# Hordle–Beacon Cliffs

[SZ 254 925]–[SZ 273 919]

## Introduction

This is one of the classic Tertiary palaeobotanical sites in Britain, having yielded the best-studied late Eocene fruit and seed flora. Over 80 species are known and for over half of these it is the type locality. In many cases, the species are unique to this site. It is the only British Tertiary site where conifer stumps can still be studied *in situ.* Several different stratigraphical levels have yielded numerous charophytes, which are of considerable importance for the correlation of these beds with sequences in continental Europe.

Hordle Cliffs (Figure 9.6) and (Figure 9.7) has long been recognized as a classic site for Eocene palaeobotany, providing a contrast with the London Clay floras from places such as Sheppey (see previous chapter). The importance of the site was first realized by Starkie Gardner during the second half of the 19th century and he collected much material from here. Examples of ferns and conifers were described in his monographs on the British Eocene floras (Gardner and von Ettingshausen, 1879–1882; Gardner, 1883–1886a). However, Gardner never published the angiosperms, which form such a dominant part of the flora. The palaeobotanical interest of the site was rediscovered by Clement Reid in the early part of the 20th century, and again he collected much material from here. Reid and Groves (1921) described the charophytes from here, but the angiosperms were dealt with by Chandler (1925–1926), in the first comprehensive review of the Hordle flora. After much further collecting, the flora was revised by Chandler (1961c). In-situ coniferous tree stumps were described by Fowler *et al.* (1973). The members of the mulberry family in the flora were reviewed by Collinson (1989) and fossils from here were included in a study of the chemistry of the seed coats of water plants (van Bergen *et al.,* 1994b). The earliest known examples of rodent-gnawed seeds have been found here (Collinson and Hooker, 2000).

## Description

### Stratigraphy

Daley (in Daley and Balson, 1999) discusses the details of the geology of this site, in an account of the stratigraphy of Barton Cliffs (Figure 9.5). The lower part of the exposed sequence here consists of *c.* 22 m of the Barton Clay and Becton Sand Formations (with Bed K (Burton, 1933) yielding plant fossils — Chandler 1960). These are overlain by *c.* 24 m of the Totland Bay Member (lower Headon Hill Formation), described in detail by Edwards and Daley (1997). The main palaeobotanical interest at the site is in the Totland Bay Member, which is a unit of mainly freshwater to brackish deposits formed as the Barton marine basin became progressively silted-up (Curry, 1965).

The plant remains occur in lenses and laterally more persistent deposits occur at various levels through the sequence, including Bed L of Burton (1933) and Beds 9, 10, 13 and 28 of Tawney and Keeping (1883; Figures 9.4 and 9.5). They mostly represent deposits formed in marsh and lagoonal settings, and one layer (known as the 'Leaf and Seed Bed', Bed 10 of Tawney and Keeping, 1883), includes a lignite layer and in-situ tree stumps.

### Palaeobotany

The bulk of the plant fossils found here are carbonaceous fruits and seeds. They are often in a soft condition, but uncrushed (Figure 9.8), and can therefore be dissected with care, to reveal details of the anatomy. Most of the accumulations of fruits and seeds are from aquatic angiosperms. For instance, the Mammal Bed has yielded *Stratiotes, Caricoidea* and *Sabrenia,* while the Rodent Bed has *Stratiotes, Limnocarpus* and *Aldrovanda* (Collinson and R. Gardner, pers. obs.). *Limnocarpus* is recorded from the Crocodile Bed, and *Sabrenia, Spirematospermum, Stratiotes* and *Caricoidea* are from the *Chara* Bed (Bed 28 of Tawney and Keeping, 1883; Chandler, 1961c; Collinson, pers. obs.). However, one level, known as the `Leaf and Seed Bed', has yielded a much more diverse assemblage and was the main

source of the material studied by Chandler (1925–1926, 1961c, 1962). In addition to the above types of aquatic plant, there is also a range of forest taxa, including members of the icacina, mulberry, rue, sweetleat tea and grape families, and mastic trees of the dogwood family. The full list of 76 species of angiosperm fruits and seeds (both of aquatic and forest plants) found at Hordle is given in (Table 9.2).

Chandler (1925–1926) recorded *Nypa* from here based on leaves found in the Leaf Bed. They indeed bear some resemblance to the leaves of the living *Nypa* but many other palms also have similar foliage. As there is no evidence here of the characteristic large fruits, such as occur so abundantly in the early Eocene deposits of southern England (see Chapter 8), this record of *Nypa* (which would be aberrant as by far the youngest from the British Tertiary record) should be rejected.

Hordle has also yielded the ferns *Acrostichum lanzaeanum* (Visiani) Chandler, *Salvinia mildeana* Göppert foliage and *Azolla prisca* Reid and Chandler megaspores (Collinson, 1980b). Conifers are mainly represented by remains of the probable taxodiaceous conifer *Sequoia couttsiae* Heer (see Footnote 2 to (Table 8.2), this volume), including twigs, cones, cone-scales and seeds (Chandler, 1922, 1925, 1961c, 1962). The Leaf and Seed Bed here has yielded in-situ coniferous stumps with taxodiaceous wood (*Glyptostroboxylon*), which on the basis of association have been suggested to have been produced by the same plant that yielded *S. couttsiae* foliage, cones and seeds (Fowler *et al.,* 1973).

The Mammal Bed (Bed 9 of Tawney and Keeping, 1883), at the base of the Totland Bay Member at Hordle, yields far fewer plant fossils (see earlier). However, Crane and Plint (1979) have also described petrified angiosperm roots of an aquatic plant from this unit under the name *Lacunoradix headonensis* Crane and Plint.

Stonewort remains are scattered throughout the succession here, but better assemblages occur at a number of restricted horizons, including Beds 9, 10, 14, 15, 17, 28 and 30 of Tawney and Keeping (1883) (Reid and Groves, 1921; Groves, 1926; Collinson, pers. obs.). The most productive level is of limestone (Bed 17 of Tawney and Keeping, 1883), but good assemblages were also found in the Mammal Bed and Rodent Bed. The charophytes include both isolated gyrogonites and vegetative remains, although only the former are named. The following list is based on the work of Reid and Groves (1921) and Groves in Reid and Chandler (1926) as emended in part by Feist-Castel (1977). *Gyrogona wrightii* (Salter) Pia, *G. caelata* (Reid and Groves) Pia, *Grovesichara distorta* (Reid and Groves) Horn af Rantzien, *Stephanochara edwardsii* Grambast, *Psilochara polita* (Reid and Groves) Grambast, *P. bitruncata* (Reid and Groves) Feist-Castel, *Sphaerochara headonensis* (Reid and Groves) Horn af Rantzien, *S. parvula* (Reid and Groves) Horn af Rantzien, *Harrisichara vasiformis* (Reid and Groves) Grambast and *Chara subcylindrica* Reid and Groves.

