The Gwithian Landscape

Molluscs and Archaeology on Cornish Sand Dunes

Thomas M. Walker

With contributions from

Rowena Y. Banerjea and C. Rob Batchelor

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Cover: Aerial view of the Godrevy Headland, looking north-east.

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Charles Thomas at Godrevy Barrow during excavations in 2012

This work is dedicated to Charles Thomas

1928–2016

Whose studies at Gwithian and elsewhere in Cornwall and throughout Britain have inspired numerous archaeologists.

Without his enthusiastic support this study could not have been undertaken.

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Preface

Coastal sand dunes are common in Britain, especially along western Atlantic coasts, and archaeological sites are well preserved under blown sand. One of the best excavated sites is at Gwithian, on the east side of St Ives Bay on the north coast of Cornwall. This is a multiperiod site, with evidence of human activity extending from the Mesolithic to the post-medieval period. Major excavations at Gwithian took place in the 1950s and 1960s under the direction of Charles Thomas, to whom this work is dedicated; these revealed a Bronze Age settlement and a post-Roman industrial area in the valley of the Red River and a medieval manor house on the summit of Godrevy Towans. There were repeated phases of occupation and abandonment.

Few studies of British coastal sites have included palaeoenvironmental evidence, and even fewer include securely dated stratigraphy. The present study uses a multiproxy approach to investigate the palaeoenvironment of the Gwithian area, with molluscs being the principal analytical method. Chronology is established by radiocarbon dating and optically stimulated luminescence so that episodic human activity can be related to periods of sand blow and instability. Attempts are made to assess how Holocene palaeoclimate variation influenced the patterns of settlement establishment and abandonment. Evidence is also sought concerning the history of mineral mining in the Red River catchment area.

Twenty three cores and a test pit were examined along a transect from the Red River valley basin to the summit of Godrevy Towans. Molluscan studies in the wider landscape of Gwithian expand understanding of the palaeoenvironment from the late Neolithic up to recent times.

The study establishes that initial sand deposition was about 3000 BC, with further marked periods of sand blow in the early and late Bronze Age, the Iron Age and the mid-medieval period. Some, but not all, sand blow occurrences correlate with periods of settlement occupation and abandonment, and with known palaeoclimate episodes such as the Little Ice Age. Difficulty in establishing periods of sand conflation and deflation and how this may lead to errors in chronology are discussed. There is weak evidence for mining activity in the Bronze Age, but strong evidence from *c.* 1050 AD.

The chronology of some mollusc extinctions and introductions is refined. *Xerocrassa geyeri* did not become extinct at Gwithian until the end of the early Bronze Age and *Cochlicella acuta* was present from the late Neolithic, about 2400 BC.

Foreword

by Jacqueline A. Nowakowski FSA
Principal Archaeologist, Cornwall Archaeological Unit
Cornwall Council, Cornwall

Gwithian, in West Cornwall, is not only a beautiful stretch of the UK coastline, but it is an archaeologist's dream landscape. Broad but expansive undulating blankets of wind-blown sands, today chequered by fields and the dunes, bonded in places by scrubby maritime prickly gorse, safeguard lost places and "lock-in" hidden landscapes. The archaeological fieldwork directed by Charles Thomas at Gwithian for over 50 years introduced the remarkable human stories hidden within this special coastal place to a wider world: for at Gwithian it is possible to uncover lost settlements (ancient and historic), and encounter animal footprints and plough marks preserved in ancient land surfaces long sealed by the sands. The Bronze Age settlements discovered at Gwithian by Charles in particular inspired a generation of landscape archaeologists and kindled a holistic approach to landscape studies. I for one learnt about the remarkable spade and plough marks preserved in the relict surfaces of these ancient fields in far-flung Cornwall as an undergraduate in Sheffield in the late 1970s. Like many, these discoveries inspired me to become a field archaeologist. Years later I happily got the chance to see for myself these unique discoveries when Charles returned to the Bronze Age settlement and re-exposed the deep multi-layered sequence of "occupation" horizons, so that we could take new scientific samples in 2005. They reappeared in fresh sharp outline and pristine condition as if they had only been made yesterday! And when Tom Walker and his team returned to Gwithian in 2012 to carry out his own small excavation (reported on here in Chapter X), I again was fortunate enough to be there and share in the team's delight as they discovered the ancient scuffled footprints of hoofed beasts stamped into the sand.

