Zone VII(a) along the Forth-Clyde line (Godwin, 1975), may require consideration when more fossil evidence is available.

It is also salutory to remember that the Rannoch rush, Scheuchzeria palustris, has, within the last one hundred years, assumed a rather similar, if more restricted, distribution to S. ratzeburgi, as a result of the activities of man (Godwin, 1975).

Platypus cylindrus

The only Platypodid currently on the British list, P. cylindrus occurred in small numbers both in the Trackway samples and Tree 1 at Thorne. At the present day, it is found locally as far north as Cheshire (Joy, 1932) and Yorkshire, where it is recorded from the Scarborough district (Walsh, 1956). One of Palm's (1959) Urwaldrelikt species in Scandinavia, it is restricted to the south-eastern corner province of Sweden, Blekinge, where it was recorded in the nineteenth century and again in the 1950's, occasionally locally in large numbers. It has also been introduced, presumably in imported oak, to the Danish island of Zealand (Hansen et al., 1960). In Central Europe, it is sufficiently common to be a pest on oaks, boring into the sap-rich base of the trunk in both felled and standing trees, cutting through to the heartwood and the larvae feeding off Ambrosia fungi, which line the galleries. The species is also recorded, less frequently, from beech, ash, elm and sweet chestnut (Hickin, 1968). In Windsor Forest, Donisthorpe (1939) noted it under the bark of both oak and beech, locally very abundant, and examples were noted flying, crawling over and burrowing in freshly felled trees. Chrystal (1937) suggests that this pinhole borer had become a forestry pest during the previous few years in the south and west of England and it is tempting to relate this apparent resurgence to the climatic amelioration which culminated in the 'thirties' (Lamb, 1969). Hickin (1968) regards it of minor importance as a forestry animal since attacks usually occurred in stumps; whether there has been a decline in its abundance over the past forty years cannot be culled from the available data.

Whilst many of the species with a limited southern distribution tend to be south-eastern, P. cylindrus occurs from Kent to the New Forest, Oxfordshire and the Forest of Dean (Hickin, 1968) and, whilst the latter lies to some extent in the rain shadow area of the Brecons, Skidmore and Johnson's (1969) specimens from old oaks near Dolgellau are from a thoroughly oceanic part of Merionethshire. These records rather negate the impression, gained from the very restricted Swedish and German (Horion, 1951) distribution, of a species with a strong preference for a more continental climatic regime.

Xiphydria prolongata

As Skidmore (1966) has noted, this large sawfly has been taken from old willows alongside the River Dearne on Denaby Ings, 20 km. west of Thorne Moors. It is largely confined to south of a line from the Wash to the New Forest, with outliers in Herefordshire and Nottinghamshire. On the Continent the larvae are also recorded from poplar and elm wood (Benson, 1951). Its congener, X. camelus, a single specimen of which was also recovered from timber from Thorne, has a more widespread, if local, British distribution and is recorded from alder and birch (op. cit).

Species no longer recorded from Britain from other post-Glacial sites

Oodes gracilis Villa

As the only Carabid currently not recorded in Britain to have been published from Flandrian deposits, Girling's (1976) find of O. gracilis from peat of pollen zone VII(b) age in the Somerset Levels requires comment. Apart from a limited area near Stockholm, this beetle is today restricted to south of the 55^0N. line of latitude and, in Germany, Horion (1951) was only able to note the species from Thuringia, Brandenburg, Prussia and Silesia. Lindroth (1945) records it from around Lake Mälär in Sweden as living exclusively by stagnant eutrophic waters, with rich fen vegetation, walking on the surface of the gyttja substrate. O. gracilis appears to be strongly thermophilous and the Swedish population could be regarded as a relict from a warmer period surviving in a sheltered locality. The widespread disruption and destruction of its very particular habitat, however, caused by the drainage of fen and marsh, may have been equally deleterious. The wings of *O. gracilis* are well developed and, as a good flier, it should be able to move to suitable habitats within its thermal range. It is therefore difficult to escape Lindroth's (1943; 1945) contention that the insect requires a fairly high, stable temperature in summer and that this is the controlling factor in its distribution. It would be interesting to know whether it survived in the abundant fenland habitats of eastern England until the seventeenth century drainage and 'Little Ice Age' jointly destroyed its niche or whether it fell victim to some earlier climatic vicissitude.

Agabus wasastjernae Sahl.

The extensive reclamation of lowland fens has resulted in the drastic retraction in range and probable extinction of some species of water beetle (Hammond, 1974). *A. wasastjernae*, however, which Osborne (1972) obtained from sediments of pollen zone VII(b) at Worldsend, Shropshire, is a northern species of acid pools and marshy areas in coniferous woodland and its disappearance may be a feature of the disruption and destruction of that habitat, although, if causes are wholly anthropogenic, absence from the Caledonian pine forests is surprising. In Scandinavia, however, this Dytiscid is predominantly eastern, occurring in most of Finland and Lapland and the central mountain chain of Sweden and Norway; it avoids the oceanic coastal provinces of Norway (Hansen et al., 1960). In isolation, it would seem to imply a more continental climate during zone VII(b) but several other species, including *Eremotes ater* from Thorne, have contradictory British and Continental distributions and a combination of factors, including historical accident, may be involved.

Porthmidius austriacus Sch.

This Elaterid, recovered by Osborne (1972) from deposits of pollen zone VII(b) at Worldsend, Shropshire, has not been found in Scandinavia and is restricted to South East and Central Europe, ranging north as far as Belgium, with a discontinuous distribution through Germany, and occurring eastwards as far as Anatolia (Horion, 1953). A rare species, Horion (op. cit.) regards it as a particularly thermophilous element in the German fauna. It is assumed to live in rotten wood (Reiter, 1911) but Horion (1953) says that the larva is unknown and, whilst including alleged records from honeysuckle, noted that imagines have been taken in flight on flowering shrubs at the edge of woods, particularly on hot sunny days. The paucity of habitat data aids a simple interpretation in terms of climatic parameters but, without further information, it is of little value.

Airaphilus elongatus (Gyll.)

Osborne's (1974) record of this rare continental European Cucujid from a fourth century well at Droitwich, Worcestershire, provides something of a caveat on the premise that forest and other habitat destruction by man have been the principal factors in the depletion of the British fauna, since it is a species of marshy meadows (Vogt, 1967), rotting grass and haycocks (Horion, 1960). Since the specimens come from a man-made feature, accidental importation is, as Osborne notes (op. cit.), a possibility, perhaps in hay or straw used as dunnage or packaging for fragile items within the Roman period, followed by the temporary establishment of a small population in a particularly favourable locality. This explanation seems singularly attractive in the light of evidence for accidental transport of many other species (c.f. Lindroth, 1957; Buckland, 1976b), but it is curious that a breeding community of this one non-synanthropic species should survive the transhipments necessary to get any object to the land-locked site of Droitwich. Several Late Glacial records of this insect are known (Osborne, 1972; Coope and Brophy, 1972) and an Interglacial one from Bobbitshole, Ipswich (Coope, 1974). Osborne favours the suggestion that it may have been native during the Flandrian and become extinct in the post-Roman period or that it is still native and has been overlooked. The latter gains some support from the continued addition of species to the British list (Hammond, 1974) and the one example of A. elongatus from Belgium was not collected until 1946 (Horion, 1960).

Pycnomerus terebans Ol.

Osborne (1972) recorded this Colydiid from a site of pollen zone VII(b) age at Minsterly, 20 km. north of Church Stretton, Shropshire. It is absent from Scandinavia and largely eastern and southern in Europe, occurring in old oaks (Ganglbauer, 1899), alders and with the ant Lasius brunneus (de Buysson, 1912). Although the latter association may be, as that of Dryophthorus corticalis, somewhat fortuitous, Vogt (1967) also associates the beetle with this ant in old, rotted deciduous wood. It is interesting to note that an Australàsian member of this genus, P. fuliginosus has managed to establish itself in this country, having been introduced with imported timber (Allen, 1968).

Dermestes laniarius Ill.

As a species with a wide distribution in the palearctic, including much of the European mainland (Horion, 1955), it is surprising that this Dermestid has been unable to establish itself in Britain. Many other members of this genus have become cosmopolitan as pests of stored products but, between 1957 and 1969, there was only one record, in a cargo of potatoes from Greece, of D. laniarius reaching this country, compared with over two thousand importations of D. maculatus Deg. and over a thousand of D. ater Deg. (Aitken, 1975). Although Osborne (1969) tended towards regarding the specimens from the Late Bronze Age Wilsford Shaft as casual introductions, perhaps with hides, the species is associated with waste ground with sparse vegetation in Rostov, east of the Sea of Azov, in the U.S.S.R., where Minoranskiy (1969) found it to be the most common and widespread Dermestid. Its Scandinavian distribution (Hansen et al., 1960) also shows a strong bias towards regions with a more continental climate, being absent from Norway, apart from the Oslo district, and from the northern parts of Sweden and Finland. It is markedly xerophilous, occurring on the surface of the soil during the hottest part of the day, feeding on dead invertebrates and very small vertebrates (Minoranskiy, 1969). It is possible that the species in Britain represented a native, open ground element, which enjoyed a brief _floruit_ during the earlier phases of forest clearance and shifting agriculture, succumbing to later changes. Only additional fossil records, away from occupation sites, can clarify its history.