(Table 9.2). Angiosperm floras from the Headon Hill Formation. Species descriptions or reference to them may be found in Chandler (1961c, 1963a), unless otherwise referenced. Discussion and other records for some of these species may be found in Mai and Walther (1978, 1985, 1991) and Mai (2000). The family classification used here is summarized in Chapter 1 of the present volume.

| Family | Species | Hordle Cliffs | Colwell Bay (Totland Bay Member) | Colwell Bay (Linstone Chine Member) |
|---|---|---|---|---|
| Acanthaceae | *?Acanthus* sp. | × | | |
| | *Actinidia* sp. | × | | |
| Actinidiaceae | *Saurauia crassisperma* (Chandler) Mai[1] | × | | × |
| Anacardiaceae | Genus (Spondicae) ? | × | | |
| Araceae | Genus ? | × | | |
| Arecaceae | Leaves | × | | |
| Betulaceae | *Carpinus boveyanus* (Heer) Chandler | × | | |
| Boraginaceae | *Omphalodes platycarpa* Chandler | × | | |
| Burseraceae | *Palaeobursera lakensis* Chandler | × | | |

| | | | | |
|---|---|---|---|---|
| Caprifoliaceae | *Sambucus parvulus* Chandler [2] | × | | × |
| Carophyllaceae | *Hantsia pukhra* (Chandler) Chandler | × | | |
| | *H. glabra* Chandler | × | | |
| Cercidiphyllaceae | *Nyssidium arcticum* (Heer) Iljinskaja[3] | × | | |
| | *Dunstania glandulosa* (Chandler) Chandler[4] | × | | |
| Cornaceae (including Mastixiaceae) | *Eomastixia rugosa (*Zenker) Chandler | × | | |
| | *Swida quadrilocularis* (Chandler) Mai, 1999[5] | × | | |
| Cucurbitaceae | Genus ? | × | | |
| | *Cucurbitospermum reidii* Chandler | × | | |
| Cyperaceae | *Caricoidea angulata* Chandler[6] | | | × |
| | C. *nitens (*Heer) Chandler | | | × |
| | *C. obscura* Chandler | × | | |
| | *Cladiocarya minima* (Chandler) Mai[7] | × | | |
| | *C. colwellensis* (Chandler) Mai[7] | | | × |
| | *Carex colwellensis* Chandler | | | × |
| | *C.* spp. | | | × |
| | *?Scirpus* sp. | | | × |
| Cyrillaceae[8] | *Scleria hordwellensis* Chandler | × | | |
| | *Epacridicarpum headonense* Chandler | × | | × |
| | *E. colwellense* Chandler | | | × |
| Droseraceae | *Aldrovanda ovata* (Chandler) Chandler | × | × | × |
| Ebenaceae | *Diospyros headonensis* Chandler | × | | |
| Ericaceae | 2 Genera ? | × | | |
| Harnamefidaceae | *Steinhauera subglobosa* Presl[9] | × | | |
| Hydrocharitaceae | *Stratiotes headonensis* Chandler | × | × | × |
| | *S. hantonensis* Chandler | × | | |

| | | | | | |
|---|---|---|---|---|---|
| | *?Iodes* sp. (or *?Natsiatum*) | × | | | |
| | *Iodes? hordwellensis* Chandler | × | | | |
| Icacinaceae | *Icacinicarya transversalis* Chandler | × | | | |
| | *I. becktonensis* Chandler | × | | | |
| | *Natsiatum eocenicum* Chandler[10] | × | | | |
| Lauraceae | Genus ? | × | | | |
| 'Legumes' | 2 Genera ? | × | | | |
| | *Decodon vectensis* Chandler | | | | × |
| Lythraceae | *Microdi ptera parva* Chandler | × | | | ? |
| | Genus ? | × | | | |
| Menispermaceae | *Palaeosinomenium obliquatum* (Chandler) Chandler | × | | | |
| | *Chlorophora bicarinata* Chandler | × | | | |
| | *Broussonetia rugosa* Chandler | × | | | |
| Moraceae[11] | *Moroidea boveyana* Chandler[12] | × | | | |
| | *Becktonia hantonensis* Chandler | × | | | |
| | *Ficus lucidus* Chandler | | | | × |
| | *Myrica boveyana* (Neer) Chandler | × | | | × |
| Myricaceae | *M. colwellensis* Chandler | | | | × |
| | *Sabrenia chandlerae* Collinson 1980a | × | | × | × |
| Nymphaeaceae | *Brasenia spinosa* Chandler | × | | | × |
| | *B. oblonga* Chandler | × | | | |
| | *Nymphaea* sp. | | | | × |
| Oleaceae | *Olea headonensis* Chandler | × | | | |
| | *Potamogeton pygmaeus* Chandler (see Collinson, 1983a) | × | | × | × |
| Potamogetonaceae | *P.* sp. | × | | | × |
| | *Limnocarpus forbesii* (Heer) Chandler[13] | × | | × | × |
| Rhamnaceae | *Frangula hordwellensis* Chandler | × | | | |

| | | | |
|---|---|---|---|
| Rosaceae | *Rubus acutiformis* Chandler | × | |
| | *?R. microspermus* Reid and Reid | | × |
| | *Phellodendron costatum* Chandler | × | |
| Rutaceae | *Acronychia ornata* (Chandler) Mai, 1976[14] | × | |
| | *Zanthaxylum hordwellense* Chandler | × | × |
| | *Z. compressum* Chandler | × | |
| Sabiaceae | *Meliosma* sp. | × | |
| Styracaceae | *Styrax elegans* Chandler | × | |
| Symplocaceae | *Symplocos headonensis* Chandler | × | |
| | *S.* sp. | × | |
| Theaceae | *Anneslea? costata* Chandler | × | |
| | *Visnea hordwellensis* (Chandler) Mai[15] | × | |
| | *Eutya becktonensis* Chandler | × | |
| | *H. stigmosa* (Ludwig) Mai[16] | × | |
| | *Gordonia minima* Chandler | × | |
| | *Polyspora truncates* (Chandler) Gregor[8] | × | |
| Thymelaeaceae | Genus? | × | |
| Typhaceae | *Typha* sp. | | × |
| Vitaceae | *Ampelopsis rotundata* Chandler | × | |
| | *Parthenocissus hordwellesis* Chandler | × | |
| | *Tetrastigma lobata* Chandler | × | |
| | *Vitis uncinata* Chandler | × | |
| Zingiberaceaei/Musaceae | *Spirematospermum wetzleri* (Heer) Chandler[17] | × | |
| *Incertae sedis* | *Carpolithus fibrosus* Chandler | × | |
| | *C. apocyniformis* Chandler | × | |
| | *C. colwellensis* Chandler | | × |
| | *C.* spp. | × | × |
| | *Rhamnospermum bilobatum* Chandler | × | × |

[1]Formerly *Hordwellia crassisperma* (Chandler) then included within the Theaceae (see Mai and Walther, 1985).