Tom's recent fieldwork at Gwithian and his analysis on land molluscs, alongside studies on pollen and buried soils by his colleagues, is presented here in full for the first time. This new work is much welcomed and is a major advance upon existing knowledge by providing us with forensic and detailed insights into the key palaeoenvironmental events and stories related to the excavated Gwithian "sites". The techniques and data collation methodologies that Tom and his colleagues have drawn upon had not been routine field practice 50 years ago (although Geoffrey Lewis did collect early samples of land snails from Gwithian in the 1960s). But these techniques were not routinely available to Charles and his team even if the research value of ancient molluscs was recognised for palaeoenvironmental archaeology was still in its infancy. Tom's research has however made good use of the chronological and sites' narratives established by Charles' earlier work and the constructive insights gained is a testimony to the robust framework established by Charles. Tom's research has been targeted and fruitful and gives us a more nuanced insight into the human story of people and land, farming and settlement at this magical coastal place from early prehistory to historical times. The new OSL and radiocarbon dates give us a tighter time frame and we learn that the impact of people at Gwithian from early prehistory is marked. The wet marshy open landscape of the Red River valley in earlier prehistory changed quite dramatically by the earlier Bronze Age when human settlement made its first firm foothold and sand blows began to make an impact on human settlement in the area. The late Bronze Age settlement in all its variety developed in a more stable landscape although its impact was probably more intensive, extensive and even pragmatic given thin agricultural soils and a background hazard of sand blows – which eventually may have forced or precipitated final abandonment. The recent discoveries of Bronze Age walls eroding at Strap Rocks shows how Gwithian will no doubt continue to yield future archaeological treasures and secrets as well as highlighting its ongoing vulnerability as a landscape. Tom's research, in the spirit of all good research, has enlarged our understanding, confirming some former working ideas and challenges others. Whether or not the Red River was always estuarine rather than intertidal is interesting in the light of the challenge of understanding the exact character of the enigmatic stone huts which form the post Roman settlement built in the dunes on a spit of land at Gwithian.

With its exotic post Roman imported pottery, Merovingian belt buckle and grass-marked pottery, this enigmatic "settlement" of small circular buildings has continuing relevance particularly with regard to current research on the post Roman citadel at Tintagel, which, with its distant maritime trading networks, like Gwithian, would have been linked into the wider world of Dumnonia. However stable Gwithian may appear today the landscape here is under constant pressure from change and it is a fragile resource and precious archaeological asset. Tom's new research just re-emphasises the regional and national importance of these special places and how safeguarding these coastal landscapes remains our present and future challenges.

Acknowledgements

This work is based on a PhD thesis undertaken in the Department of Archaeology, University of Reading, and I wish to thank the many people who have helped and supported me; if anyone is inadvertently omitted then I ffer my apologies.

Special thanks go to the late Professor Charles Thomas, the owner of much of the land at Gwithian, and to whom this work is dedicated. He readily granted access to his property and took great interest in the study.

Other land owners, Cornwall County Council and Mr & Mrs A. James at Gwithian, are also thanked for permission to work on their properties. Appropriate consents for fieldwork were obtained from English Heritage (Scheduled Monument CO 771) and Natural England (St Agnes to Godrevy Head SSSI), to whom thanks are given. The work has been continuously supported by Jacky Nowakowski of the Cornwall Archaeology Unit.

