Nature in Avon
Volume 82

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CONTENTS

Editorial

This editorial must begin with a big thank you to Dee Holladay who has retired as editor after an eight year stint at Nature in Avon. We are very grateful to her for all her hard work and pleased that she is still actively involved with the Society.

I have now taken over the reins (an appropriate metaphor as I am a keen horse-rider when not out naturalising) and would like to thank Dee for all her help in getting into the saddle, and for handing over such a well-schooled and elegant steed.

The geologists have been busy this year and we have a piece by Tony Kirkham and colleagues on Vanished Evaporites from the Eastern Mendips; and Deborah Hutchinson and Simon Carpenter describe two Dropstones from Jurassic deposits. Simon Carpenter and colleagues have also recorded two temporary exposures at Ston Easton in the Blue Lias and another temporary exposure, in Silurian rocks at Falfield, has been recorded by Charles Hiscock.

In a series of shorter pieces Jon Mortin describes a first for our region – living Pacific Oysters at Clevedon; Francis Gray and Peter Charles tell us about the Pollinator Capital of the UK project; and Harry McPhillimy shares his interest in Naturalists' Society badges.

We have a matching pair of articles in which our out-going President Ray Barnett describes 30 years of change in the invertebrate fauna of our area, whilst our in-coming President Rupert Higgins (as of March 2023) describes 40 years of change in the birdlife of Chew Valley Lake.

Ray also continues to provide our regular Invertebrate Report for the year and Barry Horton has again produced the Weather Report for the year, remarking upon the abundant continuing evidence of our changing climate.

Sadly, we have another Obituary, this time we are remembering Lesley Cox who was our hard-working Secretary for eight years. Then we finish, as usual, with the Society's Annual Report and Accounts for 2022.

My thanks to the members of the Editorial Committee, and many others, for their invaluable advice and help with this issue.

Dawn Lawrence

Vanished Evaporites in Dinantian Limestones of the Eastern Mendips, U.K.

By A. Kirkham,[1*] R.B. Pearce[2] and G. Evans[2,3]

Keywords: Bristol Diamonds, anhydrite, celestite, geode, Halecombe Quarry, Mendips

Abstract

Geodes from the Dinantian Black Rock Limestone or Vallis Limestone, Eastern Mendips, are considered to have had a similar origin to Triassic geodes containing 'Bristol Diamonds'. The Dinantian geodes appear to have formed by peripheral centripetal silica replacement of anhydrite nodules containing celestite and barytes. Various origins of the evaporite nodules are discussed in the absence of detailed facies analysis but their restriction to a relatively thin stratigraphic interval suggests that they formed penecontemporaneously and prior to severe Hercynian deformation. The origins of the quartz and sulphate minerals are also considered.

1 Introduction

This paper arises from the discovery of nodules and geodes in the Dinantian limestone strata at the giant working Halecombe Quarry (ST702 475), between Shepton Mallet and Frome, Eastern Mendips, U.K. (Fig. 1).

A nodule and a geode sample were collected from the Black Rock Limestone (Fig. 2) by Graham Evans during a Yorkshire Geological Society Field Meeting led by Ramsbottom et al. (1975). A thin section analysis of the nodule by Evans and Douglas Shearman at Imperial College at that time revealed quartz with anhydrite ($CaSO_4$) inclusions. The anhydrite was the catalyst for this study as it raised the question of whether it was related to an unexpected Dinantian sabkha environment, such as in the modern coastal sabkhas of Abu Dhabi (Evans et al., 1969), in that part of the stratigraphy. Unfortunately, that thin section was lost but the original geode has since been thin-sectioned again and used in this study. In 2008, collection of four additional geode specimens was undertaken, but under the quarry manager's strict supervision and time constraint due to his concerns about safety in the working quarry environment. There was insufficient time to log the succession and so the relative stratigraphical locations and detailed sedimentary environments of the samples are poorly understood. Halecombe Quarry has changed dramatically since Butler's (1973) research on conodont faunas there and it is impossible to relate the sampling to his logged sections, except to recognise that the samples were not collected from within his 'Main Chert' interval of the approximate middle Black Rock Limestone.

This paper describes the mineralogy and discusses a possible origin of the five available geode samples.

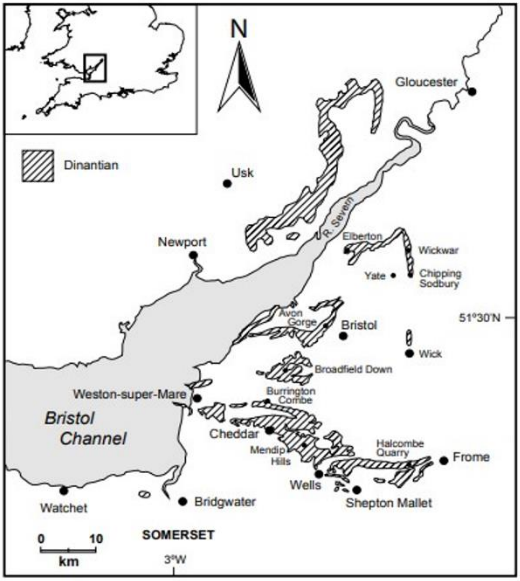

Fig. 1: Location map

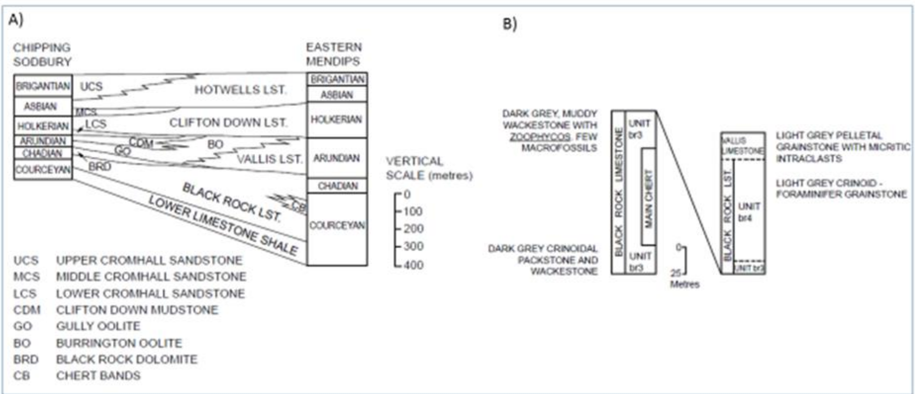

Fig. 2: Summary stratigraphy including regional substages: A) a north-south section Chipping Sodbury to Eastern Mendips; B) Black Rock Limestone of Halecombe Quarry (after Butler, 1973).

2 Methods

For thin-section making, rock slices were impregnated using a hardened, clear epoxy resin (AY105) with a refractive index (~1.54) similar to Canada Balsam. The slices were stuck to glass slides with a different epoxy resin and a refractive index again about 1.54; half-stained with alizarin red S and potassium ferricyanide; and finally cover-slipped using Canada Balsam.

Scanning Electron Microscopy (SEM) was undertake using a Zeiss Leo 1450VP SEM equipped with a Princeton Gamma Technology (PGT) light element energy dispersive X-ray microanalysis system (EDS). The SEM was operated using an Electron High Tension (EHT) of 20 kV and a working distance of 19 mm. Elemental spot analyses were acquired for individual grains and the principal mineral elemental components identified using Imix© software (manufacturer PGT). X-ray diffraction (XRD) analysis was applied to the 1975 geode.

3 Field Setting and Stratigraphy

At Halecombe Quarry, severe deformation during the Hercynian Orogeny led to steeply dipping Dinantian carbonates. They are unconformably overlain by horizontal Jurassic strata with the unconformity surface being remarkably planar. The Dinantian strata comprise the middle and upper Black Rock Limestone and overlying Vallis Limestone Formations although the contact between the two formations is difficult to define (Matthews et al., 1973). The Black Rock Limestone falls within the Courceyan-Chadian regional substages (Waters et al, 2011). It is known to thin northwards to beyond the Avon Gorge, Bristol, where a discontinuity is thought to occur at its top (Mitchell, 1971 & 1972). The Black Rock Dolomite caps the Black Rock Group in the Avon Gorge (Butler, 1973). The Vallis Limestone forms the lowest part of the Clifton Down Group and is a lateral equivalent of the Arundian Clifton Down Mudstone which outcrops further north around Bristol (Kellaway and Welch, 1955; Waters et al., 2011).

The nodules and geodes are sub-rounded and range up to several centimetres in diameter. They are embedded within a package of relatively thin, subvertically bedded strata (Fig. 3) although the exact horizon at which they occur within this Dinantian succession, or indeed whether they occur at other localities within the same formation(s), is unknown. Butler (1972 & 1973) did not refer to them, nor were they illustrated by Matthews et al. (1973) and Ramsbottom et al. (1975).

The four geodes collected in 2008 were embedded within limestones comprising bioturbated, fine grained, biomicritic wackestones/packstones with diverse marine fauna represented by finely comminuted bioclasts including brachiopod, bryozoan and echinoderm debris; disarticulated ostracod shells; calcified sponge spicules; and foraminiferids. Brachiopod clasts are occasionally beekitised. These are low energy deposits and none of the bioclasts display signs of microbial borings or micrite envelopes inferring accumulation in relatively deep water.

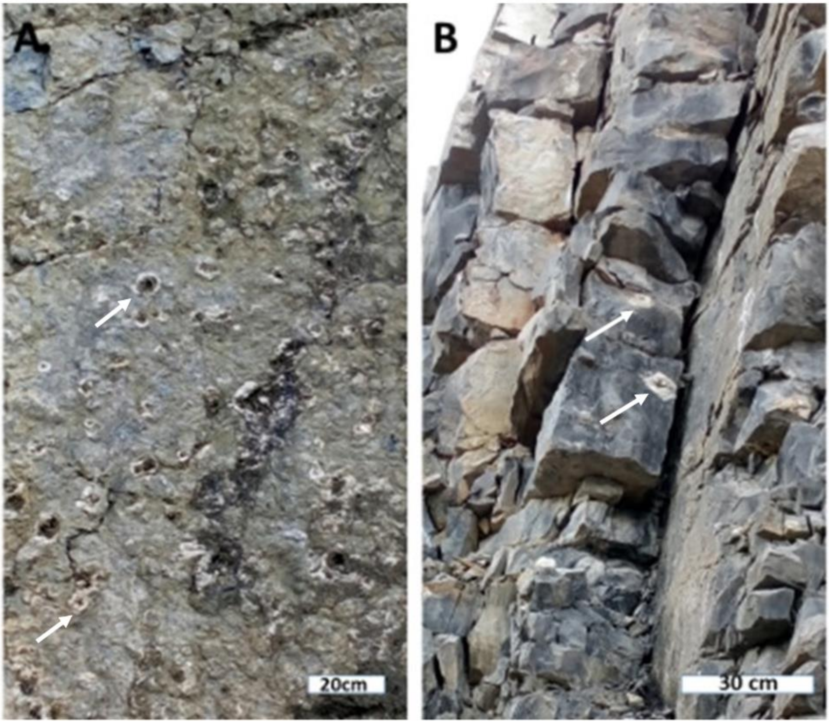

Fig. 3: Geode outcrops. A) Numerous geodes (arrowed) at the top of a limestone bed. B) Geodes (arrowed) within overturned limestone beds. Halecombe Quarry.

4 Petrography

The geodes had irregular outer surfaces and their peripheries were partially micro-stylolitic. Other microstylolites occur within the surrounding limestones but there are none within the geodes. Iron oxide crystals occur locally just inside the geode peripheries. The geode mineralogies are dominated by quartz and calcite (Fig. 4) but inclusions of anhydrite, celestite (celestine; $SrSO_4$) and barytes (barite; $BaSO_4$) have been detected optically and with the aid of SEM, EDS and XRD. Traces of cassiterite and a copper mineral also occur within the geodes.

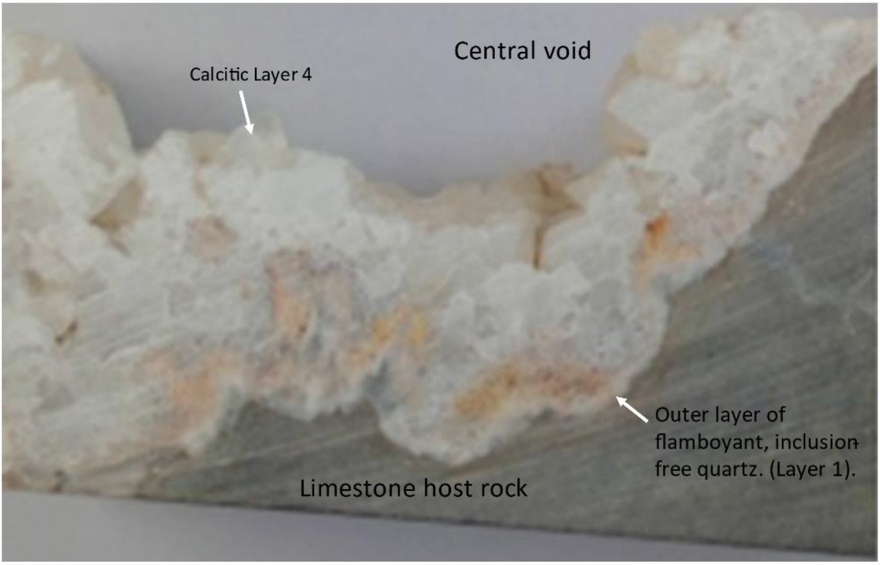

Fig. 4: Views of a slice through a typical geode revealing the thin (2-4mm thick) flamboyant quartz outer layer free of inclusions. Overlying it with a brownish discoloration is a quartzine layer followed euhedral quartz crystals both of which contain numerous inclusions. Calcite crystals form the innermost layer but did not fill the central geode void.

The hollow geodes collected in 2008 have an outer wall of variable thickness comprising a centripetal succession of four layers including:

Layer 1. Outer flamboyant quartz. It displays composite and undulose extinction and is regarded as intermediate between chalcedonic and megaquartz (Milliken, 1979). It is inclusion-free and is probably a replacement of the parent limestone.

Layer 2. Microporous crudely spherulitic growths and fans of length-slow chalcedony (length-slow quartzine; Figs. 5-7). It contains abundant lath-shaped inclusions of celestite and barytes which are grouped into sweeping swathes with alignments that vary between radial and tangential relative to the geode periphery and extend across adjacent chalcedonic habits. There are also rare, irregularly shaped inclusions of anhydrite within the chalcedony. The chalcedonic growths were in optical continuity with the inclusion-free flamboyant quartz of Layer 1 (Fig. 8).

Pittman & Folk (1971) and Folk & Pittman (1971) demonstrated that length-slow chalcedony is indicative of sulphate replacement in highly saline groundwaters. Supported by the occurrences of anhydrite inclusions, Tucker (1976) interpreted replacement of anhydrite by length-slow chalcedony in nodules/geodes from Triassic strata at localities just north of Bristol. Likewise, the chalcedonic growths of this

Layer 2 are interpreted as anhydrite replacements whilst the celestite and barytes may have crystallised simultaneously with and within the anhydrite Pseudomorphed Triassic anhydrite nodules, replaced or internally cemented by either celestite or quartz, are known in the southern Mendips or immediately to the south of them. (Bradshaw, 1968). Nickless et al. (1975 & 1976) recorded celestite replacement of anhydrite nodules in the Triassic Mercia Mudstone and Tea Green Marls.

Micropores within the chalcedony are of similar size to the celestite and barytes inclusions. They have similar orientations to the surrounding sweeping swathes of celestite and barytes and probably resulted from dissolution of those sulphates after chalcedonic replacement of anhydrite. The evidence suggests that the anhydrite was more susceptible to quartz replacement than the celestite/barytes inclusions which were far more abundant.

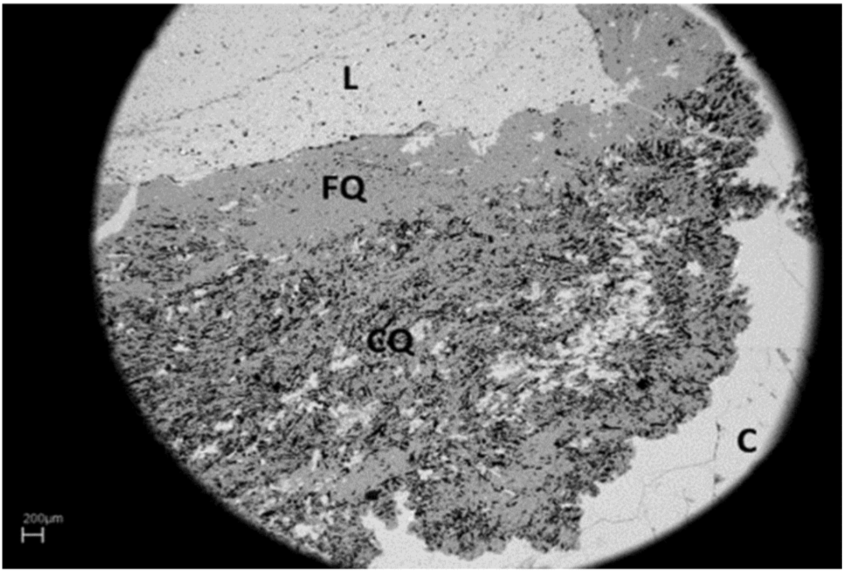

Fig. 5: (Above) SEM photomicrograph of periphery of a geode with serrated edge between limestone host (L) and outer flamboyant quartz rim (FQ) which is relatively clear of inclusions. Inner quartzine (CQ) and euhedral quart is rich in swathes of celestite and calcite lath-shaped inclusions. Relicts of anhydrite are too small to identify. Black patches are micropores. Calcite cement (C) overlies the quartz.

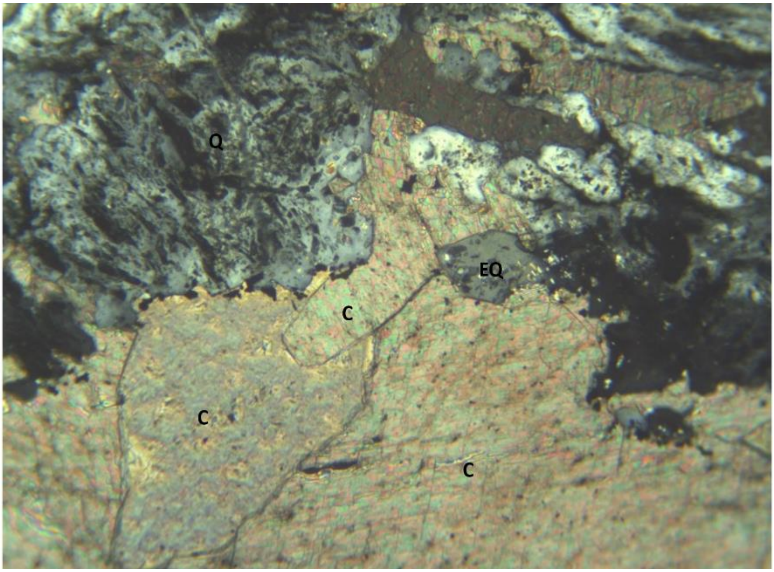

Fig. 6: Photomicrograph in cross-polarised light showing quartzine (Q) with abundant lath-shaped celestite inclusions (top left) overlain by calcite cement (C) stained pale red with alizarin red S. A euhedral quartz crystal (EQ) with inclusions also shown (right centre). Opaque iron oxide particles are concentrated along the inner surface of the quartzine.

