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Reflections on 50 years of *Land Snails in Archaeology*

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Abstract. When J.G. Evans's *Land Snails in Archaeology* was published in 1972, it established a new understanding of the environmental history of prehistoric archaeological sites in southern Britain and in the process introduced archaeologists to the value of studying assemblages of land snail shells from archaeological deposits. This paper reflects on the impact of the book, reviews developments in the discipline over the intervening half century, and proposes some future directions for the practice of archaeological land-snail analyses.

Key words. Archaeology, United Kingdom, J.G. Evans, land snails

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Introduction

The year 2022 marked the 50th anniversary of the publication by Seminar Press of J.G. Evans's book *Land Snails in Archaeology* (Evans 1972), long out of print but still a standard reference for studies of land snails from archaeological sites in the United Kingdom and elsewhere. This work codified the methodologies for archaeological land-snail studies and introduced archaeologists to a new line of evidence for the vegetation history of Britain during prehistory.

In this paper, which is based on a presentation given to the Conchological Society in December 2022, I briefly survey archaeological land-snail studies before Evans, discuss Evans and his book, and set out some of the ways in which the study of land-snail-shell assemblages from archaeological sites has progressed since 1972. Finally, I explore some potential areas for future development. In doing this, I aim to invigorate discussion about how archaeological land-snail analyses can build upon the foundations laid by Evans. This review will largely concentrate on studies from Britain, as this was the area Evans (1972) concentrated on. However, land-snail analyses are routinely carried out globally in archaeological contexts. A major limiting factor remains the state of knowledge of species ecology, however, which varies greatly in regions around the world (Cameron 2016: 292).

Archaeological land-snail studies before Evans

That land-snail shells were preserved on archaeological sites had been noted since at least the 1860s. For example, in 1869, the archaeologist General Pitt Rivers noted shells of *Pomatias elegans* (then called *Cyclostoma elegans*) at Cissbury, West Sussex (Evans 1972), while a report on lithics from Stroud Hill, Gloucestershire, was accompanied by a detailed consideration of the ecology of the molluscs identified at the site (Jones 1865). Starting in the 1890s, A.S. Kennard, an enthusiastic amateur malacologist, began a campaign of over five decades examining shells from archaeological excavations, often working alongside B.B. Woodward of the British Museum (Natural History). These shells were interpreted primarily in relation to climate, as Kennard believed that alongside humidity, climate was the main controlling factor in determining species' distribution (Preece 1990). Initially, the work included lists of species, occasionally with relative abundance; however, by the 1930s these lists were often fully quantitative, although usually sampled on a bed-by-bed basis rather than taking samples of individual stratigraphic contexts. Some of this work had important conclusions, such as a study of the snails from Grime's Graves in Norfolk, which revealed a post-glacial origin for the deposits, which was in doubt at the time (Preece 1990). Overall, Kennard authored over 200 reports, a full bibliography of which may be found in a publication by Preece (1990).

The 1920s and 1930s saw a flourishing of ecological work on living snails, allowing A.E. Boycott to systematise knowledge of the ecology of Britain's terrestrial snail species in a landmark paper (Boycott 1934). Boycott arranged the British fauna into groups based on habitat preferences; hence, some species could, for example, be considered primarily "woodland" species, or primarily species of "wet places".

This meant that there was now a more systematic possibility for matching molluscan assemblages from archaeological and Quaternary sediments to analogous modern habitats. In the late 1950s, B.W. Sparks introduced the first systematic method for sampling deposits for subfossil land snails and published the first snail diagram (a representation of environmental change through a vertical sequence of samples) in 1957 (Sparks 1957). Along with Michael Kerney, and Vojen Ložek working in Prague, Sparks introduced a more quantitative rigour to the study of land snail assemblages from Quaternary sediments (Preece 2023).

Much of the work prior to the 1960s, as Myra Shackley (1981: 125) described, placed its emphasis on climate or on using snails as dating evidence for the deposit, when in fact the true strength of land-snail analysis in archaeology, especially in the shorter timescales afforded by most archaeological sites, is in its ability to shed light on past vegetation character and structure (Allen 2017a).

Figure 1. J.G. Evans and Darwin, republished from Allen (2006). Photo by Gill Swanton.

J. G. Evans

John Gwynne Evans was born in St Albans, Hertfordshire, on 11 November 1941. He studied zoology at Reading University (1960–1963), where he met John Wymer, then curator of Reading Museum and a noted Palaeolithic archaeologist, who fueled his interest in archaeology. He followed his undergraduate studies with a zooarchaeological Ph.D. at the Institute of Archaeology, University of London, under Frederick Zeuner, a polymath famed for his work on insects, animal bones, the radiocarbon revolution, and his proposed correlation of prehistoric climatic and cultural events in Europe with Milankovitch cycles. As part of his supervision, Zeuner sent him to learn how to excavate with Derek Simpson and Isobel Smith at Rainham in Essex (Evans 2004). When Zeuner died on 5 November 1963 at age 58, Michael Kerney of Imperial College became involved in Evans's supervision, and his focus switched from bones of Pleistocene megafauna to land-snail-shell assemblages. At the Institute, he became known as "Snails" Evans, partly to distinguish him from the Mediterranean prehistorian John D. Evans, who had joined the Institute as Professor of Prehistoric European Archaeology in 1956 as successor to Vere Gordon Childe (Allen 2006; Renfrew 2015).

