Thorness Bay

[SZ 436 926]–[SZ 463 948]

Introduction

This is the classic site (Figure 9.26) for yielding plant remains from the Bembridge Marls, from the Eocene–Oligocene transitional interval (see 'Stratigraphical Background' in the introductory part of this chapter). Over 100 species of mainly angiosperms have been found here, and many are unique to this site. The preservation in some levels is particularly fine, allowing delicate structures such as seed wings and plumes to be studied. It provides important evidence of the vegetational and climatic changes occurring in Europe during the Eocene–Oligocene transition, and is thus of international importance for both palaeobotanical and palaeoclimatic studies. Uniquely in Britain, the Insect Limestone preserves plants and insects in association, allowing evidence from both to be compared in a palaeoenvironmental study. The Bembridge Limestone from here also yields an important flora.

The Insect Limestone in the Bembridge Marls (Figure 9.27) is exposed along a stretch of the Isle of Wight coast in Thorness and Gurnard Bay. It has been known as a rich source of palaeobotanical remains for over a century, with early records by Gardner (1883–1886a, 1886c, 1888). However, much of our knowledge of this flora arose from the collecting activities of an amateur geologist, James A'Court Smith, who spent some 30 years amassing a large collection of fossils from these beds. This collection eventually found its way to the British Museum (Natural History) and was the subject of the first extensive study of the flora, by Reid and Chandler (1926), who also give the historical background to A'Court Smith's work. The flora was reviewed again by Chandler (1963a), who renamed some of the species from here. Fowler (1975) described whole, fertile plants of *Azolla* from here, one of the few examples in the world and the only one from England (Collinson, 1991, 1996a, in press a). Collinson (1999) emphasized the importance of plumed seeds from here as the best-published example of Palaeogene seeds with a pappus (hair tuft) facilitating dispersal by wind.

Chandler (1963a) also reported a small flora from the Bembridge Limestone that underlies the Bembridge Marls. Collinson (1980b) included specimens from here in her revision of the Tertiary Nymphaeaceae. Fossils from both the Bembridge Marls and the underlying Bembridge Limestone were figured and named by Collinson (1978a) and Collinson *et al.* (1993a). Collinson (1983a) recorded the monocot fruit *Alismaticarpum* from Gurnard Bay, while van Bergen *et al.* (1994a,b) used specimens from here in studies on the chemistry of seed coats of fossil water plants (see also reviews in van Bergen *et al.,* 1995, 2000). Collinson and Hooker (2000) recorded rodent-gnawed seeds from here (Figure 9.28). Jones *et al.* (1996) used charophytes from here in an isotopic study showing that such fossils can potentially eluci date the geochemistry of ancient water bodies.

Description

Stratigraphy

Daley (in Daley and Balson, 1999) discuss the stratigraphy of this site and its significance. The exposed sequence is less than 30 m thick, and consists mainly of 6.7 m of Bembridge Limestone Formation overlain by 21.5 m of Bembridge Marls (including, near the base, the Insect Limestone) the basal member of the Bouldnor Formation (Figure 9.29). The rocks represent brackish to freshwater deposits formed under relatively quiet conditions.

Palaeobotany

Despite the long history of research on the flora from the Insect Limestone, not all of it has been described and named. Chandler (1963a) records that at that time, 113 taxa had been discovered, but only 54 had been identified to species. Angiosperms dominate the flora and the 44 that have been identified to species are given in (Table 9.3). In addition, Chandler (1963a) lists nine ferns (*Acrostichium lanzeanum* (Vsiani) Chandler, *?Anemia* sp. (= *?Ruffordia subcretacea* (Saporta) Barthel — see Collinson, 1996a, in press a), *?Lygodium* sp., and *Azolla prisca* Reid and Chandler *emend.*

Fowler, 1975, plus five others), one horsetail (*Equiseum lombardianum* Saporta) and nine conifers '*Araucarites*' *gurnardi* Florin, *?Pinus dixonii* (Bowerbank) Gardner, *P vectensis* Gardner, two other *Pinus* spp., *Pityospermum ambiguum* Reid and Chandler, *Sequoia couttsiae* Heer (see Footnote 2 to (Table 8.2), this volume), *Cupressus* sp. and *?Libocedrus* sp.). The fruits and seeds are mainly preserved as moulds or are carbonaceous, while the leaves may be compressions with preserved cuticles. The preservation is often remarkable, showing very fine structures such as seed and fruit wings and plumes, and whole *Azolla* plants.

