

## FOSSIL INSECTS AND THE NEOLITHIC: METHODS AND POTENTIAL

The *Insecta*, or *Hexapoda* (= 6 legs), belong to the phylum *Arthropoda*, characterised by having an external skeleton composed at least in part of chitin, a complex polysaccharide,<sup>1</sup> which can be remarkably resistant to decay. They are found in all habitats from the edge of the sea to snow patches on the highest peaks, often in profusion. It is therefore not surprising that they are the most frequent fossils of multicellular animals found in terrestrial and fresh to brackish water deposits belonging to the last two million years, the Quaternary.<sup>2</sup> Their multifarious forms mean that the fossils often show a wide range of diagnostic attributes, which allow identification, often down to the species level. Such would not be important but for the facts that many individual species have unique habitat requirements and that there is little evidence for evolutionary change, both morphological and physiological, during the Quaternary.<sup>3</sup> Faced with the stresses of changing climate and environment, species have shifted their distributions, unless trapped in the isolation of mountain top or oceanic island, where change or extinction was the only option. The identifiable parts of insects, found fossil, range from the head capsules of larval midges (*Diptera*, *Chironomidae*),<sup>4</sup> through individual mandibles of the larvae of the alder fly (*Sialis* sp.), the puparia of flies (*Diptera*) to the robust exoskeletal units of the true bugs (*Homoptera*) and beetles (*Coleoptera*). Because of the accumulated knowledge of morphology, habitat and distribution, it is the latter group which has been most exploited in archaeological interpretation, although the *Diptera* have recently been shown to have considerable potential, particularly in the archaeological context.<sup>5</sup>

Any anaerobic context is likely to preserve insect remains and preservation can be equally good within high latitude and high altitude frozen ground<sup>6</sup> as within the thoroughly desiccating conditions of deserts and the desert fringe.<sup>7</sup> In temperate Europe, however, faunas have mostly been recovered from peats<sup>8</sup> and other natural organic sediments, from alluvial silts<sup>9</sup> to lacustrine deposits,<sup>10</sup> or from waterlogged archaeological contexts, either wells<sup>11</sup> or pits.<sup>12</sup> The one neolithic well so far examined for its insect fauna, at Kolhorn in the Netherlands, has produced a rather restricted fauna.<sup>13</sup> Occasionally charring, as the

<sup>1</sup> A. D. Inms: *Insect natural history*. London 1971.

<sup>2</sup> Elias 1994.

<sup>3</sup> G. R. Coope: *Insect faunas in ice age environments: why so little extinction?* in: J. H. Lawton – R. M. May: *Extinction Rates*. Oxford 1995, 55–74.

<sup>4</sup> W. Hofmann: *Chironomid analysis*, in: B. E. Berglund: *Handbook of Holocene Palaeoecology and Palaeohydrology*. Chichester 1986, 715–727; W. Hofmann: *Late-Glacial/Holocene succession of the chironomid and cladoceran fauna of the Soppensee (Central Switzerland)*. *Journal of Paleolimnology* 25 (2001) 411–420.

<sup>5</sup> Panagiotakopulu, *in press*

<sup>6</sup> P. C. Buckland – P. I. Buckland – P. Skidmore: *Insect remains from GUS: an interim report*, in: J. Arneborg – H. C. Gulløv: *Man, Culture and Environment in Ancient Greenland*. Copenhagen 1999, 74–79.

<sup>7</sup> Panagiotakopulu 2001a.

<sup>8</sup> e.g. N. Whitehouse: *Mire ontogeny, environmental and climatic change inferred from fossil beetle*

*successions from Hatfield Moors, eastern England*. *The Holocene* 14 (2004) 79–93.

<sup>9</sup> D. N. Smith – A. J. Howard: *Identifying changing fluvial conditions in low gradient alluvial archaeological landscapes: can Colcoptera provide insights into changing discharge rates and floodplain evolution?* *Journal of Archaeological Science* 31 (2004) 109–120.

<sup>10</sup> S. J. Brooks – H. J. B. Birks: *Chironomid-inferred air temperatures from Lateglacial and Holocene sites in north-west Europe: progress and problems*. *Journal of Quaternary Science* 20 (2000) 1723–1741.

<sup>11</sup> Osborne 1969.

<sup>12</sup> M. Hellqvist: *Insect assemblages from Iron Age wells in Central Sweden*. *Norwegian Archaeological Review* 32 (1999) 1–18.

<sup>13</sup> T. Hakbijl – J. P. Pals – C. D. Troostheide: *Plant and insect remains from the Late Neolithic well at Kolhorn*. *Palaeohistoria* 31 (1989) 157–163.

assemblages from beneath the tephra of Santorini (Thera) in the Aegean<sup>14</sup> or in the disposal of stored product residues<sup>15</sup> may lead to preservation of insect remains, and in situations of high free phosphate content, as in cesspits specimens may be 'calcified'.<sup>16</sup> Casts within voids in deposits may also occur.<sup>17</sup> Research upon insects from natural Quaternary and archaeological deposits has largely been developed in England, and it is inevitable that this discussion will focus upon work carried out there.

### *Recovery of insect remains*

Until the development of an efficient paraffin (kerosene) flotation technique by Coope and Osborne,<sup>18</sup> insect remains were recovered either by splitting sediment along bedding planes and searching surfaces for identifiable sclerites or by complete disaggregation of samples and sorting under a low power binocular microscope in either water or alcohol. Splitting inevitably leads to bias in favour of the larger and/or more colourful individuals, and sorting of entire samples, even if disaggregated beforehand, can be particularly time consuming. Coope and Osborne's technique, sometimes with slight variations<sup>19</sup> has become standard for the recovery of insects from waterlogged samples, although it has the disadvantage that sclerites become disassociated, increasing the difficulties in identification. In the field, samples of at least 5 litres are recovered from each suitable stratigraphic context into polythene bags and labelled and sealed. Sample size may vary as to the nature of the deposits, and a single kilogram of deposit from a well may be sufficient to produce an extensive fauna. Stratigraphic successions with little apparent change are usually sampled in 50 or 100 mm slices, depending upon the degree of resolution required. Well sealed samples will survive in storage for several years in a cold, dark room, but storage at +3°C in a cold store is recommended, since materials slowly dry out and algal growth occurs in daylight. Processing has the advantage of being cheap in terms of materials, if sometimes slow. Samples are disaggregated in hot water and washed out over a 300 µm mesh sieve. The more indurated sediments may need breaking down with a suitable deflocculant, usually washing soda (sodium carbonate) or calgon (sodium hexametaphosphate), although occasionally hot caustic soda (sodium hydroxide) solution may be employed for the most intransigent materials. Insect remains, however, may be corroded by strong alkalis, and their use must be carefully monitored. There is often a trade-off between care in initial sample processing and ease of identification of the recovered remains: the more fragmented through rough handling the more difficult the identification. Having thoroughly desegregated the material and picked out large items from stone and pottery to twigs and hazelnuts, the material on the sieve is drained of surplus water, returned to the bowl or bucket in which the sample was first broken down, and ordinary commercial paraffin (kerosene) added, sufficient being employed to wet thoroughly the material. The light oil adsorbs onto the surface of the insect cuticle, and when cold water is added and the mix vigorously stirred, a floatant is formed, which is rich in insect remains. The float is then poured off into the sieve, washed with liquid detergent and alcohol, and stored in alcohol. The process of flotation

<sup>14</sup> E. Panagiotakopulu – P. C. Buckland: Insect pests of stored products from Late Bronze Age Santorini, Greece. *Journal of stored Product Research* 27 (1991) 179–184.

<sup>15</sup> cf. P. J. Osborne: Stored product beetles from a Roman site at Droitwich, England. *Journal of stored Product Research* 13 (1977) 203–204.

<sup>16</sup> *Girling 1979*; see also M. A. Robinson: Insects as palaeoenvironmental indicators, in: D. R. Brothwell – A. M. Pollard: *Handbook of archaeological sciences*. Chichester 2001, 121–133.

<sup>17</sup> cf. E. Panagiotakopulu – P. C. Buckland – P. Day – C. Doumas – A. Sarpaki – P. Skidmore: A lepidopterous cocoon from Thera and evidence for silk in the Aegean Bronze Age. *Antiquity* 71 (1997) 420–429.

<sup>18</sup> G. R. Coope – P. J. Osborne: Report on the Coleopterous Fauna of the Roman Well at Barnsley Park, Gloucestershire. *Transactions of the Bristol and Gloucestershire Archaeological Society* 86 (1968) 84–87.

<sup>19</sup> e.g. G. R. Coope: (1986). *Coleoptera analysis*, in: B. E. Berglund: *Handbook of Holocene Palaeoecology and Palaeohydrology*. Chichester 1986, 703–713; Elias 1994; H. K. Kenward – A. R. Hall – A. K. G. Jones: A tested set of techniques for the extraction of plant and animal macrofossils from waterlogged and archaeological deposits. *Science and Archaeology* 22 (1980) 3–15.

is usually repeated three times, although if the final float still has significant numbers of identifiable fragments, it may be necessary to repeat the additions of water until no further insects are recovered. Unfortunately floats are rarely purely of insect sclerites, and it usually necessary to sort the fragments out from a mass of plant remains. Occasionally, this has the advantage that a reasonable, if unquantifiable sample of identifiable plant macrofossils, largely seeds, is also obtained. Long term storage in alcohol is usually acceptable, but corrosion of sclerites has been noted where methanol has been used, and the material added to industrial alcohol to make it unpalatable can also result in erosion of chitin. Drying, however, often results in specimens curling up or breaking along lines of thinner chitin, although freeze-drying may alleviate these problems.

Insects either preserved by desiccation or by charring, do not respond well to wetting, and will fragment. This means that such samples cannot be treated by the paraffin flotation method. Both require sorting of the entire sample, and storage in dry conditions. This material has the advantage that individual sclerites may remain articulate, easing some of the problems of identification.