Evans's doctoral thesis, *The Stratification of Mollusca in Chalk Soils and their Relation to Archaeology*, was completed in 1967. At this time, environmental archaeology was being developed as a discipline at the Institute, which was home to a Department of the Human Environment led by the palynologist Geoffrey Dimbleby with the soil scientist Ian Cornwall (Grimes 1969; Allen 2006). As a postgraduate at the Institute, he was a contemporary of Susan Limbrey, a geoarchaeologist with whom he would later work on the Upper Kennet valley in Wiltshire (Evans *et al.* 1993). He also worked on a small number of snail reports with Hilary Jones, Honorary Assistant in the Department, publishing an important paper on rock-rubble faunas together in this journal in 1973 (Evans & Jones 1973). A paper on combined pollen and snail analyses from several sites on the Wessex chalk was published with Dimbleby (Dimbleby & Evans 1974). That paper highlighted difficulties reconciling molluscan and pollen evidence from calcareous soils, apparently suggesting that the two proxies may not be contemporaneous in a buried soil and considered the processes affecting pollen and snail distribution in biologically active buried soils. During his doctoral studies, Evans was appointed as the first field archaeologist for Buckinghamshire County Museum (Allen 2006).

Following a Research Assistantship at the Institute funded by the Natural Environment Research Council (Grimes 1971), he was appointed as Lecturer in Environmental Archaeology at University College Cardiff (now Cardiff University) in 1970, the first academic post in environmental archaeology outside of London, and promoted to Senior Lecturer in 1978, Reader in 1982, and Professor in 1994, retiring as Emeritus Professor in 2002. His retirement was tragically cut short by his death on 13 June 2005 at age 63 (Limbrey 2005; Sharples 2005).

Land Snails in Archaeology

Palynological work by Harry Godwin and others in the mid-20th century had allowed histories of environmental change linked to human activity to be described for large areas of Britain. A problem, however, was that pollen generally preserves poorly on large tracts of land with chalk and limestone geologies where terrestrial sediments are oxidised (Evans 1972; Allen 2021). Snail shells preserve well in such situations, provided there is calcareous bedrock that weathers readily and enriches the soil with calcium carbonate. However, calcareous bedrock does not always guarantee preservation of shells; for example, in anoxic waterlogged calcareous sediments, shells can be damaged when iron sulphides react with groundwater to produce carbonic acid—a process observed in certain layers at Holywell Coombe at Folkestone in Kent (Preece 1998: 169). Further, the deposition of non-calcareous deposits such as loess and brickearth over calcareous bedrock may impact preservation, for example at sites in the Yorkshire Wolds (Neal 2020). By looking at assemblages of snail shells from sediment samples at archaeological sites, Evans was able to explore the archaeology of chalk landscapes, which contain many of Britain's most well-known prehistoric monuments. His work also encompassed sites on calcareous wind-blown sand in the Western Isles of Scotland.

Land Snails in Archaeology began with a brief history of malacological studies in British archaeology, before introducing the methods used and the identification and ecology of the British fauna. An identification guide to the British snails included simple outline drawings, and drawings of juveniles of many species, a feature still largely missing from other identification manuals. This is especially useful for archaeological and Quaternary samples, which can be mostly comprised of shell fragments and juveniles (Preece 1981). The known ecology of the species was examined in some detail, and ecological groupings of mollusc species presented as an aid to interpretation. The book was subtitled "*With special reference to the British Isles*" and focussed almost entirely on British examples.

For archaeologists, the book also introduced a description of the tripartite sequence of deposits that fill monumental ditches, whose processes were subsequently explained in more detail by Limbrey (1975), and which has recently been expanded upon by Allen (2017b) (Table 1).

The work was nothing short of seminal. Keith Wilkinson (2011) described Evans as undoubtedly the father of archaeological malacology, while Mike Allen (2009: 3) went even further, stating that Evans "almost single handedly developed the discipline of environmental archaeology".

Studies since 1972

From his position at Cardiff, Evans continued his work in archaeological malacology, joined by an increasing number of other workers from the late 1970s. From his own perspective, according to his Cardiff University staff profile the year before his retirement, the heyday of his malacological work was the period 1985–1995. During this time, he supervised 10 doctoral students to completion and held numerous

Table 1. The amended tripartite sequence of monumental ditch fills (after Evans 1972; Limbrey 1975; Allen 2017b).

Deposit	Formation
Initial wash	Redeposited parent material (i.e. the geology or subsoil) and fallen turves, formed during the first episodes of rainfall. It is usually only a few centimetres thick, and most likely formed during the first 1–2 winters the ditch was open. Added by Allen (2017b).
Primary fill	Derived from weathering (rainwash and frost-shattering) and collapse of the sides of the ditch, and falling turves and topsoil. It is often poorly sorted. Because it is episodic (more likely to occur during rainfall or when there is frost) it can appear laminated and/or lumpy. In most cases it forms within a few decades of the ditch being opened. It can form in the corners of flat-bottomed ditches and at the bottom of V-shaped ditches.
Secondary fill	This forms once the ditch cut is relatively stable and the slope of the slides has become shallower. It comprises ditch silts and weathered topsoil and is fairly slow-forming (several decades to centuries). May show bedding.
Stabilisation/soil formation	This stage occurs when the sides and bottom of a ditch have been colonised by vegetation, and there is little erosion. Sediment accumulation is therefore replaced by soil formation.
Tertiary fill	This is the final infilling of most ditches, bringing the top of the ditch up to the level of the ground surface that occurs after the ditch is no longer in use. It usually consists of colluvium or ploughwash, although it may be deliberate backfill. This means it is also likely to be poorly sorted.

research grants (Evans 2001a). In a productive period in the 1990s, he also diverged into studying freshwater ostracods (e.g. Griffiths *et al.* 1993). Prompted by criticism of environmental archaeology from archaeological theorists (see, for example, Thomas 1990) in the late 1990s and early 2000s, he began turning his attention towards "a clearer understanding of how people and the biophysical environment interact and work" (Evans 2001b). This culminated in two rather theoretical books, *Land and Archaeology* (Evans 1999) and *Environmental Archaeology and the Social Order* (Evans 2003).