[2] This includes *Sambucus colwellensis* Chandler (see Collinson, 1983a).

[3] See Crane (1984).

[4] See Footnote 4 to (Table 8.1).

[5] Originally *Corpus quadrilocularis* Chandler.

[6] See Collinson (1983a).

[7] See Mai and Walther (1978).

[8] See Footnote 7 to (Table 9.1).

[9] Includes *Eoliquidambar hordwellensis* Chandler and *Protaltingia hantonensis* Chandler (see Mai and Walther, 1985).

[10] See footnotes to Tables 8.1 and 8.2.

[11] See Collinson (1989).

[12] Includes *Moroidea hordwellensis* Chandler (see Mai and Walther, 1978).

[13] Emended by Collinson (1982a).

[14] Formerly *Rutaspermum orrzatum* (Chandler) (see Mai, 1976; Collinson and Gregor, 1988).

[15] Formerly *Campylospermum hordwellensis* Chandler (see Mai and Walther, 1991).

[16] Formerly *Cleyera? stigmosa* (Ludwig).

[17] See text under Hordle site for discussion of *Spirematospermum.*

## Interpretation

This is the best locality for the study of the late Eocene floras of the lower Headon Hill Formation. Of the 76 species of angiosperm fruits and seeds found here (Table 9.2), for 17 species this is the only British locality: *Broussonetia rugosa, Chlorophora bicarinata, Hantsia glabra, Palaeosinomenium obliquatum, Acronychia ornata, Zanthoxylum cornpressum, Iodes? hordwellensis, Icacinicarya transversalis, Ampelopsis rotundata, Vitis uncinata, ?Anneslea costata, Visnea hordwellensis, Eurya becktonensis, Gordonia minima, Omphalodes platycarpa, Cucurbitospermum reidii* and *Scleria hordwellensis.* The Hordle flora also contains the earliest records of several species that range up into Miocene or Pliocene deposits of continental Europe (e.g. *Amoelopsis rotundata, Tetrastigma lobata* (Mai, 2000). It is also the type locality for another 26 angiosperm species, reflecting the long history of palaeobotanical research that there has been on this flora. No other palaeobotanical site in the late Eocene deposits of Britain can match this for diversity and history of research.

The Totland Bay Member marks the return of brackish to non-marine conditions in southern England and thus provides a more abundant and diverse plant fossil record than the immediately underlying beds, such as seen at Barton. It is markedly different from the earlier Barton Clay floras, especially among the aquatic component. The aquatic flora at Hordle has a different composition (both of genera and species), higher diversity and more widespread occurrence than the earlier floras. Among the aquatic plants, true *Brasenia* appears. This genus had been previously recorded from lower horizons (e.g. Crane, 1977) but this was based on records of *Brasenia ovula,* which are now assigned to *Sabrenia thandlerae* Collinson, 1980a. Also in the Totland Bay Member, we see the first appearance of *Stratiotes headonensis,* which starts to take over from the earlier occurring *S. hantonensis* (Collinson *et al.,* 1981), and of the *Azolla.* Earlier occurring species that do not occur in the Totland Bay Member include '*Scirpus*' *lakensis, Decodon gibbosus* and *Microdiptera minor. Nypa burtinii* has also disappeared by this level, if one discounts the indeterminate foliar remains.

Like the aquatic plants, the forest species at Hordle show clear signs of the climatic change that was taking place during late Eocene times. The palms had all but disappeared, being only represented by some indeterminate foliage. Many of the families found in earlier Eocene floras and thought to reflect warm conditions have either disappeared or have their last rare and low-diversity occurrences here: moonseed, custard apple, sumac, icacina, dillenia, flacourtia, mezerum, ebony, styrax, olive and squash families. The tea family occurs rarely above the Totland Bay Member, but has undergone a significant decline by this level.

*Sequoia couttsiae* (see Footnote 2 to (Table 8.2), this volume) is the most widespread of the taxodiaceous conifers found in the upper Eocene and lower Oligocene deposits of southern England. The presence of these conifers invites comparison between southern England at this time and the taxodiaceous swamps of today in southern Florida (e.g. Fowler *et al.,* 1973). Hordle is the best single locality for the study of this plant, having yielded cones, cone-scales, seeds, twigs and probable roots and stumps. Furthermore, the specimens from here have generally suffered less pyritization than those from other localities and thus tend to yield better-preserved cuticles. Consequently, Hordle has proved central to the development of our ideas about this important extinct conifer.

Among the angiosperms found at Hordle, the presence of *Nyssidium arcticum* is of particular interest. This member of the katsura-tree family is best known from the Palaeogene–Eocene transition interval (see Chapter 7) and until the mid-1980s was unknown above the London Clay. However, Crane (1984) found that specimens from the London Clay that Chandler (1961a) had referred to as *Carpolithus gardneri* were probably the same as his better-preserved material from the Reading Formation. Chandler (1961c) had also tentatively identified *C. gardneri* from Hordle and Crane included this material within *N. arcticum.*

Hordle has yielded four species of the mulberry family, which is more than any other British site. They have been reviewed by Collinson (1989). Some have the same level of organization as the fruits of living forms, such as *Chlorophora* and *Broussonetia,* while *Moroidea* seems to show features of more than one living genus. The taxonomic position of *Becktonia is* uncertain.

Small roots are generally rare and poorly preserved in the British Tertiary deposits. A notable exception is the anatomically preserved *Lacunoradix headonensis* Crane and Hint, 1979, which is to date known only from Hordle. These

show a small stele and well-developed system of air spaces, features normally found in roots of aquatic plants. However, because of their generalized character, it has proved impossible to link them to any of the known aquatic plants from Hordle.

Hordle is the best site in Europe for late Eocene stoneworts and is the basis of the Verzenay Biozone (Grambast, 1972). Hordle is the type locality for seven of the most widespread species of that zone. Both vegetative and fertile remains can be found here, thus providing considerable potential for work on the palaeobiology of these plants.