My main PhD supervisor, Professor Martin Bell, has actively encouraged my interests in molluscs; he initially suggested the project undertaken at Gwithian, and has supported me throughout with advice and friendship. He has provided many helpful comments on early drafts of this manuscript. My second supervisor, Dr Stuart Black, has been invaluable with advice on the appropriate laboratory methods and their interpretation.

Many staff and students in the University of Reading have been involved in both the field work at Gwithian and the laboratory work:

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Finally, I thank my wife Sue for great support and encouragement throughout the project, and for accepting the disruption caused by numerous sand samples in our house.

Note concerning dates used in this work

Radiocarbon and optically stimulated luminescence dating was obtained on samples. The former are expressed as ‘cal BC’ or ‘cal AD’ whereas the latter are absolute dates that do not require calibration. In the discussions concerning chronology there is therefore a mixture of calibrated and absolute dates. Where quoted dates refer solely to one or the other dating technique the appropriate terminology is used, but when discussion involves dates obtained by both methods then ‘cal’ is omitted.

Photographs

Acknowledgment for photographs is given when necessary. All unacknowledged photographs are by the author.

Chapter I – Introduction

> The coastal sand dune sequences that line the exposed, gale-prone Atlantic shorelines of north-west Europe are the result of poorly-known histories of storminess and quiescence, geomorphic and pedological processes, and past human activities.
>
> (Gilbertson *et al.* 1999)

Coastal sand dunes are common around the coasts of Britain and northern Europe and are likely to have been visited regularly by humans during the Holocene. Sandy bays permit access routes for sea transport and to food resources both on land and from in-shore waters. Many archaeological sites may have been lost over time as a result of coastal erosion or sea level rise, while others were buried by blown sand and remain remarkably well preserved.

Dune formation is thought to have commenced during the Devension Glacial, although many dunes are below modern sea level. In some areas of Britain Pleistocene dunes exist onshore as raised beaches, as at Brean Down in Somerset (ApSimon 2000; Currant *et al.* 2006), Saunton and Croyde in Devon (Campbell and Gilbert 1998) and Newquay and Godrevy in Cornwall (James 1994, 1995).

These glacial dunes are generally only exposed in cliff sections and are not apparent on the land surface. The majority of Holocene dunes around the British coast did not appear until sea levels became relatively stable at slightly below present levels during the early Neolithic (Carter 1988, 303; Shennan and Horton 2002, 518).

ARCHAEOLOGY AND COASTAL DUNE SITES

The archaeological sites that survive in or under coastal dunes are an important resource for understanding human presence and activity in prehistoric periods during the Holocene. The blown sand which buries the sites may accumulate slowly or rapidly; stratigraphy is well preserved and less likely to be disturbed by later ploughing or other human activity than on sites further inland. Repeated episodes of sand blow may cover sequential phases of activity or occupation, the latter representing phases of stability. Bell and Brown (2008) have outlined the key contexts in which archaeological and palaeoenvironmental evidence is preserved on dunes (Figure 1). Human presence may be represented by the remains of buildings, field walls and trackways, for example, while their activities may be seen by preserved plough marks or animal footprints, charcoal from burning, midden material and artefacts.

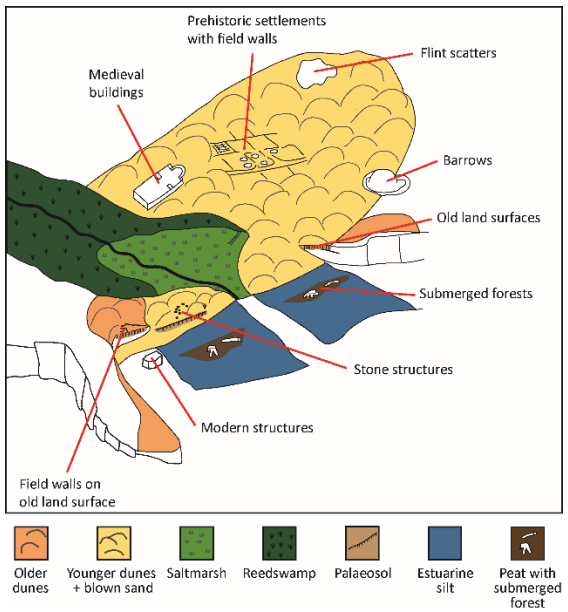

Figure 1. Diagram to illustrate some of the key contexts in which archaeological and palaeoenvironmental evidence is found in relation to coastal dunes. (redrawn from Bell and Brown 2008, 22)

