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Author(s): Jonathan D. Radley

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Fossil invertebrates: new perspectives, meanings and values in a smaller museum

Jonathan D Radley

Warwickshire Museum, Market Place, Warwick, Warwickshire CV34 4SA,
and School of Geography, Earth and Environmental Sciences, University of Birmingham,
Edgbaston, Birmingham B15 2TT
Email: jonradley@warwickshire.gov.uk

Introduction and background

Great Britain's rich legacy of palaeontological collections in museums stems largely from the early nineteenth century 'Heroic Age' of British geology. At that time, systematic collection of well-preserved fossils was a core activity of the new science, enabling museums and other learned institutions to recreate in their cabinets what was perceived as the natural biological and stratigraphical order, and to provide the material evidence for the new scientific rationale. Systematically arranged collections and displays of the country's fossil wealth proliferated, reflecting the emerging taxonomies that underpin biological and palaeontological classification, and the stratigraphic succession revealed by William Smith's geological maps (Morrell, 1994; Knell, 1996). Today, palaeontological collecting in many museums is strongly influenced by the systematic tradition – the acquisition of well-preserved or hitherto unrepresented fossil species as vouchers for ancient biodiversity and evolutionary change.

The palaeontological sciences have changed immeasurably since the 'Heroic Age'. Subdisciplines have proliferated; treating fossils as the remains of once-living organisms and/or integral components of broader physical and biological systems (Briggs & Crowther, 2001). Amongst the subdisciplines, palaeoecological studies view fossils as components of former ecosystems. To take another example, biostratinomic studies utilise fossils as vouchers for physical and chemical processes such as sedimentation and weathering. Consequently, palaeontological collections are revealing new meanings, significances and values, as their wider scientific potential is realised.

Numerically, the macrofossil record is dominated by remains of marine invertebrates which are the principal components of many palaeontological collections. Historically, as vouchers for fossil species and for display purposes, well-preserved, representative specimens of fossil invertebrates have often been favoured. Such specimens can provide important information on a range of palaeoenvironmental parameters including sedimentation rates, benthic oxygenation, palaeoclimates and/or oceanographic circulation patterns. 'Imperfections', such as bioerosion traces, abrasion and shell breakage patterns, are also potentially of considerable palaeobiological and palaeoecological value, as well as broader palaeoenvironmental (essentially non-palaeontological) interest. Furthermore, ancient skeletal concentrations (e.g. shell beds) can reveal important information bearing upon hydrodynamic activity, bathymetry, depositional rates, chronostratigraphy and sequence stratigraphy (Kidwell, 1991; Kidwell & Bosence, 1991).

This paper explores the theme of information gain from palaeontological collections with special reference to fossil marine invertebrates which feature significantly in the collections of the Warwickshire Museum (Warwick, England). The museum's collections were initiated in 1836 by the Warwickshire Natural History and Archaeological Society. One of the society's main aims was to house and display a geological and palaeontological collection at their museum in the county town of Warwick. The collections soon grew, incorporating stratigraphical and palaeontological voucher specimens from local sites and further afield. In 1932 the collections were transferred to the Warwickshire County Council. A museum was re-opened at the Warwick Market Hall in 1951, where the Warwickshire Museum has been located to the present day. The palaeontological collections continue to grow in accordance with the current acquisitions and disposal policy, and are stored within a traditional taxonomic and stratigraphical framework.

Biostratinomy

Biostratinomic studies treat modern and fossil skeletal elements (such as shells and bones) as sedimentary particles, and document their pathways between death of the parent animal and final burial. As such, preservation style of discrete skeletal particles can provide important information on a range of environmental parameters including pre-burial weathering or corrosion processes, sedimentation rates and water depth (bathymetry). In addition, the overall sedimentary fabric ('biofabric') of a modern or ancient skeletal concentration will often indicate the final concentrating mechanism (e.g. storm deposition, fair-weather winnowing, or mud-flow deposition).