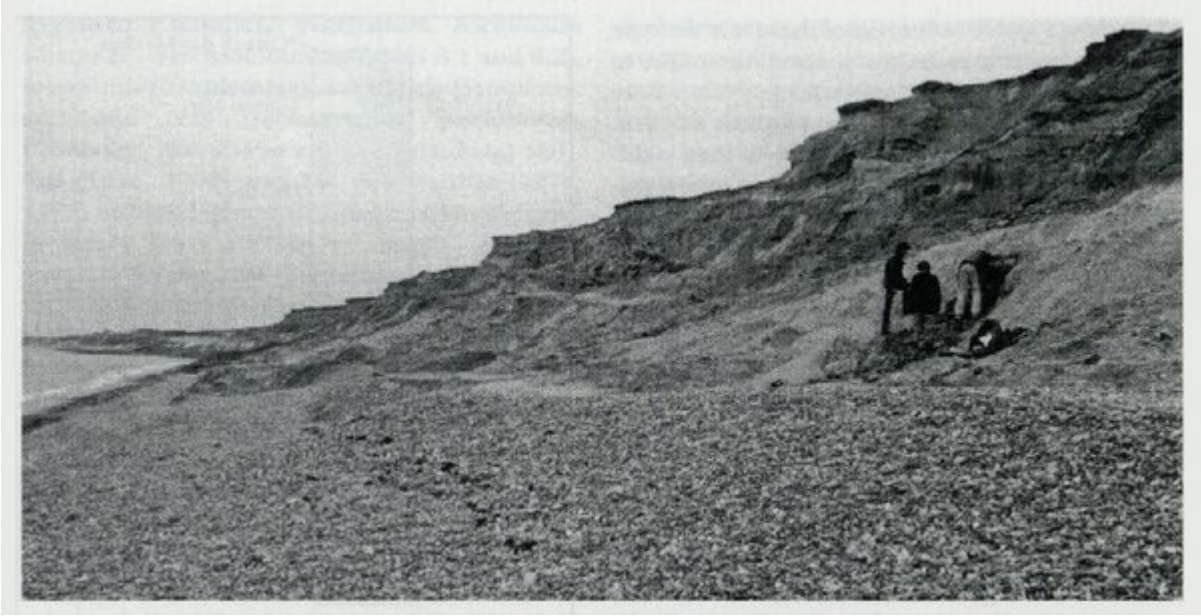
Hordle has yielded bulk samples of seeds (e.g. of *Sabrenia* from Bed L) and specific taxa that have been important for the application of new organic geochemical studies. These studies have revealed chemosystematic affinities and tapho-nomic histories of ancient plants (reviewed in van Bergen *et al.,* 1995, 2000). For instance, *Spirematospermum* seeds from here were shown to carry a chemosystematic affinity of the Musaceae (van Bergen and Collinson, 1999), supporting an affinity proposed by Manchester and Kress (1993) on morphological grounds. Because this work has not been fully published, we have not formally altered the family affinity in this volume.

Hordle has also yielded the earliest examples of trace fossils (from Bed 28 of Tawney-Keeping (1883), named *Gfirotremmorpha,* Collinson and Hooker, 2000) representing gnawing by glirid rodents in *Stratiotes* seeds. This shows that the gnawing mechanism used by the ancient rodents was similar to that used by modern wood mice.

## Conclusions

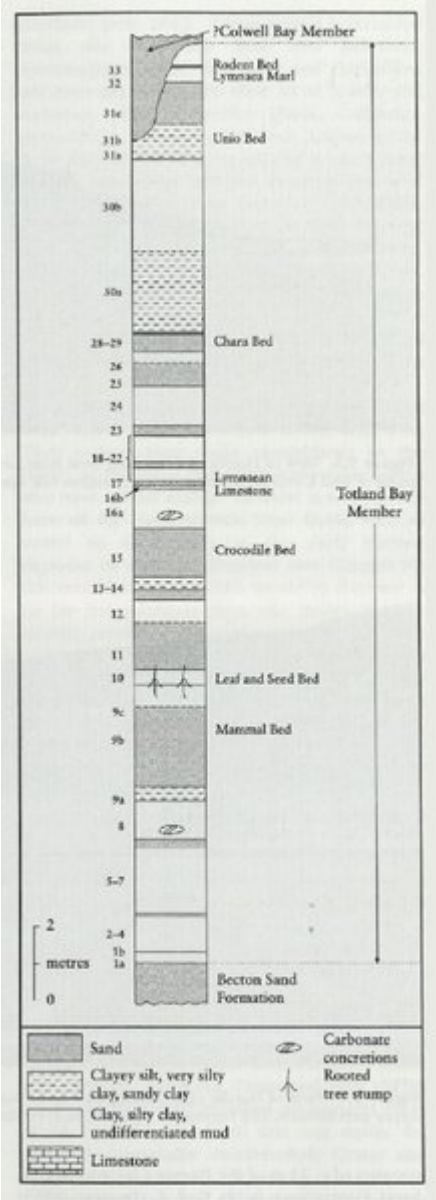
Hordle has been the subject of a longer history of palaeobotanical study than any other Upper Eocene site in this country and has yielded the types of over 40 species. It yields a mixture of aquatic and forest plants and thus provides a broad insight into the vegetation growing in southern Britain at that time. It was a time of climatic cooling in Britain and the Hordle flora reflects changes taking place in both the aquatic and forest vegetation. For instance, many of the families characteristic of the earlier floras (Barton and Bracklesham Groups and below) and thought to represent tropical to subtropical conditions, have disappeared by this time. Hordle is particularly important because several levels in the succession yield material in sufficient abundance to enable organic geochemical studies to be undertaken that are throwing a new light on the affinities and preservation of these fossils. These abundant fossil floras also enable the recovery of very rare items such as rodent-gnawed seeds. Hordle is the best site for the remains of taxodiaceous conifers, including their stumps, which invites comparison with the taxodiaceous swamps of south-eastern USA. Hordle is also the best site in Europe for stoneworts (charophytes) of the Verzenay Biozone, including both vegetative and reproductive structures. The site is clearly of international importance for the study of late Eocene floras (*c.* 37 Ma old).