Major sand blow episodes in different parts of Britain are likely to be broadly coeval, especially at times of rapid climate change, but less severe episodes will more probably impact only in local areas. Comparison of blown sand sites can aid in establishing chronologies of coastal environmental change, but only when there has been a robust programme of context dating in association with material culture and/or palaeoenvironmental evidence.

One of the most important sites where these sequences have been studied is at Gwithian in Cornwall, where excavations from the late 1940s to the mid-1960s showed three distinct phases of occupation during the Bronze Age (*c* 1800 cal BC, *c.* 1500–1200 cal BC and *c.* 1300–900 cal BC) followed by abandonment for around 1300 years before establishment of a post-Roman settlement on a nearby dune in the fifth century AD (Thomas 1958; Megaw 1976; Nowakowski *et al.* 2007). There was a Roman homestead on the adjacent headland (Fowler 1962) but no known settlement on the dunes at Gwithian during the Iron Age or Roman period. On the neighbouring hill – Godrevy Towans – a mid to late medieval manor was established overlying an Iron Age round. Little palaeoenvironmental analysis was undertaken during these excavations, and a trench was opened in 2005 within the Bronze Age settlement for this purpose, although the findings have not been fully reported (Nowakowski *et al.* 2006). The present study aims to address some of these palaeoenvironmental issues, mainly by the study of molluscs, and attempts to determine how episodes of sand blow may have contributed to the episodic settlement and abandonment of the Gwithian area. These events can be related to known climatic events during the Holocene: warm periods (Johnsen *et al.* 2001; Mann *et al.* 2009; Wang *et al.* 2012); cool periods (Barber *et al.* 1994; Van Geel *et al.* 1996; Barber *et al.* 2000; Fagan 2000; Barber *et al.* 2003; Mann *et al.* 2009; PAGES 2k Consortium 2013); instability (Bond *et al.* 1997; Bond *et al.* 2001) and flooding events (Johnstone *et al.* 2006; Macklin *et al.* 2006).

Cornwall was a major source of tin during early historic times, becoming a major industry in the eighteenth and nineteenth century. The Red River, adjacent to the archaeological site, flows from the Camborne and Redruth mining areas, and carried much of the mine effluent, leading to the river's current name. Deep coring in the valley of the river allows assessment of possible mining in prehistoric times, and also to establish when the river received its modern name, changing from the earlier Conor Dour.

MOLLUSCS AND ARCHAEOLOGY

Terrestrial molluscs living in Britain are generally small in size, the majority being less then 10mm in maximum length/width, and many less than 5mm. Their small size and rate of movement means that they are restricted to relatively small areas of ground during life, and that the site where they die is likely to be a good indicator of the habitat in which they were living. This does not necessarily hold for an assemblage found some time after death, as the dead shells may have moved large distances, especially as a result of wind and/or water action. When interpreting any death assemblage, it is important to consider whether that assemblage is autochthonous, *in situ*, and representative of the habitat during life or allochthonous, not *in situ*, and displaced from the site inhabited while alive.