The arrival of new workers injected new ideas into molluscan studies, and several new themes were explored. Themes explored below include in the timing of woodland clearance and molluscan responses to woodland regeneration in prehistory, new approaches to sampling, changes in the context within which archaeological work took place in the United Kingdom, and new analytical approaches ranging from statistical techniques to stable isotopes, population genetics and human social engagement with shells. Whereas Evans's work in *Land Snails in Archaeology* was based on vertical sequences of samples from the fills of excavated features on archaeological sites, and he extrapolated from these to describe archaeological landscapes, from the end of the 1970s work began to be carried out on contexts away from the monuments themselves. The density of studies from key landscapes (especially in the Wessex Chalk around Dorchester, Avebury, and Stonehenge) also increased. The benefit of this, as Allen (1997: 115) pointed out, is that increased resolution of the data allowed interpretation of the "landscape mosaics *within* archaeological landscapes". The regions studied have tended to be concentrated in southern England, however, largely due to better conditions for preservation that may be found on calcareous geologies there.

Higher resolution mapping of archaeological landscapes

Temporal complexity of woodland clearance

In *Land Snails in Archaeology*, Evans had established that many Early Neolithic (4000–3500 BCE) long barrows were built on arable land, which had already been cleared of woodland very early in the Neolithic period. As the geographic scope of studies expanded in the 1980s and 1990s, it became clear that the timing and rate of woodland clearance across the regions varied from the Mesolithic (9500–4000 BCE) to the Late Bronze Age (1150–800 BCE), and in some cases into the Medieval period (350–1500 CE). As examples of this, Martin Bell's (1983) work on the South Downs, using "offsite" analyses (in particular trenching through dry valleys), showed that the clearance that contributed most to soil erosion took place from the Bronze Age (2500–800 BCE). Similarly, at Holywell Coombe, Folkestone, Kent, Richard Preece and David Bridgland (1998, 1999) demonstrated that hillwash—the result of felling trees—accumulated from the Neolithic to Medieval periods, with a major clearance episode in the Early Bronze Age (2200–1500 BCE). Meanwhile, Ken Thomas's (1982) work elsewhere in Sussex showed that Neolithic causewayed enclosures were built on recently cleared land, suggesting clearance on the Downs was episodic and local. Additionally, though, increased spatial resolution of studies across landscapes has made significant contributions to an understanding that the presence of climax woodland before agriculture should not be assumed. At Cranborne Chase in Dorset, for example, analysis of snails from 22 sites has failed to identify any evidence for extensive closed-canopy post-glacial woodland (Allen 2017c).

Lateral sampling of archaeological deposits

Evans's doctoral work, like the work of Sparks and Kerney before him, was based on vertical sequences of samples derived from open sections (some of the Quaternary work was also based on samples from boreholes, e.g. Sparks (1957)). However, the excavation of monuments, structures, and landscapes subsumed by flooding or aeolian sand deposits or those buried through monument construction exposes laterally extensive deposits, such as buried soils and floors, within which spatial variation may be detected. At the Neolithic long barrow at Easton Down, Wiltshire, a vertical sequence of samples taken through a pre-mound soil suggested that the monument was constructed on grassland that had already been cleared of woodland and cultivated. A second series of samples, taken laterally across the pre-monument soil underneath the monument itself, also contained predominantly open-country fauna. Shade-demanding taxa formed a minor component, however, becoming more significant in the south-west corner of the buried soil. Clearly, this was a vegetational boundary. On molluscan evidence, it could be interpreted as a change to more rank vegetation in this area, or proximity to woodland. Other evidence suggested a grassland: woodland boundary was the most likely explanation (Whittle *et al.* 1993). Other examples of lateral sampling of buried soils include the Late-glacial "Allerød soil" at Holywell Coombe, Folkestone, Kent (Preece & Bridgland 1998, 1999); the Lower Palaeolithic (*c.* 950–300 ky BP) Goodwood-Slindon Raised Beach in Sussex (Preece & Parfitt 2022); and the Mesolithic tufa at Langley's Lane in Somerset (Lewis *et al.* 2019).

The changing context of archaeological practice

Taking a step back from thinking about snails themselves, one of the largest changes to archaeological practice in Britain since 1972 was the adoption of *Planning Policy Guidance 16 Archaeology and Planning* (PPG16) in 1990, followed by its successor *Planning Policy Statement 5: Planning for the Historic Environment* (PPS5) in 2010 (Flatman & Perring 2012; Howard 2019). Rescue excavations have also been carried out in cases where sites are protected for their geological potential, for example the Channel Tunnel site at Holywell Coombe in Kent (Preece & Bridgland 1998, 1999). PPG16 enshrined archaeology within the planning process for urban and rural development, in some cases requiring developers to fund archaeological excavations and associated analyses. This has resulted in an increase in the number of archaeological investigations being carried out in Britain, broadening the geographical coverage of archaeological investigations. It has also led to an increase in the number of samples available for analyses. Interestingly, though, a 2007 review of archaeobotanical work in Romano-British (43–350 CE) contexts found that both the number of samples taken and the quality of the data produced declined in the 1990s compared to the 1970s and 1980s (van der Veen *et al.* 2007). This situation has improved considerably since then, however, often through the actions of statutory heritage protection bodies who give advice, provide oversight, and encourage standardisation (e.g. Campbell *et al.* 2011).