Whilst there are good keys for the identification of European *Coleoptera*,<sup>20</sup> and *Diptera*, these normally require complete specimens, often utilising elements such as variations in antennal or tarsal segment length to differentiate species. In addition, many species, particularly of the smaller taxa, such as the commonly occurring *aleocharine staphylinids* amongst the *Coleoptera*, require careful examination of the genital armature (*aedeagus*) to secure identification. Fossil material is usually identified by direct comparison with modern reference material, and this requires access to full collections for the region involved, although it should also be noted that even on the historical timescale species may have substantially changed their distribution. The development of the BUGS database provides habitat and distribution data on much of the European *coleopterous* fauna, as well as listing the Quaternary fossil record for each species.<sup>21</sup> It has made the processes of site interpretation somewhat easier, but the work is still time consuming and, in comparison with palynology and plant macrofossil studies, there are few practitioners. The combination of these techniques with the study of the contemporary insect fauna makes them much more powerful tools.

### *Insects and climate*

The first modern studies of fossil insects from Quaternary sediments were carried out by Russell Coope and F. W. Shotton of the University of Birmingham, England. They had noticed well preserved beetle remains on the bedding planes of a thin layer of peat within mid-Weichselian (Würm) sands and gravels at Upton Warren in Worcestershire, and Shotton had immediately seized upon these as a possible means of zoning the Pleistocene. His reasoning was that most entomologists believed that insects belonged to a rapidly evolving group and would show rapid morphological variation through time. Coope was more circumspect and doggedly matched the material with existing species,<sup>22</sup> a process which he repeated at the Early Weichselian site of Chelford in Cheshire.<sup>23</sup> One species defied identification, a dung beetle, *Aphodius* sp. A, which was later recovered from several mid-Weichselian sites over then years later was matched with a species, *A. holdereri*, found on the high Tibetan plateau.<sup>24</sup> The Upton Warren faunas defined a temperate interlude in the middle of the last glaciation, and the contrast between a relatively thermophilous beetle fauna and an open landscape as

<sup>20</sup> e.g. H. Freude – K. W. Harde – G. A. Lohse: Die Käfer Mitteleuropas. Krefeld 1963–1989.

<sup>21</sup> P. I. Buckland – P. C. Buckland: How can a database full of Bugs help reconstruct the climate? in: G. Burenhult – J. Arvidsson: Archaeological informatics: pushing the envelope. CAA 2001. Computer applications and quantitative methods in archaeology. Proceedings of the 29<sup>th</sup> conference, Gotland, April 2001. BAR IntSer 1016 (2002) 453–462; [www.bugs2000.org](http://www.bugs2000.org)

<sup>22</sup> G. R. Coope – F. W. Shotton – I. Strachan: A Late Pleistocene fauna and flora from Upton Warren, Worcestershire. Philosophical Transactions of the Royal Society of London B244 (1961) 379–421.

<sup>23</sup> G. R. Coope: A Late Pleistocene insect fauna from Chelford, Cheshire. Proceedings of the Royal Society of London B151 (1959) 70–86.

<sup>24</sup> G. R. Coope: Tibetan Species of Dung Beetle from Late Pleistocene Deposits in England. Nature 245 (1973) 335–336.

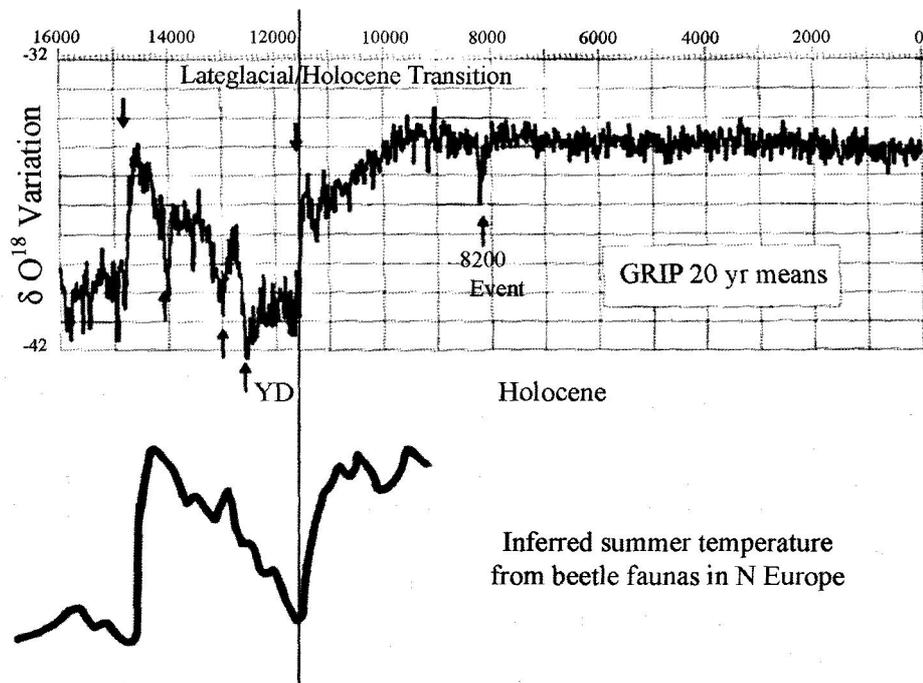


fig. 1. Climate curve as derived from the GRIP Ice Core in Greenland, compared with the Lateglacial to Early Holocene North European Coleopteran curve

indicated by the pollen provoked some discussion. The controversy was further fuelled when beetle evidence from sites at Red Moss, Lancashire,<sup>25</sup> Rodbaston, Staffordshire,<sup>26</sup> Church Stretton, Shropshire<sup>27</sup> in England and Glanllynau, Gwynedd, in Wales<sup>28</sup> all indicated that the climatic transitions during the Lateglacial and into the Early Holocene were not gradual processes of warming over hundreds if not thousands of years, but were abrupt changes from high arctic to warmer than present day at *ca.* 13 500 BP. It had been cooling to subarctic and then arctic conditions, followed by precipitate warming at *ca.* 10 000 BP to at least as warm as present day at the opening of the Holocene. Osborne's<sup>29</sup> well dated and closely sampled succession at West Bromwich, near Birmingham, indicated that the last abrupt change into the present interglacial took less than the standard deviation of a radiocarbon date, and in less time than sample resolution would allow, probably less than forty years. This pattern has been repeated at several sites, not only in the British Isles but also in Scandinavia.<sup>30</sup> Initially greeted with much scepticism, to the extent that one leading palynologist, who would perhaps now wish to remain nameless, talked about having to differentiate between 'pollen' and 'beetle' interstadials, the evidence from the Greenland ice cores, resolved to at least an annual record, firmly placed the interpretation on the side of the Quaternary entomologists (*fig. 1*).<sup>31</sup> The evidence from Stage 3, the period before the maximum expansion of ice sheets during the last glacial, is particularly striking. With its frequent swings from cold to temperate in the ice core record matched closely by the beetle evidence,<sup>32</sup> it should be a cause for concern

<sup>25</sup> A. C. Ashworth: A Late-glacial Insect Fauna from Red Moss, Lancashire, England. *Entomologica Scandinavica* 3 (1972) 211–224.

<sup>26</sup> A. C. Ashworth: The Climatic Significance of a Late Quaternary Insect Fauna from Rodbaston Hall, Staffordshire, England. *Entomologica Scandinavica* 4 (1973) 191–205.

<sup>27</sup> Osborne 1972.

<sup>28</sup> G. R. Coope – J. A. Brophy: Late Glacial environmental changes indicated by a coleopteran succession from North Wales. *Boreas* 1 (1972) 97–142.

<sup>29</sup> P. J. Osborne: The Late Devensian Flandrian transition depicted by serial insect faunas from West Bromwich, England. *Boreas* 9 (1980) 139–147.

<sup>30</sup> G. R. Coope – G. Lemdahl – J. J. Lowe – A. Walkling: Temperature gradients in northern Europe during the last glacial-Holocene transition (14–9 14C kyr BP) interpreted from coleopteran assemblages. *Journal of Quaternary Science* 13 (1998) 419–434.

<sup>31</sup> R. B. Alley – D. A. Meese *et al.*: Abrupt increase in the Greenland snow accumulation at the end of the Younger Dryas event. *Nature* 362 (1993) 527–529.

<sup>32</sup> Coope 2001.

for the complacency of the oil lobby and right wing governments everywhere. The Holocene interglacial has been remarkably stable since its last, short cold event at ca. 8200 BP,<sup>33</sup> but there is no guarantee that it will continue under increased anthropogenic pressure.

More recently the closer sample resolution available from study of the remains of the aquatic larvae of chironomids, non-biting midges from lake sediments has further refined the evidence for the precipitate nature of climate change.<sup>34</sup> This is well illustrated in the multidisciplinary study of the Lateglacial succession from the lake on Kråkenes in southwest Norway,<sup>35</sup> although sample size from cores somewhat limits the utility of the beetle evidence.

Although the ice core evidence indicates a relatively stable climate for the present interglacial between ca. 8200 BP and the onset of the post-medieval Little Ice Age, this does not mean that oscillations between regimes dominated by westerly and a more continental circulation pattern did not have impact. Annual average temperatures do not indicate seasonality, distribution of rainfall and storminess, all of which can have significant impact upon both insect and human communities. The record of Holocene climate available from the proxy of insect fossils has been discussed by Osborne,<sup>36</sup> Wagner<sup>37</sup> and Buckland and Wagner,<sup>38</sup> often with differing conclusions. Wagner<sup>39</sup> felt that the scale of human interference in the Late Holocene landscape was such that it was virtually impossible to dissect any climate signal from the insect record. Whilst Osborne<sup>40</sup> saw a swing towards more oceanic conditions in the Late Holocene, perhaps at the sub-Boreal sub-Atlantic transition ca. 850 BC, where van Geel and others<sup>41</sup> have indicated a worldwide climatic event, although its synchronicity can be doubted.<sup>42</sup> The overall patterns of extinction from the British insect fauna, with a south-eastward retreat of most species, do suggest that conditions at least as late as the Middle Bronze Age, ca. 3000 BP, were significantly more continental than the present day, and this applies as much to open ground assemblages, like that from Wilsford in Wiltshire<sup>43</sup> as still forested localities like Thorne Moors in south Yorkshire.<sup>44</sup> The Wilsford shaft, inevitably a ritual feature to archaeologists, but with the ritual bucket and remains of the rope for hauling up buckets of water in the bottom and an extensive dung fauna from the animals being watered at the top,<sup>45</sup> has a remarkably thermophilous coprophagous assemblage with large numbers of *Onthophagus* spp. and *Aphodius quadriguttatus*. The latter now extinct in Britain and most species of the former very rare.<sup>46</sup> A hide beetle, dermestid, from the site, *Dermestes lanarius*, which presently has an east European and Russian steppe core distribution,<sup>47</sup> is either a survivor in gaps in the mid-Holocene forest from the even more continental climate of the Early Holocene, when low sea level engendered continentality, or an

<sup>33</sup> D. Klitgaard-Kristensen – H.-P. Sejrup – H. Haflidason – S. Johnsen – M. Spurk: A regional 8200 cal yr cooling event in northwest Europe, induced by final stages of the Laurentide ice-sheet deglaciation? *Journal of Quaternary Science* 13 (1998) 165–169; W. Tinner – A. F. Lotter: Central European vegetation response to abrupt climate change at 8.2 ka. *Geology* 29 (2001) 551–554.