Other horizons within the Bembridge Marls have also yielded plant remains. These are mainly fruits and seeds of aquatic plants, and include *Rhamnospermum bilobatum, Stratiotes neglectus* and *Sabrenia chandlerae* (Collinson, 1983a).

The Bembridge Limestone in the lower part of the succession has yielded a small but expanding flora. Chandler (1963a) reported a small collection made by J.F. Jackson, whilst others were figured by Collinson *et al.* (1993a). The species list now includes *Azolla prisca, Sparganium multiloculare, Stratiotes neglectus, S.* cf. *headonensis, Caricoidea* cf. *maxima, Sabrenia chandlerae, Brasenia spinosa, Potamogeton pygmaeus, P tenuicarpus, Alrovanda intermedia, Sambucus parvula, ?Pilea* sp., *yuncus* sp., *Carpolithes* sp., *Rhamnospermum bilobatum, Dictyophyllum pinnatifidum,* undetermined genera of the Alismataceae and Sabiaceae, a possible taxodiaceous seed, and several other undetermined seeds. Collinson *et al.* (1993a) also reported palynomorphs from the upper part of the Bembridge Limestone.

Collinson and Hooker (2000) described a few specimens of *Stratiotes* seed from here (out of hundreds that were studied) which carried trace fossils of rodent gnaw marks (Figure 9.28). Thorness Bay is only the second site at which these have been found, and shows the persistence of this feeding behaviour in glirid rodents from the time of deposition of the Totland Bay Member (Hordle) to the Bembridge Limestone.

Charophyte remains occur in both the Bembridge Limestone and the Bembridge Marls on the Isle of Wight. Groves (1926) described several specimens in the A'Court Smith collection that came from Thorness Bay but did not specify the exact horizon (see also Feist-Castel, 1977). The species described are *Harrisichara tuberculata* (Lyell) Grambast, *Stephanochara vectensis* (Groves) Grambast and '*Chara' vespiformis* Groves. From the upper Bembridge Limestone, Collinson *et al.* (1993a) and Jones *et al.* (1996) also documented *Nitellopsis latispira* Feist-Castel, *H. tuberculata* (Lyell) Grambast, *H. vasiformis* (Reid and Groves) Grambast and *Grovesichara distorta* (Reid and Groves) Grambast.

Interpretation

This site has yielded by far the most diverse fossil floras from Bembridge Limestone and Bouldnor Formations in Britain, including the remains of aquatic plants, herbaceous plants, climbers and rare trees of the neighbouring forests, and charophytes. Among the vascular plants, only just over a half have been fully described and named. Nevertheless, for 39 of these species, Thorness Bay is the type locality. In addition to the 32 new angiosperm species described by Reid and Chandler (1926) (see (Table 9.3)), it is the type locality for *Stephanothara vectensis, 'Chara' vespiformis, Azolla prisca, Araucarites' gurnardii, Pinus vectensis* and *Pityospermum ambiguum. It* is the only British Tertiary site to yield examples of *Equisetum, Pityospermum, Najas, Epipirenznites, Costus, Palaeocarya, Hooleya, Clematis, Myosurus, Ranunculus, Papaver, Zizyphus, Phyllanthera, Tylophora, Catalpa, Incarvillea, Radermachera, Dipelta* and *Flabellicula.* It is also the only British site for fossils of the trumpet-creeper, milkweed, water nymph, poppy and buttercup families. With the exception of the walnut-tree family, and *Dipelta* (see below) and *Myosurus* (see Mai and Walther, 1978, 1991) these potentially exciting fossils have yet to be re-examined using modern approaches. The continued collecting opportunities at Thorness Bay will be vital to accomplish the full potential of this site.

(Table 9.3) Angiosperm floras from the Bouldnor Formation. Species descriptions or references to them may be found in Chandler (1963a) and Collinson (1980b, 1983a) unless otherwise referenced. The family classification used here is summarized in Chapter 1 of the present volume. (Note: records of *Tagus* and *Quercus* by Reid and Chandler (1926) are here considered indeterminate.)