Although the professionalisation of archaeology has been beneficial in that it has increased the amount of data available for synthesis, it has meant that an increasing amount of data is contained within "grey literature", which, despite the efforts of schemes like the Archaeology Data Service's Grey Literature Library, is limited in its discoverability (this was also a problem that van der Veen et al (2007) identified). It has also meant that an increasing number of samples are not taken in the field by specialists, and that specialists are increasingly offered shell from the washovers (or flots) of large bulk sediment samples for identification only, rather than complete samples.

Such bulk samples will have been processed using a Siraf-style flotation system, designed for botanical analysis, which separates a light fraction that floats from a heavy residue that sinks (Williams 1973). Many snail shells do float, although others, likely including the internal plates of slugs, or shells that expand rapidly and thus are apt to fill with sediment such as *Vitrina pellucida*, may not (Thew & Law 2021), with the result that such samples are often inherently biased and yield an incomplete picture of the true shell assemblage. Thomas and Zapata (2018) investigated "underperformance" of flotation systems for land-snail recovery at a site in the Basque Country and found that although some species were underrepresented in flotation compared to wet sieving and noted that it was difficult to determine what factors of shell morphology might drive this underperformance. The fragility of shells and their tendency to fragment are likely to be influences, however. Examination of both light and heavy fractions is clearly necessary to view the full range of species in a sample.

Evolving analytical frameworks

In 1985, Ken Thomas published an important review of the theoretical basis for land-snail analysis in archaeology (Thomas 1985). His analysis examined key themes, particularly the methods used to quantify assemblages. He specifically critiqued the overuse of percentage data in analysis, noting three main problems: percentages can suggest false ecological relationships between species, they can be skewed by the super-abundance of just one or two species, and they may distort the importance of changes in species' relative abundance. This echoed earlier critiques by Kerney (1963). Thomas (1985) also observed that although ecological groups were useful, they served to mask fine details and that examining species associations within assemblages might be more revealing. Work by Robert Cameron (Cameron 1978; Cameron & Morgan-Huws 1975) and John Evans with Hilary Jones (Evans & Jones 1973) had shown that species within the "shade-loving" category in particular may reflect a range of habitats such as rank grassland (which may be dominated by *Carychium tridentatum* with no open country taxa) or rock rubble (where *Oxychilus* spp. and *Gonyodiscus rotundatus* may be common), and so "shade-loving" should not be seen as an indicator of woodland.

A further problem with the generalisation implicit in the use of ecological groups is that several species may have more restricted ecological niches at the edge of their geographical range. *Helicidonta obvoluta*, for example, is a species of ancient woodland in Britain but occurs in a far wider range of habitats across Europe, while *Alinda biplicata*, thought to be a Roman introduction to the British fauna, is a rare species restricted to a few sites along the River Thames in and around London, yet is the most common clausiliid in Europe (Kerney 1999; Welter-Schultes 2012). *Ena montana*, considered an anthropophobic snail of old woodland in southern England, is associated with hedgerows in southern Europe and appears in Neolithic and Bronze Age contexts at archaeological sites that had already experienced woodland disturbance (Kerney 1968; Robinson 2009). Species may also move into new ecological niches over time, a phenomenon which Evans (2004) examined in relation to the spread of *Lauria cylindracea* into open grassland and sand dune habitats in western and northern Britain over the past 2000 years. As Thomas (1985) noted, it may be the case that the ecological signal of individual species changes over time in a sequence of samples.

Thomas (1985) also explored important issues such as the rate of species' responses to ecological change, and the stratification of land snails within buried deposits, with the attendant risk of time-averaging. These problems seem to be very fundamental obstacles to any hope of interpretation of subfossil land snail data at any kind of meaningful resolution, although Thomas (1985: 131) did concede that "land snail analysis in archaeology has 'worked' because the data generally make ecological sense, even if some of the assumptions of the empirical approach are rather shaky".

Numerical analysis

Thomas (1985) observed that land-snail analysis lagged behind other paleoenvironmental proxies, particularly insect analysis, in its application of numerical techniques such as diversity indices and other statistical methods. However, this gap began to close during the late 1980s and 1990s, as researchers increasingly integrated ecological principles into archaeological land-snail analysis. This period saw the adoption of ecological statistics, concepts like taxocenes and studies of modern snail stratification and response rates—all of which enhanced archaeological interpretation.

Reading of the work of quantitative ecologists such as Anne Magurran (1988) and Evelyn Pielou (1977) led to Evans introducing diversity indices into his work, drawing important conclusions about the potential value of the difference between Shannon and Brillouin indices in understanding the "completeness" of a sample relative to the population from which it was drawn (Evans 1991). With his doctoral students at the time, he also began to explore the use of ordination techniques, in particular Hill and Gauch's (1980) detrended correspondence analysis, which organises the occurrence of species in a set of samples across multiple axes that account for the variation. The statistical turn in Evans's work was especially notable in his study, with his Ph.D. student Diane Williams, of snails from various sites along the route of the then new M3 motorway (Evans & Williams 1991) and the use of detrended correspondence analysis in the work of Evans's student Paul Davies (e.g. Davies 1998).

Other ideas Evans worked on have been less fully explored, such as plotting the behaviour of pairs of species against one another, which Evans attempted at Ergolding in Bavaria, finding that the abundance of *Vallonia costata* and *Succinella oblonga* were negatively correlated, and that *Zonitoides nitidus* and *Vallonia pulchella* were mutually exclusive (Evans *et al.* 1992). This technique for exploring data has not been widely adopted, although Evans (2004) plotted numbers of *Pupilla muscorum* and *Lauria cylindracea* at blown sand sites such as Ensay in the Outer Hebrides, but it may be revealing about aspects of environmental change in a sample sequence.