**References**

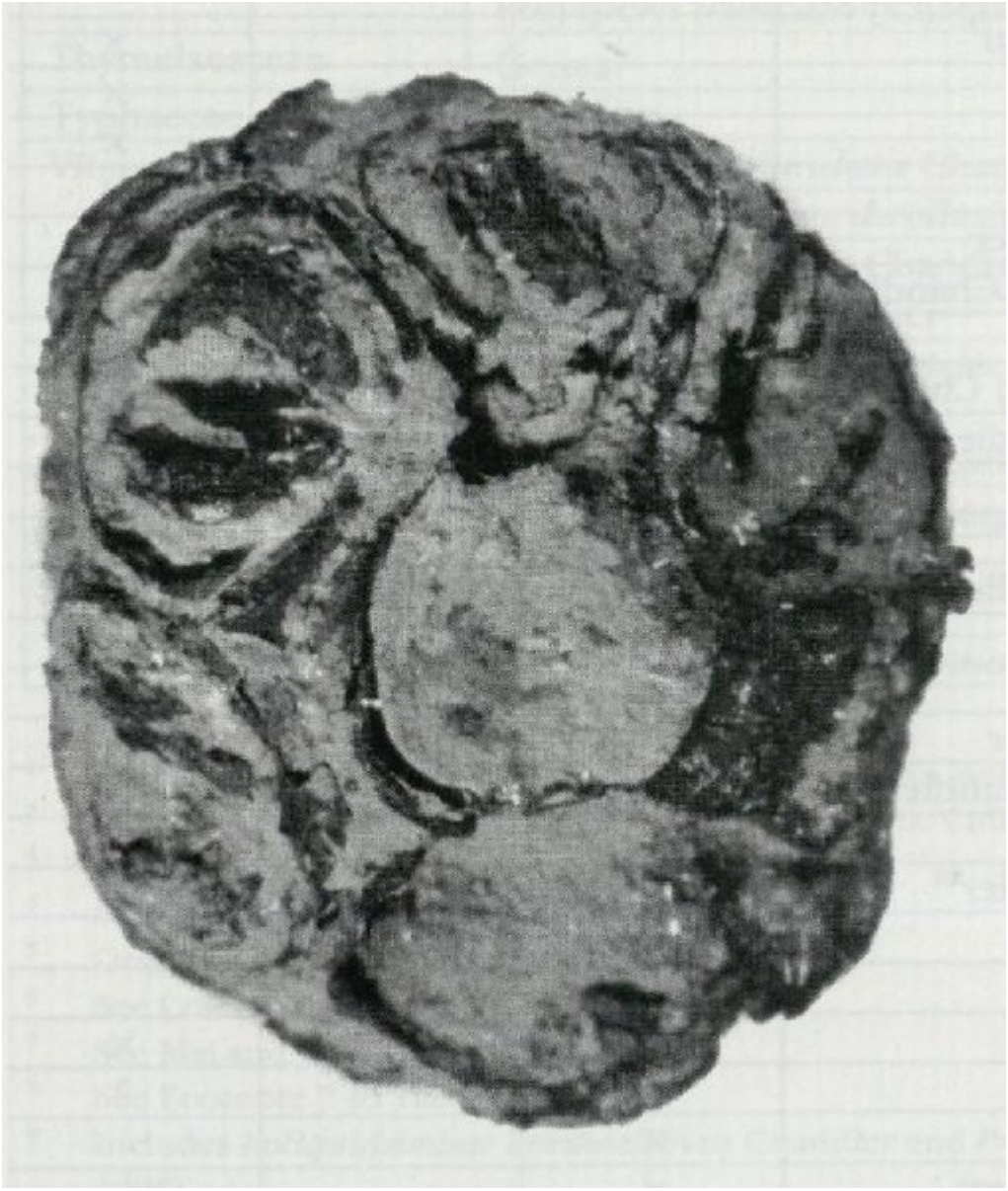


*(Figure 9.6) View of Hordle cliffs looking west from Long Mead End towards Becton Bunny, and showing sampling of Bed L rich in Sabrenia seeds (Headon Hill Formation). (Photo: M.E. Collinson.)*

*(Figure 9.7) View of Hordle cliffs looking east from Becton Bunny. Lower part is Becton Sand Formation, the upper part Headon Hill Formation. (Photo: M.E. Collinson.)*




*(Figure 9.5) A composite succession for the Totland Bay Member (Headon Hill Formation) at the eastern end of 'Barton Cliffs' (Hordle Cliff) (after Edwards and Daley, 1997). The bed numbers are those of Tawney and Keeping (1883).*



*(Figure 9.8) Compound fruiting head of Steinhauera subglobosum with bilocular fruits, in carbonaceous preservation, from the Hordle GCR site, × 6 (see footnotes to (Table 9.2)). (Photo: M.E. Collinson.)*

| Family | Species | Hordle Cliffs | Colwell Bay (Totland Bay Member) | Colwell Bay (Limestone Chine Member) |
|---|---|---|---|---|
| Acanthaceae | ?*Acanthus* sp. | × | | |
| Actinidiaceae | *Actinidia* sp. | × | | |
| | *Saurauia crassisperma* (Chandler) Mai[1] | × | | × |
| Anacardiaceae | Genus (Spondieae) ? | × | | |
| Araceae | Genus ? | × | | |
| Arecaceae | *Leaves* | × | | |
| Betulaceae | *Carpinus boreyana* (Heer) Chandler | × | | |
| Boraginaceae | *Ompbalodes platycarpa* Chandler | × | | |
| Burseraceae | *Palaeobursera lakensis* Chandler | × | | |
| Caprifoliaceae | *Sambucus parvula* Chandler[2] | × | | × |
| Caryophyllaceae | *Hamlinia pulchra* (Chandler) Chandler | × | | |
| | *H. glabra* Chandler | × | | |
| Cercidiphyllaceae | *Nyssidium arcticum* (Heer) Iljinskaja[3] | × | | |
| Cornaceae (including Mastixiaceae) | *Dunstania glandulosa* (Chandler) Chandler[4] | × | | |
| | *Eomastixia rugosa* (Zenker) Chandler | × | | |
| | *Swida quadrilocularis* (Chandler) Mai, 1999[5] | × | | |
| | Genus ? | × | | |
| Cucurbitaceae | *Cucurbitospermum reidii* Chandler | × | | |
| Cyperaceae | *Caricoidea angulata* Chandler[6] | | | × |
| | *C. nitens* (Heer) Chandler | | | × |
| | *C. obscura* Chandler | × | | |
| | *Gladiocarya minima* (Chandler) Mai[7] | × | | |
| | *C. colwellensis* (Chandler) Mai[7] | | | × |
| | *Carex colwellensis* Chandler | | | × |
| | *C.* spp. | | | × |
| | ?*Scirpus* sp. | | | × |
| | *Scleria hordwellensis* Chandler | × | | |
| Cyrillaceae[8] | *Epacridicarpum headonense* Chandler | × | | × |
| | *E. colwellense* Chandler | | | × |
| Droseraceae | *Aldrovanda ovata* (Chandler) Chandler | × | × | × |
| Ebenaceae | *Diospyros headonensis* Chandler | × | | |
| Ericaceae | *2 Genera ?* | × | | |
| Hamamelidaceae | *Stetnbauera subglobosa* Presl[9] | × | | |
| Hydrocharitaceae | *Stratiotes headonensis* Chandler | × | × | × |
| | *S. bantonensis* Chandler | × | | |
| Icacinaceae | ?*Iodes* sp. (or ?*Natsiatum*) | × | | |
| | *Iodes? hordwellensis* Chandler | × | | |
| | *Icacinicarya transversalis* Chandler | × | | |
| | *I. becktonensis* Chandler | × | | |
| | *Natsiatum eocenicum* Chandler[10] | × | | |
| Lauraceae | Genus ? | × | | |
| 'Legumes' | *2 Genera ?* | × | | |
| Lythraceae | *Decodon vectensis* Chandler | | | × |
| | *Microdiptera parva* Chandler | × | | ? |
| | Genus ? | × | | |
| Menispermaceae | *Palaeocionomenium obliquatum* (Chandler) Chandler | × | | |
| Moraceae[11] | *Chlorophora bicarinata* Chandler | × | | |
| | *Broussonetia rugosa* Chandler | × | | |
| | *Moroidea boreyana* Chandler[12] | × | | |
| | *Becktonia bantonensis* Chandler | × | | |
| | *Ficus lucidus* Chandler | | | × |