Anthicus gracilis Panz.

Of the many species recorded from fossil assemblages not presently known from Britain, _A. gracilis_ is perhaps the most likely to have been overlooked. In Central Europe, it occurs under rotting plant debris by lakes and river banks (Kaszab, 1969) and is recorded hibernating in stems of _Typha_ sp. (Horion, 1956). Both the Somerset Levels (Girling, 1976) and the Le Havre fossil records (Ters et al., 1970) suggest an association with reed-swamp litter, a habitat which is both difficult to examine and less frequently worked than many others and, as _Airaphilus elongatus_, it may yet await discovery in this country. The species tends however, to be rather southern and eastern in Europe, if not rare (Kaszab, 1969). Horion (1951) was only able to provide recent records in Germany for Mecklenburg, Brandenburg and Silesia and the Swedish record from Bohuslan is a solitary old one (Lindroth, 1933).

It is recorded from the Oslo region in Norway and, in Finland, from south-east Karelia (Hansen et al., 1960). The distribution data suggest a preference for a more severely continental climate.

Onthophagus fracticornis Preyss.

Osborne (1969) has discussed in some detail the large numbers of individuals of this species recovered from the Late Bronze Age well at Wilsford, Wiltshire. At the present day, O. fracticornis is represented in England by only eight old, unlocalised specimens, although Landin (1959) refers to Irish examples, and its place is taken by O. similis (Scriba), with which it was previously confused (Allen, 1967). Both species seem to be relatively eurytopic, occurring in all types of herbivore dung on any soil, often in the same droppings. The species are, perhaps, to some extent sympatric in their distribution in Europe and Horion (1958) produces some evidence to suggest that O. fracticornis is the more thermophilous of the pair. In contrast to the considerable dominance of this latter species at Wilsford, Osborne (1972) recovered a single example of each from deposits of Zone VII(b) at Church Stretton, Shropshire.

Onthophagus nutans (F) (verticicornis (Laich.))

Osborne (1969) recovered seven individuals of O. nutans amongst the extensive fauna of dung beetles from the Late Bronze Age well at Wilsford. In Britain, it is presently regarded as extinct, with records last century from the London region, where Stephens (1830) noted it as very common, Bath and Swansea; there is a solitary record from the north of England, from Armathwaite in Westmorland (Allen, 1965). During this century, this species has only been taken once, in Dorset in the 1920's (op. cit.). O. nutans is found from south and central Europe eastwards through Syria and the Caucasus to Turkestan but is absent from Scandinavia and the North German Plain (Horion, 1951). Its apparent decline in England is paralleled in Germany, where there are only old records from much of the south and west (op. cit.). Although the Wilsford fauna (Osborne, 1969) is indicative of open grassland on the Chalk, in Central Europe, O. nutans occurs in woodland, hilly and low mountain areas.

Aphodius quadriguttatus (Hbst.)

Along with the species of Onthophagus at Wilsford, probably extinct in Britain, occurred a minimum of five individuals of a Scarabaeid which has not been taken in this country, A. quadriguttatus. An oligotopic species preferring open pasture, where it has been taken from cow, sheep and horse droppings (Landin, 1961), one is tempted to accept Osborne's (1969) suggestion of a very slight deterioration in climate since the Late Bronze Age, which has pushed it out of England but Horion's (1956) evidence from Continental Europe causes one to be more circumspect. In Germany, A. quadriguttatus was common throughout the country in the nineteenth century but, apart from two isolated localities, which Machatschke (1969) regards as particularly warm, it is now absent from the northern half of the country. It is noted as rare in Latvia in 1891. In Austria, although not particularly rare in the south-east, there are only old records from Steiermark and Carinthia. In spite of the slight climatic amelioration of the first half of this century (Lamb, 1969), this dung beetle has continued to retract its range on several fronts and this can be seen as part of a process which has resulted in its disappearance from Britain, after the Late Bronze Age and before systematic collecting began. It is difficult to quantify factors other than thermal regime which could have led to changes in the distribution of a species associated with a widespread open habitat.

Landin (1961) has carried out extensive studies on the Aphodiini, although unfortunately not on this species, and has shown that the insects show preference for situation and microclimate rather than for the dung of any particular herbivore. The recent decline cannot, therefore, be easily linked with changes in domestic animal foodstuffs, although the possibility of a specific nutrient requirement might be considered. Extremely hot summers have a deleterious effect upon dung beetle populations and breeding is delayed until the milder conditions of autumn pertain (op. cit.). Where winter stalling of domestic stock is or has been extensively practised, the continuity of population rests upon a sufficient supply of droppings from wild animals. Similarly a summer with frequent torrential rains may interfere with propagation by both increasing mortality and dispersal of dung heaps. Although some protection from such vicissitudes can be obtained by a migration towards more shaded habitats, for a species closely associated with open ground, close to its distributional limit, as defined by macro-climatic factors, a succession of hot or wet summers in an area with little woodland or game may be sufficient to extinguish the population. The continued decline of *A. quadriguttatus*, however, may be linked to that shown by other dung beetles in Britain (Johnson, 1962), a victim of pasture improvement on the poorer, sandy soils and increased arable cultivation.

Cerambyx cerdo L.

Whether this large longhorn was native to this country has excited the interest of entomologists for over one hundred years (summarised in Duffy, 1969). It became generally accepted that it only occurred as a casual introduction until 1969, when Duffy (op. cit.) received a complete specimen from a bog oak from Isleham, near Ely, Cambridgeshire, an area where Stephens (1839) had recorded the species as indigenous over a century ago, although Allen (1968) notes that Stephen's description is in fact of congener *C. scopolii*. A 14_C assay on the wood gave a date of 4,000±66 B.P. (Birm. 1) but it is clear that Duffy did not accept the date and regarded the specimen as one of relatively recent origin. It is unlikely that Duffy, the author of a major monograph on the immature stages of Cerambycidae (1953), should have so mistaken the nutritional value of bog oak as to suggest that C. cerdo was capable of developing in it and it is more probable that he felt the tree and beetle were only a hundred or so years old and that the ^{14}C date was wholly spurious, the coincidence of the findspot with Westwood's record being, in his opinion, too great for chance. During the preparation of an interim note on the Thorne site (Buckland and Kenward, 1973), Kenward re-examined the Isleham specimen and found no reason for not accepting the contemporaneity between the insect and the wood dated in Birmingham. In view of the dubiousness of the nineteenth century records (Morley, 1943), this longhorn cannot be included on the current British faunal list, although the date of its final disappearance from this country can only be established in terms of a terminus post quem from an adequate fossil record.

In Scandinavia, the Catalogus (Hansen et al., 1960) includes C. cerdo from Skane, Blekinge and Oland but Palm (1959) states that the only known Swedish locality was Halltorp on the island of Öland, where the most recent capture known to him had been in 1956. It is not known from Denmark, where a fossil occurrence has been used to support the hypothesis of a warmer climate during the 'Climatic Optimum' (Thomsen and Krog, 1949; Deberbol, 1964). In eastern and southern Europe, however, the beetle can be a serious pest of oak timber, damaging trees in plantations (Palm, 1959). Although Palm (op. cit.) describes the species as an Urwaldrelikt, the preferred habitat of rather isolated old oaks implies at least an open canopy rather than closed primary forest. The beetle is also recorded from apple, elm, beech, willow, hornbeam and Robinia and infestation can continue in the same tree for upwards of thirty years (Duffy, 1953). Pudnev's work (1935) on the biology of this longhorn in the Ukraine provides some data which may be relevant to the factors limiting its distribution. He found that fungi infested 73% of the immature adults, 49% of the larvae and 36% of the pupae examined in the field and that the Hymenopterous parasite Tynandricus rudnevi Nov. accounted for up to 50% of the eggs. In a climatic regime more conducive to entomophagous fungi, the balance could easily be tipped towards extinction.

Eremotes elongatus Gyll. and E. strangulatus Perr.

Both these species were recorded by Osborne (1972) from deposits of Pollen Zone VII(b) at Worldsend, Shropshire. E. elongatus is recorded from a few scattered localities in southern Scandinavia and is more widespread in France and Germany. Whilst old records suggest that this wood-boring weevil is quite catholic in its choice of host trees, Palm (1953) has shown that most Swedish records are referable to E. nitidipennis and that the principal host of E. elongatus is pine, although, further south, it is also recorded from fir (Hoffman, 1958). Its congener, E. strangulatus, is also a pine species but is much more restricted in its distribution, occurring in central France and Corsica (op. cit.). The disappearance of these weevils from Britain could, at least in part, be related to the radical decline in pine in the Lowlands but thermal factors must be considered since both were unable to maintain populations in the Scottish pinewoods, where several other pine insects, including E. ater, were able to continue.