Despite these restrictions, knowledge of the varying ecological preferences can provide useful information concerning the local habitat at the time when those molluscs were living. The varying ecological preferences of different taxa are well recognised (e.g. Boycott 1934, 1936; Sparks 1959–60; Evans 1972), being divided into 'shade preferring', 'catholic' or 'intermediate' and 'open country' for terrestrial shells and 'slum', 'ditch', 'moving water', 'catholic' and 'brackish water' for aquatic species. However, it is important to stress there are serious limitations to this rather simplistic approach (e.g. Cameron 1978; Thomas 1985). This autecological approach takes the preferences of individual species using the broad groupings given above to recreate the habitats and takes little account of interactions between species. It assumes that modern preferences are no different from those in earlier periods, the principle of uniformitarianism. For some species this assumption is known not to hold, for instance that of *Lauria cylindracea*, where Evans (2004) demonstrated that in prehistoric times this species favoured shady, or least diverse, habitats, but in the last 2000 years has become associated with open grassland and sand dune habitats.

A synecological approach takes a broader view of environmental reconstruction from mollusc analyses, in that it considers interactions which cross the traditional habitat boundaries. The concept of taxocenes has been developed, which recognises associations of species found in living communities, and develops the

ecological groupings of species which may be applicable to sub-fossil assemblages. Such taxocenes have been proposed for both dry and wet ground (e.g. Ložek 1990; Evans 1991; Evans *et al.* 1992; Davies *et al.* 1996; Davies 2008).

Non-marine molluscs have been increasingly used in palaeoenvironmental analysis of archaeological sites over the last century (see Evans 1972; Davies 2008). These have concentrated mainly on the inland chalkland landscape of Britain (see Allen *et al.* 2009, and references therein), with relatively few examining dune sites (Figure 2). The latter are largely restricted to the south-west of England, Pembrokeshire in Wales, and the Scottish Islands (the Outer Hebrides and the Orkneys). Details for each individual site are given in Walker (2017), and only a few key sites are briefly discussed here.

Towan Head, Newquay, Cornwall

Mollusc analyses in the first decade of the twentieth century have been reported from buried soils with overlying blown sands within a Holocene sand cliff at Towan Head (Kennard and Warren 1903; Woodward 1908) and are important as they are among the earliest studies to use shells in palaeoenvironmental reconstruction, although they were not associated with any archaeology in the immediate area. These deposits have been revisited in later studies (Spencer 1975; Milles 1991; Walker 2014), but no radiocarbon dates have been obtained.

The basal layers show a shaded environment with a range of species indicating light wood or scrub. Although absent in the lowest deposits, *Pomatias elegans* was found above the basal old ground surface; this is a species of highly calcareous soils, associated with shady, moist habitats, and now known living in only a single area of Cornwall, just south of this site (Turk *et al.* 2001, 6). Its presence suggests some form of disturbance such as woodland clearance (Evans 1972, 133), which in this context may have been during the Neolithic and associated with forest clearances. The wood/scrub gave way to open country as blown sand accumulated, with the appearance of typical xerophile species such as *Cernuella virgata*, *Helicella itala* and *Cochlicella acuta*.

Brean Down, Somerset

The Bronze Age settlement at Brean Down is arguably the most closely dated dune sequence in Britain, being excavated in the 1980s (Bell 1990). There was evidence of Mesolithic and early Neolithic presence (flints) prior to the settlement, and continuing activity into historic times, with early medieval graves and a post-medieval building. Chronology was established with a sequence of twenty one radiocarbon dates from bone, peat and charcoal, which were correlated with five mollusc columns forming a continuous stratigraphic sequence from the settlement and a test pit (Spencer 1974; Vaughan 1976; Bell and Johnson 1990; Walker 2008).

The basal palaeosol was decalcified, but other environmental evidence, particularly micromorphology, indicated that early Holocene woodland was cleared by burning during the Neolithic; the land was cultivated before being buried by blown sand in the mid fourth millennium BC. The molluscs in a Beaker period stabilisation horizon showed open conditions (*Vallonia* sp., *Helicella itala*, *Truncatellina cylindrica*), but the presence of damper, shadier, habitats was indicated by clausiliids (*Clausilia bidentata*, *Macrogastra rolphii*, *Balea perversa*) as well as *Carychium tridentatum*, *Acanthinula aculeata* and *Aegopinella nitidula*.