| Family | Species | Hordle Cliffs | Colwell Bay (Totland Bay Member) | Colwell Bay (Limestone Chine Mbr) |
|---|---|---|---|---|
| Myricaceae | *Myrica boreyana* (Heer) Chandler | × | | × |
| | *M. colwellensis* Chandler | | | × |
| Nymphaeaceae | *Sabrenia chandlerae* Collinson 1980a | × | × | × |
| | *Brasenia aptiosa* Chandler | × | | × |
| | *B. oblonga* Chandler | × | | |
| | *Nymphaea* sp. | | | × |
| Oleaceae | *Olea headonensis* Chandler | × | | |
| Potamogetonaceae | *Potamogeton fygmaeus* Chandler (see Collinson, 1983a) | × | × | × |
| | *P.* sp. | × | | × |
| | *Limnocarpus forbesii* (Heer) Chandler[13] | × | × | × |
| Rhamnaceae | *Frangula hordwellensis* Chandler | × | | |
| Rosaceae | *Rubus acutiformis* Chandler | × | | |
| | *R. microspermus* Reid and Reid | | | × |
| Rutaceae | *Phellodendron costatum* Chandler | × | | |
| | *Acronychia ornata* (Chandler) Mai, 1976[14] | × | | |
| | *Zanthoxylum hordwellense* Chandler | × | | × |
| | *Z. compressum* Chandler | × | | |
| Sabiaceae | *Meliosma* sp. | × | | |
| Styracaceae | *Styrax elegans* Chandler | × | | |
| Symplocaceae | *Symplocos headonensis* Chandler | × | | |
| | *S.* sp. | × | | |
| Theaceae | *Annealea? costata* Chandler | × | | |
| | *Vimea hordwellensis* (Chandler) Mai[15] | × | | |
| | *Eurya becktonensis* Chandler | × | | |
| | *E. stigmosa* (Ludwig) Mai[16] | × | | |
| | *Gordonia minima* Chandler | × | | |
| | *Polyspora truncata* (Chandler) Gregor[9] | × | | |
| Thymelaeaceae | Genus? | × | | |
| Typhaceae | *Typha* sp. | | | × |
| Vitaceae | *Ampelopsis rotundata* Chandler | × | | |
| | *Parthenocissus hordwellensis* Chandler | × | | |
| | *Tetrastigma lobata* Chandler | × | | |
| | *Vitis uncinata* Chandler | × | | |
| Zingiberaceae/ Musaceae | *Spirematospermum wetzleri* (Heer) Chandler[17] | × | | |
| *Incertae sedis* | *Carpolithus fibrosus* Chandler | × | | |
| | *C. apocynoformis* Chandler | × | | |
| | *C. colwellensis* Chandler | | | × |
| | *C.* spp. | × | | × |
| | *Rhamnospermum bilobatum* Chandler | × | | × |

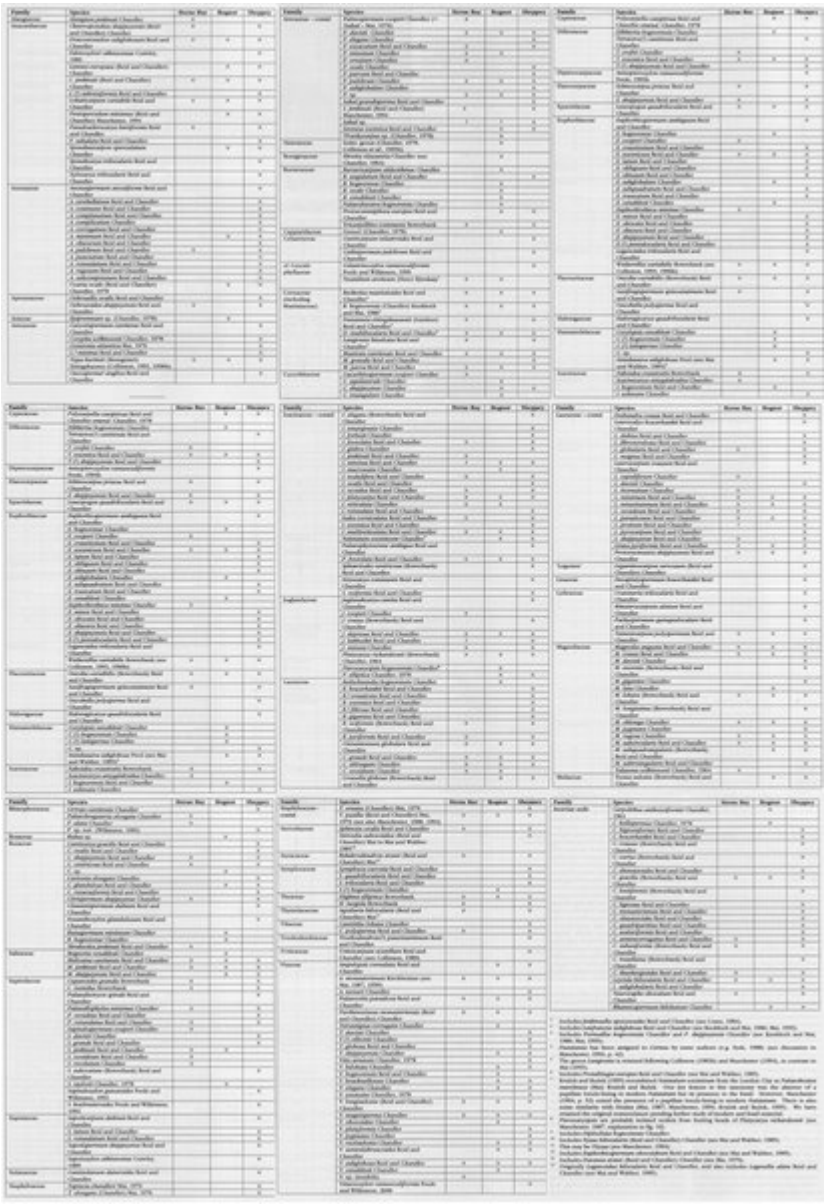
[1] Formerly *Hordwellia crassisperma* (Chandler) then included within the Theaceae (see Mai and Walther, 1985).
[2] This includes *Sambucus colwellensis* Chandler (see Collinson, 1985a).
[3] See Crane (1984).
[4] See Footnote 4 to Table 8.1.
[5] Originally *Cornus quadrilocularis* Chandler.
[6] See Collinson (1985a).
[7] See Mai and Walther (1978).
[8] See Footnote 7 to Table 9.1.
[9] Includes *Eobqualambar hordwellensis* Chandler and *Prosaltingia hantonensis* Chandler (see Mai and Walther, 1985).
[10] See footnotes to Tables 8.1 and 8.2.
[11] See Collinson (1989).
[12] Includes *Moroidea hordwellensis* Chandler (see Mai and Walther, 1978).
[13] Emended by Collinson (1982a).
[14] Formerly *Rutaspermum ornatum* (Chandler) (see Mai, 1976; Collinson and Gregor, 1988).
[15] Formerly *Campyiospermum hordwellensis* Chandler (see Mai and Walther, 1991).
[16] Formerly *Cleyera? stigmosa* (Ludwig).
[17] See text under Hordle site for discussion of *Spirematospermum*.