Further Rare British Species from the Hatfield Levels and North Lincolnshire

Hydrophilus piceus L.

It is unfortunate that the virtually complete specimen of H. piceus, found in the peat on Hatfield Moors early this century and preserved in the Doncaster Museum collections, cannot be dated in any way but a further fossil is known from the Iron Age fortifications at Stanwick, N. Yorkshire (Wheeler, 1954). Balfour-Browne (1958) has reviewed the evidence for the decline of this species, our largest water beetle, since the first half of the last century, when it seems to have been fairly common around London (Curtis, 1862). The expansion of the suburban sprawl around the Metropolis has destroyed the majority of suitable ponds and marshes but it would appear that Balfour-Browne was being unduly pessimistic when he suggested that resident populations only survived in Somerset and that captures in South-East England stemmed from recruitment from the European mainland. The species has subsequently been shown to be well established in west and mid-Kent (Massee and Southwood, 1962) and in the Sussex marshes (Foster, 1965). H. piceus has been taken in the Norfolk Broads and the Fens but there are few recent records outside Wicken Fen (Balfour-Browne, 1958). Further north, it is referred to from Repton, Derbyshire in 1863 and from near Huddersfield before 1878 (op. cit.). The filling in of many suitable ponds, drainage and progressive eutrophication of waters has severely affected many species of water beetle. If the Huddersfield examples and the fossils from Stanwick and Hatfield are taken as evidence for H. piceus having once been more widespread, then the decline clearly began before these factors became significant on a more than local scale, although the drainage of the Humberhead Levels and canalisation of its rivers, beginning in the seventeenth century, may have started the process of isolation of populations in the North.

Aphodius arenarius (Ol.)

Although Joy (1932) only records this species as far north as Cambridgeshire, the insect fauna of the contiguous county of Lincolnshire is relatively poorly known and it may have been overlooked. As its specific name implies, A. arenarius is usually associated with sandy areas and is recorded from dung in pasture on open, sandy ground (Landin, 1961). Such pasture has been increasingly subjected to improvement and turned over to arable during the last one hundred years and the disappearance of this dung beetle from north Lincolnshire since the end of the Bronze Age, when it is recorded from beneath the Brigg boat (Buckland, in press), may be a relatively recent phenomenon. The insect, however, would appear to be rather specific in its temperature requirements, being restricted to the southern provinces of Sweden (Landin, 1961) and, in France, occurring throughout north of the Loire but becoming montane in the Midi (Paulian, 1959). Osborne's (1969) fossil records from a site on the Chalk in Wiltshire could imply that it is more eurytopic than the relatively few records suggest, perhaps in a slightly warmer thermal regime; in France, it prefers dry ground and is found in plant debris as well as sheep dung (Paulian, 1959). Its probable retraction to south of Lincolnshire may have a climatic parameter and the recent fragmentation and disturbance of suitable habitats, which were widespread until the decline of extensive sheep pasturage on the Cover Sands outcrop, may have precluded successful re-immigration, although Johnson (1963) notes that the species is very rarely taken in southern England at the present day.

Gnorimus variabilis L.

Although the faunas from beneath the Late Bronze to Early Iron Age boat from Brigg, north Lincolnshire, show largely a Phragmites reed-swamp adjoining pasture, the insect lists do include a few indicators of old woodland (Buckland, in press). The large chafer Gnorimus variabilis is now restricted in Britain to Windsor Forest where it has been taken at infrequent intervals since c. 1830, locally in some numbers in all stages of development in the loose, damp wood mould in the forks of old oaks (Donisthorpe, 1939). In Scandinavia, the larvae are also recorded from fallen oaks and, less commonly, from hornbeam (Palm, 1959) and French records add alder, chestnut, beech and pine to the list of hosts (Paulian, 1959). Locally common but nevertheless a rare beetle, it reaches its northern limit in southern Sweden and Denmark (Hansen et al., 1960) and remains an uncommon insect throughout continental Europe; it was last taken in Denmark in 1915 (Johnson and Krog, 1948) and is probably now extinct there. The adult is an active flier and its presence in the Brigg assemblage need not be entirely fortuitous since it is recorded from flowers, including meadowsweet (Filipendula ulmaria) (Palm, 1959), a plant which could have grown in the wetlands of this site.

Gnorimus nobilis L.

During fieldwork with the author in 1970, Mr. P. Skidmore of Doncaster Museum found fragments of this distinctive green chafer in a rot-hole in an old oak from the base of the peat on Norton Common near Askern, 12 km. north of Doncaster (Skidmore, 1971). By analogy with the Thorne Moor succession this author[1], probably unwisely, suggested a similar Bronze Age date. Although this locality lies only 16 km. due west of the Thorne site and is less than two metres higher in the same basin, that of the River Went, such are the complexities of stratigraphy on the Chase that the Askern site must remain undated until a more detailed investigation can be attempted. In Britain, the larvae of G. nobilis are only recorded from old apple trees and its distribution is entirely southern English, lying south of the 17°C July mean isotherm although there are apparently old records from Cumberland (Skidmore, 1971). On the Continent, the species is more catholic and larvae are known from oak, beech (Palm, 1959) and willow, as well as fruit trees (Horion, 1959). The imagines swarm in hot sunshine and can be found on flowers, particularly elder (Sambucus sp.) but also Filipendula ulmaria and various Umbelliferae.

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[1] i.e. P.C. Buckland

This chafer is nowhere common, occurring throughout Europe, except Finland and northern Russia. In the South, it tends to be montane and its northern limit is reached in the Oslo district of Norway and in Västermannland and Gästrikland in Sweden (Horion, 1959). On the Continent, it is apparently rather less rare than the other member of this genus found in Britain, G. variabilis (Palm, 1959).

Pyrrhidium sanguineum L.

A head and a fragment of the thorax of this striking red longhorn beetle were recovered from the silts immediately below the Late Bronze Age/Early Iron Age boat at Brigg in the Ancholme Valley, north Lincolnshire. This horizon is of the order of three hundred years younger than the Thorne Moor site; 14C dates on the boat range from 2500±130 (Q 1261) to 2672±75 (Q. 1258), but geographically only 30 km. away. P. sanguineum usually infests recently cut fallen oak, lying above the ground surface and, in both England (Lloyd, 1950) and Sweden (Palm, 1959), it is restricted to this wood. Further south in Europe it is also recorded in horse-chestnut, sweet chestnut, hornbeam and beech (Duffy, 1953) and there is one record from pine (Fraser, 1948). In these woods, the species is occasionally imported into Britain and Duffy (op. cit.) has regarded it as doubtfully native. It is now restricted in England to the small area of Moccas Park in Herefordshire, a solitary locality shared with the small Scolytid Ernoporus caucasicus. Both Hickin (1968) and Allen (1973) accept the species as a very rare indigenous insect, its native status being now confirmed by the Brigg specimen. Although large numbers of larvae may occur in the same piece of timber, such that the insect may be very locally common, its fastidiousness in seeking out freshly fallen dead oak wood not lying on the ground makes it very susceptible to heedless habitat destruction by firewood collection and tidy forestry, factors which may be threatening its continued survival at Moccas Park.

Ernoporus caucasicus Lind.