Taxocenes

Another of Evans's innovations of the 1990s was the introduction of the taxocene concept to archaeological land snail studies. Taxocenes are comprised of ecologically related species, and the members of a taxocene are likely to be closely analogous, having a similar size and similar life histories, and competing over both evolutionary and ecological time (Deevey 1969). The abundance of different species of snail may fluctuate due to a variety of ecological reasons, each of which may vary in significance in different places and at different times. This problem may be overcome by the observation that living snails occur in associations with particular relative abundances, and that distinctive assemblages of snail species recur in some palaeoecological contexts (Thomas 1985; Evans 1991; Evans *et al.* 1992). As these tend to be limited to a single taxonomic group in palaeoecology, the term taxocene is preferred over community to describe these associations (Evans 1991).

Within a taxocene, interaction both between the member species (directly in terms of competition for food, and indirectly in terms of being the choice of a particular predator), and with the environment, are of fundamental importance. The taxocene concept does not counter the problems of habitat variation across the entire range of species however (Evans 1991), and so can only be expected to work on the local or regional scale, because climatic variation can lead to differences even when environments are otherwise similar (Evans 1991). Taxocenes should also include species that encounter one another; thus, taxocenes have restricted territorial and environmental dimensions (Hulbert 1971: 585). In his Ph.D., Tom Walker (2014: 21) also noted that "they cannot be applied to all assemblages as there are insufficient numbers of shells or species to determine groups of taxa. Also, it is clear that taxocenes may not necessarily apply across different sites where microhabitats may vary over often short distances".

Evans defined a series of wet and dry ground taxocenes applicable to sites in central southern England, while the number of wet-ground taxocenes were subsequently expanded by Paul Davies (Davies 1998). Over 30 years later, however, the concept has not been widely adopted in archaeological land-snail studies, although they have been used in a few cases by workers, such as Sarah Wyles looking at snails from the route of the A303 road (2008) and in a review by Mark Robinson of molluscs from alluvial sequences in the upper Thames (Robinson 2017). More work is certainly needed to expand the taxocene concept beyond its current geographically limited range.

Stratification and taphonomy

As Evans was exploring numerical approaches and taxocenes, Ken Thomas's Ph.D. student, Stephen Carter, was exploring the rate in which land-snail shells become incorporated into the soil horizon and how long the shells of different taxa persist in the topsoil (Carter 1990). By examining the annual input of shells of different species into the soil and from a combination of that and the number of shells of a given species within the whole "A horizon" profile he calculated their mean residence in the soil before degradation. Larger species, which have robust shells and lower input numbers, had residence times much larger than smaller species (335 years for *Helicella itala*, against 25.6 years for *Pupilla muscorum* and 5.7 years for *Cochlicopa lubricella*, the latter a larger shell than *Pupilla* but with a relatively fragile apex).

The implication is that more robust shells in a sample are likely to represent a larger timespan than fragile or smaller shells, giving rise to the suggestion that a buried soil horizon rich in *Helicella* and *Vallonia* spp. may have contained more *Vallonia* shells when it was accumulating than have survived to the present day. Preservation bias was noted by Preece *et al.* (2007) at the Palaeolithic site at West Stow, Sussex, where separate counts were made of apical and apertural fragments of several species. More recently, Yurena Yanes (2012) scored shells against six taphonomic variables and used statistical analysis to assign them to taphofacies, or layers of sediment with different degrees of shell preservation. At the very least, a simple estimate of the ratio of shells judged to be "fresh" (translucent, or with the periostracum intact) to those that are more worn can be given to highlight the input of recent shells through the action of burrowing organisms such as earthworms (Law 2020).

Responses to ecological change and boundaries

A component of Paul Davies's work in the 1990s and 2000s was the use of modern molluscan studies to understand the rate with which different species respond to ecological change. Inspired by the work at Easton Down long barrow in Wiltshire, southern England (Whittle *et al.* 2003), he investigated the snails of a woodland–grassland boundary, finding that shade-demanding taxa will cross the boundary into grassland. Some species (such as *Carychium tridentatum*, *Clausilia bidentata*, and *Aegopinella nitidula*) travel further (up to 2.5 m in the case of *C. tridentatum*) than others, although in general there is little spatial overlap and a sample taken a few metres from woodland may show no indication of its proximity to that habitat (Davies 1999). Studies of relatively narrow (up to 10 m wide) clearings revealed that discrete grassland fauna can become established, with the implication that it may not be possible to differentiate between small and large clearances (Davies & Gardner 2009). However, it was also revealed through Neville Gardner's work at the Warburg Reserve in Oxfordshire that woodland fauna may persist in a clearance for 15–20 years after opening before an open-country fauna became dominant (Davies & Gardner 2009).

Woodland regeneration during the Late Neolithic (3000–2500 BCE) has been identified within some long barrow ditches, notably Easton Down (Evans 1990; Whittle *et al.* 1993). Paul Davies and Colleen Wolski (2001) applied studies of the migration rates of different mollusc species into recently planted woodland at Pennsylvania Farm, near Bath, in combination with the calibrated ranges of radiocarbon dates, to estimate the distance to refugia for shade-demanding species from the monuments, concluding for example that the maximum distance from woodland of the Giants' Hill 2 long barrow was 568 m. The work was very much a pilot study but demonstrates the potential offered to archaeological interpretation by studies of living molluscs.