Figure 2. Coastal sand dunes in the British Isles, shown in red.
The sites which include molluscs in palaeoenvironmental analyses are named. (modified from Doody 2008, 2009).

Following a period of unstable blown sand, stability returned during the middle Bronze Age, associated with the main period of settlement, but with the introduction of *Cochlicella acuta* and *Cernuella virgata*, although the question of intrusion of material from more superficial levels is raised, as *Cernuella* is generally

considered to be a Romano-British introduction (Kerney 1999, 181; Davies 2010, 176). The presence of brackish water species during the middle Bronze Age indicated the presence of estuarine mud flats. After the Bronze Age the landscape became progressively more open, up to the sixteenth/seventeenth centuries AD, with a diverse assemblage showing greater vegetation cover being found in twentieth century levels.

Northton, Isle of Harris, Outer Hebrides

An early Mesolithic to post-medieval settlement site was excavated in the mid-1960s and in 2001 (Simpson 1966; Murphy and Simpson 2003; Murphy *et al.* 2004). There were multiple well-stratified occupation horizons interspersed with blown sand all within about five metres of windblown calcareous sand. Multiple radiocarbon dates establish the period of occupation, from the Mesolithic (Gregory *et al.* 2005) to the post-Beaker and later Iron Age (Murphy *et al.* 2004). Mollusc sequences were analysed by Evans (1971b; 1972, 294; Law and Thew 2017, 87), although interpretation was complicated by the effects of deflation and rapid deposition of sand by wind action, with subsequent loss of shells and incorporation of molluscs from a variety of habitats. Despite these limitations, Evans established a comprehensive pattern of habitat change over time.

Molluscs were absent from the Mesolithic and early Neolithic layers, but during the mid-Neolithic they indicated a woodland environment with *Cochlicopa* spp. and *Vitrina pellucida* dominating, but with a range of other hygrophile and shade-loving species. The woodland was then cleared, indicated by a marked rise in open country species (*Vallonia costata*, *Vertigo pygmaea*, *Pupilla muscorum*). Following a brief period of open country there was woodland regeneration during the later Beaker period, stability being shown by a marked increase in numbers of shells, and a fall in the proportion of open country species. The second woodland phase ended with clearance, with sand accumulation increasing during the Iron Age; the molluscan fauna now comprised largely the open country species mentioned above, together with *Vallonia excentrica*. Only towards the end of the Iron Age was stability established, with a marked shift in mollusc taxa, becoming almost entirely limited to *Cochlicella acuta* and *Helicella itala*, both species typical of open dune grassland. Regarding the periods of deforestation, Evans (1971b, 59) postulates that 'In both cases, clearance was probably for pasture as none of the sherds from the occupation horizons bore grain impressions nor were there found querns, sickles or other trappings of an arable farming community.' However, he does not rule out (1972, 296) that the destruction of the woodland was not 'an altogether natural process brought about by the overwhelming action of the sand.'

The Bay of Skaill, Mainland, Orkney

Storms in the Orkney Islands in 1850 revealed stone buildings eroding out of the cliffs on the west coast of Mainland, revealing the Neolithic village of Skara Brae in the Bay of Skaill. It was not until the 1920s that full excavation was carried out under the direction of Gordon Childe (1931). The buildings provide an unrivalled example of Neolithic settlement, and are a wonderful example of how archaeological sites can be preserved under blown sand deposits.