This small Scolytid was first recorded from deposits asscribed to Pollen Zone VII at Shustoke and at Alcester, Warwickshire, by Osborne in 1964 (Kelly and Osborne, 1965). In the same paper it was noted that A.A. Allen had recently added this species to the British list and his records, from Moccas Park, Herefordshire, were eventually published (Allen, 1969). As its congener E. tiliae Panz. also a rare, if less localised species in England, E. caucasicus is restricted to lime and has only been taken on the small leaved lime, Tilia cordata, at Moccas. In Denmark and Sweden, where it is only recorded from the southerly province of Blekinge (Palm, 1959) it is also more frequently found on T. cordata, although recorded also from T. platyphyllos (Allen, 1969). At Shustoke, where the associated plant material provided a ^{14}C date of 4830±100 B.P. (N.P.L. 39), macroscopic remains of both species of lime were frequent and Tilia pollen formed up to 50% of the total arboral pollen. The Misterton Carr site, with a date of 4330± 100 B.P. (Birm. 328) at the base of the peat succession lying only 19 km. south of the Thorne moors site, also provided abundant macrofossils of lime and its pollen reached a maximum of 39% close to the base of the two metre succession (Greig, unpubl.). At Thorne Waterside, 5 km. south-west of the Moors, the base of the c. 4 m. succession in the bed of the old River Don included lime seeds and was dated by ^{14}C to 4230±120 B.P. (Birm. 359); from samples examined for insect remains from both these sites, Ernoporus caucasicus was recovered (Osborne, pers. comm.). Tilia pollen in Smith's (1958) Hatfield Moors diagram, from only 9 km. north of Misterton Carr, nowhere exceed 6% during Zone VII(b) but it again approaches 50% at Island Carr, Brigg in the Ancholme Valley (op. cit.). Whilst differential preservation of pollen grains is possible, Godwin (1975) has noted that there is some evidence for Tilia cordata in fen edge woodlands and for its local dominance in climax forest. In such forests around the Humber, E. caucasicus appears to have been locally common during Pollen Zone VII(b). By c. 3,000 B.P. however, the lime had virtually disappeared from the area. It is absent from the basal part of the Thorne Moor diagram (Fig. 8) and reaches only 3% of the total tree pollen in the Sphagnum peat, where it is probably represented by grains from stands on the Magnesian Limestone, 16 km. to the west. Similarly, in Turner's (1962) Thorne diagram, lime forms up to 2% of the total land pollen. On Hatfield Moors, the continuous trace of Tilia ceases and at Brigg it declines drastically (Smith, 1958)·at the Zone VII(b)/VIII boundary and, nationally, this change is one of the factors used to define this zonal boundary at about 2,500 B.P. (Godwin, 1975). Turner (1962), however, has pointed out the diachroneity of this horizon and suggested that an anthropogenic caused may be involved. On the Levels, the decline in lime must partially relate to the rising watertable but continuity of native lime has been argued for woods on the Magnesian Limestone (Jackson and Sheldon, 1948) and it is in these that populations of E. caucasicus might be expected to survive. Place name evidence (Smith, 1951), however, would imply the survival of lime on the Levels at least into the eleventh century. Tilts, 15 km. south-west of Thorne Moors, 6 km. north of Doncaster, is from the Norman-French for lime and, perhaps more surprisingly, Lindholme, an island in the centre of Hatfield Moors, where Tilia disappears from the pollen diagram early in Zone VIII, is a place name of Scandinavian derivation meaning island of lime trees. The disappearance of suitable habitats for this small bark beetle on the Levels may therefore be quite late. Such woods, however, have suffered extensive exploitation for leaf fodder, timber and, as Godwin (1975) notes, particularly for bast fibre, and would have been managed on a coppice basis with little moribund timber and few old trees. Although one has to agree with Allen (1969) that this small bark beetle may have been overlooked in a number of localities, its present day rarity must to a large extent relate to the effects of man upon its host.

Ischnodemus sabuleti Fall./quadratus Fieb.

Whilst virtually all the Coleoptera discussed are associated in some way with mature forest, one species of Hemiptera would seem to give a more definite climatic indication. The European chinchbugs, Ischnodemus sabuleti and I. quadratus, can be found in numbers up to several thousand upon their host plants, which include the reed Phragmites communis and several marsh grasses; in summer, migration may take place on to oat grasses and similar plants in dry, sunny fields (Southwood and Leston, 1959). It was in such numbers that the insect was taken on Inkle Moor, adjoining Thorne Moor, in 1972 (Skidmore, 1973), yet when Southwood and Leston published their general survey of the land and water bugs of Britain in 1959, although very common, their distribution was limited to south of a line from Hampshire to Oxfordshire and down to Essex and, prior to 1893, the species were only known from a solitary locality in Surrey and Folkestone Warren, Kent. Such a primary distribution and subsequent spread could be taken to imply a recent introduction and expansion as the recent well attested appearance from the Southern Hemisphere of the Lathridiid Aridius bifasciatus (Hammond, 1974). Of the two species, however, I. quadratus remains restricted to its Folkestone locality. The bug has also shown a similar increase in distribution in Continental Europe, curiously enough paralleled in North America by the spread of another Blissine bug, the chinchbug Blissus leucopterus, an important pest of cereal crops (Southwood and Leston, 1959). The evidence which finally negates any suggestion of recent introduction, is a single thorax from Late Bronze Age deposits from beneath the Brigg boat (Buckland, in press). Unfortunately the specimen does not allow differentiation between the two species. It is apparent therefore that, two thousand five hundred years ago, this bug occurred at least as far north as the present day and has since retracted and again expanded its range. Although Skidmore (pers. comm.) has noted a winter hibernation association with the apparently warmer litter of the reed-grass Phalaris arundinacea L., the species appears to be fairly catholic in its requirements and abundant habitats, both natural and artificial, have been available throughout the Flandrian. It is difficult to find any factors other than climate to account for its distributional oscillations. Certainly the first half of this century has been marked by an amelioration of the climate (Lamb, 1969) and, allowing for a threshold temperature to which the insect has reacted, it would seem probable that its rapid recolonisation from a refugium in the South-East reflects recovery from the effects of the Little Ice Age. Of recent years a reverse trend in the overall climate has set in (Lamb, 1974); it will be interesting to note whether the European chinchbug starts to retract its range. In terms of palaeo-climates, however, it allows us to suggest that in north Lincolnshire, on the same latitude as Thorne Moor, at c. 2,600 B.P. (Q. 1258 et seq.) conditions were similar, if not warmer than the present day.

DISCUSSION : MAN, CLIMATE AND THE BRITISH INSECT FAUNA

The transformation of much of Europe from a wholly forested landscape to culture-steppe and urban karst topography represents the most dramatic change within the Quaternary, which was not accompanied by an equally substantial climatic change. The anthropogenic factor was insubstantial in earlier interglacials and the events of the Flandrian stand as largely unique because of this. Changes in the flora during the Quaternary have been extensively documented, in Britain particularly by Godwin (1975), and the vertebrates have gained similar syntheses (e.g. Kurten, 1968). Several other groups have received attention but insects, probably the most frequent invertebrate fossils in Pleistocene terrestrial and lacustrine deposits, were little studied until the examination of Devensian faunas from Chelford (Coope, 1959), Upton Warren (Coope et al., 1961) and Colney Heath (Pearson, 1961). The first post-Glacial site to suggest significant alterations in the insect fauna, Shustoke, was published some four years later (Osborne, 1964; Kelly and Osborne, 1965) and, over the past ten years, sufficient data have been accumulated to make some attempt at synthesising the available information possible. It must be apparent, however, from the notes on individual species above that no single, sweeping interpretation can cover all the taxa which have changed their distributional pattern over the past ten thousand years. Because of the radically different environment involved, Osborne's (1974) assemblage from the initial Flandrian at Lea Marston is left out of the following discussion.

The concept of a rise to a climatic optimum during the Atlantic period and a subsequent decline, with oscillations, has been widely accepted since the macroplant fossil studies of Sernander (1908) and the pioneer palynological work of von Post (1924) and even the most stringent critics of the role of climate in forest development (e.g. Smith, R.T., 1972) tend to accept its broader outlines. Recent work on insect faunas of the early post-Glacial (Osborne, 1974), however, has suggested a much more rapid warming than the botanical data might imply and the environment of the Pre-Boreal may have more resembled secondary birch forest in a central or southern European climate than the taiga. Climatic deterioration from a presumed optimum in the Atlantic, however, a fall of the order of 2°C. into the Sub-Atlantic according to Lamb, Lewis and Woodruffe (1966), is difficult to both pinpoint and substantiate since much of the available information is capable of alternative explanations and the caveats of Smith (1965) and Frenzel (1966) on botanical evidence can equally apply to insects outside the strongly xerothermic, and therefore more sensitive, communities of the Devensian and Pre-Boreal. Certain lines of evidence do appear incontrovertible : the retreat of the pond tortoise, Emys orbicularis, to south of the July 18°C. isotherm at the end of the Sub-Boreal (Degerbøl and Krog, 1951) seems particularly convincing and the retraction of hazel in Scandinavia (Andersson, in Godwin, 1975) also appears to be a factor of climate. Yet, it has to be remembered that species close to their distributional limit are more susceptible to changes, edaphic and anthropogenic, as well as climatic. In consequence, as many of the changes across the pollen zone VII(b)/VIII boundary have been shown to be diachronous and frequently at least partly related to human activities, the chronology of the climatic deterioration has been extended and Frenzel (1966) sees a gradual transition to recent climatic conditions over a period c. 1500 to 700 B.C., with the actual moment of change being registered in the biological and sedimentological record at widely varying dates. Archaeologists have tended to be more precipitous in their interpretation. Piggott (1972) places too great a reliance upon the correlation of recurrence surfaces in his comments on the Sub-Boreal to Sub-Atlantic transition. Burgess (1974) goes so far as to invoke a climatic deterioration at about 1100 B.C., a change towards a wetter, more oceanic, regime to explain what he sees as a major cultural translocation ending the Early Bronze Age.