Site formation processes

Other workers, notably Nigel Thew (2003), began to think in terms of how the numbers of shells in a sample and diversity of taxa may reflect the rate of sediment accumulation. Slow-forming archaeological deposits tend to contain both more shells and greater species diversity, as they provide more time for shells to become incorporated and for different species to colonize the area. This consideration has the benefit that it allows land snail assemblages to tell us something of archaeological value without making any reference to past species ecologies, avoiding uniformitarianist assumptions. However, taphonomic processes, and especially the inclusion of residual shells from material excavated to dig features such as pits and ditches, or that have been brought into the sediment through the action of worms and other burrowing animals, complicates interpretation (Allen 2017b).

Certain species of snail may be favoured by human activity such as middening or intensive ploughing. Middening, the practice of spreading domestic waste across fields to improve soil fertility and confer stability on sediments prone to aeolian erosion, may favour omnivorous species such as *Oxychilus alliarius* (Thew 2003). By looking at laterally distributed samples across sites and considering the ecology of both individual species and species associations, Thew was able to differentiate areas where midden material had been spread.

Biogeography

The importance of arrivals and extinctions in the subfossil record has been recognised since the early days of Quaternary malacology, but the suitability of species for use in relative dating is becoming increasingly recognised, in particular, through studies of tufa sequences in southern Britain that span the Lateglacial and Holocene (e.g. Kerney *et al.* 1980; Preece 1980b). Some key studies established our understanding of species arrivals following the Late Glacial. These include Holywell Coombe, Kent, where pollen, plant macrofossils, and insects were also preserved, allowing the molluscan succession to be tied to that of plants and insects (Preece & Bridgland 1998, 1999). The idea that *Cornu aspersum* is a Roman introduction to Great Britain and thus does not pre-date the Romano-British period is well known (Kerney 1966, 1977), and other late arrivals in the British fauna such as *Cochlicella acuta* have been similarly used as chronological markers (Davies 2010; Walker 2023). There is a risk that such arguments may be circular, however, although the advent of accelerator mass spectrometer (AMS) radiocarbon dating and studies that have found that small terrestrial gastropod shells may yield reliable radiocarbon dates (e.g. Pigati *et al.* 2010) stands to advance our understanding of the biogeography of later arrivals. Tom Walker directly radiocarbon dated *Cochlicella acuta* at Godrevy Towans, Cornwall, to 2570–2350 cal BCE, spanning the late Neolithic–Early Bronze Age (or Chalcolithic) transition, although he acknowledges that "old" carbon may have been incorporated into these shells, as modern shells of that species gave anomolously old dates (Walker 2018, 2023). Walker speculated that the species may have been introduced by traders from the continent, an important reminder that behind the movement of snail species is (often) archaeologically significant human activity.

Shell polymorphisms and morphometrics

Studies of modern fauna have shown that many snails respond to small-scale changes in vegetation or other environmental controls, and Thomas (1978) noted that such small-scale factors can lead to morphological differences between populations of the same species. This kind of variation has been observed in *Cepaea* spp., whose colour and banding may be a response to environmental factors (Currey & Cain 1968) and *Cepaea nemoralis*, whose size and shape (including relative size of the aperture) may be environmentally determined (Thomas 1978). *Cochlicella acuta* also shows colour variation related to vegetation (Lewis 1975). Goodfriend (1986) reviewed a number of species worldwide that show phenotypic plasticity, which may have archaeological relevance—commonly, shells of many species (generally larger species, in particular Helicidae) may be larger with higher rainfall, larger on high-calcium soils and smaller with higher population density, although the same change in an environmental variable may elicit a different phenotypic response from different species; for example, a rise in temperature may cause some snail species to become larger, others smaller, and other species may be unaffected (Reyment 1971: 71).

Despite pleas from Thomas (1978, 1985; reiterated by Evans *et al.* 1992), studying morphological variation within species remains an underinvestigated area of archaeological interpretation, although some metrical data from archaeological specimens has been published, leading to the conclusion that *Pomatias elegans* from the early Holocene climatic optimum tend to be significantly larger than modern populations from the same site (Kerney *et al.* 1980; Preece 1980b; Bell 1982; Burleigh & Kerney 1982), and that modern specimens of *Cernuella virgata* were significantly larger than those recovered from a late Holocene hillwash at Gore Cliff, Blackgang Chine, Isle of Wight (Preece 1980a). Comparisons between pre- and post-Iron Age assemblages of *Cepaea nemoralis* show pre-Iron Age contexts to have more unbanded and mid-banded forms, which are favoured by better summers (Currey & Cain 1968; Bell 1982).

Perhaps the most fully realised exploration of intraspecies variation to date was the study of the Australian snail *Pleuropoma extincta* by Rowe *et al.* (2001). Here it was found that rates of shell growth, as determined by size-correlated differences in whorl counts, are sensitive to moisture levels in the environment, and that the shells can successfully be used to reconstruct past changes in rainfall levels. Goodfriend (1992) reviewed several land-snail studies that have sought to reconstruct past moisture levels, along with other palaeoenvironmental factors.

A future direction for such work is the use of geometric morphometrics, a set of techniques that allows the recording and analysis of the shape of objects using Cartesian coordinates (x, y, z) of "landmarks" (assigned points) on the object rather than more traditional linear measurements.

This has the benefit that it allows consideration of small but significant geometric differences in the overall shape of an object that may not be recorded by linear measurements alone. Law (2023) presented one method of two-dimensional geometric morphometrics for gastropod shells.