Family	Species	Thorness Bay (Insect Limestone)	Hamstead Ledge	Bouldnor Cliff

Acanthaceae	*Acanthus rugatus* Reid and Chandler	×			
Actinidiaceae	*?Actinidia* sp.	×			
Alismataceae	*Alismaticarpum alatum* Collinson		×		
Apocynaceae	*Apocynospermum striatum* Reid and Chandler[1]	×			
	A. rostratum Reid and Chandler[1]	×			
	A. elegans Reid and Chandler[1]	×			
	A. dubium Reid and Chandler[1]	×			
Aquifoliaceae	*?Ilex* sp.			×	
Araceae	*Epipremnites ornata* (Reid and Chandler) Gregor and Bogner (see Mai and Walther, 1991)[2]	×			
Arecaceae	*Palmophyllum* sp.	×			
	Sabal major (Unger) Heer[3]	×		×	
Asclepiadaceae	*Phyllanthera vectensis* Reid and Chandler	×			
	Tylophora antiqua Reid and Chandler	×			
Betulaceae	*Asterocarpinus* sp.[4]	×			
Bigoniaceae	*Catalpa rugosa* Reid and Chandler	×			
	Incarvillea pristina Reid and Chandler	×			
	Radermachera pulchra Reid and Chandler	×			
	Dipelta europaea Reid and Chandler	×			
Caprifoliaceae	*Sambucus parvula* Chandler *emend.* Collinson, 1983a		×		

	?Caricoidea obscura Chandler		×		
	C. nitens (Heer) Chandler[5]		×		
	Carex gurnardii Reid and Chandler	×			
Cyperaceae	*?Caricoidea minima* (Chandler) Chandler				×
	C. sp.	×	×		×
	Cladiocarya foveolata Reid and Chandler	×			
	Genus indet. (Collinson, 1983a)		×		
Droseraceae	*Aldrovanda intermedia* Reid and Chandler	×			×
	Ottelia britannica Reid and Chandler	×			
	Stratiotes neglectus Chandler	×	×		?
Hydrocharitaceae	*S. websteri* (Brongniart) Chandler				×
	S. acuticostatus Chandler				×
	S. sp. (leaf margin teeth — see Collinson, 1983a)		×		
Juglandaceae	*Palaeocarya macroptera* (Brongniart) Jahnichen, Friedrich and Taká■ (see Manchester, 1987)[6]	×			
	Engelhardtia sp.	×			
	Hooleya hermis (Heer) Reid and Chandler	×			
Juncaceae	*Juncus vectensis* Collinson		×		
Lamiaceae	*Melissa parva* Reid and Chandler	×			
	Ajuginucula smithii Reid and Chandler	×			
Lauraceae	*Daphnogene lanceolatum* Unger[7]	×			
	Neolitsea sp.	×			
Moraceae	*Ficus* sp.	×			

Najadaceae	*Naias oligocenica* Reid and Chandler	×			
	Nymphaea liminis Collinson[8]			×	
Nymphaeaceae	*Sabrenia chandlerae* Collinson	×		×	×
	Nelumbium buchii Ettingshausen				×
Papaveraceae	*Papaver pictum* Reid and Chandler	×			
	Potamogeton pygmaeus Chandler (see Collinson, 1983a)	×			
	P. tenuicarpus Reid and Reid *emend* Collinson, 1983a			×	×
Potamogetonaceae	*P.* spp.	×		×	
	Limnocatpus forbesii (Heer) Chandler *emend.* Collinson, 1982a	×		×	×
	L. (?) spinosus Reid and Chandler (see Collinson, 1982a)	×			
	Clematis vectensis Reid and Chandler	×			
	Myosurus heterostylus (Reid and Chandler) Mai in Mai and Walther, 1978[9]	×			
Ranunculaceae	*Ranunculus ovaliformis* (Reid and Chandler) Chandler	×			
Rhamnaceae	*Zizyphus paradisiacus* (Unger) Reid and Chandler	×			
Rosaceae	*Rubus* sp.				×
Rutaceae	*Zanthoxylum(?) costatum* Reid and Chandler	×			
Sparganiaceae	*Sparganium multiloculare* Reid and Chandler	×			?
	S. sp.				×

Typhaceae	*Typha latissima* (Braun) Reid and Chandler (see Collinson, 1983a)	×	×	
	T. sp. (Collinson, 1983a)		×	×
Zingiberaceae/Musaceae	*?Costus* sp.	×		
	Spirematospermum wetzleri (Heer) Chandler[10]	×	×	
Incertae sedis	*Abelia' quadrialata* Reid and Chandler[11]	×		
	'*A' quinquealata* Reid and Chandler[11]	×		
	'*A*' *trialata* Reid and Chandler''	×		
	Carpolithes collumus Collinson		×	
	C. hamsteadensis Collinson		×	
	C. spp.	×		×
	Dicotylophyllum pinnatifidum Reid and Chandler	×	×	
	Flabellicula anglica Reid and Chandler	×		
	Monocotylophyllum sp.	×		
	Rhamnospermum bilobatum Chandler	×	×	×

[1]See Footnote 5 for (Table 8.2), this volume.

[2] Formerly *Epipremnum? ornata* Reid and Chandler.