Whilst the record does not preclude episodes of minor periodicity influencing archaeological cultures, as the historical 'Little Ice Age' did (Lamb, 1965), the insect evidence seems to favour gradual rather than precipitate change. England, at the latitude of Thorne Moors, still had a markedly continental beetle fauna at c. 3000 B.P. and elements of this continentality continue in an attenuating manner through towards the present day, still surviving in certain favoured lòcalities. If one takes, as a limiting case, the species which have retreated furthest south and east, then Isorhipis melasoides, restricted to the southern beech forests of France and Central Europe, would imply mean July temperatures of +17^{0}C. and January means of between +3^{0}C. and +5^{0}C. depending upon whether summer or winter temperatures, or both, are operative in controlling distribution. A similar indication is provided by Porthmidius austriacus from Church Stretton (Osborne, 1972), which, even in Central Europe, is confined to particularly warm localities (Horion, 1956), suggesting that it is somewhat more thermophilous than I. melasoides. A preference for warmer summers and greater continentality of climate is also shown by several species which still occur in southern Scandinavia but are no longer found in Britain. Lindroth (1943) has discussed the Swedish status of the ground beetle Oodes gracilis and concludes that it represents a post-Glacial 'Warmzeitrelikt' in the fauna. A Sub-Boreal record of the southern and central European chafer Cetonia speciosissima from Denmark has also been interpreted as implying a warmer climate (Johnson and Krog, 1948). Superficially, therefore, the available insect evidence suggests that summers in the late Sub-Boreal were of the order of 2^{0}C. warmer in northern Europe and also more continental in southern England. This substantiates the data derived from the pond tortoise, whose current northern limit closely follows the 18^{0}C. July isotherm on the North German

Plain and dips southwards, closer to 20^{0}C. in France; during the Sub-Boreal, this reptile ranged throughout Denmark and into East Anglia (Degerbøl and Krog, 1951). Similar estimates have been obtained from botanical data (Godwin, 1975).

In reality, however, as the individual species discussions have shown, interpretation is far more complicated than a superficial examination of much of the distributional data would imply. Although the presence of a species can be shown from the fossil record, an absence cannot be proven because of the incomplete nature of the evidence, a fact emphasised by the continued discoveries in the present flora and fauna (Hawksworth, 1974). Thus the date of final disappearance from Britain or of significant retraction in range can rarely be established for a species and only occasionally is there sufficient information for a dynamic model for an individual taxon to be formulated (e.g. for Xestobium rufovillosum (Buckland, 1975). The variation in distribution of a single species may be quite rapid and it may not be possible to obtain a correlation with a known climatic event. Manley (1965) has pointed out that climatic instability is a character of the oceanic fringe of north-west Europe and that the intensity of variation probably lies within that currently recorded; the events of a single year or decade may have profound effects on a particular species, although a reaction may not be noted until some threshold is crossed. If macro-climate is the principal factor in controlling distribution, it is apparent that different species will react differently and succumb to deterioration at varying moments in time. Airaphilus elongatus was present in the Midlands during the Roman period (Osborne, 1974) and has since probably disappeared; Onthophagus nutans finally became extinct in this country early this century (Allen, 1965). Several of the Thorne species may have become restricted as a result of the presumed culmination of the Sub-Boreal to Sub-Atlantic deterioration about 700 B.C. but could equally have lasted until the post-medieval 'Little Ice Age', shortly before more detailed recording began. For the more mobile species, the possibility of retraction followed by renewed colonisation consequent upon climatic amelioration has to be considered and this seems to be shown by the bug Ischnodemus sabuleti.

We remain, somewhat blissfully, ignorant of most of the parameters governing insect distribution and much of the available information relates to species which are either synanthropic or assume pest proportions. Threshold temperatures control the ability to fly of the death watch beetle (Fisher, 1940) and the swarming and breeding of the bark beetle, Ips typographus (Schimitschek, 1948). Many of the species which have retracted their range appear to avoid maritime regions and these areas may have winter temperatures which are too high for hibernation thresholds, resulting in winter activity, consumption of food reserves and consequent increased susceptibility to sudden frosts. These problems would be of limited importance for most wood-boring species. An oceanic climate, however, may promote the proliferation of entomophagous fungi and possibly other disease organisms. Abnormally severe winters can cause serious reductions in populations, as that of 1962-63 did to the introduced Cis bilamellatus (Paviour-Smith, 1969), and warm summers may have an opposite effect. Warm springs, coupled with late frosts can be equally destructive, killing imagines which have been encouraged to emerge early by the premature warmth. A slight climatic change, imperceptible on the large scale, may tip the predator-prey relationship in favour of either local extinction or expansion. Lauscher (1953) noted that, on the edge of stands in Austria, if spring was characterised by several days rich in sunshine, mass emergence of the caterpillars of the moth, Ocneria monacha, a pest of timber, occurred on the warmed trunks before the predators and parasites had come out of the ground, a minor climatic anomaly which resulted in catastrophic damage to woodland in 1946.

By far the majority of the species whose distributional range has declined - over 25% of the Thorne Moors taxa - are associated in some way with woodland, principally with moribund and decaying timber and close examination of records of captures reveals a significant correlation with areas of old woodland and relict forest. In Britain, many find their last refuge in such places as Sherwood, Windsor and the New Forest, whilst Fontainbleau contains similar survivors in France and, in the Baltic, the small island of Öland, which now has the largest area of continuous deciduous forest in Europe (Sjorgen, 1971), forms a similar refugium. The terms '_Urwaldtier_' primary woodland animal, and the related '_Urwaldrelikt_', introduced by the German entomologist K. Dorn for _Rhysodes sulcatus_, a species which occurs in the Thorne Moors material, (Horion, 1935), seem singularly appropriate to these insects. Several of the species whose current distribution would seem to contradict the thesis of climatic deterioration, by a northward rather than a southward retreat, fall more into place when their forest relations are considered. _Scolytus ratzeburgi_, from Thorne in the Middle Bronze Age, occurs from the most oceanic areas of western Scotland across to the most continental regions of Scandinavia and the one apparent unifying factor is a preference for old established birch forest. _Melolontha hippocastani_ was found by Osborne (1969) in the Late Bronze Age Wilsford Shaft in Wiltshire but, at the present day, it is restricted to the Highland Zone (Johnson, 1962; Sharpe, 1946). This species is widespread on the Continent but restricted to wooded districts, to the extent that its vernacular name in both French (Auber, 1960) and German (Escherich, 1923) translates as 'the forest maybug'. Whilst it cannot be maintained that more semi-natural woodland survives in the

Highland than the Lowland Zone, it is evident that edaphic and climatic factors must combine to exclude it from most of England and this distribution can be matched by other species - *Sphaerites glabratus* (Kelly and Osborne, 1965) and *Eremotes ater*. Of the species no longer recorded from Britian which have been found fossil, only five cannot be directly related to forest habitats - *Oodes gracilis*, *Airaphilus elongatus*, *Dermestes laniarius*, *Anthicus gracilis* and *Aphodius quadriguttatus*. Of these, three relate to fen and other wetland environments, one, *D. laniarius*, may be anthropochorous (Osborne, 1969) and *A. quadriguttatus* shows a preference for wooded habitats (Landin, 1961).

The forest provides a particularly stable ecosystem, largely insulated against the climatic vicissitudes of more open habitats. Something of this stability is encountered upon entering a wood from summer heat, high wind or winter cold but equally important in terms of the indigenous fauna is the relative permanence of the environment. In undisturbed forest, with a decay period of ten years and assuming an individual tree lifespan of three hundred years, three or four trees per hundred would be dead and, with a more realistic decay period of up to fifty years, one in eight would be dead (Streeter, 1974) and additional *pabula* would be provided by partially dead trees. It is significant that it is the faunal assemblage associated with this aspect of the forest, rotting and moribund timber, that has suffered most since the Sub-Boreal. The thermal stability of the spaces between the trunks in closed forest has been examined by Geiger (1965); nights are warmer and days cooler. In deciduous woodland, winter is marked by increased cold penetration facilitated by the loss of the leaves, although the chilling effect of the wind is mitigated by the trunks and the fallen foliage itself protects a further habitat, the forest floor. The relative warmth of the litter, particularly as a site for hibernation, is apparent from measurements made under broom by Danthanarayara (Woloff, 1968). He was able to show that, during the severe winter of 1962-3, the litter temperature never fell below 0.5^{0}C. Pools and similar habitats within the forests also experience a relatively benign regime and several of our rarer water beetles, including *Hydroporus scalesianus* and *H. neglectus* occur in such situations. The humidity factors within the forest are also relevant. *Hypulus quercinus* prefers shaded moist wood and root stock (Horion, 1956) and the depredations of chafer larvae are less severe in moister, shaded localities (Remezov and Pegrebnyek, 1965). In contrast, the evident *Urwaldtier* *Cerembyx cerdo* shows a marked inclination towards isolated oaks in Central Europe (Palm, 1959). Such isolated trees, when dead, however, are prone to heat dessication (Stubbs, 1972), a process which renders the wood unsuitable for colonisation by many species. Whilst such comments are generally valid, it has to be stressed that detailed ecological information is lacking for virtually all the insect species involved; for several, it may be too late to attempt to obtain it.

The effects of extensive forest cover upon the limited open environments and the macroclimate in general are difficult to quantify and many of the available data are debatable. Its role in the hydrological and erosional regimes is considerable (Molchanov, 1960; Raikes, 1967) but the overall climatic effects may be limited to the relatively ameliorated nature of the smaller clearings (Gieger, 1965), not only those created by natural decay and regeneration but also the more permanent openings resulting from herbivore pressures without the intervention of man (Knapp, 1971). Thornthwaite (1956) found no evidence for changes in regional climates induced by human activity but the transition from a wholly forested landscape to culture-steppe may, in itself, have contributed to our current climatic regime.