<sup>34</sup> S. J. Brooks: The response of Chironomidae (Insects: Diptera) assemblages to Late-Glacial climatic change in Kråkenes Lake, Western Norway. *Quaternary Proceedings* 5 (1997) 49–58.

<sup>35</sup> H. H. Birks – R. W. Battarbee – H. J. B. Birks – E. G. Bradshaw – S. J. Brooks – C. A. Duigan – V. J. Jones – G. Lemdahl – S. M. Peglar – S. M. Solem – T. Solhøy – M. K. Stalsberg: The development of the aquatic ecosystem at Kråkenes lake, western Norway, during the Late-glacial and early-Holocene – a synthesis. *Journal of Paleolimnology* 23 (2000) 91–114.

<sup>36</sup> P. J. Osborne: Some British later prehistoric insect faunas and their climatic implications, in: A. Harding: *Climatic Change in Later Prehistory*. Edinburgh 1982, 68–74; Osborne 1997.

<sup>37</sup> Wagner 1997.

<sup>38</sup> P. C. Buckland – P. Wagner: Is there an insect signal for the Little Ice Age? *Climate Change* 48 (2001) 137–149.

<sup>39</sup> Wagner 1997.

<sup>40</sup> Osborne 1997.

<sup>41</sup> B. van Geel – J. Buurman – H. T. Waterbolk: Archaeological and palaeoecological indications of an abrupt climate change in the Netherlands and evidence for climatological teleconnections around 2650 BP. *Journal of Quaternary Science* 11 (1996) 451–460.

<sup>42</sup> cf. C. van den Bogaard – W. Dörfler – R. Glos – M.-J. Nadeau – P. M. Grootes – H. Erlenkeuser: Two tephra layers bracketing Late Holocene paleoecological changes in Northern Germany. *Quaternary Research* 57 (2002) 314–324.

<sup>43</sup> Osborne 1969.

<sup>44</sup> Buckland 1979.

<sup>45</sup> Bell et al. 1989.

<sup>46</sup> Osborne 1969.

<sup>47</sup> V. A. Minoranskiy: Some data on the ecology of the hide beetle *Dermestes lanarius* Illiger (Coleoptera Dermestidae). *Entomological Review* 48 (1969) 477–478.

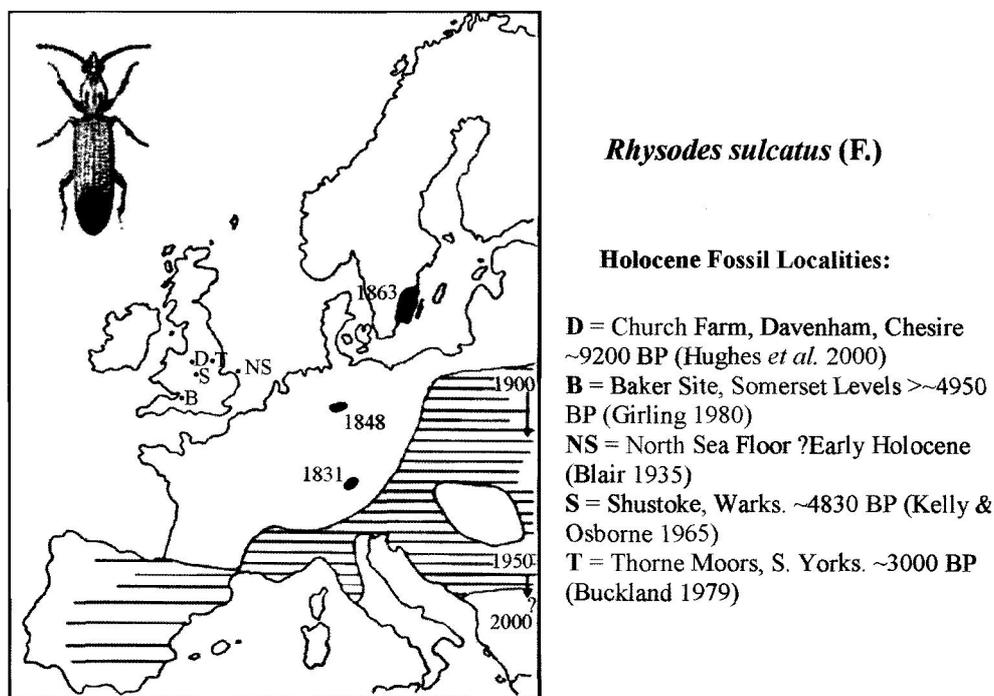


fig. 2. The declining distribution of the Urwaldrelikt *Rhysodes sulcatus* (revised from Speight 1989). Climate change, destruction of old growth forests (*Urwald*) or both?

accidental import. Even in the latter case, the site lies sufficiently far inland to suggest that the species was able to establish viable populations in the climate of Bronze Age southern England. Fossil evidence shows that over thirty species of beetle have disappeared from Britain during the Holocene.<sup>48</sup> Most of these are associated with declining woodland habitats (*fig. 2*), but the list is sufficiently varied to implicate climate change.

The Elm Decline, an almost synchronous event across much of northern and western Europe, marks the boundary between pollen zones VIIa and VIIb in Britain. Its origin has perhaps occasioned more discussion than any other aspect of the Holocene, largely because it is co-incident with the first clear evidence for settled agriculture in the British Isles at about 5200 BP (= *ca.* 3900 cal BC). Interpretation, recently reviewed by Parker and others,<sup>49</sup> has vacillated between climate change, disease and human impact. At West Heath Spa, London, the finds of the bark beetle, scolytid, *Scolytus scolytus*, the chief vector in the spread of the fungus responsible for Dutch Elm Disease, which has devastated elms across Europe over the past few decades, in deposits across the VIIa/b boundary has occasioned much discussion<sup>50</sup> and helped to revive interest in the disease hypothesis. Rowley-Conwy<sup>51</sup> had, however, already dispelled the simple model of human collection of fodder for animals by calculating the necessary population densities of humans and domestic stock for the scale of impact on the elms of mid-Holocene Denmark. Recently Bonsall and others<sup>52</sup> have

<sup>48</sup> Buckland, *in press*

<sup>49</sup> A. G. Parker – A. S. Goudie – D. E. Anderson – M. A. Robinson – C. Bonsall: A review of the mid-Holocene elm decline in the British Isles. *Progress in Physical Geography* 26 (2002) 1–45.

<sup>50</sup> M. A. Girling – J. R. A. Greig: A first fossil record for *Scolytus scolytus* (F.) (Elm Bark Beetle): its occurrence in Elm Decline deposits from London and the implications for Neolithic Elm Disease. *Journal of Archaeological Science* 12 (1985) 347–352; P. D. Moore: Hampstead Heath clue to historical decline of elms (Find of Dutch elm

disease beetle in pre-elm decline level). *Nature* 312 (1984) 103.

<sup>51</sup> P. Rowley-Conwy: Forest grazing and clearance in temperate Europe with special reference to Denmark: an archaeological view, in: M. Bell – S. Limbrey: *Archaeological aspects of woodland ecology*. BAR IntSer 146 (1982) 199–215.

<sup>52</sup> C. Bonsall – M. G. Macklin – D. E. Anderson *et al.*: Climate change and the adoption of agriculture in northwest Europe. *European Journal of Archaeology* 5 (2002) 9–23.

resurrected the climate change model as explanation for final phase of neolithic expansion which took agriculture north-westwards to the most remote islands of Scotland, after an 800 – 1300 year falter at the English Channel. Using evidence largely drawn from around Oban on the west coast of Scotland, they have suggested that a short phase of drier conditions around 4000 cal BC facilitated expansion onto soils previously too wet for cereal cultivation. Such a model is likely to be appropriate on the local scale, but it ignores the fact that much of lowland Britain has well drained soils, often based on well drained loess,<sup>53</sup> similar to those across the Channel in France and the Low Countries, and unlikely to be adversely affected by waterlogging. In addition, the insect evidence from the Somerset Levels, which they adduce to support their case,<sup>54</sup> can only be used to show that a more continental climate existed at least until the time of their deposition, and not only at that period. In fact, similar elements in the biota are still present much later. Of the two freshwater littoral ground beetles, which provide the best evidence, *Oodes gracilis* is still present in the Iron Age at Goldcliff across the Severn Estuary,<sup>55</sup> and *Chlaenius sulcicollis* occurs in the deposits around the Bronze Age Meare Heath trackway.<sup>56</sup> The implication of this and other fossil insect evidence is that the climate of the Holocene was more continental until some yet to be determined event, at the sub-Boreal sub-Atlantic transition, if not as late as the beginning of the Little Ice Age. This does not mean, however, that minor oscillations, insufficient to cause major extirpations from the beetle fauna, did not have effects upon agricultural productivity, leading to fluctuations in the degree, nature and density of human settlement. It is a truism of the farming community that what affects them is weather and not climate. In the subsistence economy, long term change can be adjusted for, the one disastrous poor summer leading to insufficient fodder for overwintering core stock and poor grain and other crop yields cannot, and starvation may be inevitable.