[3] This may not be a true *Sabal* (Collinson, pers. obs.).

[4] Described by Reid and Chandler (1926) as *Carpinus* sp. and *Abelia* sp. 4, each from a single specimen. They were transferred to *Asterocarpinus* by Manchester and Donoghue (1995, p. 721).

[5] Includes *C.* cf. *maxima* Chandler *emend.* Chandler *sensu* Collinson, 1983a (see Mai and Walther, 1978).

[6] Formerly *Engelhardtia macroptera* (Brongniart) Reid and Chandler.

[7] Reid and Chandler (1926) referred to this as *Cinnamomum lanceolatum* (Unger) Heer (see Mai and Walther, 1978, 1985).

[8] The generic position of this species as a *Nymphaea* has been confirmed by new, more complete material (Collinson and van Bergen, work in progress).

[9] Formerly *Ranunculus heterostylus* Reid and Chandler.

[10] See text for the Hordle GCR site for discussion of *Spirematospermum.*

[11] These are regarded as *incertae sedis* by Manchester and Donoghue (1995).

The flora shows marked changes from the earlier floras of the British Tertiary record, in both the aquatic and forest components. The bulrush *Typha latissima* and the bur-reed *Sparganium multiloculare* become the most abundant of the aquatic species, replacing the cyperaceans as the common reed-like plants. The combination of *Typha* and the leather fern (*Acrostichum) is* a characteristic of these Eocene–Oligocene transition floras in southern Britain (Collinson, 1983a; Collinson and Hooker, 1987). *Potamogeton tenuicarpus* is progressively replacing *P. pygmaeus,* although some examples of the latter can still be found in the Bembridge Marls. *Stratiotes headonensis* is replaced by *S. neglectus.* These are all part of the progressive change in the aquatic flora of southern Britain that occurred during the Palaeogene Period (Collinson *et al.,* 1981, 1993a; Collinson and Hooker, 1987; Collinson, 1990b, 1992).

Pappus hairs are very rare in the Palaeogene record and those from the Insect Limestone are among the best examples (Collinson, 1999). Seeds of *Apocynospermum* from here have a pappus up to 13 mm long. Similar, unpublished examples occur in the German Eocene succession (Collinson, in press b). Manchester (1999) mentions other examples, and draws attention to the fact that the name '*Echitonium*' has priority for these seeds. The fine-grained limestone has also enabled the preservation of whole plants of the water fern *Azolla* — the only examples from England, and the only examples of this age in the world (Collinson, 1991, 1996a, in press a).

The forest component of the fossil flora also appears markedly different and is very rare. Chandler (1964) interpreted this as being in part taphonomic, as the Insect Limestone preferentially preserved wind-transported fruits and seeds with wings or plumes. Many of the tropical-subtropical families found in the British Eocene fossil record are absent here, despite the depositional environment not being so different. Even the palms, although still present, are of low diversity and rare. Instead we see the remains of wing nuts (Juglandaceae), and of elder and birch families, all of which are also very rare. The decline in the tropical-subtropical elements in the Bembridge Marls flora, give the clear impression of cooling conditions.

The species of the walnut-tree family (Juglandaceae) from the Insect Limestone belong to *Palaeocarya* of the Engelhardiae (modern tropical trees of Asia and Central America) and *Hooleya* of the Platycaryae (modern trees in broad-leaved forests of eastern China and Japan). Both had wind-dispersed small winged nutlets, and were discussed in detail in a wide-ranging review of the fossil history of the family by Manchester (1987).

The record of *Dipelta* (Caprifoliaceae, a family of modern deciduous trees of central and south China) was critically re-appraised and accepted by Manchester and Donoghue (1995). However, the same authors rejected all records of *Abelia* from here, excluding all of them from the Caprifoliaceae.

Fossils of the Bignoniaceae (trumpet creeper family) are very rare and the seeds from the Insect Limestone are the earliest examples (Collinson *et al.,* 1993b). Meyer and Manchester (1997) described a similar seed of *Catalpa* (Indian Bean Tree) from the Oligocene deposits of Oregon. However, the Insect Limestone fossils are now in very poor condition and all three genera are each based on only a single specimen. New collections are needed to confirm the recognition of this family in the Eocene–Oligocene transitional strata.

A single partial impression of a nut assigned tentatively to *Quercus* by Reid and Chandler (1926) was not considered by Kva■ek and Walther (1989) in their revision of European Fagaceae fossils, or by Manchester (1994) who described the oldest fossil acorn. The Insect Limestone specimen is best considered indeterminate. The leaf tentatively referred to *Fagus* was also not discussed by Kva■ek and Walther (1989) and, as no cuticle details are known, is also probably indeterminate.