Accepting climatic change as a factor in the creation of our present depauperate insect fauna, it is apparent from the disjunct distribution at the present day of several of the Thorne species that other factors have had over-riding influences on dispersal and that the surviving fragments of woods, parklands of the nobility and monotonous monocultures of the Forestry Commission, are inadequate substitutes for the primaeval forest. Westoff (1971) had divided the landscape into four categories. His first, the natural, that in which the fauna has evolved, no longer exists in western and central Europe. The subnatural has a native spontaneous flora and fauna, with minor exceptions, and is to a small extent influenced by man. This was the dominant vegetational form from the Mesolithic until the beginning of extensive forest clearance but it is now restricted to the peripheral areas, the tundra and high mountains and a few protected reserves, like the Bielowecza Forest in Poland. The semi-natural, spontaneous but essentially changed by man, as meadow, moorland and coppice, predominated until the end of the nineteenth century but has since rapidly given way as the cultivated landscape, in nearly all its aspects controlled by man, has taken its place. With the exception of those species able to exploit the commercial monocultures or those of eurytopic requirements, the cultivated landscape represents a hostile environment for most species of insect. The widespread improvement of pastures has probably led to the decrease in dung beetle diversity observed by Johnson (1962) and several phytophages associated with rough grassland have also become less frequent. Raw (1957) suggests that the most effective method of controlling the chafer <u>Phyllopertha horticola</u>, sometimes a pest in pasture consists in ploughing and re-seeding. Xerothermic species, however, tend to be good fliers with relatively high dispersal potential, able to combat fragmentation of habitat by extensive flight in search of suitable oviposition sites. These species have, on the whole, suffered less from the activities of man, until the advent of pesticides, many having seen an unprecedented expansion of available habitat as forest clearance proceeded. The present fauna, however, remains somewhat out of phase, a basically Urwald fauna occupying a Cultursteppe, the open ground elements having once been restricted to refugia from the forest, been accidentally introduced by man or late immigrants. The flooding of the English Channel during the Boreal effectively sealed Britain from all but the most efficient fliers and those arriving by chance aeolian transport in sufficient numbers to establish a breeding population. Leistus rufomarginatus and Amara montivaga have established, or perhaps re-established themselves in England during the past century (Hammond, 1974) and occasional numbers of the Colorado beetle are swept across the Channel by south-easterly winds (Hurst, 1970) but Britain remains essentially poor in species, particularly of Coleoptera, when compared with Central Europe. From the Boreal onwards, the picture has been one of progressive impoverishment in species, in part only balanced by introductions.

Whilst the decline in several open ground insects may be a relatively recent phenomenon, in many cases after something of a floruit, the old forest element has been suffering at the largely unwitting hands of man for a much longer period. Several have retracted with their hosts. Ernoporus caucasicus, which must have been relatively common at least as late as the Early Bronze Age, would have been seriously affected by the widespread reduction in Tilia at the end of pollen zone VII(b), an event which Turner (1962) has shown to be both diachronous and probably anthropogenic. The virtual disappearance of pine from most of England would have reduced the population of conifer insects drastically and some, perhaps including Eremotes ater and Corticeus fraxini, may have only been reintroduced by afforestation. In East Anglia, both pine and beech became extinct by the late medieval period and it has been suggested (Rackham, 1971) that their disappearance relates to their inability to withstand heavy coppicing. Although several species which are relatively host specific have become restricted in their distribution, some apparently more catholic beetles have also been affected. Catholicity, however, may be dependent upon a temperature preferendum; as Allen (1956) noted, a species becomes more host specific towards the limits of its range. *Eremotes ater* only appears in pine in Britain but has a whole range of deciduous and coniferous hosts in more continental regions. *Isorhipis melasoides* is recorded from several species of deciduous tree but its preference for beech may have become more decisive during a climatic deterioration, resulting in a gradual extinction from Britain, perhaps before the widespread establishment of beechwoods on the Chilterns during Pollen Zone VIII.

For the majority of insects, however, it is not the disappearance or restriction of a particular host that has contributed to their decline but the widespread disruption and fragmentation of habitat consequent upon forest clearance. In a landscape which is a mosaic of Cultursteppe and fragments of *Urwald*, the problems of corridors of movement for woodland species would have become progressively more acute as the attack on the forest continued. Having evolved in a world carpeted with continuous forest and immediate proximity of suitable hosts for oviposition, many woodland insects tend to have a very low dispersal potential. Unable to colonise newly created isolated woodland habitats, many insects have become restricted to the more permanent areas of relict woodland. Yet, although Rackham (1974) has shown that some of the Cambridgeshire and East Suffolk woodlands are substantially the same as those when documentary sources began in the thirteenth century, it is not particularly these and similar woods which survive as refuges for the rare species but the more nebulous forest districts, as Sherwood, Windsor and the New Forest. Here draconian forest laws, instituted by our first great conservationist, William, Duke of Normandy, preserved the forest environment from the destructive effects of pannage by numerous semiferal pigs, coppicing, charcoal burning and timber collection. The forests of royalty and the aristocracy reached their greatest extent under Henry II, when a third of England lay under its laws (Hoskins, 1955), forming a broad strip of territory through the Midlands from Hampshire to South Yorkshire. It should not be assumed that forest in the medieval sense is synonymous with trees. Many chases, as that of Hatfield, lay on marginal lands, fens, bog and moorland. Much of the New Forest lies on the nutrient poor Tertiary beds of the Hampshire basin and Sherwood lies on the similar podzolised soils of the Bunter Sandstone (Hopkinson, 1927) and Drift deposits. Tree cover would therefore tend to be fitful and incomplete. There can be little doubt that the later forest areas of the East Midlands were extensively farmed during the Roman period, perhaps on the basis of intermittent arable in a preponderantly pastoral cycle, which the poor soils dictated in the early post-medieval period (Emery, 1973). This phase of widespread clearance seems, on the limited amount of palynological (Smith, 1958; Turner, 1965) and aerial photograph data (c.f. Riley, 1973), to have begun during the Iron Age. Sites, like those at Sandtoft (Fig. 22), and St. Catherine's Junction on Potteric Carr (Fig. 23), both within a few kilometres of Thorne Moor, are frequent on both the Permo-Triassic outcrops and the Drift and are not restricted to the lighter soils. Associated systems of enclosures and small rectangular fields can be traced virtually continuously from the Doncaster region southwards in Sherwood, where they are occasionally glimpsed through the welter of coniferous plantation. East of Doncaster, similar features appear on most outcrops outside the modern alluvium and peat cover. Despite the paucity of local Iron Age artifacts these systems, similar to the Celtic fields of southern England (Bowen, 1961) are, in some instances, demonstrably pre-Roman. At Rossington Bridge, the fields lie oblique to both the fortress, probably of the 50's and 60's A.D., and the Roman road, and fields clearly underlie the fort of Robin Hood's Well, north of Doncaster. Surface finds suggest continuity into the Roman period on many sites and a solitary sherd of third or fourth century pottery occurred in the ditch of the Dunsville enclosure (Magilton, 1978). At Bessacarr, late second century pottery kilns respect earlier field boundaries and the complex appears to have been demolished and returned to agriculture after abandonment (Buckland and Magilton, in press). Figure 24 attempts to summarise the available aerial and artifactual data for Roman settlement on Hatfield Chase and across towards Sherwood. Any enclosure, localised from the air, and any significant concentrations of finds implying an occupation site, is surrounded by a circle of 2 km. radius, based upon the average limit of successful land utilisation defined by Chisholm (1968), assuming that such marks a theoretical limit to forest penetration and damage from each settlement. Known field systems without located enclosures are also marked. It must be apparent from the figure that by one thousand years after the Thorne Moors site, the inroads into the Urwald were so extensive as to virtually destroy it, replacing it by a patchwork of small fields and conserved, or rather managed, areas of woodland which fulfilled the timber needs of the communities. Similar evidence is forthcoming from much of England, from the gravel terraces of the major rivers (e.g. Benson and Miles, 1974; Hampton, 1975) and the Fens (Phillips, 1970) to the Chalk uplands (e.g. Bowen, 1975) and it is clear that many of the Urwaldtieren of Thorne and other sites must have reached relict status by the end of the Roman period, confined to the surviving fragments of relatively undisturbed woodland and neglected coppice, isolated by great barriers of wholly cleared country along the river valleys and Chalk and

Figure 22:

Sandtoft, S. Humberside : extensive Roman settlement and field systems lying on the south bank of the former course of the River Don, between Thorne and Hatfield Moors, looking S. (1974). Photo : D.N. Riley.