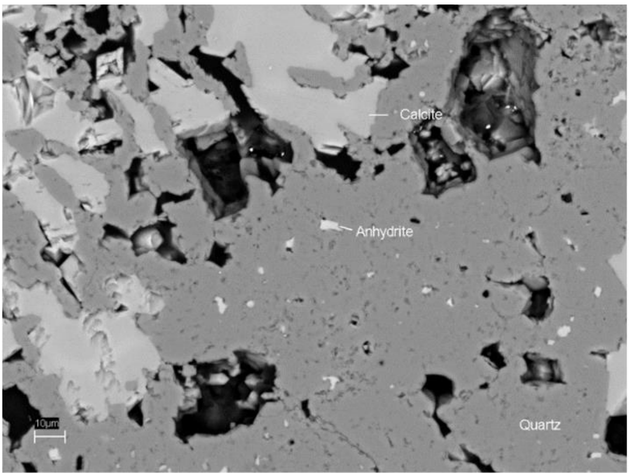

Fig. 7: SEM photomicrograph of quartzine rim of geode showing partial calcite cementation of micropores. Also small anhydrite relicts.

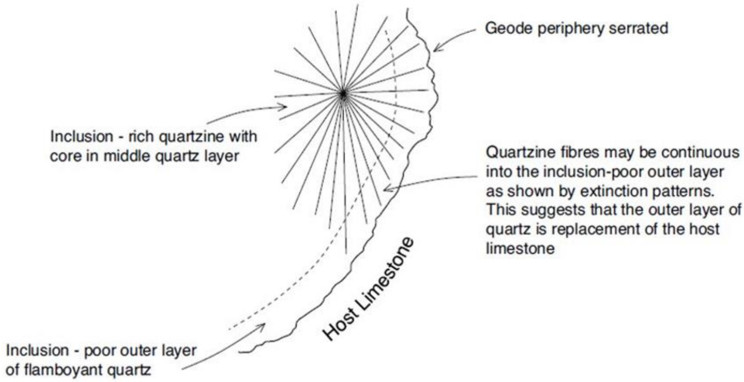

Fig. 8: Sketch of Layers 1 and 2 being in optical continuity. Layer 1 is inclusion-free and replaced the limestone host rock whereas layer was inclusion-rich and replaced former evaporite.

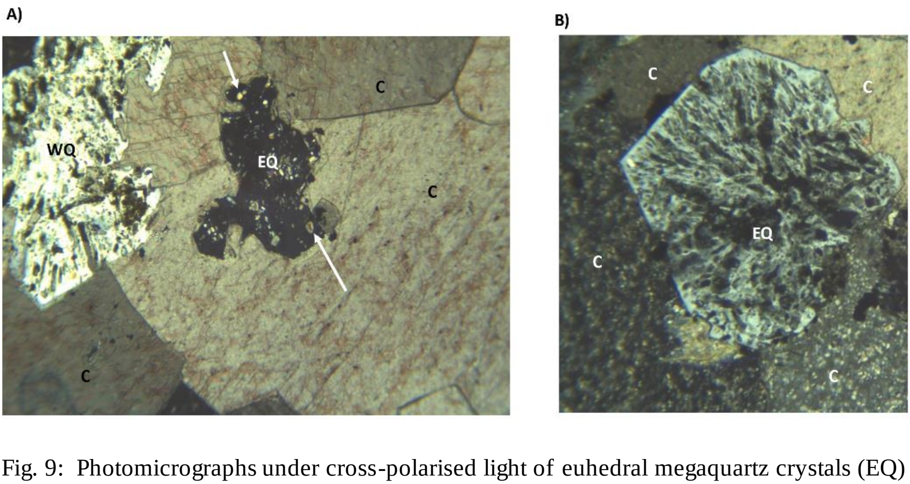

Fig. 9: Photomicrographs under cross-polarised light of euhedral megaquartz crystals (EQ) with anhydrite and celestite inclusions. Although apparently isolated within calcite (C), they are probably attached to the quartzine crystals of Layer 2 . A) Two anhydrite inclusions are arrowed in the megaquartz crystal which is in extinction. B) A euhedral megaquartz crystal with numerous celestite inclusions except around the inclusion-free rim.

Layer 3. Euhedral megaquartz crystals. These also contain in anhydrite, celestite or barytes inclusions but their outer margins are sometimes inclusion-free which, together with their euhedral habits (Fig. 9), suggest that at least their later stages of growth were perhaps cement rather than replacement and their final stages grew centripetally into the central vugs of the geodes formed after evaporites had been leached from the cores of the pre-cursor anhydrite nodules.

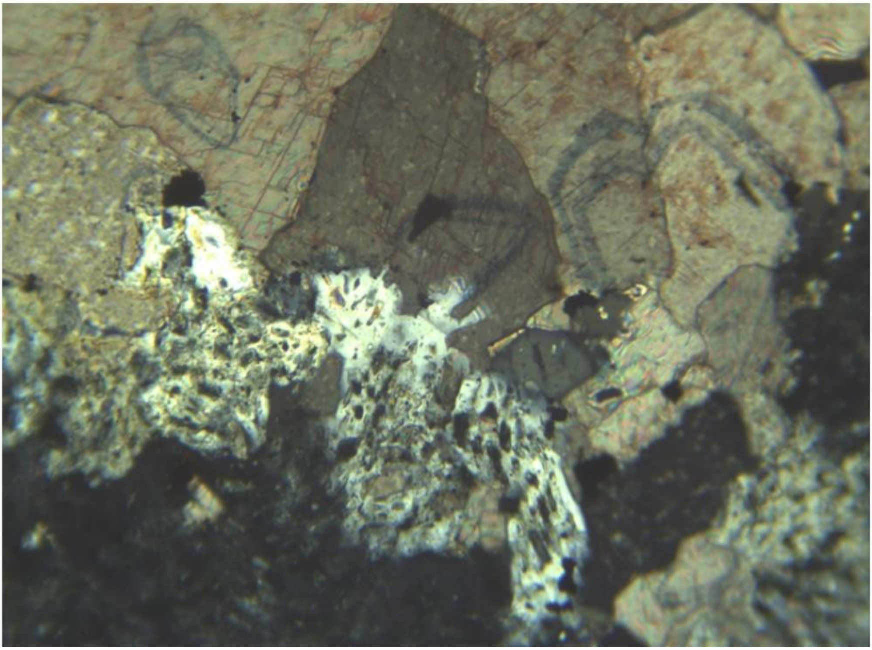

Fig. 10: Pink stained calcite cement crystals overlying inclusion-rich quartz layer. Calcite crystals display thin growth zones of ferroan calcite coloured blue by potassium ferricyanide.

Layer 4. Centripetally grown drusy non-ferroan calcite cement containing thin ferroan calcite zones (Fig. 10). This lacks inclusions and only partially infilled the central vugs of the geodes. It also partly replaced its three earlier precursory quartz layers as well as acting as cement in some of their lath-shaped micropores formed by dissolution of celestite and barytes crystals. Calcite crystals cementing several neighbouring former micropores sometimes go into extinction simultaneously under cross-polarised light indicating occasional 'porphyritic' calcite habits internal to the quartz.

The parent rock of the geode collected in 1975 was totally replaced by medium crystalline dolomite. The habit of the geode quartz was more coarsely crystalline than in the 2008 geodes and displayed undulose extinction reminiscent of undulose megaquartz (Milliken, 1979). It lacked chalcedonic habits, but the quartz was length-slow and rich with anhydrite inclusions with common orientations locally but are smaller than in the 2008 samples. Traces of calcite cement occurred between the quartz crystals but there is no significant calcite towards the centre of the geode.

5 Discussion

5.1 'Bristol Diamonds'

The internal crystal fabrics of the geodes from Halecombe Quarry are very similar to the fabrics of geodes within scree deposits of the Triassic Dolomitic Conglomerate and its laterally equivalent lacustrine/playa deposits of the upper Triassic Mercia Mudstone (Keuper Marl) around Bristol. There the nodules and geodes were referred to in the 16th Century as 'Bristol Stones' and latterly as 'Potstones' and 'Potato Stones'. They also occur in the underlying Pennsylvanian Coal Measures and Dinantian Limestones.

Their internally exposed quartz crystals resemble jewels and have historically been referred to as 'Bristol Diamonds' (Bradshaw, 1968; Tucker, 1976). The 'Diamonds' were not exposed in four 2008 geodes studied herein due to later calcite overgrowth in the geode interiors but the euhedral megaquartz crystals would equate to the 'Diamonds'.

Tucker (1976) described two types of geodes in Triassic strata of the Bristol area. They were either dominated by chalcedony or megaquartz. Both types are reminiscent of Layers 2 and 3 above respectively. The chalcedonic type contained length-slow chalcedony (quartzine) with inclusions that were too fine to identify. The megaquartz occurrences contained anhydrite inclusions and formed 'Bristol Diamonds'.

There is no direct evidence to indicate the relative timing of $CaSO_4$ and celestite/barytes precipitation but celestite and subsidiary barytes/baryto-celestite are known to be associated with $CaSO_4$ (Green, 1992), or celestite to have replaced $CaSO_4$, in nodules containing 'Bristol Diamonds' north of Bristol (Nickless *et al.*, 1975 & 1976). The timings of the silica emplacements in the 'Diamonds' is unknown but clearly post-dated the anhydrite and celestite/barytes precipitation as indicated by their presence as inclusions.

5.2 The pre-cursor anhydrite nodules

Although the geodes containing 'Bristol Diamonds' of the Dolomitic Conglomerate may have been reworked (Tucker, 1976 & 1978) it is less likely for those in the Mercia Mudstone. Both formations accumulated under hypersaline conditions. Tucker (1976) concluded that the anhydrite inclusions in the quartz of the 'Bristol Diamond' geodes of the Bristol area originated in a marginal continental sabkha or playa environment (see also Milroy et al., 2019). Bradshaw (1968) recorded 'Bristol

Diamonds' occurring in the Dolomitic Conglomerate near Wells. Triassic Dolomitic Conglomerate and Mercia Mudstone occur in the present study area but are not closely associated with the geodes of Dinantian limestone of Halecombe Quarry although one cannot exclude the possibility that Triassic strata have been completely eroded at the top-Carboniferous unconformity. A different origin from the previously described 'Bristol Diamonds' of Bradshaw and Tucker therefore seems possible although their origins remain inescapably linked to the initial development of anhydrite nodules.

Alonso-Zarza et al. (2002) described similar geodes but which were rich in dolomite and formed in the vadose zone in Triassic fluvial deposits with pedogenic overprints. Anhydrite may also form in deep water according to Dean et al., (1975). Based on Devonian anhydrite nodules of eastern Canada such as the Leduc reefs, Machel and Burton (1991) and Machel (1993) stressed that anhydrite nodules can develop during deep burial (>2500-3000m) and the present authors presume that the source of that sulphate was the underlying Devonian evaporitic Upper Elkpoint succession.

Machel and Burton (1991) listed several petrographic criteria to distinguish between deep burial and penecontemporaneous sabkha-like anhydrite nodules which included: 1) evidence of nodules traversing or concentrating along stylolites; 2) bitumen inclusions in the nodules; 3) host rocks which accumulated in open marine depositional environments (as is apparently the case of four of the Halcombe Quarry nodules) rather than supratidal. Apart from stating that the Devonian host rocks were strongly dolomitised, Machel and Burton avoided discussion on the connate water model from which the dolomite and anhydrite (or its possible precursor gypsum) originated. Their Devonian anhydrite crystals displayed euhedral to subhedral blocky habits typical of late diagenetic anhydrite rather than felted finely crystalline laths typical of sabkha anhydrite but Machel and Burton suggested this may reflect change from precursor gypsum, or anhydrite recrystallisation. At least the swathes of celestite/barytes inclusions within the Halcombe Quarry replacement quartz give the impression of having originally displayed sabkha-like habits but the lack of obvious trinities of subtidal-intertidal-deflated supratidal sequences fail to support a sabkha origin. However, sabkha anhydrite nodules tend to form as bed-parallel concentrations as may be the case in Fig. 4. A detailed facies analysis would clearly have been instructive but impossible at the time of the outcrop visit.

The previously known, most southerly occurrences of Dinantian anhydrite nodules (albeit calcified) were in a sabkha deposit of the Holkerian Clifton Down Limestone of the Avon Gorge (Kirkham, 1977). Whilst there is no proof that the Halcombe Quarry anhydrite nodules were sabkha related, they are at least believed to be the most southerly known occurrences of Carboniferous anhydrite of southwest England.

5.3 Origin of the silica

Bradshaw (1968) recognised that quartz crystals were associated with iron ore (hematite, goethite, or limonite) pipes and fissures in both the Dolomitic Conglomerate and the underlying Carboniferous limestones. The iron ores had been leached supposedly from the Triassic strata or perhaps also from shales of Late Carboniferous Coal Measures. The implication is that silica of the 'Bristol Diamonds' has similar sources but Green and Welch (1965) suggested that extensive silicification of the Dolomitic Conglomerate in the southern Mendips around Wells and Cheddar possibly had a deep hydrothermal origin.

Instead, the origin of the silica could have been sponge spicules as calcified examples of these occur in the host limestones surrounding the geodes. Silica precipitation or replacement was relatively late diagenetically and would have required a low pH.

5.4 Sulphate source and saline water origin

There are no known pre-Carboniferous evaporitic strata in the area, which implies an underlying sedimentary sulphate source is unlikely, but an extensive deposit of primary and secondary evaporites exists as the Somerset Halite of the Mercia Mudstone Group in the Central Somerset Basin immediately to the south and nodular masses and veins of gypsum occur in the Rhaetian Blue Anchor Group (Tea Green Marl and Grey Marl) at Watchet (Green, 1992). Downward circulation of saline post-Hercynian Permo-Triassic groundwaters to create the anhydrite nodules seems unlikely because the nodules and geodes would have been more erratically distributed throughout the folded Dinantian limestones rather than restricted to a relatively confined stratigraphical level.

If indeed the anhydrites originated at relatively shallow depth by reflux of saline waters from above prior to Hercynian deformation, it is reasonable to assume that a saline environment such as a sabkha or salina existed relatively soon after deposition of the strata containing these nodule- and geode-rich Dinantian limestones. The authors are unaware of local penecontemporaneous evaporitic depositional environments within the Black Rock Limestone and Vallis Limestone accumulations but the 1975 sample is almost totally dolomitised and may indicate close proximity to a hypersaline horizon.

Evidence of overlying saline lagoonal-peritidal Black Rock Group strata as evaporite sources at Halcombe Quarry may have been eroded during the Dinantian. As the 1975 sample occurred within a dolostone, it is possible that the evaporite nodules formed *in situ* during presumed arid conditions that caused dolomitisation of the Black Rock Dolomite at the top of the Black Rock Group in western Mendips; north beyond Bristol; and into southeast Wales. Its top is a non-sequence to the north of the Mendips. Mitchell (1971 &1972) recognised a hiatus at the top of the Black Rock

Limestone in the Avon Gorge, Bristol, and Butler (1973a) using conodonts correlated it to about half way up the much thicker equivalent succession in eastern Mendips although he found conodont occurrences in the upper part of the Black Rock Group were especially poor. That same hiatus may exist in Burrington Combe at the Courceyan-Chadian boundary (Green, 1992). No sabkha sequences are yet recognised in the Dinantian limestones of the east Mendip Hills to cause extensive dolomitization, but they may have been removed during the abovementioned hiati. Overall there is a lack of detailed facies information and so lagoonal-peritidal deposits may well exist within or perhaps more likely just above the subject nodule- and geode-rich beds.

Alternatively, arid conditions may have temporarily existed during Vallis Limestone deposition as saline lagoonal and peritidal environments similar to those of the laterally equivalent Clifton Down Mudstone may well have extended to the Halecombe area. Downward circulation of those saline groundwaters could perhaps have been sufficient to develop the anhydrite nodules.

Modern sabkha anhydrite nodules enlarge by continued anhydrite precipitation within the nodules which displace sediment and hydraulically jack up the sabkha surface. The jacking-up is barely detectable even in modern sabkhas and so would be difficult to recognise in ancient sediments. Sabkha anhydrites are as soft as toothpaste although they do, of course, harden and recrystallize with burial. The initial anhydrite crystal habits form swathes similar to the anhydrite inclusions in these geodes. There is no evidence of displacement or differential compaction associated with these Halcombe Quarry nodules and geodes and so they are likely to have been replacive – as indeed Layer 1 appears to be at the outer peripheries of the geodes.

5.5 Sources of strontium and barium

Relatively little is known about the strontium and barium geochemistry of carbonates and evaporites. Their minerals are rare in occurrence (Stow, 2007) although celestite is a relatively common occurrence in coastal sabkhas and saline lakes such as the Coorongs (Bathurst, 1971) and barytes is a common replacement mineral in early Archean strata of Western Australia (Tucker, 1994).

Celestite associated with 'Bristol Diamonds' elsewhere in the Bristol-Mendip area is largely confined to the Triassic Mercia Mudstone and Tea Green Marl (Nickless et al 1975 & 1976; Green, 1992), but also occurs in the Carboniferous Coal Measures and Triassic Dolomitic Conglomerate (Bradshaw, 1968), although those of the Dolomitic Conglomerate may be reworked from the Carboniferous Limestone (Tucker, 1976). It typically forms nodules and veins in those strata. Kirkham (1977) observed isopachous celestite cement zones 2 - 3 cm thick intercalated with dogtooth calcite spar cements within karstic vugs in the Dinantian Clifton Down Limestone at Elberton, north of Bristol.