This was one of the main sites to yield material used in the study of the composition and diagenesis of the seed coats of fossil water plants by van Bergen *et al.* (1994a,b) (material was also obtained from Headon Hill and Bouldnor Cliff). This has helped considerably in our understanding of how these fossils are preserved and the degree to which they have become altered during fossilization. The analytical techniques used in this study are amongst a number of newly developing procedures (e.g. carbon isotope analysis for understanding palaeoatmospheric compositions) that require newly collected specimens. Without sites such as Thorness Bay, where fresh fossils can be collected *in situ,* work of this kind would be impossible.

Collinson *et al.* (1993a) analysed the differences between the floras found in the Bembridge Limestone and the Bembridge Marls, which they interpret as due to differing ecologies. The Bembridge Limestone was formed in calcareous-rich ponds or lakes in relatively dry surroundings, while the Bembridge Marls represent marshlands with more immediately adjacent woodlands. This is argued as possibly being a reflection of a fluctuation in temperatures during deposition.

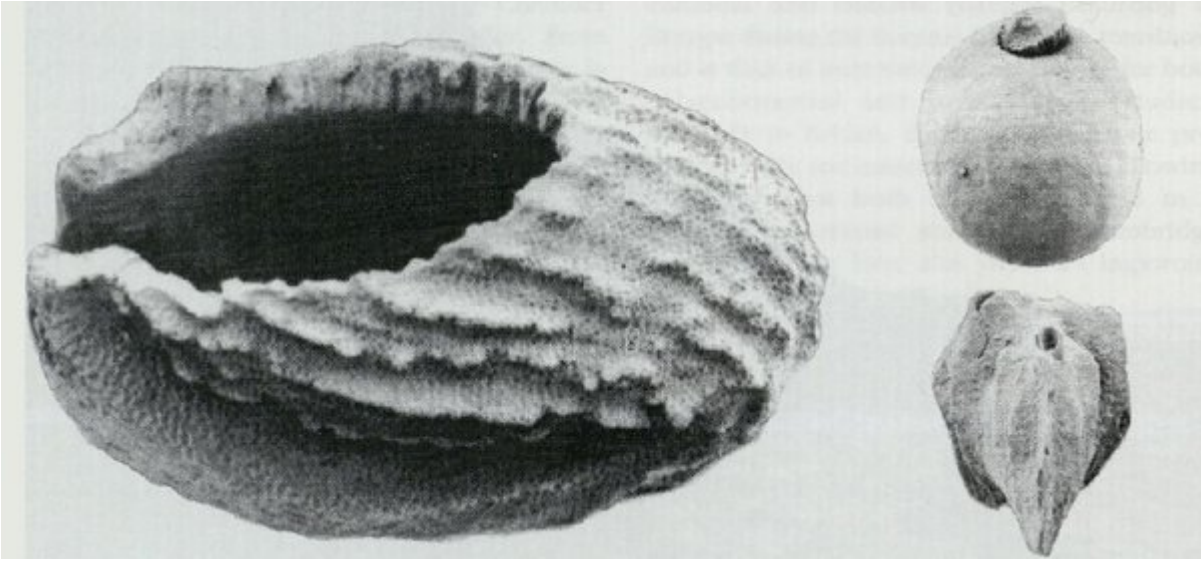
Conclusions

Thorness Bay is the best site for studying the plant fossils from the Eocene–Oligocene transition beds, which are about 34–35 Ma years old. The flora consists of over 100 species and for many of them this is the only known locality. The flora consists mainly of aquatic plants, especially of bulrushes and leather ferns, but there are also rarer remains of plants from the surrounding forests, including wing nuts and elders. The flora is thus important for understanding the broader environmental history of Britain during the Palaeogene Period and its relationship to the global cooling of the climate that was then taking place. The association of plants and insects is valuable for environmental interpretation. Trace fossils on seeds have proved rodent gnawing and seed predation by glirid rodents. The high quality of preservation in the Insect Limestone at Thorness Bay provides one of the very few examples of Palaeogene seeds with a hairy pappus for wind dispersal, as well as the only known examples of whole *Azolla* (water fern) plants in the English Tertiary record.