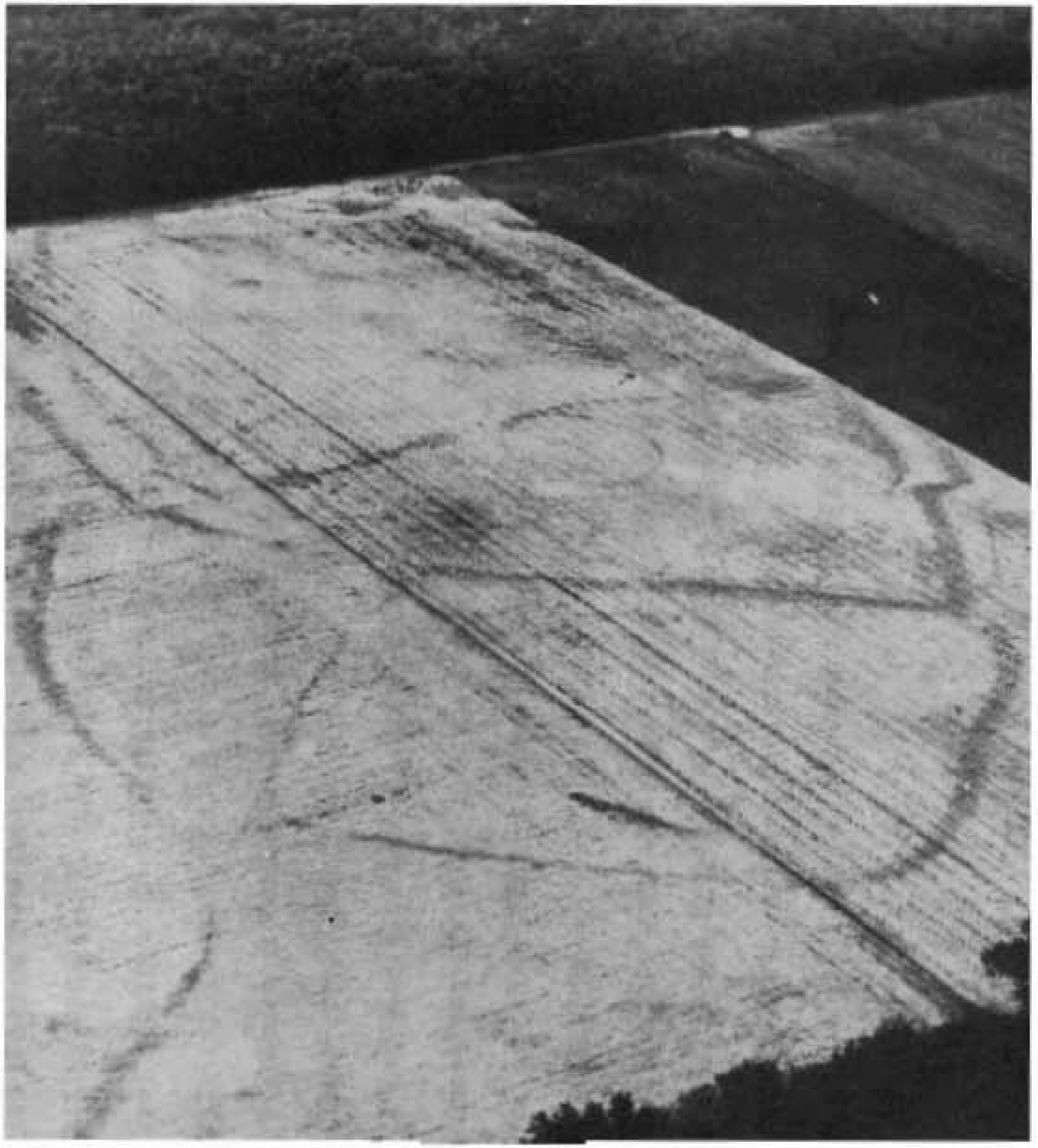

Figure 23:

Potteric Carr, S. Yorks. : extensive ? Iron Age and Roman enclosures with circular huts and associated droveway, south of Doncaster (1975). Photo : M.J. Dolby.

vulnerable to any slight environmental change, from clearance and forest utilisation to minor climatic oscillations.

The termination of the economic stimuli of the Roman occupation and the influx of large numbers of new settlers, beginning in the fourth century, brought considerable changes in the landscape. Something of a population collapse, resultant upon plague or civil anarchy, may well have occurred and, as people returned to a subsistence based economy, much marginal land went out of cultivation. Yet, in part, the collapse is an archaeological one, resulting from the absence of datable artifacts, and the processes are more probably towards a nucleation of settlements, as Cunliffe (1973) has argued from the Chalton district of Hampshire, than actual decline. Such nucleation, whether for social or defensive reasons, would inevitably lead to the redistribution of woodland and some fresh clearance as woods were consolidated into larger blocks for the needs of each enascent village or group of settlements. In some areas this process had begun during the Roman period (op. cit.) and it is tempting to relate the apparent reduction in land under cultivation to the adoption or introduction of more intensive farming techniques, including the growing of winter wheat and the wider usage of manuring rather than unaided fallowing. It has to be noted, however, that the use of manure was not unknown to the Roman world (e.g. Pliny, VII, 57) and may have been an essential part of the villa economy (Applebaum, 1972). The frequent general scatters of flint debris over considerable area might also suggest that the merits of midden material were recognised as early as the Neolithic. Whatever the reason, much of what was later to become the chases of Hatfield and Sherwood seems to have gone out of evident cultivation in the post-Roman period. Place-name evidence suggests that it is on the edges of these wastes and the unstable margins of the alluvium, where the character of the deposits had changed considerably, that later Anglo-Scandinavian farmsteads were founded, perhaps after a few hundred years of natural regeneration had somewhat upgraded the poor soils.

It was in such areas of partially regenerated woodland and heath, impoverished by unsympathetic farming techniques and representing but a pale reflection of the Urwald, that the Conqueror placed his protected reserves which, although intended for larger vertebrates, the deer, boar, hare and fox, incidentally provided refuges for forest orientated invertebrates. Outside the game parks, it is probable that Rackham's (1974) comment that, in eastern England, there was not enormously more woodland at the time of Domesday (1086) than by 1945, holds true for much of the country. Certainly by the thirteenth century, when the first detailed documents occur, woodland had a scarcity value (op. cit.), owned by the lord of the manor and all activities therein carefully controlled (Bennet, 1937). Most were clearly defined, often by banks and ditches. At Serlby, on the northern fringes of Sherwood, the park was embanked in 1191 (Court Rolls, unpubl. Dolby pers. comm.) and the 146 hectares (360 acres) of Edlington Wood, overlying well preserved Romano-British farmsteads (Corder, 1951; Ramm, 1973), is enclosed by an undated bank along the parish boundary. Such woods, where not wholly reserved for private sport, were under heavy anthropogenic pressures and few have formed safe retreats for endangered insect species. Most were managed as coppice with standards to provide building timber cut, on rotation, at three to twenty year intervals, a practice which can be traced back as far as Domesday, where it is referred to as silva minuta (Rackham, 1967). As well as these somewhat periodic demands for large timber and for charcoal, the needs of the community for firewood, oak bark for tanning and withies for wattling, as well as other woodwork, had to be met. Fourteenth century documents record considerable sums for loppio et chippio (op. cit.) and both the twigs and foliage of oak were burnt to provide potash for soap manufacture and bracken under-growth was similarly exploited (Brown, 1974). Dead wood was not suffered to remain either on the ground or on the tree and the phrase "by hook or by crook" owes its origin to the right to obtain firewood from the lord's wood by these means (Bennett, 1937). Any decaying timber which might escape these pressures outside the actual enclosed wood would be subject to the rooting of pigs; as sheep in rough pasture, there would preclude natural regeneration and would be effective destroyers of forest floor habitats. The fall in swine assessment between 1066 and 1086 (Rackham, 1974) may reflect a realisation that an essential element in the landscape was being over-exploited. Social changes or an actual decline in the amount of beechmast and acorns available at pannage, a practise which is now only continued in the New Forest (Tubbs, 1968), may also be implied. By the mediaeval period and in some areas earlier, the surviving woodland represented that which was economically necessary to the continuance of the community. It is unlikely that such prolific insect habitats as old oaks would have been present and the oldest trees would have been the pollards of woodland edges, boundaries and pastured parkland, cut above the level of damage by herbivore grazing, poor substitutes for closed forest.

This picture differs considerably from that portrayed by many historical geographers:

> "If one walked half a mile, a mile at the most out
> from village, one came to the edge of the wild,
> to .... the massed trunks of the primaeval woods still
> waiting to axe." (Hoskins, 1955).