As the abovementioned Triassic and Rhaetian celestite occurrences typically replace gypsum, Nickless *et al*. (1975 & 1976) suggested that strontium was released from anhydrite as it was hydrated to gypsum. Anhydrite and gypsum do incorporate strontium during crystallization (Butler, 1973b) but the amounts are very small and it is debatable whether they could provide sufficient to establish the large celestite resource that is known to occur especially around Yate. Evans and Shearman (1964) discovered that strontium was also released during dolomitization of aragonite in modern carbonates of Abu Dhabi to form celestite. Aragonite contains about 20 times the amount of strontium as calcite (>8000ppm; Purser and Loreau, 1973) and Nickless et al. (1975 & 1976) concluded that release of excess strontium during the conversion of aragonite to calcite in the Dinantian limestones was the main strontium source. They suggested that celestite replacement of $CaSO_4$ (gypsum and anhydrite) is more complete along the margins of the basin adjacent to subcropping and exposed Dinantian limestones which mainly defined the Triassic and Rhaetian topography. However, the Dinantian oceans were more prone to calcite production than current aragonite-prone oceans (Sandberg, 1983). Extensive dolomitizations of the Dinantian limestones of the area north of the Mendips and in southeast Wales are thought to have occurred during the Carboniferous (Kirkham, 1977), so even if extensive dolomitization of the Carboniferous carbonates was a source of the strontium, the process pre-dated the *in situ* celestitic 'Bristol Diamonds' of Triassic strata. It is also noted that the geode collected in 1975 contained no celestite despite its wall rock being dolostone. According to Green (1992), the source of the strontium remained a mystery.

Celestite is regarded as part of the Barite Group of minerals because independent barium and strontium minerals tend to occur together or as baryto-celestite. Barytes is found at significant depth in the Mercia Mudstone Group at Puriton, near Bridgwater (Kellaway and Welch, 1948) and filling fissures in the Dinantian Limestone at Cannington Park, near Bridgwater (Green, 1992). Perhaps the Somerset Halite beds were a source. Green and Welch (1965) also described barytes as a gangue mineral associated with chert and occasional galena and sphalerite along silicified joints in the Dinantian Limestone of the western Mendips. They also recorded abundant barytes and barytocelestine together with quartz-chalcedony from surface drift around Shepton Mallet. Barytes, together with lead, was hydrothermal in origin around Bridgend, South Wales.

6 Conclusions

- Geodes, similar to Triassic geodes containing 'Bristol Diamonds', occur within the Dinantian Black Rock or Vallis Limestones of Halecombe Quarry, eastern Mendips.
- By analogy with geodes elsewhere in the Bristol-Mendip region, the Halcombe Quarry geodes probably originated as anhydrite nodules with subordinate celestite and barytes. All three sulphates now survive only as relict inclusions within replacive quartz.
- The Halecombe Quarry geodes probably formed during the Dinantian.
- It is still unclear how the saline groundwaters supplied the sulphates. Reflux of saline waters from sabkhas or salinas could have provided a mechanism for anhydrite emplacement but the origins of the strontium for celestite formation, barium for barytes and the replacive silica are more uncertain.
- A detailed sedimentological description of the carbonate facies above and within the nodular and geode beds at Halcombe Quarry is highly recommended to better understand the model for anhydrite formation.
- The original anhydrite nodules from Halecombe Quarry are thought to be the southernmost occurrences of Dinantian anhydrites in the UK.

Acknowledgements

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Oyster-encrusted chert dropstones from the Lower Lias (Hettangian) of Sutton Hill Quarry, Northeast Somerset, England

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Abstract

Two oyster-encrusted chert clasts from within the Blue Lias Formation, Lower Jurassic, discovered in Sutton Hill Quarry, North East Somerset, are identified as dropstones. They occur as isolated rock clasts (lonestones) within fine-grained moderately deep-water calcareous mudstones. The dropstones are hand-sized (Cg3028 125 x 70 x 60 mm and Cg3026 210 x 120 x 110 mm) with a dark grey/black colour and a smooth, flinty appearance. The chert clasts do not appear to contain fossils but there are bioturbation features within one of them. The clasts are interpreted as Lower Carboniferous in age. Since the clasts are too big to be gastroliths and there was no glaciation in the region in the Lower Jurassic, these dropstones are interpreted as having been transported out to sea caught up in the roots of a tree or within a mass of rafted vegetation. The clasts were likely derived from Carboniferous strata being eroded in the Mendip Hills during the Lower Jurassic when they formed an emergent archipelago. Fossil plants found in the Blue Lias of the Bristol district indicate that the archipelago was clearly vegetated. Dropstones of this type are a relatively rare occurrence in the marine stratigraphic record.

Key words: Dropstone, Lias, chert, Jurassic, sediment, clast.

Institutional abbreviations: BRSMG: Collection of Bristol Museum & Art Gallery

1 Introduction

During a collecting trip in 2006 to the Blue Lias (Lower Jurassic) at Sutton Hill Quarry (ST 597586), North East Somerset, Jon Radley (Curator of Natural Sciences, Heritage & Culture Warwickshire) found a bivalve encrusted chert clast. A few years later in 2011, Norman Binsted (Geologists' Association member) found a larger chert clast enclosed within a loose block of limestone from the same locality. Under normal sedimentary conditions, clasts of rock in an open-marine, deeper-water facies are extremely unusual, unless there is a glaciation in the vicinity with icebergs transporting rock debris.

There are few descriptions in the literature of dropstones from the geological record in England. A derived Lower Jurassic clast, described as a large, rounded cobble, is reported from a plant debris bed in the Wessex Formation (Wealden Group, Lower

Cretaceous) of the Isle of Wight (Radley, 1993). A large clast of Palaeozoic origin has also been recorded from the Wessex Formation (Sweetman and Goodyear, 2020). In both cases, the clasts are interpreted by the respective authors as dropstones transported to their final resting place via rafting within tree roots. In modern times, floating rafts of kelp (*Durvillaea antarctica*) in the southern oceans are capable of transporting rocks weighing up to several kilograms (Craw & Waters, 2018); much of the rock is derived from coastal substrates several hundred kilometres away.

Dropstones generally arrive in a sedimentary environment by sinking through the water column rather than being transported by normal sediment gravity flows, such as turbidity currents, debris flows, contour or geostrophic currents. Dropstones vary in size from small pebbles to boulders and are mostly composed of materials different from the sedimentary rocks that enclose them. Glacial ice and icebergs, as well as biological rafts (tree roots, vegetation or microbial mats) are all capable of carrying individual rocks over considerable distances. Active volcanoes can also provide a source of dropstones when molten rock and consolidated lava blocks ('bombs') are expelled explosively, as projectiles, over water. There is also the possibility that dropstones could have come from marine reptiles regurgitating gastroliths which have been in their stomach to help with food digestion.

Plesiosaurs, common in Lower Jurassic seas, are known to have used gastroliths and have been found at Sutton Hill Quarry (Carpenter, 2001). Studies of plesiosaur skeletons that have been found with associated gastroliths (Everhart, 2000) show that stomach stones are typically small with dimensions of between 5 mm and 100 mm in maximum length. The larger size of the dropstones at Sutton Hill Quarry would exclude them from being marine reptile gastroliths.

Several features are typical of dropstones: they are usually single clasts (lonestones) dispersed in the deposit, commonly creating a characteristic depression in the sediment with some local deformation of underlying laminae. Subsequent material deposited to bury the clast typically shows a draping effect over the rock. Dropstones are also composed of a different lithology from the surrounding sediments in which they are found (Bennett, 1995).

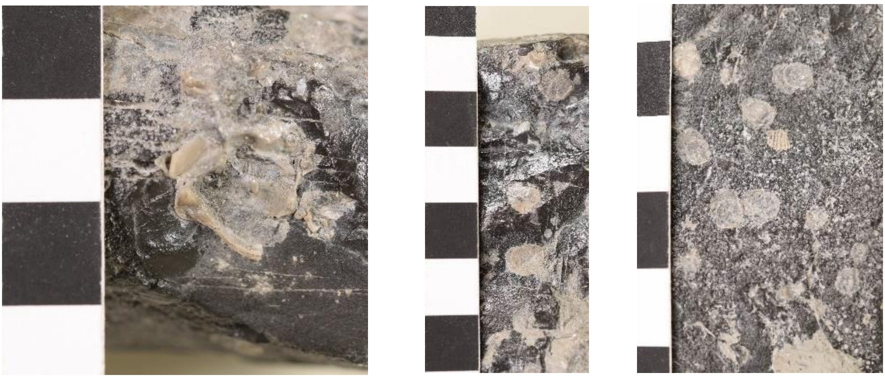
2 Dropstones

Both dropstone specimens described here are in the collection of Bristol Museum & Art Gallery (BRSMG).

Dropstone 1 BRSMG Cg3028 (125 x 70 x 60 mm)

The specimen (Figure 1) weighs 860 grams and is roughly rectangular in shape (125 x 70 x 60 mm). It was found on a spoil tip of Lower Lias rocks known to have originated from Sutton Hill Quarry and not from an outside source. The surface of the specimen is encrusted by small irregular marine bivalves, *Plicatula,* but there are also shell fragments of the bivalve, *Chlamys*, seen adhering to the dropstone surface (Figure 2). Both *Plicatula* and *Chlamys* range from the Triassic to the present day.

Fig. 1: Dropstone 1 BRSMG Cg3028 found by Jon Radley in 2006. Scale bar is in cm © Bristol Culture



(a) (b) (c)

Fig. 2: Details of BRSMG Cg3028 with encrusting bivalves, (a) *Plicatula* and *Chlamys.* (b) *Plicatula* (c) *Plicatula* and *Chlamys.* Scale bar is in cm © Bristol Culture

Cg3028 has a thin layer of grey Lias matrix adhering to it in several places, identical to the Lower Jurassic sediments exposed in the Sutton Hill Quarry. The chert colour is black to dark grey. It has rounded edges and a variety of surface textures including pitting. It is mostly smooth to the touch and has a glassy appearance. No fossils were seen within the dropstone. The encrusting bivalves *Plicatula* were attached to the chert during its exposure on the seafloor before burial by later sediments.

Stratigraphy

Found *ex situ*, but from direct comparison with *in-situ* rocks exposed in the quarry, it is likely to have come from the lower part of the Blue Lias Formation: Hettangian Stage.

It was found by Jon Radley, in 2006, exact date not known.

Dropstone 2 BRSMG Cg3026 (210 x 120 x 110 mm)

This specimen (Figure 3) is similar in size, shape, colour and weight to Cg3028 (125 x 70 x 60 mm). The main difference is that this specimen is partly enclosed in a limestone matrix. The limestone containing the dropstone was found as part of a tumbled mass of rock, fallen from the eastern face of the quarry. The limestone matrix is approximately 10 cm thick at its widest, light grey in colour with finely disseminated shell debris throughout. A few, small poorly-preserved bivalves are attached to the chert.

Fig. 3: BRSMG Cg3026 enclosed by limestone. Found by Norman Binsted, 4th June 2011
Scale bar is in cm © Bristol Culture

Stratigraphy

As part of the quarry scree slope, this specimen has not travelled far from its original position in the rock face approximately 0.5 m away. This unit of rocks is characterised by clays and shales with lenticular-spaced, thin beds of nodular limestone that characterise the Saltford Shale Member (part of the Hettangian Stage) of the Blue Lias Formation. The ammonite, *Alsatites liasicus*, ranges throughout this unit of rocks. The Saltford Shale Member at Sutton Hill Quarry represents sediments accumulating in moderately deep water (several 10's of metres, below fair-weather wave base).

Found by Norman Binsted. Date: 4th June 2011.

Fig. 4: Norman Binsted with his dropstone (Cg3026) find in Sutton Hill Quarry, 4th June 2011 © Simon Carpenter

Chert is a hard, fine-grained sedimentary rock consisting almost entirely of silica (SiO_2). The silica is mostly derived from skeletal material such as sponge spicules or radiolarians, with some being of an inorganic or chemical source. Chert also forms nodules, especially within limestones, as a result of dissolution and reprecipitation of biogenic opaline silica, as in the form flint occurring in the Chalk. Fossils and wood may also be silicified.

3 Geological Setting and Background to Locality

Sutton Hill Quarry is now infilled and a closed landfill site but formerly exposed one of the most important inland exposures of Late Triassic and Lower Jurassic rocks in the southwest of England **(**Figures 5 and 6**).** The site is associated with the history of geology: John Strachey (1671–1743), who lived at nearby Sutton Court in Bishop Sutton, produced the first ever published cross-section of sedimentary strata in 1719, based on the local quarries and coal mines. William Smith (1769–1839), the 'Father of English Geology' referred to Strachey's paper (1719) when he was working on his 'Order of Strata' and producing the first geological map of England and Wales in 1815 (Fuller, 2004).

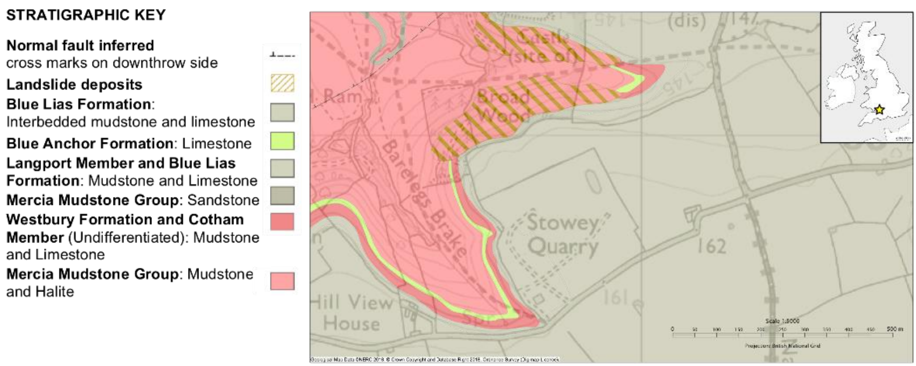


Fig. 5: The geology around Sutton Hill Quarry (ST 597586). The morphological top of Sutton Hill is dominated by Early Jurassic rocks. Sutton Hill Quarry was opened to work the Early Jurassic rocks, and the quarry floor rested on the Rhaetian-Lias contact. © Crown Copyright and Database Right 2015. Ordnance Survey (Digimap License).

Desmond Donovan published the first detailed geological description of the site in 1956 (Donovan, 1956a), but since then the quarry has been deepened and extended. The first evidence of a stone quarry at this site can be seen on the 1844-1888 Ordnance Survey, 25", First Edition map (Ordnance Survey, 1985). Stone extraction ceased in 2010 and following this, the quarry was acquired for landfill. As a result, many of the features of geological interest have been lost.

The fossil assemblage of the site is a rich and diverse one. Pelagic animals are represented by ammonites, fish and reptiles, including species of ichthyosaur and plesiosaur (Carpenter, 2001). The benthic fauna is dominated by byssally-attached or free-swimming bivalves. The majority of larger fossils are encrusted by sessile bivalves, particularly Liostrea and Plicatula, suggesting that the seafloor (likely a soft substrate at this time) provided few suitable habitats for encrusters.

Stone extraction at Sutton Hill Quarry exploited the thicker limestone layers of the Langport Member and Pre-*Planorbis* Beds of the Late Triassic **(**Figure 6**)** exposed close to the quarry floor. These were a valuable source of building stone as well as being crushed as an aggregate. As an example of its use locally, the Sutton Hill stone was used for the new porch of St Mary's Church, Bishopsworth, Bristol, in 1970. Above these, the basal Lias limestones are thin and irregular alternating with grey clay and shale. These belong to the Hettangian Stage of the Blue Lias Formation (Divisions A, B and C of Donovan and Kellaway, 1984). These limestone beds had little commercial value to the quarry operators and were removed, stockpiled, and used as backfill at a later stage of operations. It was from one of these stock-piled heaps that the first of the Sutton Hill Quarry dropstones was found by John Radley.

Fig. 6: View of Sutton Hill Quarry, looking towards the northeastern corner of the site in April 1999. This site is now infilled so the quarry face is no longer visible. © Simon Carpenter.

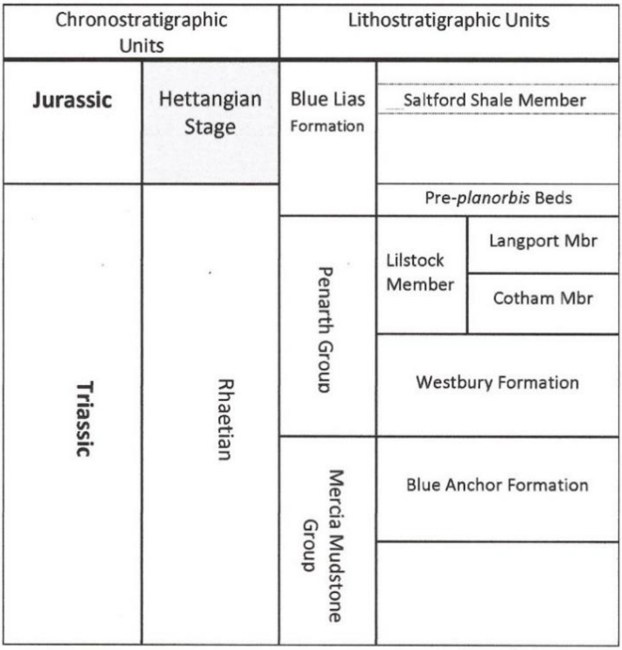


Fig. 7: Late Triassic and Lower Jurassic stratigraphy with the Hettangian Stage shown.

4 Lower Jurassic palaeogeography and sedimentation

At the start of Lias sedimentation, a major area of non-deposition, the London Platform, was situated about 65 km (40 miles) away to the north-east (Donovan *et al.*, 1979). Sutton Hill Quarry lies on the north-eastern edge of the Mendip Hills which in early Jurassic times formed an extensive group of islands known as the Mendip Archipelago. A sublittoral zone fringed the Mendip Archipelago, 1 to 3 km wide, where the Lias directly overlies and gradually buries the Carboniferous limestone. Rocks forming in the sublittoral zone consist of pale-coloured, massive, coarse, shelly and commonly pebbly limestones in which the pebbles and much of the coarse debris are derived from the Carboniferous limestone. These littoral rocks were deposited in offshore shoals and banks in strongly agitated water. The sublittoral facies is known informally as Downside Stone in the Mendips and Brockley Down Limestone on Broadfield Down. The thickest development, around 30 m, is exposed in the Shepton Mallet area and is mainly Hettangian in age. A fine Lias section at the Bowlish Road cutting (ST 612438), Shepton Mallet, described in the publication 'New Sites for Old' (edited by KL Duff *et al.*, 1985) includes a prominent bed containing abundant chert pebbles and fragments of wood, suggesting a close proximity to the Mendip

Archipelago. These chert pebbles would have come from the destruction and erosion of earlier rock deposits and are unlikely to have travelled far. As erosion during the Jurassic Period removed rocks from across the Mendip Archipelago, older rocks were exposed at its core. By early Triassic times, much of the Coal Measures had been removed by erosion to expose the underlying Carboniferous limestone. In the Dinantian (Lower Carboniferous), chert bands and nodules are strongly developed in the Black Rock Limestone of the Mendip Hills (Green, 1992). At Leigh-on-Mendip (Butler, 1973), the main chert bed is 89 m thick. A lower bed of chert occurs below this. These chert bands and nodules from the Dinantian may well be the source of our Sutton Hill dropstone. However, a distance of approximately 8 km (5 miles) separates the Sutton Hill Quarry and the eastern edge of the Mendip Hills.