Warwickshire Museum's palaeontological collection is rich in Jurassic echinoderm material (principally echinoids and crinoids) collected from local sites and 'classic' localities (many of which are no longer extant) further afield. Amongst the crinoids there are intact groups of the Lower Jurassic pseudoplanktonic taxon *Pentacrinites fossilis* Blumenbach from the West Dorset coast (Fig. 1), and typically complete calices of Middle Jurassic *Apiocrinus parkinsoni* (Schlotheim); collected long ago from Bradford-on-Avon, Wiltshire. Representing multi-element structures, calcite crinoid skeletons commonly disarticulate rapidly after death of the parent animal. It is thought that the articulated skeletons of *Pentacrinites fossilis* were preserved through burial in anoxic mud (Simms, 1986). Complete calices of *Apiocrinus parkinsoni* represent shallow-water, hard-substrate crinoid 'meadows' that were preserved by subsequent mud deposition (Palmer & Fürsich, 1974). Thus, specimens of this type, representing vouchers for Jurassic invertebrate species, can also function as vouchers for geochemical and sedimentary processes. In the stratigraphic record, crinoidal limestones confirm the breakdown of countless crinoid skeletons through time, under conditions of slow to moderate net sedimentation (Ausich, 1997). Within the Warwickshire Museum collection, such scenarios are represented for example by crinoidal limestone slabs collected from the Lower Jurassic Blue Lias Formation of eastern Warwickshire, as well as specimens of Lower Carboniferous limestone.

Fig. 1. *Pentacrinites fossilis* Blumenbach. Lower Jurassic Charmouth Mudstone Formation, West Dorset coast, England. Warwickshire Museum specimen WARMS G10385.

Skeletal growth studies

Invertebrate growth lines, commonly preserved on and within fossil shells and coral skeletons, can provide a high-resolution record of environmental change and events during life of the parent organism. Many specimens of the Lower Jurassic oyster *Gryphaea arcuata* are present within the Warwickshire Museum collection. Recent studies (Jones & Gould, 1999) have identified annual growth bands on and within *Gryphaea* shells. A brief inspection of *Gryphaea* specimens within the collection has clearly revealed such growth bands (Fig. 2), underlining their additional value as repositories of geochronological and palaeoclimatic data.

Fig. 2. *Gryphaea arcuata* Lamarck, showing regular (probably seasonal) growth banding on right (upper) valve. Lower Jurassic Lias Group, locality unknown. Warwickshire Museum specimen WARMS G7730/2; length of specimen is 70 mm.

Bioerosion

Microscopic inspection of *Gryphaea* shell surfaces has additionally revealed previously undocumented grazing traces attributable to the feeding activity of regular echinoids and gastropods. Such traces indicate a former cover of algoids and/or bacteria on the Jurassic shell substrates, suggesting that the *Gryphaea* lived and died in shallow-water (photic) settings (Bromley, 1994). Accordingly these fossils are revealing a further significance as indicators of invertebrate activity, and as bathymetric (water depth) indicators.

Unsuccessful predation

Modern and fossil marine shells occasionally reveal repaired skeletal injuries. These are tolerably common in shells of gastropods which can retract the mantle margin deep inside the whorl, but are also sometimes revealed in bivalves (Vermeij, 1983). In modern and ancient shells collected from high-energy (typically littoral) settings, such sub-lethal breaks can indicate impact of shells against rocks or other hard substrates. In low energy, typically offshore settings, unsuccessful predation attempts are generally invoked and have an important bearing on predation rates and evolutionary escalation through time (Vermeij, 1987). Amongst bivalves, repaired breaks are now being recognised from Mesozoic and Cenozoic oysters (Dietl *et al*., 2000). Brief inspection of Warwickshire Museum's collection of Upper Cretaceous invertebrate fossils has revealed repaired breaks in examples of the oyster shell *Pycnodonte vesiculare* (Lamarck), collected long ago from the Chalk of Norfolk, eastern England (Fig. 3). The breaks closely resemble those figured from North American Cretaceous-Palaeocene shells and attributed to failed predation attempts by large durophages (Dietl *et al*., 2000). Importantly, once again, this demonstrates an instance of previously unrecognised palaeobiological information, revealed by historically collected specimens.

Conclusions

These new categories of information underline the need for curators and collectors to be aware of the ranges of data that fossils might encapsulate, above and beyond their value as taxonomic voucher specimens. This bears upon the value of collections as data repositories, and the nature of contemporary and future collecting. Fossil invertebrates act as vouchers for physical, chemical and palaeobiological processes, not just as 'fixed' biological species. As such, it is important to consider imperfect and/or otherwise abnormal specimens, during acquisition.

Fig. 3. Chalk oyster (*Pycnodonte vesiculare* (Lamarck)). Arrows indicate positions of repaired breaks, representing unsuccessful predation attempts. Warwickshire Museum specimen WARMS G3464/1; width of specimen is 48 mm.

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