The idea is still repeated (e.g. Kirby, 1974) and may indeed apply to some areas of royal forest. Even in these however, there were problems. An impecunious Crown was not averse to assarting and timber extraction, provided due fee was paid, and, as well as supplying royal timber requirements, concessions were given to many monasteries to exploit the forests; by the middle of the fourteenth century, the extent of royal forest had fallen by one third (Donkin, 1973). Overstocking with animals for the chase, particularly deer, occurred and fodder had to be provided in winter, implying that over-exploitation was already a problem. Throughout the mediaeval period, a precarious balance existed between population and timber resources, a delicately poised ecosystem which was finally completely upset by the beginnings of an industrialised society in the sixteenth and seventeenth century. Concern for timber resources was expressed under the Tudors and the first act for the conservation of woodland was passed in 1543 (Baker, 1973). At a period when climate became more severe than at any time since the end of the Devensian (Lamb, 1965), the refugia of Urwaldtieren were subjected to increasing pressures. The financial difficulties of successive Tudor and Stuart monarchs resulted in the disbandment of many of the remaining chases and the Dissolution saw the end of extensive monastic woodland. Hatfield Chase, described as 'utterly wasted' in a timber survey of 1608 (Baker, J.N.L., 1936), was dispersed in 1630. Iron smelting made increasing demands for charcoal; in 1613, 180,000 tons of iron were smelted, requiring 3.6 million tons of timber, four times the current annual extraction by the Forestry Commission (Carlisle and Brown, 1967). Large amounts of timber were also required for other industrial processes - salt extraction and the refining of other ores, and increasing populations kept up its need for wood and land. Industrial activitity was particularly concentrated in such areas as the Weald, Severn Valley, Derbyshire, and West Riding and the Lake District and, by the end of the eighteenth century, when coal had finally ousted charcoal in most industries, large areas were virtually treeless apart from scrub. Whilst there was some small park creation in the sixteenth century and, from the late seventeenth century, the landscaped gardens of the new nobility provided fresh habits, the essential continuity of woodland was broken and some forest insects, unable to reach, or find sufficient protection in the remaining woodlands, probably succumbed to the effects of the 'Little Ice Age'. The survivors remained in the often neglected rather than protected royal parks. The 1608 survey of state timber resources records 1,541 decaying trees in Windsor Forest, 34,900 in Sherwood and 62,422 hectares (154,252 acres) of trees in similar condition in the New Forest (Baker, J.N.L., 1936). These extensive areas of untidy woodland, in the modern forester's sense, were the saviours of many of our remaining Urwaldtier.

Such a thesis is impossible to prove on the present fossil record, but a reasoned case has been made out for the death watch beetle, based upon records from timber-framed buildings (Buckland, 1975). More recently, the almost total abandonment of coppicing between the two world wars has resulted in an increase in the amount of unmanaged woodland and therefore of the dead wood habitat but the actual amount of deciduous woodland continues to decline and even important old forest and parkland areas are subject to the over-enthusiastic attentions of foresters, often pursuing a 'perk' to have firewood which has existed since the Middle Ages. By example, in mid-Suffolk deciduous woodland covered 4.4% of the land area in 1837; by 1971 this had declined to 1.8% (Rackham, 1971). The alarming expansion of alien coniferous monoculture has frequently taken place at the expense of broad-leaved trees and concern has been expressed by entomologists at the dearth of decaying wood in old forest areas (e.g. Chalmers-Hunt, 1969; Stubbs, 1974).

The question of conservation of areas containing the remaining endangered forest insects in Britain is a vexed one. Certainly the formation and maintenance of reserves with the minimum of management will conserve already existing populations, yet the low potential for dispersal of many forest species means that communities tend to be isolated entities, liable to inbreeding effects which increase the probability of extinction of individual populations (Hooper, 1971). One apparent effect, genetic drift, however, has never been proven and, although Berry's (1971) comment:

> "In general, it seems that if a population of organisms is regularly of so small a size that drift changes can occur, it will be close to the point where it may be unable to survive for ecological reasons".

is perhaps valid, it would be naive to transfer apparent occurrences in some vertebrate and laboratory population to poorly studied invertebrate populations of unknown size. The same idea, stated in a more phylogerontic manner, occurred to Allen (1966) in his discussion of another Urwaldtier, *Hylecoetus dermestoides*, and he refers to species having "lost the vigour required for spreading"; this contrasts with the more dynamic approach adopted by Southwood (1960), who suggests that insect host preferenda may evolve very rapidly, something which the post-Glacial fossil record does not support. There is little need to evoke any genetic mechanisms. Each isolated community is liable to destruction by local changes, whether edaphic or climatic, with little possibility for the immigration of fresh stock. Hooper's (1971) disappearing hedgerows are too narrow to form corridors of dispersal for closed forest species and the general outlook for much of our woodland insect fauna is bleak. In many ways, in view of the picture of the history of forest clearance which is gradually emerging, it is surprising that it remains so diverse.

Some form of change is inevitable, as inexorable as Time itself, yet the destruction of the surviving remnants of our semi-natural woodland, the final refuges of a fauna of nearly ten thousand years standing, may be laid at the door of our apparently enlightened and conservation conscious age. Rarely, a dissident voice is raised but most are smothered beneath the complacency of the Nature Conservancy (c.f. Mellanby, 1974). It is hoped that the Thorne data will drive home the magnitude of the changes in one part of the forest over the past three thousand years and that its information can be used to aid the conservation of a much under-rated aspect of the landscape - its insect fauna.

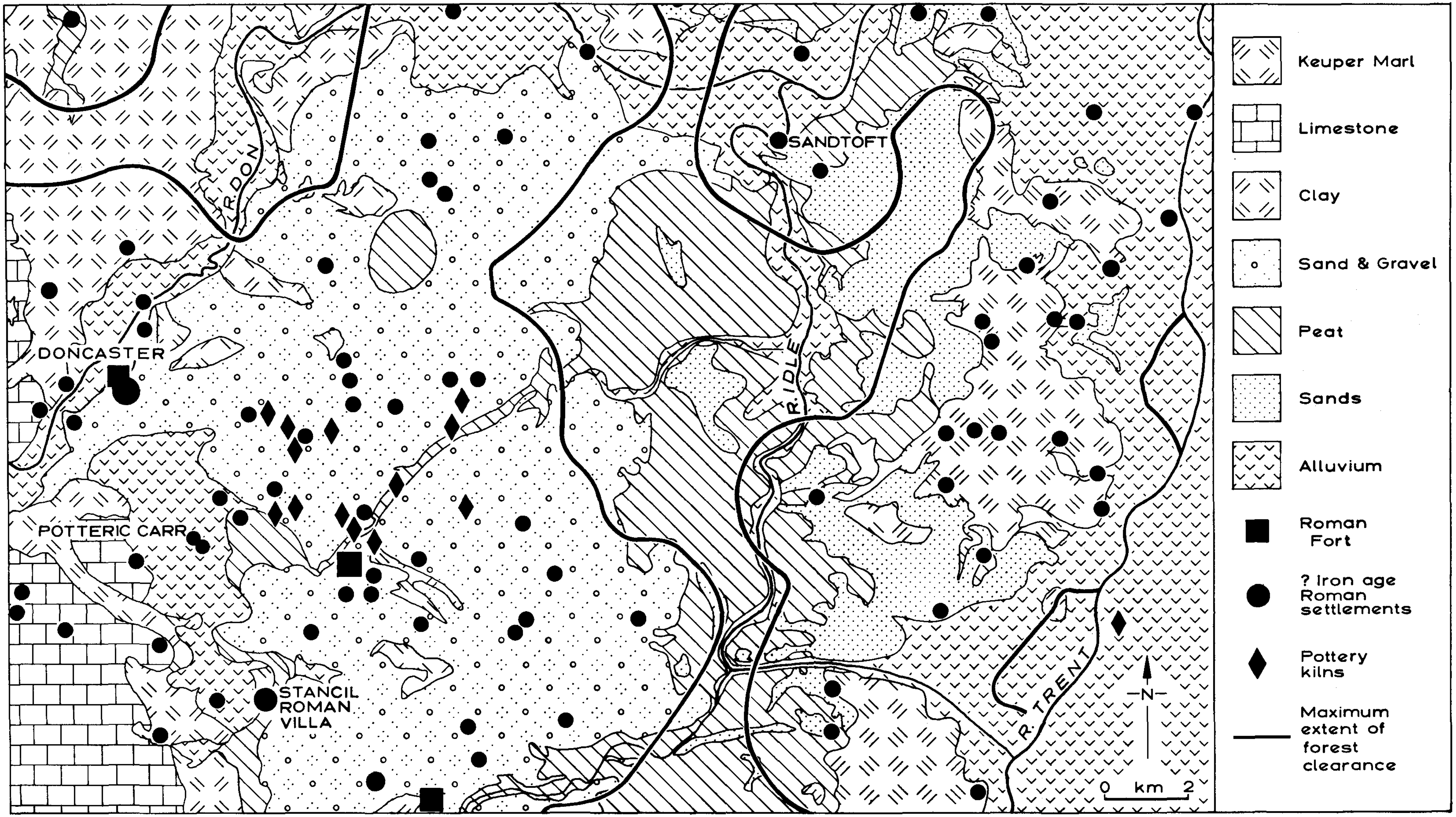

Figure 24: Iron Age and Roman sites on the Humberhead Levels : 2km. site catchment areas and simplified Drift geology - sample area. Data to 7.1978.

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