The Elm Decline remains enigmatic. The presence of the relevant vector is no guarantee of the presence of a sufficiently virulent strain of the disease to cause a widespread decline, and as Clark<sup>57</sup> has shown in north east Scotland, like other scolytids, *S. scolytus* is one of the many bark beetles, which form part of the natural forest assemblage through the mid-Holocene; it was not an accidental neolithic introduction to north west Europe. One point, however, is particularly relevant in that scolytid attack is not a random process and the adult beetles actively search out trees under stress, those damaged by wind throw drought or bark stripping by herbivores. Increase the level of stress, either by climate change, increased grazing pressure or other opening up of closed forest cover, and the numbers of bark beetles will increase exponentially and apparently healthy trees overwhelmed. Which species will be given the selective advantage may be purely stochastic, but its impact may be dramatic. In North America, in the absence of evidence for a significant human presence in the forests, hemlock, *Tsuga* sp, shows a precipitate decline in the mid-Holocene, apparently the result of insect attack.<sup>58</sup> In Europe, we still do not know who held the gun. Did drought open up the forest to human expansion, or did human expansion put the forest under stress leading to catastrophic insect attack? Perhaps before this question can be answered, the nature of the pre-neolithic forests themselves needs to be examined in more detail.

<sup>53</sup> J. Catt: The contribution of loess to soils in lowland Britain, in: S. Limbrey – J. G. Evans: The effect of man on the landscape: the Lowland Zone. London, Council for British Archaeology Research Report 21 (1978) 12–20.

<sup>54</sup> Girling 1979; M. A. Girling: Investigations of a second insect assemblage from the Sweet Track. Somerset Levels Papers 10 (1984) 79–91.

<sup>55</sup> D. N. Smith – P. J. Osborne – J. Barrett: Preliminary palaeo-entomological research at the Iron Age sites at Goldcliff, Gwent, Wales, 1991–1993. Quaternary Proceedings 5 (1997) 255–268.

<sup>56</sup> Girling 1982.

<sup>57</sup> S. H. E. Clark: Holocene environmental change in Northeast Scotland: a palaeontomological approach. Unpubl. PhD, University of Sheffield 2002.

<sup>58</sup> N. Bhiry – L. Filion: Mid-Holocene hemlock decline in eastern North America linked with phytophagous insect activity. Quaternary Research 45 (1996) 312–320.

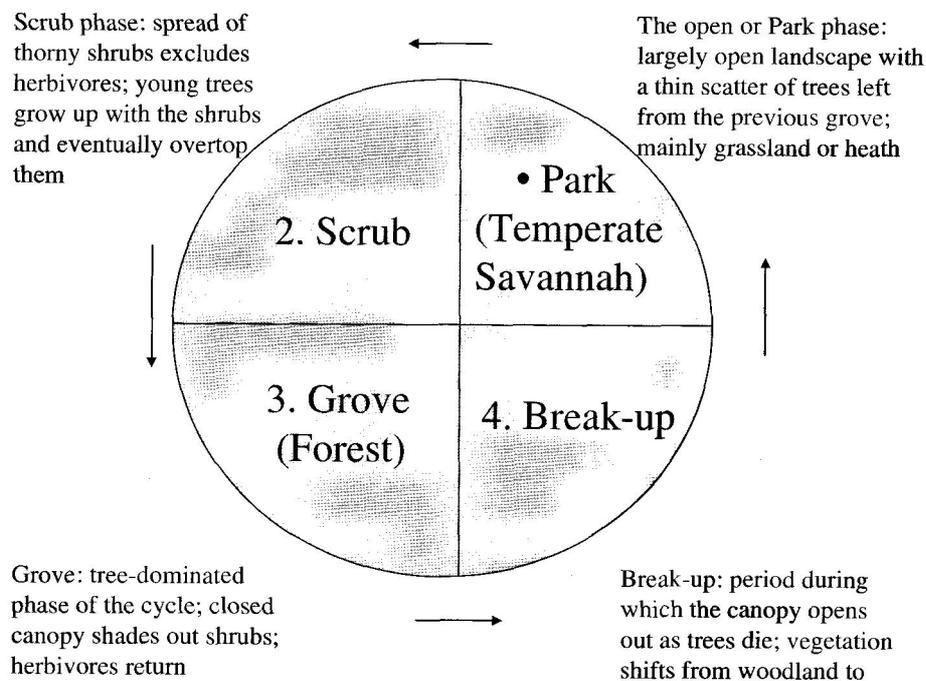


fig. 3. The Vera Model of forest succession driven by large herbivores, as modified by Kirby 2003.

### *The nature of the Urwald*

The natural ‘climax’ vegetation of Europe, outside the aridity of the Mediterranean zone and Steppe and below the cold of the high mountains and Arctic, is forest. Whilst there is no doubt that an overall regional picture of the composition of the vegetation is best obtained from pollen,<sup>59</sup> insects in particular provide levels of resolution not available from palynology. Osborne,<sup>60</sup> for example, had pointed out the relative frequency of the lime bark beetle, *Ernoporus caucasicus* in mid-Holocene deposits before Greig,<sup>61</sup> also working at the University of Birmingham, had re-evaluated the pollen and plant macrofossil record and suggested that much of the primary lowland woodland of western Europe had been dominated by *Tilia* rather than *Quercus*. Recent work by Frans Vera<sup>62</sup> has raised doubts over another aspect of the primary forest, the *Urwald*. His model essentially puts large herbivores back into the landscape and has implications for conservation as much as for interpreting the past. He sees a cycle in which grazing pressure leads to semi-permanent natural clearings in the woodland and a succession of pasture woodland through to mature forest with regeneration largely taking place in the margins protected from animals by the development of thorn scrub (fig. 3). It has much to commend it over the mechanistic model of progressive tree immigration from Lateglacial refugia once favoured by many palynologists,<sup>63</sup> and more recent work has re-opened the debate over just where the refuges from glacial cold and ice lay.<sup>64</sup> The idea that herbivores had a significant role in the

<sup>59</sup> Moore et al. 1991.

<sup>60</sup> M. R. Kelly – P. J. Osborne: Two faunas and floras from the alluvium at Shustoke, Warwickshire. Proceedings of the Linnean Society of London 176 (1965) 37–65.

<sup>61</sup> J. R. A. Greig: Past and present lime woods of Europe, in: M. Bell – S. Limbrey: Archaeological Aspects of Woodland Ecology. BAR IntSer 146 (1982) 23–56.

<sup>62</sup> Vera 2000.

<sup>63</sup> H. Godwin: History of the British flora: a factual basis for phytogeography. Cambridge, 1975.

<sup>64</sup> e.g. K. J. Willis: Where did all the flowers go? The fate of temperate European flora during glacial periods. Endeavour 20 (1996) 110–114; J. R. Stewart – A. M. Lister: Cryptic northern refugia and the origins of the modern biota. Trends in Ecology and Evolution 16 (2001) 608–613.

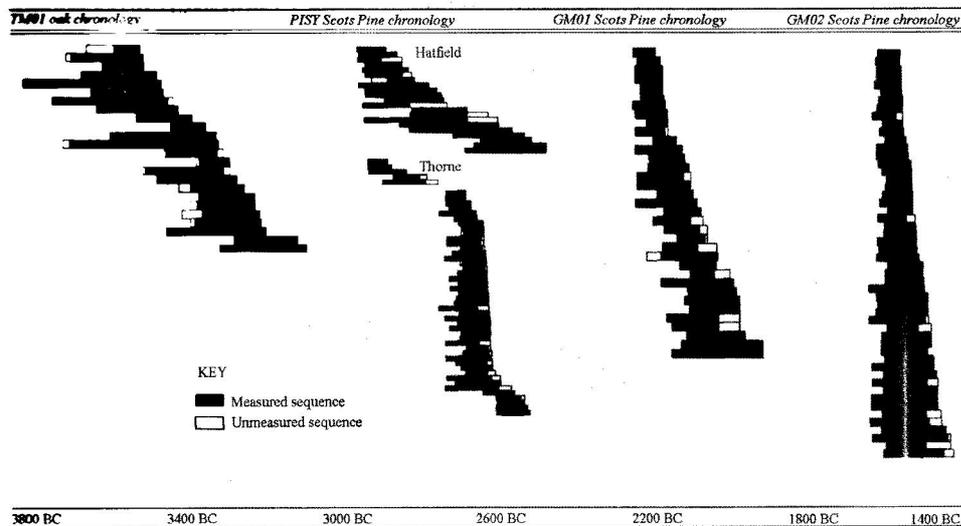


fig. 4. Dendrochronological sequence from Thorne and Hatfield Moors, S. Yorks. The gaps in the sequence reflect phases in which peat growth expands across the pine forested bog after extensive fire (from *G. Boswijk: The buried forests of Thorne Moors. Thorne and Hatfield Moors Papers 6 [2003]*)

**maintenance** of mid-Holocene forest diversity has provoked an often hostile response,<sup>65</sup> although there have been some attempts at compromise.<sup>66</sup> The fossil insect record provides an independent check upon models derived from other palaeoecological evidence. Not only can individual species be *monophagous*, restricted, like *E. caucasicus*, to a single host plant, but also a succession of species tracks the death and decay of trees. Whilst these elements in the fauna may not be host specific, they chart the progress from death of terminal twigs to incorporation in the forest litter layer. Much of this fauna has suffered extensively at the hands not only of forest clearance but also of tidy forestry, in which dead wood was not suffered to remain on the forest floor. Species, like *Rhysodes sulcatus* (fig. 2), which lives in damp, decaying wood on the forest floor, were common in the mid-Holocene but are now approaching extinction, not regionally but totally.<sup>67</sup> Pre-neolithic forests were perhaps different from anything that survives today and both Peterken<sup>68</sup> and Vera.<sup>69</sup> for different reasons, have stressed that even those few places, like the Bielewski Forest on the Polish-Byelorussia border, held up as examples of pristine forest habitats, have not escaped some impact, be it virtual elimination of predators on the large herbivores or selective logging. Yet, viewed with the perspective of the Quaternary, the Holocene is from the beginning an atypical interglacial. The old forest fauna, having evolved in a landscape of fairly contiguous woodland in the mid-Tertiary, is broken up and re-assembled at the end and beginning of each glacial interglacial cycle. Mid-Holocene faunas, before significant neolithic impact contain the same Urwald elements as previous interglacials, be they Marine Isotope Stage 5e (= Eemian, Riss/Würm), 7, 9 (= Hostenian, Mindel/Riss), 11 or older,<sup>70</sup> but there are differences in other elements of the faunas, which cannot be simply ascribed to biogeographic accident or climate. As Rackham<sup>71</sup> has remarked, the last interglacial (Riss/Würm) at sites like Trafalgar Square in London<sup>72</sup> and Deeping St.