By way of contrast, the rocks exposed at Sutton Hill Quarry were forming in calmer waters away from the more turbulent sublittoral zone. Here, the water was still relatively shallow (several 10's of m) and under these conditions muds accumulated on the seafloor. It is unlikely that a hard seafloor surface was present except at times when a hiatus in sedimentation occurred and a hardground was established. These are locally developed and are recognised by their upper surfaces being encrusted with various organisms (notably bivalves).

Although a possible source for the Sutton Hill dropstone has been proposed, we have yet to explain how it got there.

5 Origin of the dropstones

Four processes of formation are recognised for dropstones (Bennett *et al.*, 1996). These involve three different rafting agents: a biological process; ice; and flotation and gravitational process. Volcanic projectiles comprise the fourth process. The mode of transport for the Sutton Hill Quarry dropstones is unlikely to be ice as there is no evidence for glaciation at this time in this region. Indeed, the climate was warmer than now and the poles were ice-free at this time (Sellwood & Valdes, 2008). The region was also free of volcanic activity during the early Jurassic, so this can also be excluded. Flotation and gravitational processes are not relevant here either; flotation implicates the movement of small particles and gravitational processes suggest larger objects associated with much closer proximity to land. Turbidity currents triggered by earthquakes, underwater avalanches and other geological disturbances are responsible for rapid, downslope turbulent flows of water and sediment. The authors have not recognised any turbidite deposits (the resultant deposit left by turbidity currents) in the Blue Lias succession at Sutton Hill Quarry. Characteristic sedimentary features associated with turbidites include graded bedding, ripple marks and sole structures (Tucker, 2011). Storms can also transport coarse sediment and deposit so-called tempestites (Tucker, 2011) which show some features similar to

turbidites, but the context is generally one of outer shelf mudstones rather than deeper-water (basinal) mudrocks.
A biological agent would seem the most probable mechanism for transporting the dropstones across the shallow sea from their likely origin in the Mendips to their final resting place, a distance of several kilometres. This assumes that the island archipelago was vegetated during Early Jurassic times and that some of this vegetation was carried away from the land by storms and currents, and drifted out to sea. Abundant, fragmentary fronds of the cycad *Otozamites* are commonly found in the Pre-Planorbis beds at Sutton Hill Quarry. These fossils preserve very delicate and fragile structures that have only survived intact because they have spent so little time in the water. Larger fragments of plant material and wood also occur throughout the early Jurassic rocks at the quarry, much of it unidentifiable to species level.

During the Early and Mid Jurassic, the United Kingdom area was situated in the subtropical belt of the Northern Hemisphere (Vakhrameev, 1991). During the Early Jurassic, most of England and Wales was covered by a shallow to moderate depth sea and the marine Lower Jurassic Series contains mainly washed-in plant remains (Cleal et al., 2001). The climate was mainly humid and the woody vegetation was dominated by conifers (especially the families Cheirolepidiaceae and Araucariaceae) and the order Ginkgoales. We know that cycads, bennettites, ginkos and conifers dominated world floras during the early Jurassic, and, for the first time, global floras contained a significant component of vegetation with recognisable forms in the present day (Willis & McElwain, 2002).

6 Discussion

Dropstones by their very nature are intriguing and interesting objects. The discovery of chert clasts in the Blue Lias Formation at Sutton Hill Quarry is particularly unusual as they have not been recorded from the Blue Lias Formation of the United Kingdom before. Chert, a fine-grained silica mineral, does not naturally occur in the Lower Jurassic rocks of the region. Its occurrence in other formations suggests marine palaeo-environments where concentrations of dissolved silica in the sea were extremely high or there was abundant biogenic siliceous material in the sediment, as from sponges or radiolarians. The closest source to Sutton Hill Quarry of chert-bearing rocks occurs in the Lower Carboniferous (Green, 1992) of the Mendip Hills. The Black Rock Limestone is characterised by sheets and nodules of chert, occurring approximately 30 m and 150 m above the base of the unit. When these chert-bearing Carboniferous rocks were exposed to weathering during the early Jurassic Period, the chert they contained was eroded, reworked and carried from the shores of the archipelago by marine currents. The majority of coarse, weathered material entering the ocean from the land would have contributed to the sediments accumulating in the sublittoral zone. Rocks forming in the sublittoral zone consisted of massive, coarse, shelly and commonly pebbly limestones, a completely different sedimentary regime from that seen at Sutton Hill Quarry where the rocks are fine-grained and were deposited at a greater distance from the archipelago.

The available evidence at Sutton Hill Quarry suggests strongly that the chert dropstones were probably carried on rafts of vegetation or lodged in the roots of driftwood. Rocks can still be found lodged in the roots of driftwood on beaches today and there are rare accounts in the literature to substantiate this, including from Charles Darwin (1809-1882). Darwin recorded a dropstone from his travels on HMS *Beagle* between 1831 and 1836 when he visited the Cocos Keeling Islands and coral formations in the Indian Ocean (Darwin, 1859). Here he noted:

A few miles north of Keeling there is another small atoll, the lagoon of which is nearly filled up with coral-mud. Captain Ross found embedded in the conglomerate on the outer coast, a well-rounded fragment of greenstone, rather larger than a man's head: he and the men with him were so much surprised at this, that they brought it away and preserved it as a curiosity. The occurrence of this one stone, where every other particle of matter is calcareous, certainly is very puzzling. The island has scarcely ever been visited, nor is it probable that a ship has been wrecked there. From the absence of any better explanation, I came to the conclusion that it must have been entangled in the roots of some large tree: when, however, I considered the great distance from the nearest island, the combination of chances against a stone thus being entangled, the tree washed into the sea, floated so far, then landed safely, and the stone finally so embedded as to allow of its discovery, I was almost afraid of imagining a means of transport apparently so improbable.

Darwin continued by writing:

It was therefore with great interest that I found Chamisso, the justly distinguished naturalist who accompanied Kotzebue, stating that the inhabitants of the Radack Archipelago, a group of lagoon-islands in the midst of the Pacific, obtained stones for sharpening their instruments by searching the roots of trees which are cast upon the beach.

We cannot prove this vegetation-rafted hypothesis categorically, but with no other more plausible explanation, this seems to be the most likely agent of transportation, even though (as Darwin said) it seems 'so improbable'. The occurrence of wood in the rock succession at Sutton Hill Quarry at least provides evidence of a mechanism of transport even though we have no direct evidence of it. The dropstones described from the plant debris beds from the Wealden Group of the Isle of Wight provide further evidence to support the vegetation-rafted hypothesis.

7 Acknowledgements

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Temporary exposures in the Blue Lias Formation (Lower Jurassic, Hettangian to Sinemurian) at Ston Easton, Mendip, Somerset

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1 Introduction

We describe two temporary exposures located very close to each other near to the village of Ston Easton, Somerset. Between them they expose rocks ranging from the top of the Upper Triassic, Langport Member, to the base of the Lower Jurassic, Sinemurian Stage, Blue Lias Formation. They are located north of the Mendip axis but expose a succession that is not typical of the deposits on the Radstock Shelf to the east.

In the early Jurassic much of the Mendips formed a large island in a string of smaller islands, stretching westwards into South Wales. The land was fringed in places by a sublittoral zone, where shallow marine sedimentary rocks were deposited directly on a basement of older rocks, including of Carboniferous Limestone, Coal Measures and Triassic rocks. To the south of the Mendips the sediments are detrital and biogenic, generally comprising fine-grained sediments, with carbonate material in the form of coral, shell and ammonite fragments. The palaeoecology suggests shallow lime-mud seas. The rocks are known informally as Downside Stone (Green, 1992).

North of the Mendips, gentle uplift had the effect of restricting sedimentation (the Radstock Shelf facies) but also resulted in the erosion or re-elaboration of the pre-existing Liassic sediments (Green and Welch, 1965). The exposures at Ston Easton include marker horizons which may be recognised on the Radstock Shelf, but are somewhat different from the very condensed sequence to the east. They show affinities with the thicker successions exposed at Stowey. This thickening is thought to be related to on-going seafloor movement in a local trough on the north side of the Chewton Fault, which may thus be classed as a growth fault (Donovan et. al., 1989). The classic description of the Radstock Shelf by Tutcher and Trueman (1925) did not cover the area of the current study and for this reason, it is hoped that this account provides new information on the stratigraphy of the Ston Easton area and in particular, elements of the Sinemurian succession.

STAGE	ZONE	SUBZONE
SINEMURIAN	Turneri	Birchi
		Brooki
	Semicostatum	Sauzeanum
		Scipionianum
		Lyra
	Bucklandi	Bucklandi
		Rotiforme
		Conybeari
HETTANGIAN	Angulata	Depressa
		Complanata
		Extranodosa
	Liasicus	Laqueus
		Portlocki
	Planorbis	Johnstoni
		Planorbis

Fig. 1: Zones and subzones of the Hettangian and Sinemurian Stages of the Lower Jurassic. After Page (2002).

2 The exposures

The two exposures are located 200 m apart on either side of the A 37 at Home Farm on the north-western edge of the village Ston Easton, Mendip, Somerset.

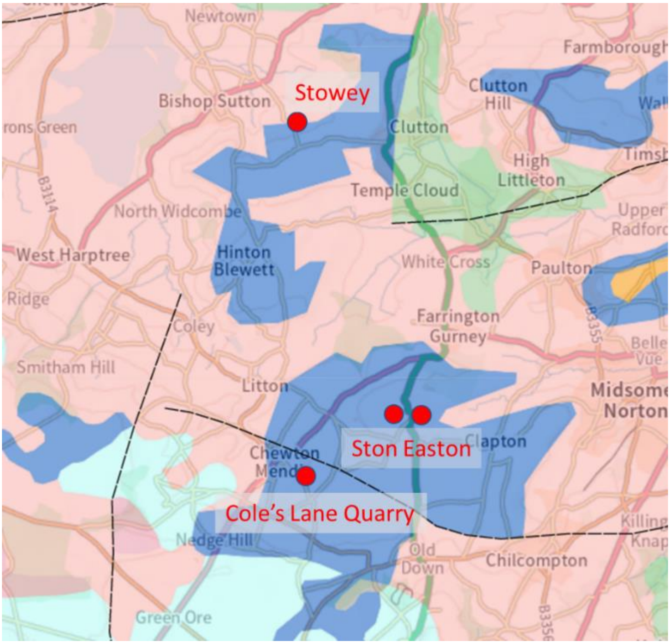

Fig. 2: Map showing the Ston Easton exposures, Stowey Quarry and Cole's Lane Quarry. Dark blue areas are Lias outcrops. (Based upon the Geology of Britain Viewer, with the permission of the British Geological Survey).

2.1 Exposure 1

At Home Farm a large excavation on the west side of the A 37, about 20 m deep, for a slurry pit (Grid Reference: ST 361915, 154397), provided an excellent exposure of Lower Liassic limestones and the associated spoil heap weathered to provide a fine collecting ground for *ex situ* sedimentary features and fossils. Unfortunately, owing to the unstable nature of the excavation walls, only the top part of the succession could be logged in detail (Figs. 3, 4, 5).

Fig. 3: Exposure 1, showing the Hettangian and Sinemurian succession.

Fig. 4: Exposure 1, *Metophioceras conybeari* in Bed 32 (Bucklandi Zone, Conybeari Subzone).

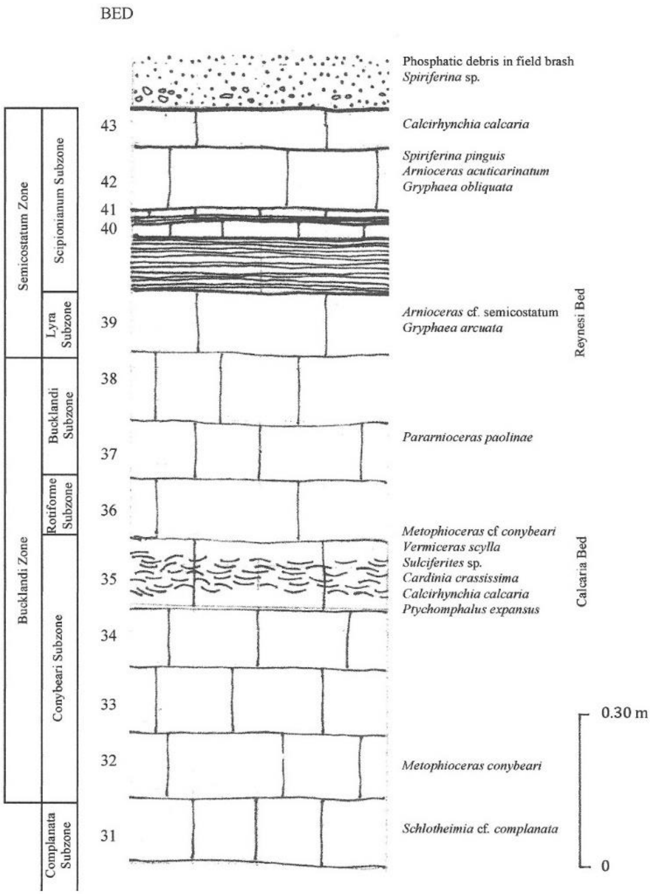

Fig. 5: Vertical section through the top of Exposure 1 showing the Sinemurian succession.

2.2 Exposure 2

On the east side of the A 37 there was another exposure in the garden of a residential property (Grid Reference: ST 362275,154183). This was a shallow, stepped excavation to create a large rockery and provided a very good section for study as the surface of each bed was exposed as ledges and platforms over tens of metres. In addition, a vertical section behind the house provided a section 2.10 m deep (Figs. 6-9). This site provided the cleanest and most accessible section of Hettangian rocks.

Fig. 6: Exposure 2.

Fig. 7: Exposure 2.

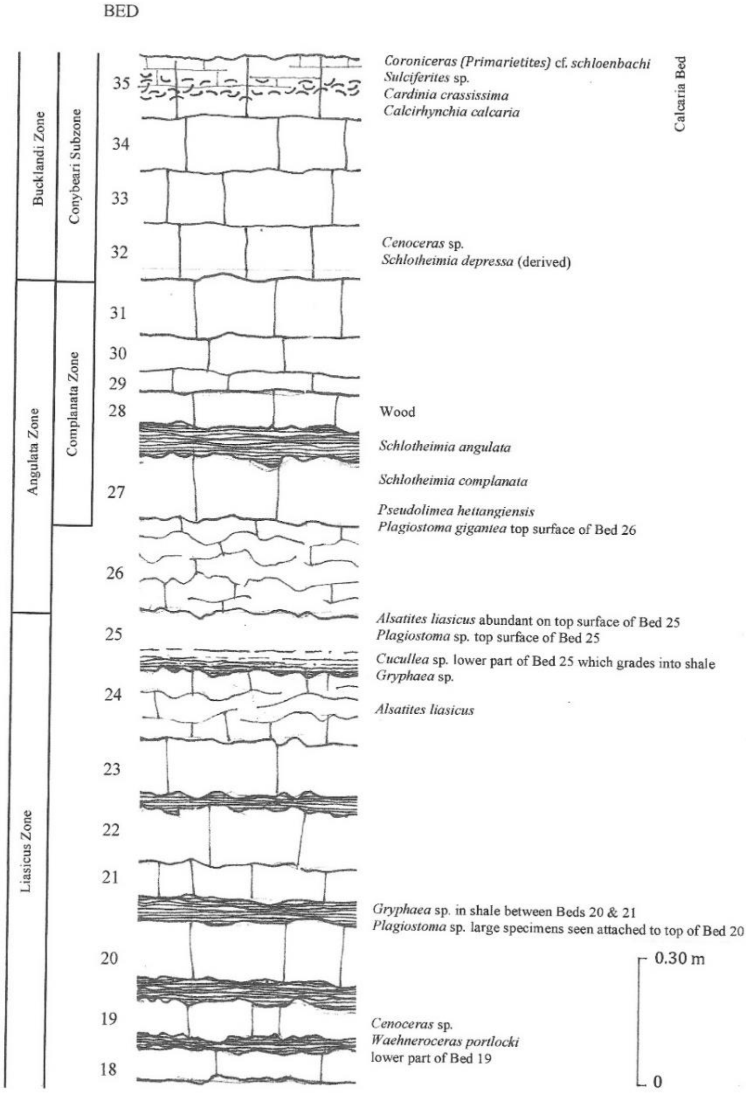

Fig. 8: Vertical section of top part of Exposure 2.

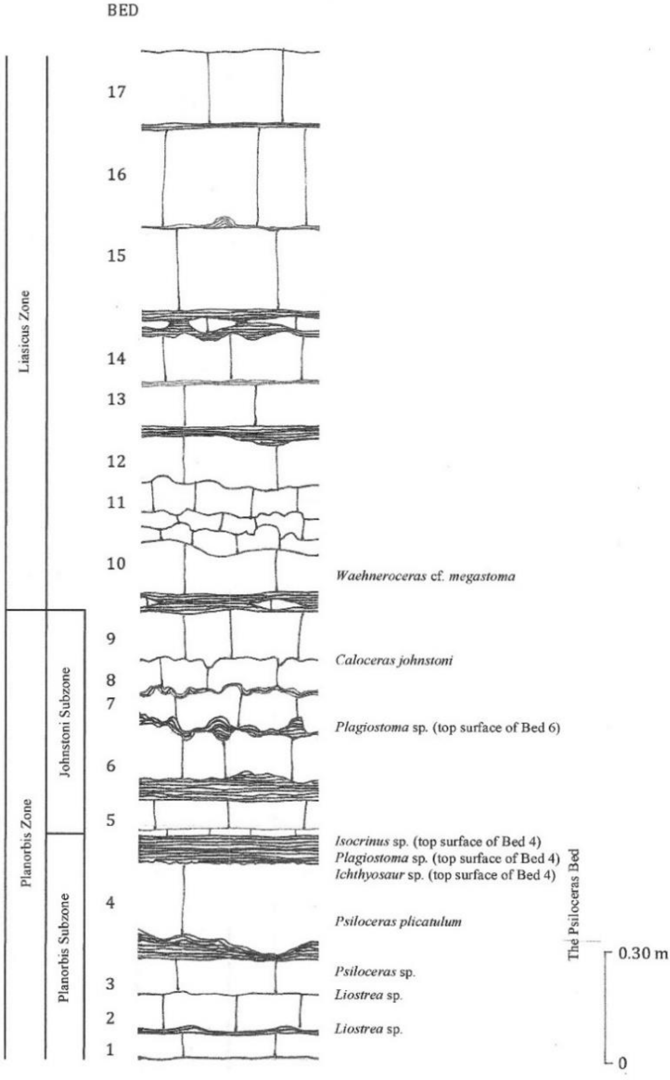

Fig. 9: Vertical section of lower part of Exposure 2.