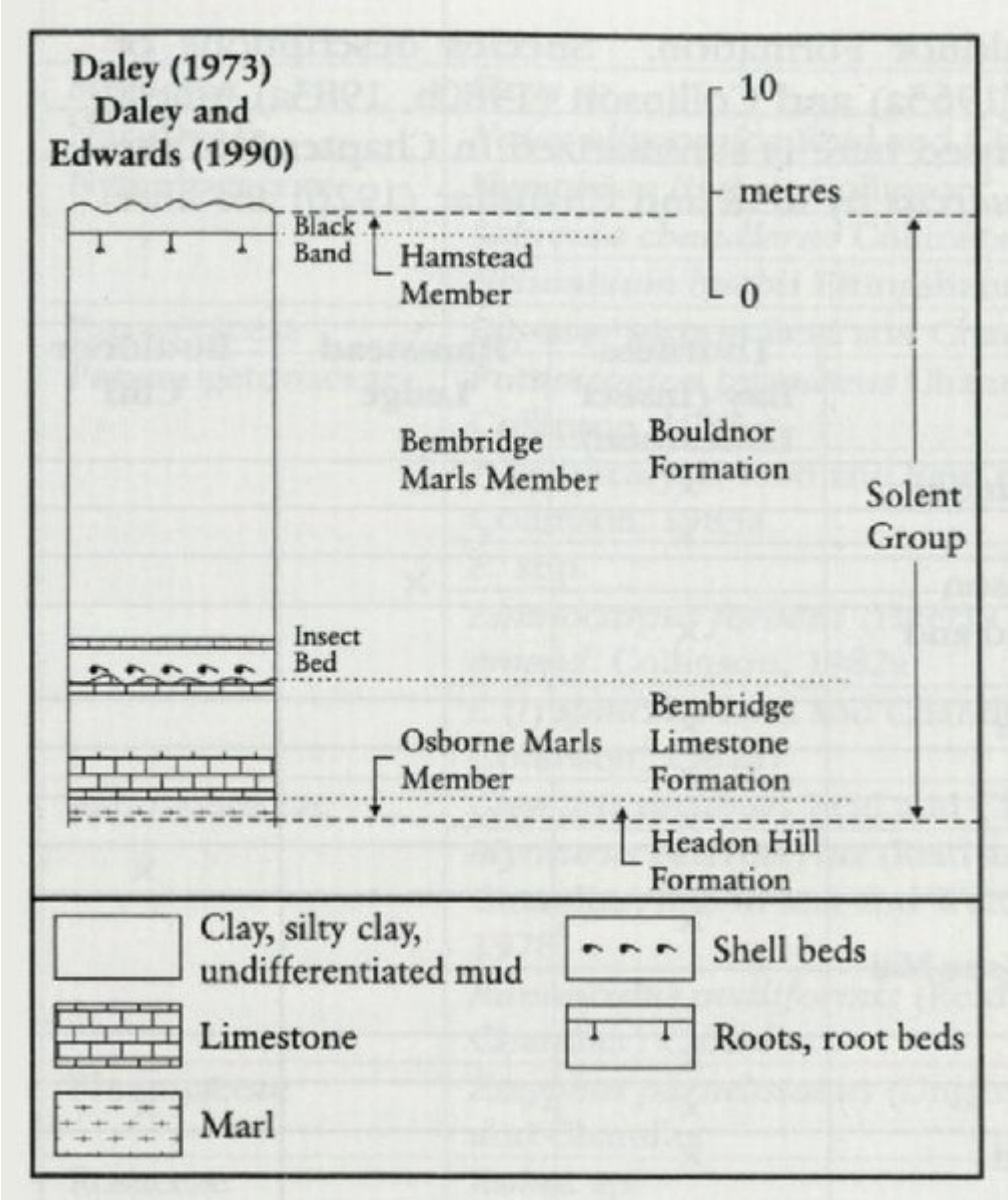
References

(Figure 9.26) General view of the cliffs of Bembridge Marls, with Bembridge Limestone at the base, at Gurnard, Isle of Wight. The foreshore outcrop of Bembridge Limestone forms the Gurnard Ledge in the foreground. (Photo: M.E. Collinson.)

(Figure 9.27) The lowest part of the cliffs at Gurnard, showing, at the base, the Bembridge Limestone muds rich in fruits and seeds. The overlying Bembridge Marls include patches of plant-rich Insect Limestone (the 10 cm scale is on the Insect Limestone). (Photo: M.E. Collinson.)



(Figure 9.28) Fruits and seeds of aquatic plants typical for the Bembridge Limestone Formation viewed under the Scanning Electron Microscope. Left shows a seed of a free-floating aquatic plant Stratoites, showing rodent gnaw marks in the seed coat, × 20 (see Collinson and Hooker, 2000). Upper right shows the fruit of the water lily Brasenia, × 20. Bottom right shows the fruit of the bur reed Sparganium, × 8. All from Thorness Bay. (Photos: M.E. Collinson.)