<sup>65</sup> Rackham 2003.

<sup>66</sup> e.g. R. H. W. Bradshaw – G. E. Hannon – A. M. Lister: A long-term perspective on ungulate-vegetation interactions. *Forest Ecology and Management* 181 (2003) 267–280; J. C. Svenning: A review of natural vegetation openness in north-western Europe. *Biological Conservation* 7 (2002) 290–296.

<sup>67</sup> Speight 1989.

<sup>68</sup> G. F. Peterken: *Natural forests*. Cambridge 1996.

<sup>69</sup> Vera 2000.

<sup>70</sup> Buckland, *in press*

<sup>71</sup> O. Rackham: *Savannah in Europe*, in: K. J. Kirby – C. Watkins: *The ecological history of European forests*. Wallingford, CABI 1998, 1–24.

<sup>72</sup> Coope 2001.

James in Lincolnshire<sup>73</sup> look like temperate savannah rather than forest. It is probably 3 °C warmer<sup>74</sup> and with increased summer aridity, the London site perhaps did approximate to that of its host institution – it lay beneath Uganda House. The last interglacial in Britain also had other similarities with East Africa. The fauna included elephant, rhinoceros, hippopotamus, buffalo, hyena and lion, none of which returned to Central or Western Europe after the last glacial maximum.<sup>75</sup> This fauna is reflected in the extensive dung beetle faunas of Stage 5e, which not only include the alleged Sicilian endemic *Onthophagus massai*, but also an unidentified species of *Heptalaucus* of north African affinities and a *Drepanocerus*, a genus widespread in sub-Saharan Africa, but whose closest match to the fossils comes from the lowland valleys of Nepal.<sup>76</sup> The last interglacial was clearly a very different world, and such an assemblage of large game would have a major impact upon vegetation cover, not least upon floodplains. By the time neolithic farmers came to make inroads into the forests of Central Europe, earlier human impact had already had a profound impact upon its vegetation.<sup>77</sup> If the floodplain forests were as dense as both the pollen and insect evidence would seem to indicate,<sup>78</sup> it was because a very significant proportion of the large grazers and their predators had already been eradicated. The question posed by Vera's<sup>79</sup> reassessment of the nature of the Holocene forest cycle. Whether their place was taken by increased numbers of the resident large to medium sized herbivores, of aurochs, horse, elk, red deer, roe deer, wild boar and beaver, and whether these were the creators and maintainers of clearings in the forest, which the first neolithic colonists were able to move into. In Skåne, southern Sweden, Lemdahl<sup>80</sup> has already pointed to the diverse nature of the Holocene forest and assessment of the British evidence suggests a similar picture.<sup>81</sup> However there are serious spatial problems with the sampling – most samples come from the structurally complex closed forests of floodplain and lowland fen, and only Osborne's<sup>82</sup> study of the Church Stretton valley in the Welsh Borders, on the edge of the uplands of the Longmynd, indicates an essentially open, grazed pre-neolithic landscape. Part of the problem is also taphonomic, if pollen from wetland hollows in forest provides a clear view of the immediate closed woodland,<sup>83</sup> the attenuated nature of these successions leads to poor insect preservation. In addition, insect dispersal of those taxa, which do not form part of the aerial plankton,<sup>84</sup> is not random. A point made emphatically by the failure of insect samples from the heart of raised mires at Thorne and Hatfield Moors in south Yorkshire to register the processes leading to complete forest clearance on the surrounding higher ground evident in pollen and aerial archaeological evidence.<sup>85</sup> It is evident, however, from the limited amount of insect data available that neolithic penetration was probably not along the floodplains of the major rivers, which look to have been particularly densely vegetated,

<sup>73</sup> D. H. Keen – M. D. Bateman – G. R. Coope – M. H. Field – H. E. Langford – J. S. Merry – T. M. Mighall: Sedimentology, palaeoecology and geochronology of Last Interglacial deposits from Deeping St James, Lincolnshire, England. *Journal of Quaternary Science* 14 (1999) 411–436.

<sup>74</sup> G. R. Coope – A. R. Beesley: How warm was the Ipswichian interglacial: evidence from insect assemblages. *International Union for Quaternary Research XII international Congress: Program with Abstracts, Ottawa 1987.*

<sup>75</sup> A. J. Stuart: Mammalian extinctions in the Late Pleistocene of northern Eurasia and North America. *Biological Review* 49 (1991) 225–266.

<sup>76</sup> C. Gao – D. H. Keen – S. Boreham – G. R. Coope – M. E. Pettit – A. J. Stuart – P. L. Gibbard: Last Interglacial and Devensian deposits of the River Great Ouse at Woolpack Farm, Fenstanton, Cambridgeshire, UK. *Quaternary Science Reviews* 19 (2000) 787–810.

<sup>77</sup> cf. C. Turner: Der Einfluß großer Mammalier auf die interglaziale Vegetation. *Quartärpaläontologie* 1 (1975) 13–19.

<sup>78</sup> e.g. Buckland 1979; Girling 1982.

<sup>79</sup> Vera 2000.

<sup>80</sup> G. Lemdahl: Holocene forest environments in southern Sweden and wood living insects. *Geological Society of America Annual Meeting, Colorado 2002, Program with Abstracts, 46–11.*

<sup>81</sup> Buckland, *in press*

<sup>82</sup> Osborne 1972.

<sup>83</sup> R. H. W. Bradshaw: Spatially precise studies of forest dynamics. B. Huntley and T. Webb III: *Vegetation History*. Dordrecht 1988, 725–751.

<sup>84</sup> sensu R. A. Crowson: *The biology of the Coleoptera*. London 1981.

<sup>85</sup> Buckland 1979; D. N. Riley: *Early Landscape from the Air*. Sheffield, 1980; B. M. Smith: A palaeoecological study of raised mires in the Humberhead Levels. *BAR BS 336* (2002).

if occasionally and locally broken up by flooding. As Bogucki<sup>86</sup> has remarked on other evidence, may be Gradmann's<sup>87</sup> hypothesis was not all bad, although the mechanisms for maintaining openness were perhaps large herbivores, particularly herds of aurochs, rather than drought.

Despite their opposing views, neither Rackham<sup>88</sup> nor Vera<sup>89</sup> seems prepared to include fire as part of the natural sequence in lowland forest. In the uplands, beginning with Simmons,<sup>90</sup> fire, if largely (if not entirely) anthropogenic, has been seen as a natural element in Holocene vegetation succession, and even in the lowlands, charred trees are a familiar feature of the stratigraphy of most bogs.<sup>91</sup> At Thorne, Boswijk<sup>92</sup> was able to show a return period of about 400 years for serious fires across many square kilometres of pine forested raised mire, and the basal wet, deciduous forest, largely of oak, was similarly fire-scarred, although the return period could not be calculated. Microscopic charcoal, either from domestic or forest fires is a consistent feature of Lateglacial and Holocene sediment profiles.<sup>93</sup> There are elements in the European insect fauna which show that fire has been an integral part of forest history long before there were any significant human impacts, although there can be no doubt that human activities, both deliberate and accidental, have significantly pushed up fire frequency. The classic example of a pyrophilic species is provided by the jewel beetle, buprestid, *Melanophila acuminata*. This is able to locate fires from at least one kilometre away and oviposits in burnt birch or conifers whilst the wood is still in excess of 40 °C.<sup>94</sup> In Britain it has declined to the edge of extinction, surviving only on the Surrey heaths, west of London.<sup>95</sup> Elsewhere in Europe it is restricted to those areas where fire suppression by foresters is less than complete. Several ground beetles, carabids,<sup>96</sup> are also attracted to burnt ground, and Whitehouse and Eversham (2002) have used the presence of *Pterostichus angustatus*, previously regarded as a recent immigrant to Britain,<sup>97</sup> in samples from Hatfield Moors to argue for continuity of fire generated habitats. Two species of *Agonum* show similar attractions. *A. quadripunctatum*, also increasingly restricted to lowland heaths in England,<sup>98</sup> is known from Middle Pleistocene deposits at Waverley Wood in Warwickshire,<sup>99</sup> and *A. bogemanni* appears to have been associated with slash and burn cultivation in Scandinavia,<sup>100</sup> although its primary habitat must have been on naturally burnt ground. Whether these and several other pyrophilic species show a similar if temporary rise in frequency during neolithic landnam remains to be seen.

<sup>86</sup> P. I. Bogucki: Forest farmers and stockherders. Early agriculture and its consequences in North-Central Europe. Cambridge 1988.

<sup>87</sup> R. Gradmann: Die Steppenheide-Theorie. Geographische Zeitschrift 39 (1933) 265–278.

<sup>88</sup> Rackham 2003.

<sup>89</sup> Vera 2000.

<sup>90</sup> Simmons 1969; most recently Simmons 2002.

<sup>91</sup> F. M. Chambers – J. G. Lageard – G. Boswijk – P. A. Thomas – K. J. Edwards – J. Hillam: Dating prehistoric bog fires in northern England to calendar years by long distance cross-matching of pine chronologies. Journal of Quaternary Science 12 (1997) 253–256.

<sup>92</sup> G. Boswijk: A dendrochronological study of oak and pine from the raised mires of the Humberhead Levels, eastern England. Sheffield 1998.