Stable isotopes

Aragonite, one of the three most commonly occurring crystal forms of calcium carbonate, from mollusc shell is suitable for isotopic analyses. Oxygen-isotope analyses in particular have been carried out using shell aragonite from a number of sites globally (e.g. Jenkins *et al.* 2022). The isotope ratios may be used to reconstruct past climatic conditions, the $\delta^{18}O$ in the shells being primarily controlled by water ingested by the mollusc (Colonese 2017). However, in both terrestrial and especially freshwater shells several environmental variables, along with seasonal variability in individual species' metabolic activity, may influence the $\delta^{18}O$ of shell carbonate. In temperate regions, temperature and humidity tend to be the dominant variables, whereas in humid regions the dominant variables are meteoric water or precipitation (Prendergast & Stevens 2014).

In the case of molluscs collected for food, oxygen isotope analysis of the final growth increment (in gastropods, the edge of the shell lip; in bivalves, the outermost edge of the shell) may reveal the season of harvesting (Yanes *et al.* 2013). Carbon isotope ratios ($\delta^{13}C$), meanwhile, reflect the isotopic composition of vegetation, and especially whether plants use C_3 or C_4 photosynthetic pathways (Jenkins *et al.* 2022).

Shell assemblages and climate

Another approach to climate reconstruction using land-snail-shell assemblages is the Mutual Climatic Range (MCR) method. This was originally developed for beetle assemblages (Atkinson *et al.* 1987) and has been applied to large-scale climate change through the Quaternary. In this approach, the past climate of a location can be defined by the overlapping range of climatic conditions which would permit the taxa found within a sample to coexist (the climatic envelope of the individual species) and is expressed in terms of the mean temperature of the warmest and coldest months (T_{MAX} and T_{MIN}) (Moine *et al.* 2002). Some of the species found in Britain may be limited by climatic factors (e.g. *Pomatias elegans* (Kerney 1968, 1999) or several of the *Vertigo* species such as *V. alpestris* and *V. genesii* (Kerney 1999)), and contractions in the ranges of some species since the climatic optimum between 7 and 5 ka BP have been observed (Kerney 1968; Limondin-Lozouet & Preece 2014), which suggest the method may be applicable to some British assemblages.

Population genetics

As described earlier, the arrival of new species is very likely to relate to issues of wider archaeological significance, such as the movement of people, plants, and livestock along prehistoric seaways. DNA analysis of living populations of latecomers to the British fauna across their European range may pinpoint their origin. Such work has been undertaken for *Cepaea nemoralis* in Ireland, revealing an Iberian origin for populations there (Grindon & Davison 2013). In this way, snails can reveal livestock trade networks that are not easily visible in the archaeological network.

Human social engagements with molluscs

Evans (2003: 45) argued that the experience of textures within the environment has not often been acknowledged as a medium of social agency, yet it is precisely land-surface textures—along with their distinctive ecological communities—that distinguish places from one another. In *Environmental Archaeology and the Social Order*, he speculated that:

> Even snails may have been introduced into an area or at least encouraged: many have a striking visuality in their shapes and different colour morphs. Many have vernacular names which go back to the Middle Ages or Celtic times and places like Snail Creep Hanging may be so called not for the presence there of edible species but for the general sense of snailiness their surfaces evoke. (Evans 2003: 250)

His study of the snails from the long barrow at Ascott-under-Wychwood, Oxfordshire, included consideration of how aware Neolithic populations may have been of different snails, and suggested that they may have sought to encourage some of the more visually striking taxa (Evans 2007). In this respect, his later writing anticipates the concept of "becoming-with" animals articulated by Donna Haraway (2008), in which humans learn to appreciate non-human species' capacity for meaning-making and worlding (Wright 2014).

The idea of becoming-with snails has recently been explicitly considered in Hawaii in relation to the invasive *Euglandina rosea* and the threatened native *Achatinella* spp. on which it preys, demonstrating the importance of enhancing understanding of both prey and predator to navigate a future in which both are features of the island fauna (Galka 2022).

It is worth noting that some of the snail assemblages covered in our work would also have been quite visible to the people moving within the landscape. Whereas the early

Vallonia–Pupilla fauna of open coastal grassland is almost invisible due to the small size and relatively low frequency of the snails, the *Helicella–Cochlicella* fauna that often succeeds them is likely to have been noticed for the strikingness of the striped shells and their habit of resting high on the stems of long dunefield grasses. Similarly, the hydrobiid mud snails of intertidal alluvium and brackish-water lagoons and ditches commonly occur in dense populations millions strong, which give the clays a gritty appearance that would have been immediately distinctive.

Expanding archaeological contexts

A final area of growth, fuelled partly by the rise in developer-funded archaeology in cities, has been the investigation of urban deposits and domestic spaces. Such contexts have largely been overlooked within syntheses of archaeological land snail analyses, which have tended to concentrate on vegetation reconstruction (Evans 1972; Davies 2008). In part, this may be because there are often low numbers of individuals recovered from such samples, and they may reflect unstable, transient environments. However, they also offer opportunities to investigate the ecological history of synanthropic species, and the arrival of new species in hubs of international trade, and so even assemblages comprising low numbers of shells may be of interest. As an example, increased human activity during the post-Roman period in Oram's Arbour ditch, Winchester, was linked by Thomas (2009) to a rise in numbers of the synanthropic *Trochulus striolatus*. In general, cities and towns are rarely considered as wildlife habitats, although in modern times they are becoming wildlife refuges (Caiza-Villegas *et al.* 2022), and unique urban habitats may have existed in different locations at different times in the past that may have favoured certain species in the same way that the seaweed fly *Thoracochaeta zosterae* was found in Medieval cesspits in cities as far from the coast as Oxford (Webb *et al.* 1998).