*(Table 9.2). Angiosperm floras from the Headon Hill Formation. Species descriptions or reference to them may be found in Chandler (1961c, 1963a), unless otherwise referenced. Discussion and other records for some of these species may be found in Mai and Walther (1978, 1985, 1991) and Mai (2000). The family classification used here is summarized in Chapter 1 of the present volume.*

| Family | Species | Lake | Arne | Studland |
|---|---|---|---|---|
| Pteridaceae | *Acrostichum lanzaeanum* (Visiani) Chandler | | × | × |
| Schizaeaceae | *Lygodium kaulfussii* Heer *emend.* Gardner and Ettingshausen | | | × |
| | *L. poodensis* Chandler | × | | |
| | *Anemia poodensis* Chandler | × | × | |
| | *Ruffordia subcretacea* (Saporta) Barthel, 1976[1] | | × | |
| Taxodiaceae | *Taxodium lakensis* Chandler | × | × | |
| | *Sequoia couttsiae* Heer[2] | | | × |
| Actinidiaceae | *Saurauia crassisperma* (Chandler) Mai[3] | × | | |
| | *S. poodensis* (Chandler) Mai, 1970[4] | × | | |
| Anacardiaceae | *Dracontocarya glandulosa* Chandler | × | | |
| | ?*Lannea* sp. | × | | |
| | *Rhus lakensis* Chandler | × | | |
| | *R.* spp. | × | | |
| Apocynaceae | *Apocynospermum acutiforme* Chandler[5] | × | | |
| | *A. lakense* Chandler[5] | × | | |
| Arecaceae | *Calamus daemonoropa* (Unger) Chandler | × | | |
| | ?*Sabal* sp. | | × | |
| Boraginaceae | *Ehretia lakensis* Chandler | × | | |
| Burseraceae | *Palaeobursera lakensis* Chandler | × | | |
| Capparaceae | *Buetnerella emarginata* Chandler | × | × | × |
| | *Palaeocleome lakensis* Chandler | × | | |
| | *Capparidispermum eocenicum* Chandler | × | | |
| Caprifoliaceae | *Sambucus parvula* Chandler | × | | |
| Cornaceae (including Mastixiaceae) | *Dunstania lakensis* Chandler[6] | × | | |
| | *Eomastixia rugosa* (Zenker) Chandler (see Mai, 1995) | × | × | |
| | *E. urceolata* Chandler | × | | |
| | ?*Mastixia cantlensis* Reid and Chandler[7] | | × | |
| | *Mastixicarpum crassum* Chandler (see Mai, 1995) | × | | |
| | *Swida quadrilocularis* (Chandler) Mai, 1999[8] | × | | |
| Cucurbitaceae | *Cucurbitospermum lakense* Chandler | × | | |
| | *C. obliquum* Chandler | × | | |
| Cyperaceae | *'Scirpus' lakensis* Chandler | × | × | |
| | ?*Scirpus* sp. | × | | |
| | *Caricoidea arnei* Chandler | | × | |
| | *C. obscura* Chandler | × | | |
| | ?*Caricoidea* sp. | × | | |
| | *Gladiocarya minima* (Chandler) Mai in Mai and Walther, 1978[9] | | × | |
| Ebenaceae | *Diospyros headonensis* Chandler | × | | |
| Euphorbiaceae | *Euphorbiotheca lakensis* Chandler | × | | |
| | *E. platysperma* Chandler | × | | |
| | *E. tuberculata* Chandler | × | | |
| | *E. digitata* Chandler | × | | |
| | *Euphorbiospermum punctatum* Chandler | × | | |
| | *Wetherellia variabilis* Bowerbank | | × | |
| Flacourtiaceae | *Oncoba rugosa* Chandler | | × | |
| Hamamelidaceae | *Stetnbauera subglobosa* Presl[10] | × | | |