<sup>93</sup> e.g. K. J. Edwards – G. W. Whittington: Multiple charcoal profiles from a Scottish lake: taphonomy, fire ecology, human impact and inference. Palaeogeography, Palaeoclimatology, Palaeoecology 164 (2000) 67–86; K. J. Edwards – G. Whittington – R. M. Tipping: The incidence of microscopic charcoal in lateglacial deposits. Palaeogeography, Palaeoclimatology, Palaeoecology 164 (2000) 247–262.

<sup>94</sup> H. V. Danks – R. G. Footitt: Insects of the boreal zone of Canada. Canadian Entomologist 121(1989) 625–690.

<sup>95</sup> K. N. A. Alexander: The invertebrates of living and decaying timber in Britain & Ireland. A provisional annotated checklist. Peterborough, 2002.

<sup>96</sup> L.-O. Wikars: Effects of forest-fire and the ecology of fire-adapted insects. Uppsala 1997.

<sup>97</sup> P. S. Hyman: Review of the scarce and threatened Coleoptera of Great Britain. Part 1. Peterborough, 1992.

<sup>98</sup> M. L. Luff: Provisional atlas of the ground beetles (Coleoptera, Carabidae) of Britain. Monks Wood, Centre for Ecology and Hydrology 1998.

<sup>99</sup> F. W. Shotton – D. H. Keen – G. R. Coope – A. P. Carrant – P. L. Gibbard – M. Aalto – S. M. Peglar – P. Skidmore: Dipterological perspective on the Holocene history of the North Atlantic area. University of Sheffield 1996.

<sup>100</sup> C. H. Lindroth: Changes in the Fennoscandian Ground-beetle fauna (Coleoptera, Carabidae) during the twentieth century. Annales Zoologici Fennici 9 (1972) 49–64.

### Insect communities and reaction to some human events

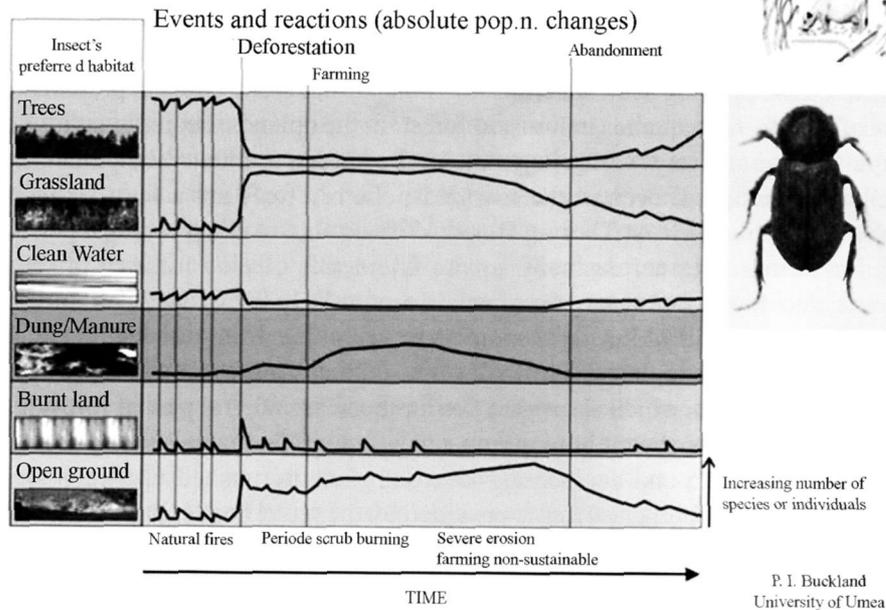


fig. 5. A theoretical model of the impact on the composition of insect faunas occasioned by a 'small temporary clearance'

Fig. 5. attempts to summarise some of the impacts upon elements of the insect fauna created by an episode of clearance and partial regeneration in a forested landscape, a small temporary clearance, perhaps prolonged by natural or domestic animal grazing.<sup>101</sup> Open ground may have been extended by ring barking of large trees, rather than felling, and this could have led to a peak in dead wood species before a decline in forest elements. Robinson<sup>102</sup> has suggested that the presence of the large chafer *Valgus hemipterus* at the South Stanwick long barrow in Northamptonshire reflects suitable breeding habitats in the decaying tree stumps of recently cleared land.

#### *Insects in immediate human landscapes*

Not only are insects sensitive indicators of climate and environmental change, their food requirements may be such that they are confined to one species or a group of species not separable in the pollen diagram. The example in *Table 1* summarises the plant hosts of the fauna identified by Robinson<sup>103</sup> from the sealed old ground surface and structural turves beneath Silbury Hill, a large neolithic mound on Salisbury Plain in southern England. Radiocarbon dates on the turves indicate construction around 4500 BP. The beetle fauna shows no trace of woodland, and includes many species now characteristic of old established unimproved grassland, including the elaterids *Agrypnus murina*, *Agriotes* spp. *Athous haemorrhoidalis*, whose larvae encompass the familiar wireworms of pasture, *Dascillus cervinus* and the garden chafer *Phyllopertha horticola*. This picture of pasture is further reinforced by the suite of dung beetles of the genera *Onthophagus* and *Aphodius*, which would have lived in the droppings of domestic animals. The table also shows the level to which the pollen would have allowed identification. In this particular example, it is the character of the landscape which is better indicated by the *Coleoptera*, but there are many

<sup>101</sup> cf. P. C. Buckland – K. J. Edwards: The longevity of pastoral episodes of clearance activity in pollen diagrams: the role of post-occupation grazing. *Journal of Biogeography* 11 (1984) 243–249.

<sup>102</sup> M. Robinson: Coleopteran evidence for the Elm Decline, Neolithic activity in woodland, clearance and the use of the landscape, in: A. S. Fairburn: *Plants in Neolithic Britain and beyond*. Neolithic

studies group seminar papers 5. Oxford 2000, 27–36.

<sup>103</sup> M. Robinson: The insects, in: A. Whittle: *Sacred mound holy rings. Silbury Hill and the West Kennet palisade enclosures: a Later Neolithic complex in north Wiltshire*. *Oxbow Monographs* 74. Oxford 1997, 36–46.

situations, where the plants, particularly those utilised by man for either their leaves or stems, for example flax, *Linum*, and nettles, *Urtica*, are more likely to be recorded by the presence of their *phytophages* amongst the insects than by their pollen spectra. Nettles, for example, have a particularly broad suite of insect feeders,<sup>104</sup> and may be harvested either as food, before flowering, or as a source of fibres. Similarly the leaves of docks and sorrel, *Rumex* spp, can form an important source of essential vitamin C, and like crop plants in the *Chenopodiaceae*, are harvested before coming into flower; both may be represented only by their phytophages. In the Silbury Hill list, the most likely species of *Rhinoncus* are those which live on terrestrial species of *Rumex* and *Polygonum*, *R. pericarpus* and *R. bruchoides* and *R. castor*.

<b>Taxon</b>	<b>Host</b>	<b>Pollen</b>
<i>Chrysolina haemoptera</i> (L.)	<i>Plantago</i> spp.	<i>Plantago</i> (to species)
<i>Hydrothassa glabra</i> (Hbst.)	Ranunculaceae	Ranunculaceae (some genera)
<i>Galeruca tanacetii</i> (L.)	Asteraceae	Asteraceae (subfamily)
<i>Neocrepidodera ferruginea</i> (Scop.)	Poaceae	Poaceae (some genera)
<i>Mantura matthewsi</i> (Curt.)	<i>Helianthemum nummularium</i>	<i>Helianthemum</i> sp.
<i>Sphaeroderma rubidum</i> (Graells)	<i>Carduus</i> & <i>Cirsium</i> spp.	<i>Carduus</i> & <i>Cirsium</i> spp.
<i>Bruchus/Bruchidius</i> sp.	Leguminosae	Leguminosae
<i>Sitona sulcifrons</i> (Thun.)	Leguminosae, esp. <i>Trifolium pratense</i>	Leguminosae
<i>S. lepidus</i> Gyll.	<i>Trifolium</i> spp.	Leguminosae
<i>Cleonis pigra</i> (Scop.)	<i>Carduus</i> & <i>Cirsium</i> spp.	<i>Carduus</i> & <i>Cirsium</i> spp.
<i>Liparus coronatus</i> (Goez.)	Umbelliferae	Umbelliferae
<i>Hypera punctata</i> (F.)	<i>Trifolium</i> spp.	Leguminosae
<i>Rhinoncus</i> spp.	Polygonaceae	Polygonaceae (to some species)
<i>Mecinus pyraster</i> (Hbst.)	<i>Plantago</i> spp.	<i>Plantago</i> (to species)

Table 1. The plant hosts of the fauna identified by *Robinson 1997*.

One of the characters of Western society is the apparent dominance of meat and cereal products in the diet, and this is often transferred onto cultures in the past, which may have found it wholly alien, having evolved a more balanced diet, away from the Big Mac. In part the plant macrofossil record inevitably reinforces this position, largely because the chances of preservation of cereals by charring, either during processing<sup>105</sup> or by burning of residues in hearths, are so much the greater than most other crops. Pulses therefore tend to be under-represented, unless unusual circumstances lead to their preservation. The material figured (*fig. 6*) was charred by the Late Bronze Age eruption of Santorini in the Aegean, and shows evidence of infestation by the field pest *Bruchus rufipes*. Archaeologists put great effort into sieving large amounts of sediment to recover a few charred grains of wheat or barley, often of doubtful stratigraphic integrity; the degree to which rodents and invertebrates have bioturbated sediments is rarely assessed. Not only are seed crops more likely to appear in the archaeological record, but they also have the advantage over leaf crops for human consumption in that they can be stored from one season to another, providing subsistence at times when plant and animal productivity is low. Survival, however, also relies upon being able to overwinter sufficient livestock to maintain breeding populations and in most climates of Europe this requires collection of additional fodder, either in the form of grass

<sup>104</sup> B. N. K. Davis: Insects on nettles. Cambridge, 1983.

Mercer: Farming Practice in British Prehistory. Edinburgh 1981, 123–162.

<sup>105</sup> G. Hillman: Reconstructing crop husbandry practices from charred remains of crops, in: R.