The analysis of shells from archaeological remains of buildings can also yield significant results. Recent work in the Bronze Age roundhouses at Cladh Hallan on the island of South Uist in the Western Isles has shown that shells from housefloor deposits may reveal materials imported into houses (turves, reeds, and seaweed) as well as episodes of floor maintenance through the addition of blown sand. Rupestral species such as *Clausilia bidentata* and *Lauria cylindracea* may feed on algae accumulations on the surfaces of walls (Thew & Law, forthcoming). Shells may also be present in building materials such as mortar, where they may provide clues as to the origin of the sedimentary component used in the manufacture of the material (Law 2014). There are several routes through which snails may enter house deposits, many of these are of archaeological concern even when shells occur in low numbers, as they may reveal aspects of past human behaviour (Fig. 2).

Agendas for the future

Some key priorities for archaeological land-snail analyses should be addressed to maximise the discipline's value to studies of past human-environment relations. Compared to the end of the 20th century, work on land snails from British archaeological sites in the early years of the third decade of the 21st century has been rather more focused on the analysis and interpretation of assemblages as part of larger excavation reports. There has been rather less work on methodological refinements, applications of archaeological data to present-day environmental challenges, or on

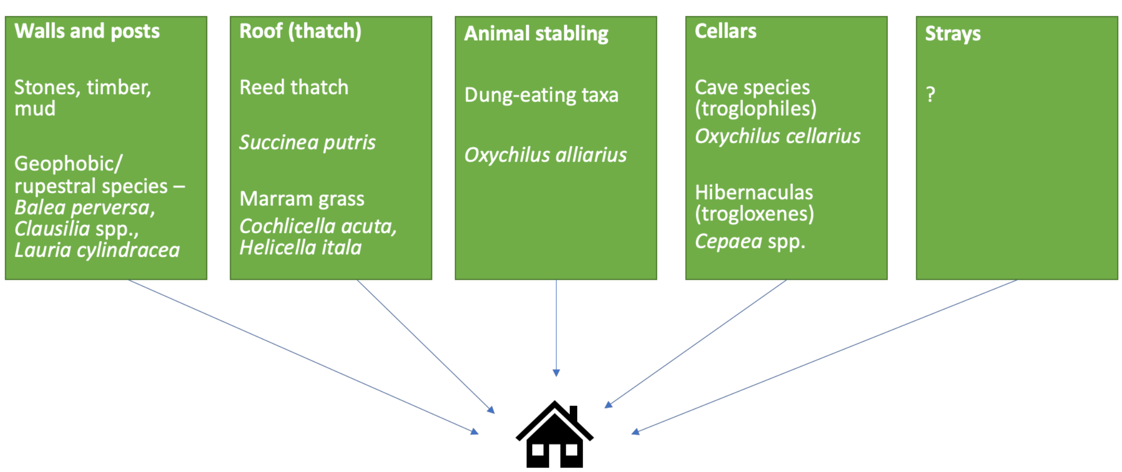

Figure 2. A conceptual model for snail shells in house deposits. Strays could be any species that enters a house through chance.

hypothesis testing. That is not to discount this kind of analysis, which can provide data for hypothesis testing, although discoverability (and accessibility once discovered) of the datasets remains an obstacle, with most work residing in unpublished reports or as tables within excavation monographs. Methodological advancements could include further application of statistical techniques and of digital tools for analysis.

Lodwick (2019) reviewed the practice of archaeobotany and found that, in comparison to vertebrate zooarchaeology, studies of archaeological plant remains, especially in Britain, are less theoretically engaged, and less likely to make use of digital analysis. The same can be said for archaeological land-snail analyses, and indeed environmental archaeology as a whole. Howard (2019) noted that it is developer-funded archaeology that pays for most environmental archaeologists in Britain, and as Pearson (2019) laments, time for research is seldom included in project budgets, which with the exception of some larger projects are not required to advance synthetic research. Making funding available, for example from specialist research groups and national research councils, for syntheses of contract projects and investigation of the research questions that arise from them, as well as supporting the adoption of new methods, should be a priority.

A further danger for the future is that there is not a structured supply of new workers into the discipline. Many of the authors whose work is discussed above are retired or close to retirement, and few people remain in university posts where new generations of students may be trained. This situation is unlikely to be unique to archaeological land-snail analysis within environmental archaeology, and wider succession planning for primary identification skills is urgently required. Funding for specific training programmes and workplace mentoring should be explored to ensure the future vitality and rigour of the discipline.

Conclusions

With *Land Snails in Archaeology*, John Evans played an instrumental role in establishing environmental archaeology as a science in the United Kingdom and laid the groundwork for over five decades of land-snail analyses. He continued to refine methods until his early death, in particular by drawing on modern ecology. With the input of other workers, including several of Evans's doctoral students, land snail analysis in archaeology developed into an established discipline over the last decades of the 20th century. The growth of the discipline enabled new histories of environmental change to be written. These have ranged from the scale of the rates of infilling of single archaeological features to broader topics of woodland clearance and regeneration, and agricultural land use such as middening. Emerging scientific approaches such as stable isotope analysis, population genetics, and shell morphometrics, as well modern studies of species' responses to ecological change, remain to be fully explored and offer promising new avenues for research. Challenges exist in the form of succession planning and being available for methodological research, however, addressing both of which would enable a return to the vigour the discipline enjoyed in the 1980s and 1990s. It is hoped that the above review will stimulate some discussion of the directions in which land-snail analysis in archaeology has successfully grown in the past 50 plus years, and some of the fertile grounds for future development of the discipline.

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