3 The succession

The exposures have much in common. Both sites preserve Late Triassic, and Lower Jurassic rocks representing the Hettangian Stage of the Lower Lias. At Exposure 1, younger beds belonging to the base of the Sinemurian Stage of the Blue Lias Formation are preserved. Despite the proximity of the sites, identifying beds in common proved difficult. In addition, due to rubble obscuring the sections, detailed logs could only be made over parts of the exposures.

3.1 Late Triassic

Loose blocks of the Sun Bed were found on the spoil heap of Exposure 2, but not seen *in situ*. These rocks would have occurred at the very base of the excavation. The Sun Bed is a conspicuous pale, creamy porcellanous limestone with a bored surface and occasional desiccation cracks. It is recognised across the Radstock Shelf and Avon Valley and represents the top of the Langport Member, of Late Triassic age. It was deposited in a shallow water, sometimes emergent, environment (Hallam and Lang, 1960, Donovan and Kellaway, 1984).

3.2 Early Jurassic, Pre-Planorbis Beds

The beginning of the Jurassic marks the start of a transgression as the ocean advanced across the land. The basal succession of mudstones and limestones at both sites are devoid of ammonites and is assumed to belong in the lower part to the Pre-Planorbis beds. The Pre-Planorbis beds, 'Corn grits' of early publications (Tawney, 1875) are a succession of thin bioclastic limestones with shaly partings. They are considered as part of the Blue Lias and Jurassic in age (Wignall, 2001), although the placing of the Triassic to Jurassic boundary is controversial. Some workers propose the first appearance of *Psiloceras planorbis* (Warrington et al. 1994), while others prefer the base of the Blue Lias (Hallam, 1990) or even the base of the Langport Member (Poole, 1979). These beds are also known as the Ostrea beds due to the abundance of *Liostrea hisingeri*. Fossil diversity is low; the most frequently found fossils were bivalves, *Plagiostoma.* sp. The individual beds were relatively thin, many had surfaces covered by irregular mounds or protuberances (see Figs. 3 & 6). The bumps and lumps on top surfaces of limestone beds may be due to the early concretion formation due accretion of calcium carbonate during diagenesis, possibly enlarging pre-existing bioturbation and burrow features.

3.3 Lower Jurassic, Hettangian. Blue Lias Formation.

3.3.1 Planorbis Zone (Beds 1-9, Exposure 2)

The base of the Hettangian Stage at both Ston Easton sites was represented by the Planorbis Zone of the Blue Lias Formation. The Psiloceras Bed is a distinctive limestone in the succession on account of the sheer abundance of the preserved ammonite, *Psiloceras*. The Psiloceras Bed was seen at both exposures (Bed 35) and contained plicate *Psiloceras* indicating the top of the Planorbis Subzone of the Planorbis Zone. Donovan (1956) describes *Psiloceras plicatulum* (Quenstedt) *bristoviense* Donovan as the common species in this bed, but also records that *Psiloceras sampsoni* (Portlock) is found at some localities. *Psiloceras* also occurs sporadically in the layers above and below this bed. At Stowey Quarry the Psiloceras Bed divides into three courses with *P. psilonotum* (Quenstedt) at the bottom, *P. plicatulum* in the middle, and the first *Caloceras* in the top. In Exposure 2 we place Beds 1-4 in the Planorbis Subzone and Beds 4-9 in the Johnstoni Subzone.

3.3.2 Liasicus Zone

There is no obvious break in lithology as the succession continues upwards into beds that begin to preserve ammonites in some abundance and diversity. *Waehneroceras portlocki* (Wright) was recorded from lower part of Bed 19 at Exposure 2. This indicates the base of the Hettangian, Liasicus Zone, Portlocki Subzone. At a higher horizon in the same exposure (Bed 25) several specimens of *Alsatites liasicus* were found, indicating the Liasicus Zone. Specimens of *Plagiostoma* were common and often with their valves disarticulated.

3.3.3 Angulata Zone

Schlotheimia complanata was found at the bottom of Exposure 1 (base of Bed 31) and the top of Exposure 2 (Bed 27) indicating the overlap of the two exposures at that horizon. This indicates the Complanata Subzone of the Angulata Zone. This is significant as the Angulata Zone is absent on the Radstock Shelf, the ‘lower Angulata Zone’ of Tutcher and Trueman (1925) being now placed in the Liasicus Zone. At Cole’s Lane Quarry, 600 m south-east of Chewton Mendip Church and 2.5 km south-west of our exposures, 3 m of limestones attributed to the Angulata Zone are present (Donovan and Kellaway, 1984). This quarry is on the same block of Liassic rocks as our exposures (Fig. 2). Our observations indicate that the Angulata Zone is present at Ston Easton. *Plagiostoma* was found associated with examples of *Pseudolimea hettangiensis*.

4 Lower Jurassic, Sinemurian. Blue Lias Formation

4.1 Bucklandi Zone

In Exposure 1 the top 1.5 m of the section (not seen in Exposure 2) comprised more massively bedded limestones which we were able to log (Fig.5). A specimen of *Metophioceras* cf. *conybeari* was exposed in the wall of the excavation, near the base of Bed 35, indicating the Conybeari Subzone, lowest subzone of the Sinemurian, Bucklandi Zone (Fig 4). At this level there is a condensed horizon rich in invertebrate fossils including various species of *Coroniceras*, the brachiopod, *Calcirhynchia* *calcaria* (in abundance), the gastropod, *Ptychomphalus expansus* and large numbers of the bivalve, *Cardinia crassissima* that formed a prominent shell layer. some are preserved in full articulation, while the majority are found as disarticulated valves. The bivalve, brachiopod and gastropod fossils all had their calcite shells preserved in some sections of the bed. In other places they were completely decalcified and present only as casts. The ammonites were generally poorly preserved, incomplete and without shell. The occurrence of brachiopods in the succession, suggests that, at times, sedimentation rates slowed and hardgrounds developed. Brachiopods required clear water and a hard substrate for attachment. It is probable that Bed 35 represents the Calcaria Bed (Donovan and Kellaway, 1984).

The only evidence for the Rotiforme Subzone is the ex situ *Coroniceras deffneri*.

The Bucklandi Zone is absent across the Radstock Shelf, probably due to non-deposition (Donovan and Kellaway, 1984). Deposition re-started in the Semicostatum Zone with a condensed phosphatic facies, the Bucklandi Bed, which, despite its name is of Semicostatum Zone, Sauzeanum Subzone age. The Bucklandi Zone is present in the Avon valley to the north. It is present at Stowey where there is a condensed ammonite pavement of Rotiforme Subzone age resting on hard limestones, 5.6 km to the north-north-west. The ammonite evidence suggest that Exposure 1 displays all the Subzones of the Bucklandi Zone, though it is not possible to subdivide it.

4.2 Semicostatum Zone

Towards the top of Exposure 1 the limestone beds thinned and contained the ammonites, *Arnioceras acuticarinatum, Eucoroniceras* aff. *hebe,* the bivalve, *Gryphaea* and the brachiopod, *Spiriferina pinguis*.

The shale and thinly bedded limestones between Beds 39 and 42 replicate the situation around the Scipionianum Bed at Keynsham (Donovan and Kellaway, 1984), and we have no hesitation in assigning the shale and Beds 40 to 43 (0.35 m) to the Scipionianum Subzone of the Semicostatum Zone. This places Bed 39 in the position of the Reynesi Bed at Keynsham, which at that location, is usually full of giant Arietitids and *Paracoroniceras*, but they are absent here. It is thus impossible to draw the boundary between the Lyra Subzone at the base of the Semicostatum Zone and the Bucklandi Subzone of the Bucklandi Zone.

The top of Bed 43 is phosphatised and probably a hardground and contained Arnioceras acuticarinatum, that and a loose specimen of Agassiceras indicate the presence of Scipionianum subzone of the Semicostatum Zone.

In the subsoil, phosphatic debris was seen including an example of the phosphatised brachiopod, Spiriferina and fragments of Coroniceratid ammonites. This was taken to be a remnant of the Spiriferina Bed which represents the lowermost part of the Turneri Clay of Sauzeanum Subzone. Small fragments and pellets of water-worn chert were observed throughout the succession at Ston Easton and it is thought that these are derived from the erosion of the Lower Carboniferous (Dinantian), Black Rock Limestone.

Table 1: Fossils collected from the Exposures.

Fossil type	**Bed number**	**Exposure**
Vertebrates		
Crushing tooth from a hybodont shark in field wall	ex situ	1
Ammonites:		
Arnioceras acuticarinatum (Simpson)	42 **Fig. 11b**	1
Arnioceras cf. *semicostatum* (Young and Bird)	39	1
Pararnioceras paolinae (Reynes)	37	1
Coroniceras (Primarietites) cf. *schloenbachi* (Reynes)	35	2
Eucoroniceras aff. *hebe* (Reynes)	35	1
Coroniceras deffneri (Oppel)	ex situ	1
Metophioceras cf. *conybeari* (J. Sowerby)	35	1
Vermiceras scylla (Quenstedt)	35	1
Sulciferites sp.	35	1
Sulciferites sp.	35	2
Schlotheimia complanata von Koenen	base 31	1
Schlotheimia complanata von Koenen	32	2
Schlotheimia sp.	32	2
Schlotheimia angulata Schlotheim	shale between 27 & 28 **Fig. 11a**	2
Schlotheimia complanata von Koenen	27 **Fig. 10a**	2
Schlotheimia sp.	ex situ	
Alsatites liasicus (d'Orbigny)	top surface of 25 **Fig. 10d**	2
Alsatites liasicus (d'Orbigny)	24 **Fig. 10c**	2
Waehneroceras portlocki (Wright)	lower part of 19 **Fig. 10b**	2
Waehneroceras sp.	10	3
Caloceras johnstoni (J de C. Sowerby)	8	3
Psiloceras plicatum (Quenstedt)	4	3
Nautloids:		
Cenoceras malherbii (Terquem)	32 **Fig. 13a**	2
Cenoceras sp.	32	2
Cont.		

Fossil type	**Bed number**	**Exposure**
Gastropods:		
Pleurotomaria sp.	32/34 eg. **Fig. 12f**	2
Ptychomphalus expansus (J. Sowerby)	35	1
Acromya dunkeri (Terquem)	ex situ	2
Cardinia crassissima (J. Sowerby)	35	1
Cardinia crassissima (J. Sowerby)	35 **Fig. 13b**	2
Cucullea sp.	lower part of 25	2
Eopecten velata (Goldfuss)	ex situ	2
Gryphaea arcuata Lamarck	top of 39.	1
Gryphaea obliquata J. Sowerby	42	1
Gryphaea sp.	top surface of 24	2
Gryphaea sp.	shale between 20 & 21	2
Liostrea irregularis (Münster)	top surface of 2	2
Liostrea sublamellosa Dunker	ex situ	
Plagiostoma gigantea J. Sowerby	top surface of 26	2
Plagiostoma hermanni (Voltz)	ex situ **Fig. 12a**	2
Plagiostoma sp	ex situ	3
Plagiostoma sp	attached to top of 4	3
Plagiostoma sp.	attached to top of 25	2
Plagiostoma sp.	attached to top of 20	2
Pleuromya sp.	ex situ. **Fig. 12d**	2
Plicatula spinosa J. Sowerby	top surface of 26 **Fig. 13c**	2
Pseudolimea hettangiensis (Terquem)	top surface of 26	2
Brachiopods:		
Calcirhynchia calcaria S. Buckman	35	1
Calcirhynchia calcaria S. Buckman	43	1

Fossil type	**Bed number**	**Exposure**
Spiriferina pinguis (Zieten)	42	1
Spiriferina sp.	phosphatic debris in subsoil above 43	1
Corals:		
Unidentified coral	ex situ	1
Unidentified coral	Attached to *Cenoceras* sp.	2
Unidentified coral	ex situ limestone block with several corals	2
Serpulidae		
Encrusting serpulids	Common throughout	1 & 2
Plant:		
Wood.	28	2

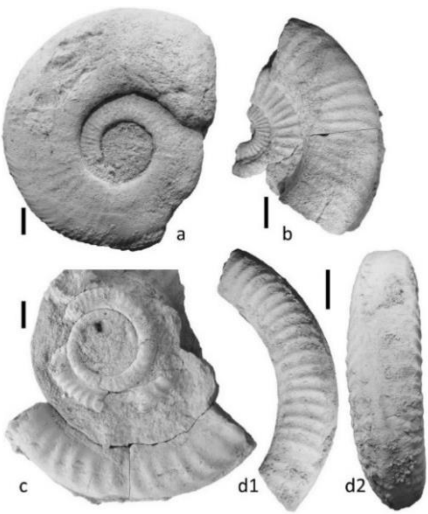

Fig. 10: (a) *Schlotheimia complanata* von Koenen, Bed 27, Exposure 2. (b) *Waehneroceras portlocki* (Wright), lower part of Bed 19, Exposure 2. (c) *Alsatites liasicus* (d'Orbigny), Bed 24, Exposure 2. (d) *Alsatites liasicus* (d'Orbigny), top of Bed 25 or ex situ, Exposure 2. Scale bar 20 mm.

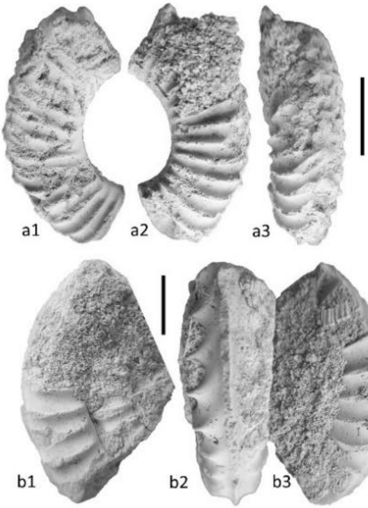

Fig. 11: (a1-3) *Schlotheimia angulata* Schlotheim, shale between beds 27 and 28, Exposure 2. (b1-3) *Arnioceras acuticarinatum* (Simpson), Bed 42, Exposure 1. Scale bar 10 mm.

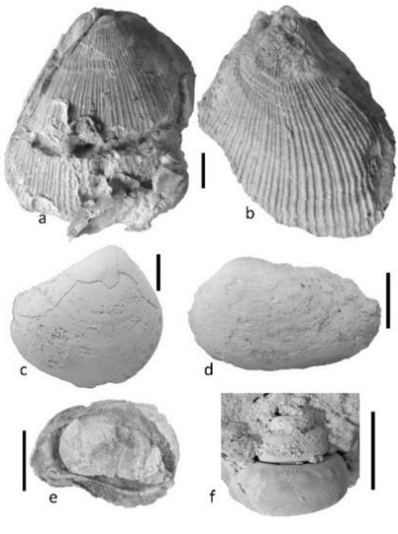

Fig. 12: (a) *Plagiostoma hermanni* (Voltz), with adhering *Liostrea irregularis* (Münster), ex situ, Exposure 2. (b) *Plagiostoma hermanni* (Voltz), ex situ, Exposure 2. (c) *Plagiostoma gigantea* J. Sowerby, Bed 26, Exposure 2. (d) *Pleuromya* sp. ex situ, Exposure 2. (e) *Liostrea irregularis* (Münster), top of Bed 2, Exposure 2. (f) *Pleurotomaria* sp, ex situ, top part, Exposure 2. Scale bar 20 mm.

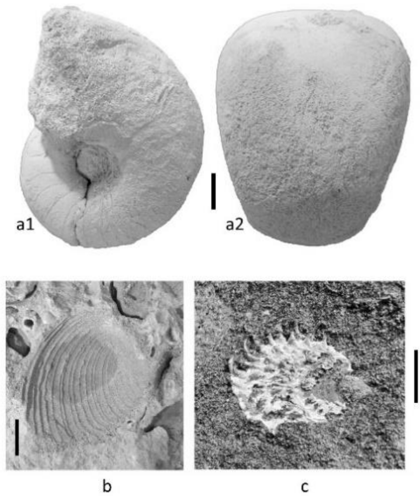

Figure 13: (a1-2) *Cenoceras malherbii* (Terquem), Bed 32, Exposure 2. (b) *Cardinia crassissima* (J. Sowerby), Bed 35, exposure 1. (c) *Plicatula spinosa* J. Sowerby, Bed 26, Exposure 2.

5 Conclusion

The exposures described herein lie to the south-west of the classic Radstock Shelf quarries studied by Tutcher and Trueman (1925). In all of those localities the Angulata and Bucklandi Zones are absent and the Sinemurian is very attenuated. In contrast to the north-west at Stowey the Angulata Zone and the Conybeari and Rotiforme Subzones of the Bucklandi Zone are present. At Cole's Lane Quarry, Chewton Mendip the Angulata Zone and the Semicostatum Zone are present but the Bucklandi Zone is absent. Our exposures lie on the same 'block' of Lias as Cole's Lane Quarry and expose elements of the Pre-Planorbis beds, the Angulata Zone, the Bucklandi Zone and the Semicostatum Zone demonstrating, yet again, the considerable lateral variations in thickness and component subzones of the Blue Lias as described by Donovan (1956).

6 Acknowledgements

Brian and Sarah Clothier are thanked for providing access to the exposures on their land at Home Farm, Ston Easton and Giles Clothier is also thanked for allowing visits to his property at Ston Easton. Steve Smith is thanked for his company and geology input during our field trips.

Please note that both geological sites, described in this paper, are no longer available to visit.

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All photographs are by the authors.

Temporary exposures in the Llandovery and Wenlock rocks of the Silurian Inlier at Falfield, South Gloucestershire (UK)

Charles Hiscock

Abstract

Excavations in a field west of the village of Falfield, South Gloucestershire (UK), have produced two temporary exposures where, historically, exposures of the rocks have been rare, one each in the Llandovery Tortworth Beds and the Wenlock Brinkmarsh Beds of the Silurian Tortworth Inlier. The rocks in the localities are described and enable the junction between the two formations to be established and compared with historical descriptions. The fauna of the Wenlock is listed and compared with the type locality in the Inlier.