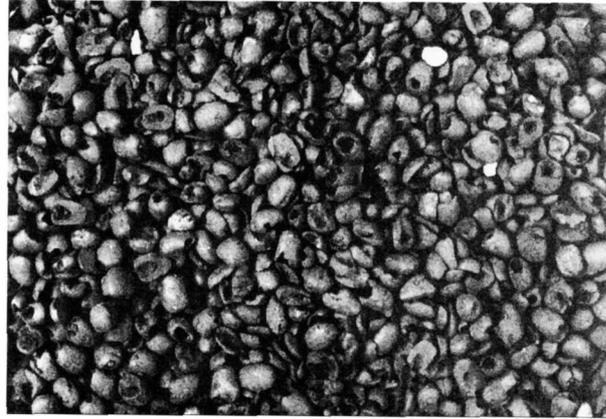


fig. 6. Charred pulses from Late Bronze Age Akrotiri, Santorini, Greece. Note the frequent exit holes of the bean weevil, bruchid, *Bruchus rufipes*

hay or leaf fodder. The role of elm in this has been much discussed since Troels-Smith's<sup>106</sup> original paper, but other trees have been widely exploited as fodder sources,<sup>107</sup> and there is direct evidence from Weier in Switzerland for neolithic winter stalling of animals and use of leaf fodder.<sup>108</sup> The site also provides one of the few examples of study of an insect fauna from a neolithic settlement rather than landscape context.<sup>109</sup> The assemblage is dominated by puparia of the flies *Musca domestica* and *Thoracochaeta zosteræ*, both of which are associated with the warm of fermenting accumulations of herbivore dung. The former, the common house fly, is essentially a warm temperate species and it has been suggested that it probably first became closely associated with Man in Egypt.<sup>110</sup> If this is the case, it represents one of his first fellow travellers, able to exploit the artificially cushioned habitats, which he created, and extending its distribution during the neolithic at least as far as central Sweden<sup>111</sup> where similar evidence for stalled animals has been adduced. *T. zosteræ* at the present day in Britain is restricted to coastal wrack beds, whilst as a fossil it can be very common in archaeological assemblages from cess pits and similar foul accumulations.<sup>112</sup> Although it was possible that seaweed was being transported inland for industrial or other use, it seems more likely that its current habitat restriction reflects improved hygiene, a point later proved by biochemical analysis of *puparia*;<sup>113</sup> in Germany, old records of this so-called seaweed fly occur from byre residues.<sup>114</sup> The insect evidences from both Weier in Switzerland and Alvastra in Sweden provide convincing evidence of stalling at least of cattle during the neolithic. In the Netherlands, Schelvis<sup>115</sup> has shown that another group, the mites can be similarly employed in the detection of dung, some appearing specific to the source animal. In this context, however, ectoparasites can be more useful and may provide evidence beyond the simple species present.

<sup>106</sup> J. Troels-Smith: Ivy, mistletoe and elm. Climate indicators – fodder plants. Danmarks geologiske Undersøgelse IV/4 (1960) 1–32.

<sup>107</sup> e.g. beech, J. N. Haas – S. Karg – P. Rasmussen: Beech leaves and twigs used as winter fodder: examples from historic and prehistoric times. *Environmental Archaeology* 1 (1998) 81–86; holly, J. Radley: Holly as winter feed. *Agricultural History Review* 9 (1961) 89–92.

<sup>108</sup> P. Rasmussen: Leaf-foddering of livestock in the Neolithic: archaeobotanical evidence from Weier, Switzerland. *Journal of Danish Archaeology* 8 (1989) 51–71.

<sup>109</sup> Nielsen et al. 2000.

<sup>110</sup> Panagiotakopulu, in press

<sup>111</sup> Skidmore in: H. Göransson: Alvastra pile dwelling – a 5000-year-old byre? K. Viklund: *Nordic*

*Archaeobotany* – NAG 2000 in Umeå. Umeå, University of Umeå Environmental Archaeology Laboratory, Dept. of Archaeology & Sami Studies 15 (2002) 67–84.

<sup>112</sup> Skidmore 1998.

<sup>113</sup> S. C. Webb – R. E. M. Hedges – M. Robinson: The seaweed fly *Thoracochaeta zosteræ* (Hal.) (Diptera: Sphaerocidae) in inland archaeological contexts: 13C and 15N solves the puzzle. *JAS* 25 (1998) 1253–1257.

<sup>114</sup> F. Köhlnhorn: Über die Dipterenfauna des Stallbiotops. *Beiträge zur Entomologie* 14 (1964) 85–118.

<sup>115</sup> J. Schelvis: Predatory mites (Acari: Gamasida) in excrements of five domestic animal species. *Pedobiologia* 38 (1994) 72–80.



fig. 7. An almost complete human flea, *Pulex irritans*, from the Norse farm at Gården under Sandet, in the Western Settlement, Greenland

The cattle louse, *Damalinia bovis*, occurs at Weier in the byre,<sup>116</sup> but Buckland and Perry<sup>117</sup> have argued that the presence of large numbers of sheep lice, *D. ovis*, and the wingless parasitic fly, *Melophagus ovinus*, the ked, is more likely to indicate wool processing than simply the presence of their host. Insect remains may offer an original contribution to the debate concerning the timing of the secondary products revolution.<sup>118</sup>

*Ectoparasite* remains can also be used to define other activities, of which delousing provides an example. Humans have three lice, one bug (*Hemiptera*) and one flea.<sup>119</sup> The flea, *Pulex irritans*, is probably a primary parasite in the nests of an early South American domesticate, the Guinea pig, *Cavia* sp. It found human blood to its liking and by the Late Neolithic had travelled up the Americas and crossed Eurasia to reach remote Orkney off the northern tip of Scotland,<sup>120</sup> probably utilising small steps in the gift exchange of furs as a transport mechanism. It appears in large numbers everywhere from New Kingdom Amarna in Egypt (fig. 7) to Norse Greenland.<sup>121</sup> The origins of the bed bug, *Cimex lectularius*, have been explored by Panagiotakopulu and Buckland;<sup>122</sup> it is present at Bronze Age Amarna, but is unlikely to have found suitably warm habitats in Central and Northern Europe until the advent of heated stone housing in the Graeco-Roman period. Lice have probably been with, and co-evolved with, Man since his departure from Africa. The earliest records of the crab or pubic louse are from Roman Carlisle in northern England,<sup>123</sup> but, closely related to a species on gorillas, it was perhaps more widespread on the human body when ancestors were more hairy. This point is also relevant to the head and body lice of the genus *Pediculus*, *P. humanus capitis* and *P. h. corporis*, which are sometimes accorded specific rank. As the body louse breeds in the clothing of its host, has it diverged from the head louse since humans began to wear clothes? The head louse is recorded from the Pre-Pottery Neolithic in Palestine<sup>124</sup> and again is a common find in suitable desiccated, frozen or anaerobic deposits from Egypt to Greenland and Peru.<sup>125</sup> On the post-medieval farm at Reykholt in western

<sup>116</sup> Nielsen et al. 2000.

<sup>117</sup> P. C. Buckland – D. Perry: Ectoparasites of sheep from Stóraborg, Iceland and their interpretation. *Piss, parasites and people, a palaeoecological perspective*. *hikuin* 15 (1989) 37–46.

<sup>118</sup> A. G. Sherratt: The secondary exploitation of animals in the Old World. *World Archaeology* 15 (1983) 90–104.

<sup>119</sup> J. R. Busvine: *Insects, hygiene and history*. London 1976.

<sup>120</sup> P. C. Buckland – J. P. Sadler: A biogeography of the human flea, *Pulex irritans* L. (Siphonaptera: Pulicidae). *Journal of Biogeography* 16 (1989) 115–120; P. C. Buckland – J. P. Sadler: *Insects,*

*in*: K. J. Edwards – I. B. M. Ralston: *Scotland: environment and archaeology 8000 BC-AD 1000*. Chichester 1997, 105–108.

<sup>121</sup> Panagiotakopulu 2001a; Panagiotakopulu 2001b.

<sup>122</sup> E. Panagiotakopulu – P. C. Buckland: The bed bug, *Cimex lectularius* L. from Pharaonic Egypt. *Antiquity* 73 (1999) 908–911.

<sup>123</sup> H. K. Kenward: Pubic lice (*Phthirus pubis*) were present in Roman and medieval Britain. *Antiquity* 73 (1999) 911–915.

<sup>124</sup> J. Zias – Y. Mumcuoglu: Pre-Pottery Neolithic B head lice from Nahal Hemar Cave. *Atiqot* 20 (1991) 167–168.

<sup>125</sup> Panagiotakopulu 2001a.

Iceland, concentration of lice in one room sample has been interpreted as the result of de-lousing,<sup>126</sup> on the fossil evidence a very necessary activity.

Stored hay, particularly grass and sedge hay, has a distinctive beetle fauna in storage, including species of the *cryptophagid* genera *Cryptophagus* and *Atomaria*, the *lathridiid*, *Lathridius minutus* (grp.), the *endomycid* *Mycetaea hirta* and the *mycetophagid* *Typhaea stercorea*. Their presence in large numbers in structures normally indicates fodder storage.<sup>127</sup> However elements of this part of the synanthropic fauna would also be able to exploit other habitats in farms, including floors on which hay was spread to provide a working surface, and interpretation requires the careful evaluation of other lines of evidence as well as the coleopteran. This allows many of the problems raised by Kenward<sup>128</sup> and often repeated, to be minimised, although what constitutes an indoor or outdoor assemblage may still be problematic.<sup>129</sup> Fig. 8, based upon work in the Norse North Atlantic region<sup>130</sup> summarises possible routes by which insect remains could come to be incorporated in rural archaeological sediments.