| Family | Species | Lake | Arne | Studland |
|---|---|---|---|---|
| Icacinaceae | *Iodes acutiformis* Chandler | × | × | |
| | *Natsiatum eocenicum* Chandler[11] | × | | |
| | ?*Palaeophytocrene foveolata* Reid and Chandler | × | | |
| | *Icacinicarya incornata* Chandler | × | × | |
| Lauraceae | *Laurocarpum* spp. | × | | |
| Lythraceae | *Ammannia lakensis* Chandler | × | | |
| | *Alatospermum lakense* Chandler | × | | |
| Menispermaceae | ?*Tinospora armensis* Chandler | × | × | |
| | *Palaeococculus lakensis* Chandler | × | × | |
| | *Wardenbeppeya poolensis* (Chandler) Hyde, 1970 | | × | |
| Moraceae | *Ficus lucidus* Chandler (see Collinson, 1989) | × | | |
| | *F.* sp. | | | × |
| ?Moraceae | *Orticarpum reticulatum* Chandler (see Collinson, 1989) | | × | |
| Nymphaeaceae | *Palaeonymphaea eocenica* Chandler (see Collinson 1980a) | × | | |
| Nyssaceae | *Nyssoidea eocenicum* Chandler | × | × | |
| Rosaceae | *Rubus acutiformis* Chandler | | | × |
| Rutaceae | *Phellodendron costatum* Chandler | | × | |
| | *Rutaspermum excavatum* Chandler | | × | |
| | *R. glabrum* Chandler | × | | |
| | *R. magnificum* Chandler | | × | |
| | *R. striatum* Chandler | × | | |
| Sabiaceae | ?*Meliosma sheppeyensis* Reid and Chandler | × | | |
| Sapotaceae | ?*Sapoticarpum* sp. | | × | |
| Solanaceae | *Solanum armense* Chandler | | × | |
| | *Solanispermum reniforme* Chandler | | × | |
| Styracaceae | *Styrax elegans* Chandler | × | | |
| Symplocaceae | *Symplocos headonensis* Chandler | | × | |
| | *S. lakensis* Chandler | × | × | |
| Theaceae | *Cleyera? obliqua* Chandler | × | | |
| | ?*Gordonia* sp. | × | | |
| Thymelaeaceae | *Thymelaeaspermum lakense* Chandler | × | × | |
| | *T.? vulcatum* Chandler | × | | |
| Vitaceae | *Vitis ambigua* Chandler | × | | |
| | *V. armensis* Chandler | | × | |
| | *V. cuneata* Chandler | × | | |
| | *V. excavata* Chandler | × | | |
| | *V. lakensis* Chandler | × | | |
| | *V. lusatica* Czeczott and Skirgiello[12] | × | × | |
| | *V. platysperma* Chandler | × | × | |
| | *V. poodensis* Chandler | × | | |
| | *V. pygmaea* Chandler | × | × | |
| | *V. goodhartii* Chandler | × | × | |
| | *V. symmetrica* Chandler | × | | |
| | *V. triangularis* Chandler | | × | |
| | *Tetrastigma acuminata* Chandler | | × | |
| | *?T. lobata* Chandler | × | | |
| Zingiberaceae | *Alpinia armense* (Chandler) Mai in Mai and Walther, 1985[13] | | × | |
| *Incertae sedis* | *Rhamnospermum bilobatum* Chandler | × | × | |
| | *Carpolithus armense* Chandler | | × | |

*(Table 8.2) Composition of floras from the Dorset Pipe Clays, Hampshire Basin. Species descriptions, or references to them, can be found in Chandler (1962), unless otherwise referenced. Discussions on some of these species can also be found in Manchester (1994), Mai and Walther (1978, 1985), Mai (2000) and Collinson (1996b, in press a). The family classification used here is summarized in Chapter 1 of the present volume*



*(Table 8.1) Angiosperm fruit, seed, wood and twig fossils from the Eocene London Clay GCR sites. Species and details from Reid and Chandler (1933) and Chandler (1961a), unless otherwise referenced. The family classification used here is summarized in Chapter 1 of the present volume.*

| Family | Species |
|---|---|
| **Actinidiaceae** | *Actinidia eocenica* Chandler |
| | *Saurauia crassisperma* (Chandler) Mai[1] |
| **Arecaceae** | *Calamus daemonorops* (Unger) Chandler |
| **Betulaceae** | *Carpinus boveyanus* (Heer) Chandler |
| Boraginaceae | Genus? (?Ehretioideae) |
| Caprifoliaceae | *Sambucus mudensis* Chandler |
| Caryophyllaceae | *Hantsia pulchra* (Chandler) Chandler |
| Clethraceae | *Clethra bantonensis* Chandler |
| Cornaceae (including Mastixiaceae) | *Dunstania glandulosa* (Chandler) Chandler, 1961c (see also Chandler, 1963b)[2] |
| | *Eomastixia rugosa* (Zenker) Chandler |
| | *Mastixia? glandulosa* Chandler |
| | *Mastixicarpum crassum* Chandler |
| Cucurbitaceae | *Cucurbitospermum mudense* Chandler |
| Cyperaceae | *Caricoidea obscura* Chandler |
| | *Scleriocarya tribrachteata* Chandler |
| | *Cladiocarya foveolata* Reid and Chandler |
| Cyrillaceae[3] | *Epacridicarpum beadonense* Chandler |
| | *E. mudense* Chandler |
| Epacridaceae | *?Leucopogon* sp. |
| Flacourtiaceae | *Oncoba rugosa* Chandler |
| Hydrocharitaceae | *Stratiotes bantonensis* Chandler |
| Lythraceae | *Microdiptera parva* Chandler |
| | *Palaeolythrum bournense* Chandler |
| Menispermaceae | *Palaeosinomenium* spp. |
| Nymphaeaceae | *Sabrenia chandlerae* Collinson |
| Nyssaceae | *Nyssoidea eocenica* Chandler |
| Potamogetonaceae | *Potamogeton pygmaeus* Chandler (see Collinson, 1983a) |
| | *Limnocarpus forbesii* (Heer) Chandler *emend.* Collinson 1982a |
| Rosaceae | *Rubus acutiformis* Chandler |
| Rutaceae | *Rutaspermum rugosum* Chandler |
| | *Toddalia excavata* (Chandler) Gregor[4] |
| | *Toddaliospermum ornatum* Chandler |
| Solanaceae | *Solanispermum reniforme* Chandler |
| Symplocaceae? | Genus? |
| Theaceae | *?Cleyera* sp. |
| | *Eurya dubia* (Chandler) Mai[5] |
| | *Eurya stigmosa* (Ludwig) Mai[6] |
| | *Eurya mudensis* Chandler |
| | *?Gordonia truncata* Chandler[7] |
| Thymelaeaceae | *Thymelaeaspermum bournense* Chandler |
| Tiliaceae | *Grewia minima* Chandler |
| Vitaceae | *Vitis* sp. |
| *Incertae sedis* | *Carpolithus echinatus* Chandler |
| | *C. ornatus* Chandler |
| | *C. mudense* Chandler |
| | *Dicotylophyllum pinnatifidum* Reid and Chandler |
| | *Rhamnospermum bilobatum* Chandler |
| | *Wessexia fibrosa* (Chandler) Chandler |

[1] Formerly *Horduellia crassisperma* (Chandler) Chandler (see Mai and Walther, 1985).
[2] See Footnote 4 to Table 8.1.
[3] See comment on *Epacridicarpum* in the Barton GCR site report.
[4] Formerly *Toddaliospermum excavatum* Chandler (see Mai and Walther, 1978).
[5] Formerly *Cleyera? lentiformis* Chandler (see Mai and Walther, 1985).
[6] Formerly *Cleyera? stigmosa* (Ludwig) Chandler (see Mai and Walther, 1978, 1985).
[7] *Gordonia truncata* = *Polyspora truncata* (Chandler) Gregor (see Mai and Walther, 1985). *Gordonia* and *Polyspora* are both modern genera, which are considered synonyms by some authors.

*(Table 9.1) Composition of the angiosperm flora from the Boscombe Sand Formation, Highcliffe. Species are described in Chandler (1963b) unless otherwise referenced. Some  are also discussed by Mai and Walther (1978, 1985) and Mai (2000). The family classification listed here is summarized in Chapter 1 of the present volume.*