Introduction

The Tortworth Inlier is a region of lower Palaeozoic rocks occupying an area of about 26 sq.km. (10 sq. miles) between Milbury Heath, approximately 3 km. (2 miles) north east of Thornbury, and Purton, 4.5 km (3 miles) north of Berkeley, of which the southerly portion is composed of rocks of the Silurian Llandovery and Wenlock Series (Fig 1 after Curtis 1972). The southern section of the Inlier has been affected by the synclinal folding of the Bristol Coalfield basin with the Silurian outcrop following a semi-circular pattern around the edge of the Devonian and Carboniferous outcrops on the northern rim of the coalfield basin. While the concentric nature of the outcrop is seen on the northern and eastern borders of the inlier, the western side is less obvious. Here the rocks are in a south-south westerly pitching anticline relative to the synclinal nature of the rest of the inlier. The core of the anticline follows the route of the A38 Bristol to Gloucester trunk road from Whitfield to just north of Falfield and then veers eastwards. The Silurian rocks on the eastern side are well exposed and curve easterly from Falfield towards Damery and Charfield. In the locality under study close to the village of Falfield, the crest of the anticline has been eroded exposing the Damery Beds which are bounded on both sides by the Tortworth Beds. To the west of the anticline and Llandovery rocks, the poorly exposed Wenlock Brinkmarsh Beds form the generally level and low-lying land from Eastwood Park north to Stone (Fig 1 after Curtis 1972).

The succession in the Inlier is –

Silurian	Ludlow Series	*not exposed in the southern area*
	Wenlock Series	Brinkmarsh Beds
	Llandovery Series	Tortworth Beds
		Upper Trap
		Damery Beds
		Lower Trap
	Unconformity	
Ordovician	Tremadoc Series	Micklewood Beds { *not exposed in the*
		Breadstone Shales { *area of study*

Previous Research

The Silurian rocks of the Inlier have attracted attention from 1824 when Weaver was the earliest to describe them. Reed and Reynolds (1908a and b) described the rocks of the southern half of the Inlier and recorded fossils from certain localities. Reed and Reynolds (1908b, p 531) recorded exposures in the lane west of Heneage Farm (ST684937 - Falfield Farm recorded by Curtis 1972 and Cave 1977) and assigned the outcrop to the Wenlock Series while R.W. Pocock (1935, in Cave 1977) recorded that the beds were vertical and included a red crystalline limestone. In a geological excursion guide Reynolds (1912) recorded that Wenlock fairly fossiliferous limestone and shales dipping NW at 30 deg., were found in the stream bed just west of Daniel's Wood, and farther east the dip rapidly increased to 75 deg. NW. In the wood, the strata are vertical, being so for 36 metres and at some point, slightly overturned. Curtis (1955a) gave a full review of earlier research and then recorded specimens that had been found to date (Curtis 1956). He then comprehensively described the rocks, providing a full faunal list and erected the stratigraphical names for the divisions which have been used subsequently by the British Geological Survey (Curtis 1972). It is of interest that Curtis makes no mention of vertical bedding but records steeply dipping limestones with interbedded shales in the same location as Reynolds (1912). Cave (1977) summarised the work by Curtis and others and added later research.

Descriptions of the Locations

The area under study lies to the west of the A38 trunk road in the village of Falfield, South Gloucestershire. The rocks are poorly exposed with only loose fragments in the fields giving indications of the underlying outcrops.

The Wenlock Brinkmarsh Beds are extensive, the loose brash in the fields and the banks of the stream the only indications of the underlying rock. The author collected small pieces of red crinoidal limestone from the banks of the stream north of the hamlet of Moorslade. There is no obvious change in the lithologies in the field as the bottom of the Brinkmarsh Beds resemble the top of the Tortworth Beds. These are fine-grained hard sandstones alternating with reddish mudstone although the Wenlock is often coarser and calcareous. The boundary between the Tortworth Beds and the bottom of the Brinkmarsh Beds was fixed by Curtis at the calcareous sandstones with abundant crinoid ossicles or at the first limestone. The fauna changes significantly at the boundary due to changes in depositional conditions.

The Llandovery Tortworth Beds form extensive outcrops along the anticline through Falfield and Whitfield and occasional exposures of the beds have been recorded. The position of the Llandovery outcrop is indicated by fragments of the hard greenish parallel-bedded sandstone on the surface which is mostly unfossiliferous apart from trace fossils and sedimentary structures. Curtis and the British Geological Survey map a major fault, an extension of the Whitfield Fault, 250 metres west of the A38 trending north-north west with the downthrow to the west but there are no obvious manifestations on the surface. The British Geological Survey maps the fault through the Tortworth Beds unlike Curtis who maps the fault as the junction of the Brinkmarsh Beds with the Tortworth Beds, placing the boundary between the two formations approximately 200 metres west of the A38 trunk road. The fault then trends westwards towards Stone (Figs. 1a, 1b and 2).

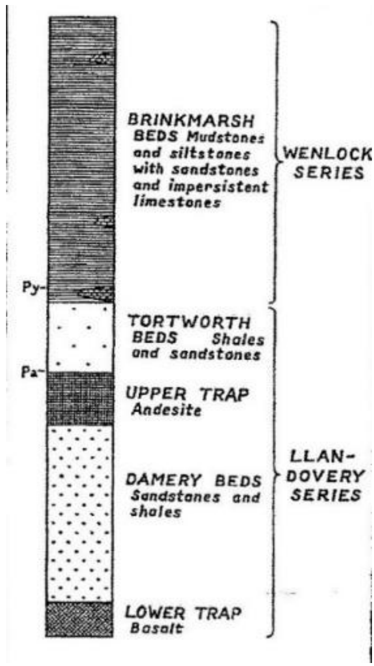

Fig 1a: Key to the stratigraphy in Fig 1b. (Pa - Palaeocyclus Zone: Pa - Pycnactis Band) (After Curtis 1972).

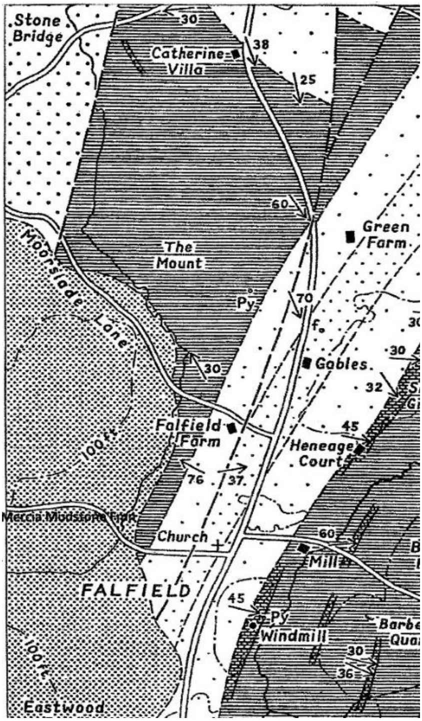

Fig 1b: Distribution of Llandovery and Wenlock rocks in the Falfield district (after Curtis 1972).

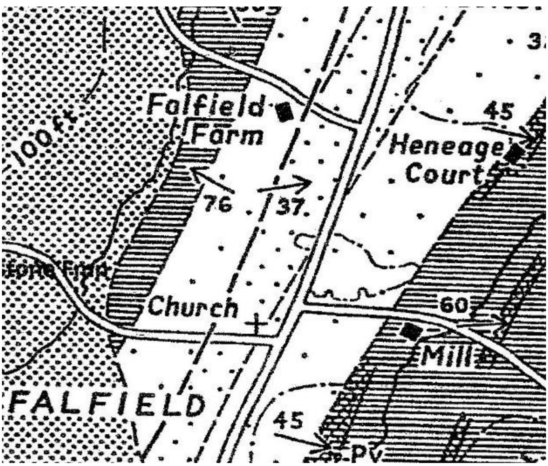

Fig. 2: Rocks of the Falfield area, Detail.

In 2019 work commenced on a new housing development between Sundayshill Lane and Moorslade Lane, with the initial work being the widening of Moorslade Lane from the junction with the A38 to just past Heneage Farm, a distance of approximately 200 metres. On the north side of the road a deep ditch was excavated which exposed loose rock of the Tortworth Beds from which was recovered a specimen of *Tentaculites anglicus* Salter and, from the Damery Beds, a section of an orthoconic cephalopod. In 2021 a new access road, Jenkinson Way, was opened from Moorslade Lane, just west of Heneage Farm across a field to the housing development just north of Sundayshill Lane and north west of St Georges Church (Fig. 3).

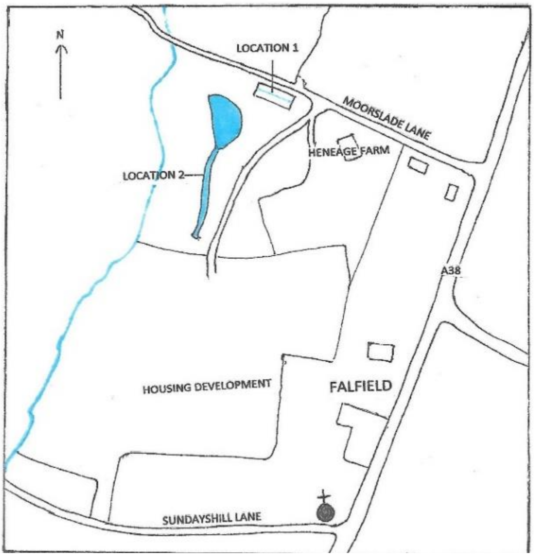

Fig. 3: Map of Falfield showing positions of localities 1 and 2.

The field slopes to the west down to a small brook and has been landscaped and flood mitigation work carried out to include a flood drain just south of, and parallel to, Moorslade Lane and a flood relief channel, approximately 1 metre deep, running 10 to 20 metres west and roughly parallel to the access road. Another pond, of an ornamental nature, was formed to the north between the two localities, which receives water from the new channel.

Location 1 – Flood relief drain just south of Moorslade Lane

The flood relief drain (9m wide X 40m long X 3.5m deep) is located 20 metres west of the junction of Jenkinson Way and Moorslade Lane and 8 metres south of Moorslade Lane (Fig. 3). The excavation of the drain produced a depression with sides sloping at approximately 45 degrees to a water way in the bottom between two culverts (Plate 1).

Plate 1: Flood drain parallel to Moorslade Lane

Plate 2: West end of flood drain showing overturned bedding.

Loose rock fragments of the underlying outcrop were exposed. On the north bank the bedding was exposed so that vertical beds were clearly displayed, being very slightly overturned to the west in the upper half (Plate 2).

The sequence showed vertical beds of hard fine greenish sandstone alternating with red to purple unfossiliferous mudstone up to 25 cm thick, the red colouration being due to the once overlying red Mercia Mudstone Group. The majority of the sandstone beds were thin, less than 2 cm but a few were 3 to 4 cm thick. Many of the sandstone beds displayed sedimentary features such as prods and flute marks on both surfaces and trace fossils such as *Chondrites sp* and a single example of the vertical burrow Skolithos were found. A few moulds produced by small solitary rugose conical corals or lengths of crinoid columnals appeared as raised impressions on the sandstone surfaces (Plate 3). The purple to red mudstone was structureless, friable and unfossiliferous.

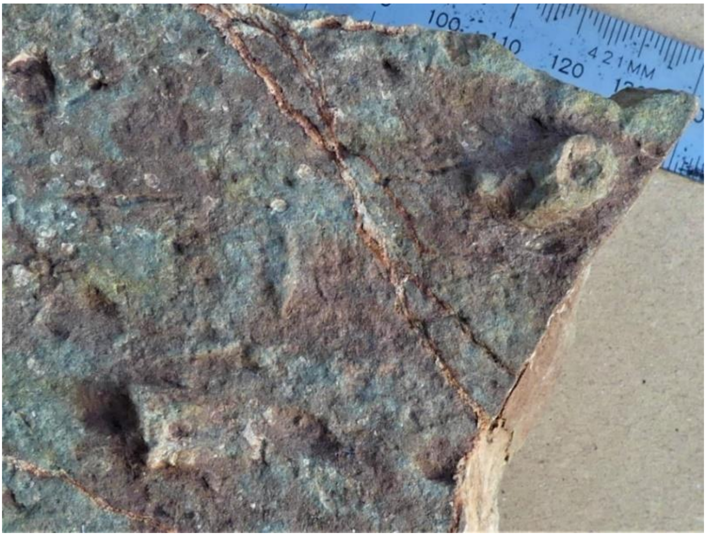

Plate 3: Moulds of crinoids or corals in Tortworth Beds.

The bottom of the Brinkmarsh Beds was fixed by Curtis at the crinoidal calcarenite bed or the lowest limestone band. In the location it is difficult to ascertain where the bottom of the Brinkmarsh Beds can be placed but 4 metres east of the western culvert a 4 – 5 cm thick distinctive vertical sandy limestone bed was exposed in which there was abundant crinoidal and small amounts of coral debris (Plates 4 and 5).

Plate 4: Basal crinoidal limestone

Plate 5: Vertical crinoidal limestone bed 4 metres from west end

A single specimen of the rugose button coral *Palaeocyclus porpita* in pale greenish sandstone was found on the top face of the crinoidal limestone (Plate 6). The coral is abundant in the ashy limestone named by Curtis the Palaeocyclus Band, which is the basal bed of the Tortworth Beds that overlies the Upper Trap. It has been recorded above the Upper Trap in the stream bed in the south west corner of Daniel's Wood, in Cullimore's Quarry, Charfield, and Middlemill Quarry.

Plate 6: The rugose coral *Palaeocyclus porpita*

The Upper Trap does not outcrop on the west side of the Inlier but *P. porpita* has been found in the south of the Inlier at Eastwood Park and, with the discovery of the coral at Falfield, places the Damery Beds at the core of the anticline, bounded laterally by the Tortworth Beds. However, the vertical bedding in the Tortworth Beds west of Heneage Farm has foreshortened the outcrop between the Damery and Brinkmarsh Beds thus providing an explanation for the close proximity of all three formations.

Another thinner, less fossiliferous sandy limestone bed occurred 13 metres east of the west culvert. It has been previously observed that the lithology of the rocks in the lower Brinkmarsh Beds and the upper Tortworth Beds west of Falfield are quite similar and this was obvious in the exposure. At the west end, adjacent to the culvert there was a significant change where the bedding became indistinct, pale cream in colour and more calcareous. Close examination at this location showed fragmentary, structureless unfossiliferous calcareous sandstone but within 0.5 metre east the vertical bedding was established. The position of this feature as determined from the British Geological Survey maps corresponds closely to the line of the major fault. It is therefore, postulated that the disaggregated calcareous sandstone is the fault breccia formed at or close to the junction of the Tortworth and Brinkmarsh Beds (Plate 7).

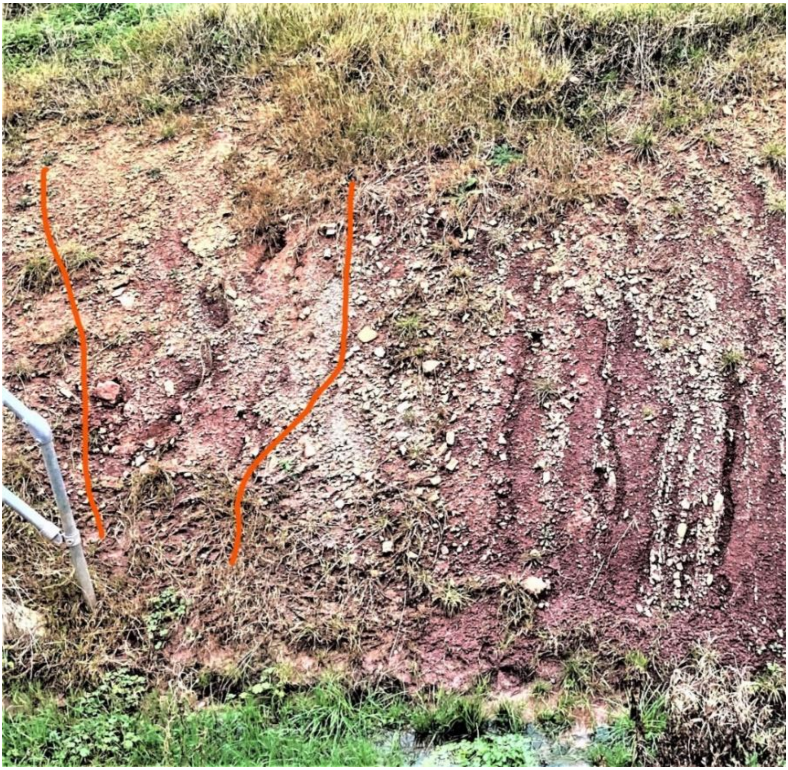

Plate 7: Bottom bed of Brinkmarsh Beds showing possible fault breccia.

Location 2 – Flood relief channel west of Jenkinson Way

The flood relief channel is approximately 100 metres long and follows a sinuous path west of the access road with both banks at about 30 degrees. The land slopes gently down from the road to the shallow channel at the south end of which is a culvert under the Falfield Pumping Station building. The channel trends north past another (central) culvert entering from the east side (Plate 8) to a third culvert at the northern end which takes the water through to the large ornamental pond located between the two exposures.

Plate 8: Drainage channel looking north to centre culvert.

Plate 9: East bank with brick-red rock fragments.

The channel was cut into brick red clays with abundant pieces of rock which had been disturbed by the excavation (Plate 9)

On the east bank between 0 and 2 metres north and south of the central culvert were abundant pieces of sandy limestone, much being highly crinoidal (Plate 10).

Plate 10: Basal crinoidal limestone.

On the surface of the mudstone the winter freeze/thaw process had released large numbers of loose crinoid ossicles. Binocular microscope examination at X10 of the washed material showed abundant ossicles from 6mm diameter down to <1mm. Among the loose blocks on the bank were found specimens of the small rugose coral *Pycnactis mitratis* Schlotheim (Plate 11) and a single rugose coral *Tryplasma loveni* showing rejuvenation ridges and partially encrusted by the bryozoan *Fenestella sp.* (Plate 12).

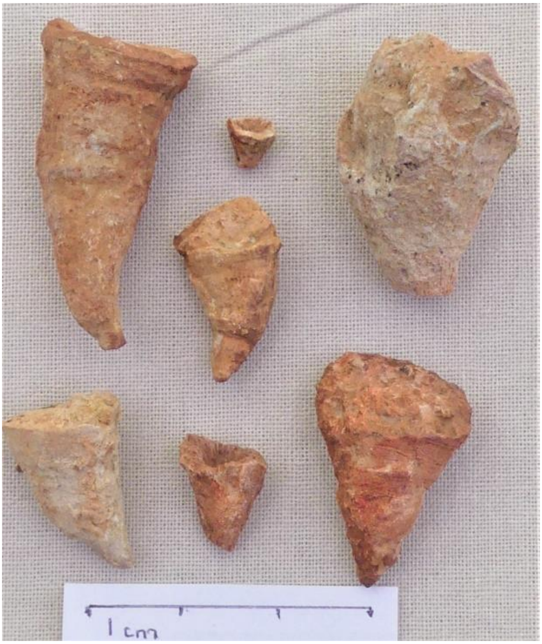

Plate 11: Rugose coral *Pycnactis mitratis*.