(Figure 9.29) Stratigraphical succession at Thorness Bay, Isle of Wight. (After Daley and Balson, 1999, fig. 5.43.)

Family	Species	Thorness Bay (Insect Limestone)	Hamstead Ledge	Bouldnor Cliff
Acanthaceae	*Acanthus rugatus* Reid and Chandler	×		
Actinidiaceae	?*Actinidia* sp.	×		
Alismataceae	*Alismaticarpum alatum* Collinson		×	
Apocynaceae	*Apocynospermum striatum* Reid and Chandler[1]	×		
	A. rostratum Reid and Chandler[1]	×		
	A. elegans Reid and Chandler[1]	×		
	A. dubium Reid and Chandler[1]	×		
Aquifoliaceae	?*Ilex* sp.			×
Araceae	*Epipremnites ornata* (Reid and Chandler) Gregor and Bogner (see Mai and Walther, 1991)[2]	×		
Arecaceae	*Palmoxylon* sp.	×		
	Sabal major (Unger) Heer[3]	×		×
Asclepiadaceae	*Phyllanthera vectensis* Reid and Chandler	×		
	Tylophora antiqua Reid and Chandler	×		
Betulaceae	*Asterocarpinus* sp.[4]	×		
Bignoniaceae	*Catalpa rugosa* Reid and Chandler	×		
	Incarvillea pristina Reid and Chandler	×		
	Radermachera pulchra Reid and Chandler	×		
Caprifoliaceae	*Dipelta europaea* Reid and Chandler	×		
	Sambucus parvula Chandler *emend.* Collinson, 1983a		×	
Cyperaceae	?*Caricoidea obscura* Chandler		×	
	C. nitens (Heer) Chandler[5]		×	
	Carex gurnardi Reid and Chandler	×		
	?*Caricoidea minima* (Chandler) Chandler			×
	C. sp.	×	×	×
	Cladiocarya foveolata Reid and Chandler	×		
	Genus indet. (Collinson, 1983a)		×	
Droseraceae	*Aldrovanda intermedia* Reid and Chandler	×		×
Hydrocharitaceae	*Ottelia britannica* Reid and Chandler	×		
	Stratiotes neglectus Chandler	×	×	?
	S. websteri (Brongniart) Chandler			×
	S. acuticostatus Chandler			×
	S. sp. (leaf margin teeth – see Collinson, 1983a)		×	
Juglandaceae	*Palaeocarya macroptera* (Brongniart) Jährächen, Friedrich and Takáč (see Manchester, 1987)[6]	×		
	Engelhardtia sp.	×		
	Hooleya hernii (Heer) Reid and Chandler	×		
Juncaceae	*Juncus vectensis* Collinson		×	
Lamiaceae	*Melissa parva* Reid and Chandler	×		
	Apiginucula smithii Reid and Chandler	×		
Lauraceae	*Daphnogene lanceolatum* Unger[7]	×		
	Neolitsea sp.	×		

Family	Species	Thorness Bay (Insect Limestone)	Hamstead Ledge	Bouldnor Cliff
Moraceae	*Ficus* sp.	×		
Najadaceae	*Natas oligocenica* Reid and Chandler	×		
Nymphaeaceae	*Nymphaea limnia* Collinson[8]		×	
	Sabrenia chandlerae Collinson	×	×	×
	Nelumbium buchii Ettingshausen			×
Papaveraceae	*Papaver pictum* Reid and Chandler	×		
Potamogetonaceae	*Potamogeton pygmaeus* Chandler (see Collinson, 1983a)	×		
	P. tenuicarpus Reid and Reid *emend.* Collinson, 1983a		×	×
	P. spp.	×	×	
	Limnocarpus forbesii (Heer) Chandler *emend.* Collinson, 1982a	×	×	×
	L. (?) *spinosus* Reid and Chandler (see Collinson, 1982a)	×		
Ranunculaceae	*Clematis vectensis* Reid and Chandler	×		
	Myosurus heterotylus (Reid and Chandler) Mai in Mai and Walther, 1978[9]	×		
	Ranunculus ovaliformis (Reid and Chandler) Chandler	×		
Rhamnaceae	*Ziziphus paradisiacus* (Unger) Reid and Chandler	×		
Rosaceae	*Rubus* sp.			×
Rutaceae	*Zanthoxylum*(?) *costatum* Reid and Chandler	×		
Sparganiaceae	*Sparganium multiloculare* Reid and Chandler	×		?
	S. sp.			×
Typhaceae	*Typha latissima* (Braun) Reid and Chandler (see Collinson, 1983a)	×	×	
	T. sp. (Collinson, 1983a)		×	×
Zingiberaceae/ Musaceae	*Nipa* sp.	×		
	Spirematospermum wetzleri (Heer) Chandler[10]	×	×	
Incertae sedis	'*Abelia*' *quadrialata* Reid and Chandler[11]	×		
	'*A.*' *quinquealata* Reid and Chandler[11]	×		
	'*A.*' *trialata* Reid and Chandler[11]	×		
	Carpolithes collomus Collinson		×	
	C. hamsteadensis Collinson		×	
	C. spp.	×		×
	Dicotylophyllum pinnatifidum Reid and Chandler	×	×	
	Flabellicula anglica Reid and Chandler	×		
	Monocotylophyllum sp.	×		
	Rhamnospermum bilobatum Chandler	×	×	×