### *The grain fauna*

Although the insect fauna associated with fodder may occur in other habitats, one particular assemblage that found in stored grain is unlikely to be found outside that habitat. Both the silvanid *Oryzaephilus surinamensis* – the name is perhaps unfortunate as the saw-toothed grain beetle is first recorded in charred grain from the late neolithic site at Mandalo in Macedonia<sup>131</sup> – and cucujid *Cryptolestes ferrugineus* are occasionally recorded from under bark.<sup>132</sup> This is probably their natural habitat, but the grain weevil, *Sitophilus granarius*, is not known from the wild. This flightless weevil is probably a primary occupant of large grass seeds in the nests of wild rodents, and its usual pabulum with humans, in granaries and grain stores, is merely an extension of the same. The insect's original distribution probably coincided with that of the wild progenitors of wheat and barley in the Near and Middle East, and the fossil record suggests that it probably travelled westwards with early agriculturists.<sup>133</sup> Although able to maintain breeding populations in the Mediterranean zone, to the North it needs the artificial warmth of large stocks of grain to survive. It is therefore not surprising that the grain fauna first reaches northwest Europe in the baggage train of the Roman army, appearing in the Rhineland and England shortly after the conquest in the first century AD.<sup>134</sup> There are, however, two earlier records, both from Linienbandkeramik (LBK) sites in Germany, one near Göttingen<sup>135</sup> and the other at Erkelenz-

<sup>126</sup> P. C. Buckland – J. P. Sadler –

G. Sveinbjarnardóttir: Palaeoecological investigations at Reykholt, western Iceland, in: C. Morris – J. Rackham: Norse and Later Settlement and Subsistence in the North Atlantic. Glasgow 1992, 149–168.

<sup>127</sup> T. Amorosi – P. C. Buckland – K. J. Edwards – I. Mainland – T. H. McGovern – J. P. Sadler – P. Skidmore: They did not live by grass alone: the politics and palaeoecology of fodder on the North Atlantic islands. *Environmental Archaeology* 1 (1998) 41–54.

<sup>128</sup> H. K. Kenward: Pitfalls in the environmental interpretation of insect death assemblages. *Journal of Archaeological Science* 2 (1975) 85–94.

<sup>129</sup> cf. A. R. Hall – H. K. Kenward: Disentangling dung: pathways to stable manure. *Environmental Archaeology* 1 (1998) 123–126.

<sup>130</sup> P. C. Buckland – J. P. Sadler – D. N. Smith: An insect's eye view of the Norse farm, in: C. Batey – J. Jesch – C. D. Morris: The Viking Age in Caithness, Orkney and the North Atlantic. Proceedings of the 11<sup>th</sup> Viking Congress, Kirkwall. Edinburgh 1993, 506–527.

<sup>131</sup> S. M. Valamoti – P. C. Buckland: An early find of *Oryzaephilus surinamensis* from final Neolithic Mandalo, Macedonia, Greece. *Journal of stored Product Research* 31 (1995) 307–309.

<sup>132</sup> A. Horion: Faunistik der Mitteleuropäischen Käfer, 7. Clavicornia, Sphaeritidae – Phalacridae. Überlingen-Bodensee 1960; K. Koch: Ökologie. Die Käfer Mitteleuropas. Krefeld, 1989.

<sup>133</sup> P. C. Buckland: Granaries, stores and insects. The archaeology of insect synanthropy, in: D. Fournier – F. Sigaut: La préparation alimentaire des cereales. PACT 1991, 69–81.

<sup>134</sup> K. Koch: Zur Untersuchung subfossiler Käferreste aus römischer und mittelalterlicher Ausgrabungen im Rheinland. *Rheinische Ausgrabungen* 10 (1971) 378–448; H. K. Kenward – D. Williams: Biological Evidence from the Roman Warehouses in Coney Street. *Archaeology of York* 14/2. London 1979.

<sup>135</sup> S. Büchner – G. Wolf: Der Kornkäfer – *Sitophilus granarius* (Linné) – aus einer bandkeramischen Grube bei Göttingen. *AKorr* 27 (1997) 211–220.

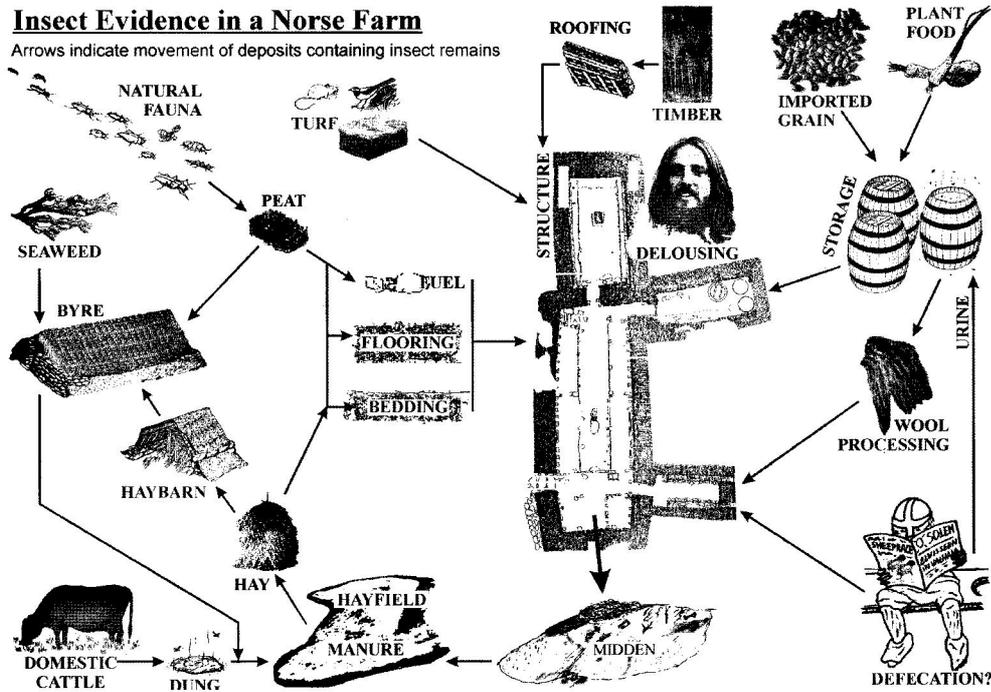


fig. 8. Pathways for fossil insect assemblages on a farm site

Kückhoven, in East Rhine province.<sup>136</sup> The implications of these finds are considerable. They imply not only that this neolithic group practiced large scale storage and transport of grain, but extracting a tithe by destroying part of the crop in storage, they present a factor which requires building into any palaeoeconomic models of the remarkable episode of LBK expansion.

### Conclusion

Insects offer considerable potential for refining the interpretation of archaeological contexts at both the regional and immediate level. The few neolithic sites, which have been examined, provide evidence of the nature of the pre-settlement landscape and of the manner in which the cleared landscape was exploited. They also provide palaeoeconomic evidence, which is not available from other palaeoecological sources.

<sup>136</sup> E. Schmidt: Der Kornkäfer *Sitophilus granarius* Schön. (Curculionidae) aus der Schuttschicht des bandkeramischen Brunnens von Erkelenz-Kückhoven, in: Brunnen der Jungsteinzeit.

Internat. Symposium Erkelenz 27–20 Okt. 1997. Materialien zur Bodendenkmalpflege 11 (1998) 261–269.

## REFERENCES

- Buckland 1979* *P. C. Buckland*: Thorne Moors: a palaeoecological study of a Bronze Age site. Birmingham, Dept. of Geography, University of Birmingham 1979.
- Coope 2001* *G. R. Coope*: Biostratigraphical distinction of interglacial coleopteran assemblages from southern Britain attributed to Oxygen Isotope Stages 5e and 7. *Quaternary Science Reviews* 20 (2001) 1717–1722.
- Elias 1994* *S. A. Elias*: Quaternary Insects and their Environments. Washington 1994.
- Girling 1979a* *M. A. Girling*: Calcium carbonate-replaced arthropods from archaeological deposits. *JAS* 6 (1979) 309–320.
- Girling 1979b* *M. A. Girling*: Fossil insects from the Sweet track. *Somerset Levels Papers* 5 (1979) 84–93.
- Girling 1982* *M. A. Girling*: Fossil insect faunas from forest sites, in: S. Limbrey – M. Bell: *Archaeological Aspects of Woodland Ecology*. Oxford, BAR IntSer 146 (1982) 129–146.
- Nielsen et al. 2000* *B. O. Nielsen – V. Mahler – P. Rasmussen*: An arthropod assemblage and the ecological conditions in a byre at the Neolithic settlement of Weier, Switzerland. *JAS* 27 (2000) 209–218.
- Osborne 1969* *P. J. Osborne*: An insect fauna of Late Bronze Age date from Wilsford, Wiltshire. *Journal of Animal Ecology*. *Journal of Animal Ecology* 38 (1969) 555–566.
- Osborne 1972* *P. J. Osborne*: Insect faunas of Late Devensian and Flandrian age from Church Stretton, Shropshire. *Philosophical Transactions of the Royal Society of London B263* (1972) 327–367.
- Osborne 1997* *P. J. Osborne*: Insects, Man and climate in the British Holocene, in: A. C. Ashworth – P. C. Buckland – J. P. Sadler (eds.): *Studies in Quaternary Entomology - An Inordinate Fondness for Insects*. *Quaternary Proceedings* 5 (1997) 193–198.
- Panagiotakopulu 2001a* *E. Panagiotakopulu*: Fossil records of ectoparasites. *Antenna* 25 (2001) 41–42.
- Panagiotakopulu 2001b* *E. Panagiotakopulu*: Fleas from pharaonic Amarna. *Antiquity* 75 (2001) 499–500.
- Panagiotakopulu in press* *E. Panagiotakopulu*: Dipterous remains and archaeological interpretation.
- Rackham 2003* *O. Rackham*: Ancient woodland - its history, vegetation and uses in England. Dalbeattie 2003.
- Speight 1989* *M. C. D. Speight*: Saproxylic invertebrates and their conservation. *Nature and Environment Series* 81. Strasbourg 1989.
- Vera 2000* *F. W. M. Vera*: Grazing ecology and forest history. Wallingford, CABI. 2000.
- Wagner 1997* *P. Wagner*: Human Impact or Cooling Climate? The “Little Ice Age” and the beetle fauna of the British Isles, in: A. C. Ashworth – P. C. Buckland – J. P. Sadler (eds.): *Studies in Quaternary Entomology – An Inordinate Fondness for Insects*. *Quaternary Proceedings* 5 (1997) 269–276.