Plate 12: Rugose coral *Tryplasma loveni* with encrusting bryozoan *Fenestella*.

Plate 13: Reef-like mass of the tabulate coral *Coenites juniperinus*.

On the east bank were blocks of reef-like masses of the tabulate coral *Coenites juniperinus* Eichwald (Plate 13) with a small piece with a trilobite pygidium.

In the loose brash were abundant small brachiopods including *Atrypa reticularis, Howellella anglicans*, *Microphaeridiorynchus nucula*, one poor brachial valve of *Resserella whitfieldensis*, a single internal mould of gastropod *Poleumita sp*. and internal moulds of gastropod *Cyclonema sp*. All these forms have been collected and recorded by Curtis (1956 and 1972) and the author from the Pycnactis Band overlying the lowest limestone in the Type Locality, Brinkmarsh Quarry in the south of the Inlier. A distinct difference is the almost complete absence of *R. whitfieldensis* (except the one poor example) in Locality 2 and the Pycnactis Band in Brinkmarsh Quarry where it is abundant. The fauna listed has also been recorded 600 metres due north of Heneage Farm and in the small quarry at Skays Grove, north of Heneage Court.

About 2 metres north of the central culvert a short exposure of the vertically bedded crinoidal sandy limestone was recorded (Plate 14), the alignment being north-north-east passing approximately 2 metres east of the west culvert in Location 1.

Plate 14: Vertical crinoid bed.

A small piece of sandy limestone from Location 2 was immersed in dilute acid for about a week. Initially there was effervescence indicating the presence of carbonate but it soon ceased. The material was washed in fresh water for a week and then allowed to dry. The acid process was repeated but with no effervescence. However, the dissolution process loosened a substantial amount of fine gritty material and brick-red clay. The nature of the limestones in the Wenlock of the Inlier has been described as ‘sandy’. Microscopic examination of the sediments confirmed the presence of quartz sand and showed that the remains of the small piece of rock was mainly silica cemented quartz sand. The carbonate content of the sample was estimated to be, at most, 10%.

On the east side of the access road, loose rock fragments of the fine, hard sandstone of the Tortworth Beds exhibited surfaces showing sedimentary features and occasional trace fossils but the absence of material typical of the Brinkmarsh Beds indicates that the boundary between the two formations lies between the channel and Jenkinson Way.

Discussion

The excavation of the two locations has provided an insight into the Llandovery Tortworth Beds and Wenlock Brinkmarsh Beds in an area where exposures have been rare or non-existent. The British Geological Survey does not record Brinkmarsh Beds south of Moorslade Lane but Curtis recorded the beds continuing south just beyond Sundayshill Lane where it is overstepped by Mercia Mudstone Group and placed the boundary between the two formations about 300 metres west of the A38. The base of the Brinkmarsh Beds was placed by Curtis at the crinoidal limestone bed or the bottom of the first limestone. In the south of the inlier, the lowest limestone is exposed in the south face of Brinkmarsh Quarry overlain by the Pynactis Band mudstone containing the abundant small rugose coral *Pycnactis mitratis* Schlotheim. The presence of the coral on the east bank of the drainage channel at Location 2, just above the vertical reef-like masses of *Coenites juniperinus* and highly crinoidal sandy limestone, indicates the position of the Pycnactis Band. Thus, the boundary between the Tortworth and Brinkmarsh Beds follows the east bank of the channel, north-north-east across the ornamental pond (where no exposure exists) to the west end of Location 1. Fig. 4 shows the route of the Pycnactis Band (red line) and the junction of the Brinkmarsh and Tortworth Beds, marked by the lowest crinoidal bed (black dotted line).

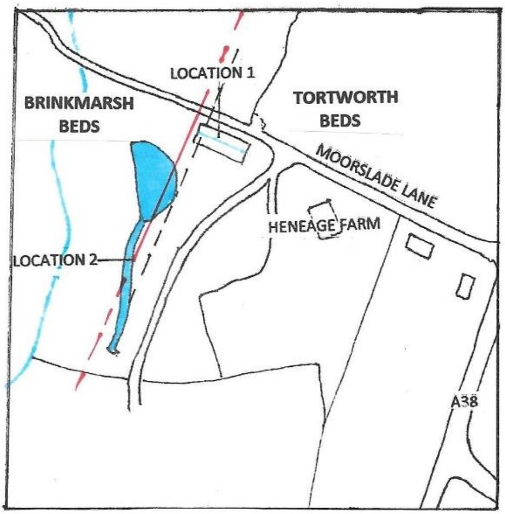

Fig. 4: Map showing the positions of the Pycnactis Band (red line) and the junction (black line) between the Brinkmarsh and Tortworth Beds west of Heneage Farm, Falfield.

As has been remarked, no fossils typical of the Pycnactis Band have been found in Location 1 so the boundary between the formations can be placed just west of the drain excavation at Location 1 and is not seen at the surface. Furthermore, the study has shown that the Brinkmarsh Beds extend farther south than recorded by the British Geological Survey and concur with Curtis' (1972) mapping of the outcrop.

In March 2022 both locations were covered with top soil, obscuring most of the rock outcrops and it is anticipated that vegetation will quickly grow to complete the process.

In conclusion, the findings of this study have confirmed the mapping made by Curtis (1972) who showed that -
a) the boundary between the Tortworth Beds and the Brinkmarsh Beds lies approximately 200 metres west of the A38 but is not seen on the surface,
b) the Brinkmarsh Beds extend south towards Sundayshill Lane while the British Geological Survey does not record them south of Moorslade Lane, and
c) the study also confirms the outcrop of vertical bedding reported by Reynolds (1912) and Pocock (1935) in an area where exposures are poor or have been rare.

Acknowledgments

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Pacific Oyster *Magallana gigas*: new to the Bristol Region

Jon Mortin

The Pacific Oyster *Magallana gigas* is a large oyster native to the Pacific coast of Asia. It is found as an introduced species in North America, Europe, New Zealand and Australia where it is often farmed commercially. In the wider region there are 55 records from South Wales dating back to 1998 and at least 3 records from Flatholm (2017-2018). Until recently it had not been recorded alive in the Bristol Region although David Howell has been finding shells in small but increasing numbers, sometimes containing the dead or dying animal, from the shoreline in the Redcliffe Bay area since the winter of 2019-20.

Pacific Oyster *Magallana gigas* from Clevedon Marine Lake ©Jon Mortin

The Pacific Oyster is generally found attached to hard substrates in shallow estuarine or intertidal waters, so might be expected to occur along our shoreline. It can grow up to 180mm in length (or even 400mm in favourable conditions). It is generally pale or blue-grey in colour but with purple streaks and is quite rough in texture with a crenulate shell margin (see image above). It has been farmed in around 300 places in the UK with the first recorded introduction into Poole Harbour as long ago as 1890.

More commercial introductions happened in the 1960s partly in response to declining stocks of our native European Oyster *Ostrea edulis*. Initially it was not thought to pose a threat as UK waters were too cold to allow spawning. However, as sea water temperatures have risen in recent years the oysters have been able to reproduce and populations have now established away from the commercial farm locations. These naturalised populations can then reproduce and further the spread in conjunction with prevailing ocean currents.

Specimens were spotted in the Marine Lake in Clevedon in October 2022 when the lake was drained for routine cleaning. I was shown an image of a small colourful specimen attached to stone in the centre of the lake and then spotted a larger specimen (130mm in length) attached to stone near the edge of the lake. Initially I had no idea what they were, but subsequent investigations revealed their identity. The records have been verified on irecord (an online national recording and verification scheme) and submitted to BRERC and accepted as the first living specimens in our area.

Where did the Clevedon individuals come from? Perhaps from the naturalised populations in South Wales (eg Milford Haven) where ocean and tidal currents could send their planktonic larvae into the Bristol Channel. They have also been recorded at Flatholm in recent years so have clearly already reached the Bristol Channel. It has also been suggested that UK waters may still be generally too cold for successful spawning and new populations are coming from as far away as Brittany where sea temperatures are higher. An individual oyster can release as many as 50 million eggs into the water column which can spread considerable distances.

There is some concern that the spread of the Pacific Oyster could pose a threat to UK coastal ecosystems. They can alter marine habitats by reef formation and displace native oysters. The sharpness of their shells underfoot could also present issues in the future!On the plus side Pacific Oysters (like their native counterparts) help to purify seawater by removing heavy metals and biotoxins. These accumulate in the oyster's soft tissue without harming it.

No doubt there will be more records along our coastline in the future.

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Pollinator Capital of the UK

Frances Gray and Peter Charles

Background

In 2022, Dan Norris – Metro Mayor for the West of England Combined Authority - announced the ambition for the West of England to be the 'Bee and Pollinator Capital of the UK' (the Combined Authority covers the areas of Bristol, Bath & North East Somerset and South Gloucestershire). This ambition aims to tackle the ecological emergency which includes a rapid decline of insect and pollinator populations (globally and locally) as well as dependent populations of birds and mammals. Pollinators spread pollen from the male part of one flower to the female part of another flower and a wide range of insects carry out this process, from bees to butterflies, through moths, flies and beetles. Bats and birds can also act as pollinators.

Wild pollinators in the UK are undergoing a progressive decline with, for example, two-thirds of moth species in long-term decline and 80% of butterfly species decreasing in abundance or distribution, or both, since the 1970's. On average, UK butterflies have lost 6% of their total abundance and 42% of their distribution since the 1970s (Butterfly Conservation, 2022). Additionally, two species of native bumblebee became extinct in the UK during the 20th century and a further eight are listed as conservation priority species in at least one of the English, Welsh and Scottish lists due to large-scale declines in distribution (Bumblebee Conservation Trust, 2021). This decline in pollinators jeopardises sustainable food production as well as other ecosystem services. The Combined Authority has enlisted the help of a panel of local experts in the field of nature recovery and entomology (including the Bristol Naturalists' Society's own Ray Barnett), spanning academia, government and the private sector, to define the 'Pollinator Capital' ambition and to provide guidance and advice on the approach.

The Community Pollinator Fund and Projects

The Combined Authority established a three-year £1m 'Community Pollinator Fund' to support the 'Pollinator Capital' ambition, as a solution which can be deployed rapidly, reflecting the urgent nature of the problem. The fund expects to award grants to around 100 community-led ecology projects that enhance biodiversity habitats across Bath & North East Somerset, Bristol, and South Gloucestershire. In total, the fund is expected to deliver 31.2 hectares of new and improved pollinator habitats, which although modest in scale, aims to act as a springboard by demonstrating habitat creation techniques, whilst empowering and inspiring further action to be taken across the region to tackle the ecological emergency. Over 3,600 community members are expected to take part in practical action throughout the duration of the three-year fund. The outputs are expected to increase the number and variety of pollinators and other

species and increase the resilience of ecosystems. The fund will be one of several measures which will help deliver the Combined Authority's objective of increasing wildlife abundance by 30% by 2030 which aligns with the global target of 30 by 30 set out in the Post-2020 Global Biodiversity Framework.
The fund provides an opportunity to trial a new community-led approach to addressing the ecological emergency. It will also complement a range of other volunteer-focussed community initiatives being run by key regional partners that provide practical training in land management and conservation. This should further strengthen the Combined Authority's relationships with key partners within the region's Nature Partnership and support future partnership working.

Thirteen projects were funded in late 2022 and have begun creating and improving habitats across the region as of early 2023. Projects are trialling a range of measures including the creation of wildflower meadows, installation of pollinator shelters, practical training on habitat creation, and campaigns to encourage action, such as for pesticide reduction. Several methods are being implementing to capture the ecological impact of the grants, including the procurement of an ecological consultant to conduct site surveys to identify invertebrate and plant species present. The Natural History Consortium is providing practical advice to many projects funded in round 1 to enable measuring of ecology data at the project sites. Each funded project will also provide information on project progress, outcomes and impact. In addition to the grants, the Combined Authority is running other initiatives such as the Bee Bold Awards to identify and share good practice by all sorts of organisations in creating pollinator habitats.

Residents and community groups (including organisations such as the Bristol Naturalists' Society) are encouraged to get involved with the project, by taking part in the habitat creation projects, or supporting efforts to measure the ecological impact by conducting surveys and adding to the base-line data held by the Bristol Regional Environmental Records Centre (BRERC).

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Naturalists' Society badges

Harry McPhillimy

Plate 1: Vintage enamel Naturalists’ Society badges © Harry McPhillimy

I collect vintage enamel Naturalists' Society badges and part of my collection is shown above. My first was a beautifully designed one for the Route Naturalists' Society. This was a Naturalists' group for people on the North coast of Northern Ireland, which was run for a while by my mum and dad. They organised the outings and walks and were the backbone of the group. Sadly, as with so many Naturalists' Societies, the group eventually folded because, as members aged, there were no longer people left to run it. Many Naturalists' groups no longer exist, their badges left as the only memento of the enthusiastic amateur natural historians who, over the years, had such a thirst for scientific knowledge.

Berwickshire is the oldest Naturalists' Society that I know of, indeed it is the oldest continuously active Club of its kind in the UK. It was founded in 1831 and called Berwickshire Naturalists’ Club, though the badge illustrated below is likely to date from the 1920’s. Cotteswold Naturalists’ Field Club, based in Gloucestershire, started in 1846, and Belfast Naturalists' Field Club began in 1863. The badges take many different forms but many are examples of the fine enamelling skills of the Birmingham jewellery quarter as well as other badge makers. There are badges of Natural History Societies connected to individual schools such as St. Ivo in Cambridgeshire and Sir Thomas Rich’s in Gloucester, no doubt initiated by one charismatic teacher or head.

There are badges of national UK organisations such as The Young Naturalists' League and British Junior Naturalists’ Association and the tradition of Naturalists’ Societies and their badges extended to Australia and other parts of the Commonwealth.

Plate 2: Badge from Berwickshire Naturalists’ Club, likely to date from the 1920’s and depicting a Wood Sorrel, apparently the favourite plant of the club’s founder Dr George Johnston.© Harry McPhillimy

Finally, I have to admit to being a little disappointed by the Bristol Naturalists' Society badges that I have come across - the earliest I have is a rather prosaic red and chrome square badge, possibly of the 1960s. I suspect there may be older versions lurking out there somewhere.

And that is what keeps me collecting.

The changing invertebrate fauna of the Bristol region

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At the end of 2022, I left Bristol Museums after working there for the previous 33 years. At such a time one inevitably thinks back over one's career and, in my case, it has also been an opportunity to consider the changes that have taken place to the local invertebrate fauna whilst I have been employed in Bristol (and been a member of the Bristol Naturalists' Society over that same time).

If you were able to return to the Bristol of 1990, would you notice much difference in the landscape compared to today? Perhaps most people would not, the main vegetational structure of habitats may have changed to the expert eye but to most people the suite of trees and plants would appear much the same. However, close examination of the invertebrate fauna might reveal a different story.

Plate 1: Rose chafer beetle *Cetonia aurata* ©Maico Weites

The short life cycle (often annual) of most invertebrates means that these species react much more quickly to changing environmental factors than long-lived plants such as trees. Therefore, studying the changes to such populations can be revealing as regards monitoring the impacts of changes on our ecosystems as a whole and can be the equivalent perhaps of the proverbial canary in a coal mine.

In 1990, arriving back in Bristol after graduating and leaving in 1982, I was immediately taken with the discovery that the Light Brown Apple Moth *Epiphyas postvittana* was a common moth in urban gardens in the city. At that time the available literature and indeed knowledge and understanding of the status of insects in the UK was in its infancy compared to today. The internet was still to arrive along with more sophisticated ways for recorders and recording schemes to bring together information. Consequently, the main available publication on tortricoid moths had been published in 1973 and it suggested that *E. postvittana* was an Australian species thought to have arrived in West Cornwall accidentally amongst apple imports around 1936. By 1973 it had spread slightly further east and had even been recorded from Torquay in Devon and one site in Hampshire. In the subsequent 20 years or so, clearly the moth had spread northwards to Bristol and become very well established. What had changed to enable this expansion out of Cornwall where it had been largely confined for 40 years?

Another species which caught my attention at the start of the 1990s was the Rose Chafer beetle *Cetonia aurata* (see above). Each spring considerable numbers of the adult beetle were being killed by being trodden on by pedestrians walking along Upper Berkely Place, to and from the West End Car Park on the edge of Clifton in Bristol.

At that time my impression was that this striking beetle was largely confined to a relatively small number of green squares in the city centre. Today the beetle is a very common inhabitant of gardens across the city and elsewhere (and ironically seen much less around Upper Berkeley Place). In both these cases, the moth and the beetle, it is very likely that the reason these populations have expanded from a previously somewhat limited range is due to increasing average temperatures due to man-made climate change and probably specifically to the impact of climate on the overwintering success of insect species such as these two.

One further example which is also worth emphasising is that of the Scarlet Tiger moth *Callimorpha dominula*. In the 1980s this species had been categorised as Nationally Notable, in other words known from fewer than 30 10km squares across Britain. Locally there had been just a couple of sightings in the region prior to 1980 but then from that point onwards individuals started to be recorded sporadically. By the end of the 1990s the moth had remarkably become widespread and common in the region and almost replaced the Cinnabar *Tyria jacobaeae* as the red day-flying moth to see in your Bristol garden in the summer. Once again the reason is likely to be related to climate. The larva of the Scarlet Tiger feeds on many common plants (such as bramble) and displays aposematic colouration ie warns off potential bird predators.

This is the life stage by which it overwinters and again warming winter average temperatures may explain this surge in the population.
Climate change is one of the factors determining the changes to invertebrate populations that have been taking place. The release of climatic limitations on the distribution of indigenous species can be seen in many different groups. In the Orthoptera, the Long-winged Conehead *Conocephalus fuscus* and Roesel's Bush-cricket *Roeseliana roeselii* are species which 30 years ago were not found around Bristol and Bath but were limited to more southerly areas of England. Both have since colonised the region and are now common in grassy areas throughout, even in central Bristol sites such as Brandon Hill. Similar expansions can be seen in the Hemiptera as exemplified by the Box Bug *Gonocerus acuteangulatus* and Brassica Bug *Eurydema oleracea* which again have rapidly become established and even relatively common locally.