Although the original excavations predated modern concepts of palaeoenvironmental analysis, mollusc studies have since been performed at Skara Brae (Spencer 1974, 1975; de la Vega-Leinert *et al.* 2000). There was clear evidence of original open woodland or scrub (*Cochlicopa* spp., *Lauria cylindracea*, *Clausilia bidentata*, *Oxychilus alliarius*, *Aegopinella nitidula*, *Vitrina pellucida*), but with a strong open country element (*Vertigo pygmaea*, *Pupilla muscorum*, *Vallonia excentrica*); this woodland/scrub then gave way to purely open country and catholic species, possibly a result of anthropogenic clearance. On the north side of the Bay of Skaill bore hole studies indicated that there was initial ponding in dune slacks during the woodland phase, shown by the presence of several freshwater mollusan species (de la Vega-Leinert *et al.* 2000). This was followed in the later Neolithic with multiple episodes of sand blow on open grassland, interspersed with ponding and a rising water table.

THE PRESENT STUDY

The majority of archaeological studies that incorporate palaeoenvironmental analyses, and in particular molluscs, tend to concentrate on the areas of primary concern, usually in or very close to the sites being

excavated. Relatively few explore the wider landscape or attempt to place settlement activity in the context of environmental change beyond the bounds of the area of immediate interest. The study described in this monograph explores a wide area around the main occupation sites, showing evidence of human activity over a span of around 8000 years, in a landscape that is now blanketed by sand. A wide variety of environmental and geoarchaeological modalities have been employed to examine change over time, in an attempt to establish how changes in the environment have influenced human presence and activity, and how, in turn, that activity may have altered the local landscape.

Molluscs have been used in this study as the main palaeoenvironmental indicator, obtained both from mollusc columns and from core samples. There are particular problems in mollusc analyses in dune environments resulting from the instability of sand. Winnowing during windy conditions can rapidly cause deflation of assemblages, either with loss of entire stratigraphic sequences or with removal of lighter shells or fragments leaving a biased residue of heaver material. Equally, conflation of small or large deposits of sand in stormy weather may result in allochthonous assemblages that are not representative of the area under consideration. These problems are discussed in the relevant chapters.

EXTINCTION AND INTRODUCTION OF MOLLUSC SPECIES

The fauna of Britain is not constant. Some species become extinct either through natural causes or the action of people, while other are introduced, often inadvertently but sometimes deliberately. The aurochs, lynx and brown bear are examples of mammals that no longer inhabit Britain, while fallow deer, rabbits and rats are introductions during the Holocene (Kerney 1966; O'Connor and Sykes 2010). Molluscs are no exception. Many species survived from the last Ice Age and are still found in Britain, although some with very restricted distributions. A few species did not survive the warming during the early Holocene and are now extinct in Britain. Others have been introduced (Davies 2010; Cameron 2016, 371). Introductions may be accidental, arriving, for example, on garden produce, although a few species were almost certainly brought to Britain intentionally; an example is the Roman snail, *Helix pomatia*, which is thought to have been a food resource during Roman times (Davies 2010).

If the timing of extinctions and introductions can be established with a high degree of certainty, then this can be useful from the chronological point of view in archaeological deposits. It is, however, very important to consider how secure is the stratification, as the presence of molluscs in unexpected strata is frequently due to intrusion, often by worms or rodent activity. Dating correlation should, whenever possible, be obtained by independent testing rather than relying on the presence or absence of molluscs, although the latter may be helpful in some circumstances. For example, if *Xerocrassa geyeri*, a species now extinct in Britain, is present in a sediment then that sediment almost certainly dates to the very early post-Glacial period (Kerney 1999, 184); only at Gwithian in Cornwall has it been found in horizons dating to the Bronze Age.

The introduction of particular species is perhaps more useful from the chronological point of view, although the problems of bioturbation need to be taken into consideration, and shells found in inappropriately deep levels may be ascribed to older sediments than they should be. For example, the various species introduced into Britain in medieval or later periods should not be present in deposits considered to date from earlier centuries or millennia, and if present at inappropriate early dates probably indicate bioturbation or other forms of contamination. However, the *caveat* is that not all is yet known concerning introductions and extinctions of many species, and detailed work may change present understanding of the time scales, as the present study shows.