[1] See Footnote 5 for Table 8.2, this volume.
[2] Formerly *Epipremnum? ornata* Reid and Chandler.
[3] This may not be a true *Sabal* (Collinson, pers. obs.).
[4] Described by Reid and Chandler (1926) as *Carpinus* sp. and *Abelia* sp. 4, each from a single specimen. They were transferred to *Asterocarpinus* by Manchester and Donoghue (1995, p. 721).
[5] Includes *C.* cf. *maxima* Chandler *emend.* Chandler *sensu* Collinson, 1983a (see Mai and Walther, 1978).
[6] Formerly *Engelhardtia macroptera* (Brongniart) Reid and Chandler.
[7] Reid and Chandler (1926) referred to this as *Cinnamomum lanceolatum* (Unger) Heer (see Mai and Walther, 1978, 1985).
[8] The generic position of this species as a *Nymphaea* has been confirmed by new, more complete material (Collinson and van Bergen, work in progress).
[9] Formerly *Ranunculus heterotylus* Reid and Chandler.
[10] See text for the Hordle GCR site for discussion of *Spirematospermum*.
[11] These are regarded as *incertae sedis* by Manchester and Donoghue (1995).

(Table 9.3) Angiosperm floras from the Bouldnor Formation. Species descriptions or references to them may be found in Chandler (1963a) and Collinson (1980b, 1983a) unless otherwise referenced. The family classification used here is summarized in Chapter 1 of the present volume. (Note: records of Fagus and Quercus by Reid and Chandler (1926) are here considered indeterminate.)

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

Family	Species	Lake	Arne	Studland
Icacinaceae	*Iodes acutiformis* Chandler	×	×	
	Nattiatum eocenicum Chandler[11]	×		
	?*Palaeophytocrene foveolata* Reid and Chandler	×		
	Icacinicarya incornata Chandler	×	×	
Lauraceae	*Laurocarpum* spp.	×		
Lythraceae	*Ammannia labensis* Chandler	×		
	Alatospermum labense Chandler	×		
Menispermaceae	?*Imostpora arnensis* Chandler	×	×	
	Palaeococculus labensis Chandler	×	×	
	Wardenabeppeya poolensis (Chandler) Eyde, 1970		×	
Moraceae	*Ficus lucidus* Chandler (see Collinson, 1989)	×		
	F. sp.			×
?Moraceae	*Oreicarpum 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 arnense* Chandler		×	
	Solanispermum reniforme Chandler		×	
Styracaceae	*Styrax elegans* Chandler	×		
Symplocaceae	*Symplocos headonensis* Chandler		×	
	S. labensis Chandler	×	×	
Theaceae	*Cleyera*? *obliqua* Chandler	×		
	?*Gordonia* sp.	×		
Thymelaeaceae	*Thymelaeaspermum labense* Chandler	×	×	
	T.? *sulcatum* Chandler	×		
Vitaceae	*Vitis ambigua* Chandler	×		
	V. arnensis Chandler		×	
	V. cuneata Chandler	×		
	V. excavata Chandler	×		
	V. labensis Chandler	×		
	V. lusatica Czeczott and Skirgiello[12]	×	×	
	V. platysperma Chandler	×	×	
	V. poolensis Chandler	×		
	V. pygmaea Chandler	×	×	
	V. goodhartii Chandler	×	×	
	V. symmetrica Chandler	×		
	V. triangularis Chandler		×	
	Tetrastigma acuminata Chandler		×	
	?*T. lobata* Chandler	×		
Zingiberaceae	*Alpinia arnensa* (Chandler) Mai in Mai and Walther, 1985[13]		×	
Incertae sedis	*Rhamnospermum bilobatum* Chandler	×	×	
	Carpolithus arnensa 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