Plate 2: Box bug *Gonocerus acuteangulatus* ©Rupert Higgins

The largest hoverflies in the UK are further examples. The Hornet Hoverfly *Volucella zonaria* is thought to have naturally colonised certain English cities in the 1940s from Europe. It only managed to survive in London, Southampton and Bristol initially, possibly associated with the heat islands created by these urban centres. However, it too has now massively expanded its range and can no longer be claimed to be a speciality of the city. A very close relative, slightly smaller and more yellow than orange is *V. inanis*. This species was restricted to the London area until relatively recently but has now widened its distribution so that it has joined *V. zonaria* as being a regular member of the Bristol region hoverfly fauna.
To understand better the processes that are ongoing it seems easiest to divide these expanding species into several different categories. The first would be those species

which, like *E. postvittana*, are not native to Britain but some time ago had established small populations through the agency of human activity. The Jersey Tiger moth *Euplagia quadripunctata* is another such example being a native of the Mediterranean (noted for the large colonies which aestivate in The Valley of the Butterflies on the Greek island of Rhodes during the hottest period of the summer). A colony became established on the Devon coast in the 1880s, either by accident or through direct intervention) where the mild climate of the 'English Riviera' enabled them to survive. Since the early 2000s, this moth has suddenly expanded its UK distribution across southern England and it is now a very common moth in Bristol in mid-summer

Plate 3: Wasp spider *Argiope bruennichi* ©Mike Williams

. The Wasp Spider *Argiope bruennichi* is yet another European species which somehow became established on the Dorset coast in the 1920s. It is just in the last few years that it too has expanded across England and reached the Bristol region. Clearly non-winged invertebrates are unable to colonise new areas as rapidly as those which can fly.

Other well-known examples of spiders conforming to similar patterns are the Noble False Widow *Steatoda nobilis* known from Torquay since 1879 but now widespread and *Segestria florentina* a tube-web spider noted for its green chelicerae and taste for woodlice. The latter parallels the Hornet Hoverfly story in part as it has been an established part of the Bristol fauna since the 19th century (no doubt accidentally imported by ships returning to Bristol from the Mediterranean) before recently spreading across England.

A second category to consider is comprised of species which were once an accepted part of the British fauna but died out only to re-emerge in recent years. Whether these represent new colonisation from Europe or the resurgence of native populations which had been reduced to almost undetectable levels is debateable, but the former is perhaps more likely. The Downland Villa *Villa cingulata* is a fly related to the beeflies we commonly see in spring in gardens. Thought to have become extinct in Britain in the 1920s, one was found on the Cotswolds by Matthew Oates in the year 2000.

Plate 4 : Clifden Nonpareil *Catocala fraxini* ©Rich Andrews

Shortly afterwards examples were found at Tucking Mill near Bath and then in Leigh Woods, Bristol. Given the rarity of the species at that time, a Biodiversity Action Plan was drawn up by local authority ecologists to highlight the need to protect it and a wooden bench placed in Leigh Woods had an image of the fly carved on it to raise awareness. Since that time the species has become common and widespread across England. Like other beeflies, *V. cingulata* is a parasitoid as a larva and it is thought that it utilises the larvae of noctuid moths, so this is not a limiting factor. Nor is the availability of open grassland which it is associated with a restriction which does point the finger at a climatic control on its distribution.Other examples in this same category include the moths the Clifden Nonpareil *Catocala fraxini* and the Small Ranunculus *Hecatera dysodea*. The Clifden Nonpareil (sometimes called more descriptively the Blue Underwing) is a very large and impressive species. It was a resident species across East Anglia and Kent in the 1930s but by the 1960s had probably ceased to be a breeding species in Britain and was known only as a very rare migrant. That all changed a few years ago when it started to appear in moth traps across England and has now been shown to be breeding across England including in the Bristol region where it first appeared in 2015 and where a larva was found in 2020 on someone's jumper after walking through woods at Banwell (the larvae usually feed on Aspen). The Small Ranunculus was widespread across South-eastern England up until the 1930s when it suffered a dramatic decline and extinction. At that time it was mainly a coastal species in the South East which may suggest it needed mild winters to survive, the larvae feed on wild and cultivated lettuce and so foodplants would not have been a limiting factor. Recolonisation from Europe has seen it not just return to the South East but now to be common in the Bristol region for example, where it has been shown to be breeding since at least 2009.

A third category can be formed of species which until very recently were not known from the British Isles at all. The Tree Bumblebee *Bombus hypnorum* is one such example, arriving in the country in the 1980s and is now perhaps the commonest bumblebee seen in Bristol gardens. Nesting in holes in trees it can also take advantage of roof spaces in buildings perhaps competing with wasps for nesting sites.

Plate 5: Ivy mining bee *Colletes hederae* ©Maico Weites

The Ivy Mining Bee *Colletes hederae* is a similar example again colonising in the 1980s and now a familiar site on ivy blossom in the autumn in our region. Wasp species too have arrived from the continent. In the Bristol region the Median Wasp

Dolichovespula media has now been with us for over 30 years. At first glance similar to other social wasps, some individuals can be much blacker than those of other species. It also likes to nest in bushes and shrubs creating a hanging often grey-looking nest but this does mean those hedge trimming should be on the lookout for the nests!

In the Odonata, the Bristol fauna has now been augmented by the arrival of breeding populations of the Small Red-eyed Damselfly *Erythromma viridulum* and the Southern Migrant Hawker *Aeshna affinis*. And in the well recorded lepidoptera several new or established migrants have for the first time started to breed on our islands and in our own local patch. These include the Oak Rustic *Dryobota labecula*, Dewick's Plusia *Macdunnoughia confusa*, Ni Moth *Trichoplusia ni* and Clancy's Rustic *Caradrina kadenii*. The Oak Rustic's larva feeds on the Holm Oak, a non-native and very invasive tree.

A fourth category of new arrivals is those species entirely introduced by the artifice of humans. Many of these have been brought into the country unwittingly through the horticultural trade. The Harlequin Ladybird *Harmonia axyridis* is perhaps the best known example. A native of Asia, it is now a cosmopolitan species found across the globe. Concerns were raised when it first appeared in Britain in 2004 as to the potential impact upon native ladybird species populations but the tide of millions of individuals was impossible to stem once here. A very common insect in the region now, its presence is suspected of being responsible for the decline of the Two-spot Ladybird *Adalia bipunctata* which it most closely out competes or even dines on. There are many other such examples of invertebrates arriving in this fashion and the latest to gain notoriety is probably the Box Tree Moth *Cydalima perspectalis*. Again a native of Asia, since arriving in the UK it has spread very rapidly and catches of 30 plus individual moths in one night's moth trapping in Bristol are not uncommon now. The impact of the larvae on box hedges and other ornamental box shrubs has been dramatic as the species has no natural predators or parasitoid wasps and flies to help reduce numbers.

Other examples commonly met with in Bristol gardens include the bright red Lily Beetle *Lilioceris lilii* whose striking appearance contrasts with the larvae covered in slimy excrement to deter predators and which can devastate lilies and fritillaries in gardens. Perhaps somewhat less damaging is the Rosemary Beetle *Chrysolina americana* (another native of the Mediterranean with nothing to do with the Americas), now a regular on Lavender and Rosemary plants in local gardens (see below).

Plate 6: Rosemary beetle *Chrysolina americana* ©Maico Weites

Away from the new arrivals, what has been happening over the last three decades with respect to our established native invertebrate fauna? In the first instance perhaps we should consider one of the rarest species in our region. The Silky Wave moth *Idaea dilutaria* occurs in the Avon Gorge and just two other locations in Wales in the British Isles, although it is found across Europe. Monitoring by the Bristol Zoological Society would suggest that this moth is doing well with a strong population in the Gorge. The reasons for this may be two fold: the warmer winters may favour the overwintering larva; and the site management, to largely protect and encourage the rare plants of the Gorge to survive, may also be improving the habitat for the moth, providing warm, dry micro-climates.

As for our butterflies things are not so rosy. If you take the long view, Silver-spotted Skipper *Hesperia comma*, Wood White *Leptidea sinapis*, Black-veined White *Aporia crataegi*, Mazarine Blue *Cyaniris semiargus* and Large Blue *Phengaris arion* were all lost from the region in the 19th century. Then in the 1980s we lost Silver-studded Blue *Plebejus argus*, Adonis Blue *Polyommatus bellargus*, Large Tortoiseshell *Nymphalis polychloros* and High Brown Fritillary *Fabriciana adippe*. In the 1990s the Duke of Burgundy *Hamearis lucina* and Pearl-bordered Fritillary *Boloria euphrosyne* also went. Other species are now only just clinging on, such as the Grayling *Hipparchia semele,* Small Blue *Cupido minimus*, Chalk Hill Blue *Polyommatus coridon,* Brown Hairstreak *Thecla betulae*, White Admiral *Limenitis camilla*, Marsh Fritillary *Euphydryas aurinia* and Small Pearl-bordered Fritillary *Boloria selene* and could be lost at any time. Even once relatively common species such as Dingy Skipper *Erynnis tages* and Grizzled Skipper *Pyrgus malvae* now give considerable cause for alarm. This sad state of affairs can be probably directly attributed to loss or the degradation of suitable habitat, especially whilst in the larval form. The caterpillars of fritillaries and blue butterflies in particular may be susceptible to changes in sward height or scrub encroachment so that they do not receive enough sunlight and warmth at crucial stages of development (ironic at a time of increasing global temperatures).

Unlike with moths, we are not seeing new arrival butterfly species colonising the region. The Long-tailed Blue *Lampides boeticus* perhaps being the one exception which shows signs of perhaps becoming a regular visitor and even resident eventually. The long term native moth species are also not faring that well. Data from the national moth recording scheme coordinated by Butterfly Conversation show a dramatic decline in the abundance of common moth species across the UK over the last 40 years or so. Local data held at the Bristol Regional Environmental Records Centre (BRERC) would seem to support that view along with anecdotal evidence of declining catches at moth traps. Data on the less popular insect and invertebrate groups is harder to find and analyse effectively but nationally the concern that all insect populations are declining in abundance has been demonstrated by the so called Bug Splats project. The RSPB carried out there 'Big Bug Count' in 2004 across the country which asked people to record the number of insects dead on their car registration plates after journeys. This project was recently repeated in the SE of England by BugLife and their results showed a very dramatic and concerning decrease in insect abundance since 2004 by 58.5%. It is highly likely that similar declines have taken place in and around Bristol and Bath. It is also highly likely that local extinctions of certain species has taken place and more may be following down that path, however it is much harder to demonstrate an extinction than it is to spot new arrivals to the region.

So, in summary, in the last 30 years or so the evidence we do have plus anecdotal impressions would suggest that there have been many examples of colonisation or expansion of range by certain species on invertebrate in our region. It would seem likely that much of those changes are driven by our changing climate. However, these new arrivals or newly abundant species disguise a more general and very serious decline in abundance and loss of once common species. These declines and losses are very concerning and can be shown, by data held at BRERC and elsewhere, to be reflected in declines in invertebrate predators, notably bird species which rely on insect prey primarily or as a food source for their nestlings. Specific declines are being noted nationally eg the decline in the abundance of large hairy moth caterpillars has been directly linked to declines in the Cuckoo as a breeding bird across southern England.

If climate change is suspected to be the root cause of many new colonisations is it also responsible for the declines of once common species? The answer would seem to be that in some instances it may be but more important factors are likely to be the continued degradation of natural habitats associated with industrial farming practice (just as many new arrivals are also associated with direct human interventions such as importations through the horticultural trade). At a time when there is increased pressure to produce cheap food (given the cost of living increases) and pressure to increase self-sufficiency as a nation with regard to food production, will the need to reduce our pressure on natural habitats in order to protect our wildlife hold sway or will we see a continued drop in the richness of wildlife around us? Continuing to monitor invertebrates to warn of the changes taking place at a local, national and international level remains very important.

Plate 7: Small Ranunculus *Hecatera dysodea* ©Rupert Higgins

Forty Years of Change in the Avifauna of Chew Valley Lake

Rupert Higgins

It is just over forty years since I first visited Chew Valley Lake, two weeks after I first arrived in Bristol: in fact, proximity to the reservoir and its birdwatching opportunities was a factor in my choosing to study in the city, although I may not have envisaged quite how many times I would find my way to the lake over the years. I certainly would not have predicted the changes I have witnessed in the area's birdlife; these have been driven by a variety of wider changes, which I will discuss in turn below.

Plate 1:View from Moreton Hide, Chew Valley Lake ©Dawn Lawrence

The first factor to consider is that Chew Valley Lake is a relatively young ecosystem whose vegetation and wildlife have been in flux and continue to mature. The lake is older than me, having been created in the 1950s, but the sobering truth is that I have now known the site for more than half of its life and it has, inevitably, changed over this time. The basic outline of the lake remains unchanged and major features such as blocks of plantation woodland are still recognisable from the 1980s. But there have been other changes, which even if they have been fairly subtle and very gradual, have had a profound influence on the lake's birdlife: reedbeds have spread at the expense of more open plant communities along shorelines and also into areas of open water; scrub and small trees, most frequently various willow species, have colonised the upper margins of reedbeds; scrub has also spread across areas that were previously open grassland; and plantations have matured.

There have also been changes in the way that the land around the lake is used: in particular, recreational facilities have been enlarged and previously private areas have been opened up to the public. Recreational interests have had other dramatic influences on the lake. Bristol Water were keen, from the start, to establish a trout fishery at the lake and to this end they employed chemicals to kill coarse fish in the catchment. This was not entirely successful and species such as Roach *Rutilis rutilus* and Perch *Perca fluviatilis* survived and became abundant, but it did succeed in eliminating Pike *Esox lucius*. This species remained absent for around forty years, but in the 1990s it was deliberately introduced by persons unknown, presumably with the finally successful aim of establishing a fishery for this species. Pike has flourished, and several specimens close to the British weight record have now been caught.

There have been less obvious changes as well, many of them related to the ways that the surrounding land is managed. Again, at first glance the landscape of fields, predominantly down to permanent pasture, separated by hedges and dotted with small woodlands appears very similar to how it did when I first visited. There have, however, been changes that have had a huge effect on the birdlife. I recall the conclusions in a paper produced by Dr Wilson of University of Bristol in the 1970s, that Chew Valley Lake remained in a state of "ecological immaturity" caused by high levels of phosphorous in the lake's water and sediments, resulting, notably, in very sparse growths of aquatic macrophytes (Wilson *et al*, 1975). Since then, almost all the houses in the catchment have been connected to mains sewerage. The septic tanks on which they previously relied were a major source of contamination and their replacement has led to a huge improvement in water quality. Pollution now arises largely from agricultural sources and there are ongoing efforts to limit inputs from farming. These improvements have belatedly allowed the lake to mature, leading to a huge increase in the abundance and diversity of aquatic macrophytes (Higgins, 2015).

The lake does not, of course, exist in a vacuum and the enormous changes that have occurred across the world have inevitably had a profound impact on its birdlife. The main factors have been agricultural intensification and climate change. The effects of the former on birdlife have been almost entirely negative and are the main driver behind the well-publicised and appalling statistic that we have, as a nation, lost 70 million breeding birds, almost a third of the total, since 1970. Climate change has had more varied consequences, and whilst there have been, and will doubtless continue to be, many negatively impacted birds there are also species to which global warming has been a benefit. Direct persecution has had a profound impact on the British avifauna and for many years was the focus, to the exclusion of virtually everything else, of the bird conservation movement. Small scale wildfowling was allowed at Chew in the early days, and the lake has doubtless been visited by egg collectors, but persecution at the lake itself was probably never a major factor affecting its birdlife. Persecution elsewhere, however, had a major impact and the beneficial consequences of a reduction in levels, both across Britain and abroad, continue to be seen.

The birds for which Chew Valley Lake is of greatest importance are waterfowl, taken here to mean grebes, coot, cormorant and similar birds, as well as ducks, geese and swans. Numbers of all these species fluctuate enormously through the year; many species are migrants that breed to our north and east and either take advantage of our relatively mild winters or visit sites in our region to feed up on the way to and from wintering grounds further south. Other species, such as Little Grebe *Tachybatus ruficollis,* are broadly resident in the region but move to large lakes such as Chew outside the breeding season, to take advantage of food resources and the relative safety from predators provided by large expanses of water. Because of these factors the annual maxima for water fowl always occur outside the breeding season.

Plate 2: Winter flocks of water fowl at Chew Valley Lake ©Rupert Higgins

Waterfowl are highly sensitive to disturbance and the huge increase since the 1980s in recreational pressure at the lake would have been expected to cause a dramatic decline in numbers. In fact, the opposite has happened: the average maximum of wildfowl at the lake in my first five years of the visiting the lake was 5,858; in the latest five years it was almost double at 11,314; had the 1970s been used as a baseline the difference would be even more marked. How has this increase been possible in the face over a period of ever-increasing recreational pressure? One answer lies in changes in the behaviour of the birds themselves. Most species now face far lower levels of persecution than they previously did; this means that they allow boats and people to approach much closer than they did in the 1980s and are able to continue to use areas from which they would previously have been excluded. This explains why there has been no decline in numbers, but the reasons for the increase lie elsewhere. The most important change has been the improvement in water quality and the consequent increase in the growth of water plants. The link between plants and birds is obvious enough for herbivorous species such as Coot *Fulica atra,* whose average of annual maxima has risen from 1,437 to 3,820. The link is less obvious for an insectivorous species, such as Tufted Duck *Aythya fuligula*, whose average annual maximum has risen from 576 to 2,650. It seems likely that the increased plant growth has provided increased food supply, a much greater variety of microhabitats and, possibly, better shelter from fish, all of which have led to a rise in invertebrate population sizes and an increased food supply for Tufted Duck. The fortunes of several other species, notably Teal *Anas crecca*, are closely linked to water levels at the lake: falling levels in the autumn expose food resources and allow rapid growth of ruderal plant species, both providing optimum feeding conditions for many birds (Higgins, 2009 and 2010).

There are several other species whose numbers have increased, but there have been losers too. Prominent amongst these is Pochard *Aythya farina*, whose average maximum has fallen from 756 to 540. It seems unlikely that this decline has been driven by factors at Chew: its largely herbivorous diet is very similar to that of Coot. Pochard numbers are falling throughout Europe, for reasons that are not yet fully understood, and the decline at Chew reflects this. Goosander *Mergus merganser* is another species not doing well, its average maximum having fallen from 66 to 14, despite having risen in the earlier years of this period – counts of over 200 were not unusual in the 1990s. It feeds on fish, but it seems unlikely that any problem relating to its food has been a factor, as some other piscivorous species have done well over the same period. It seems likely that climate change is the cause, with warner weather allowing birds to winter further north and east, closer to their breeding grounds.

Plate 3: Smew *Mergellus albellus*, once a regular winter visitor, not seen in recent years. ©Rich Andrews

The same factor is probably responsible for the absence of Smew *Mergellus albellus* at the lake in recent years, the disappearance of this species from much of Britain having been reflected in increases in populations wintering elsewhere.

Waterfowl also breed at Chew Valley Lake, and in its early years it was an important nesting site for species such as Shoveler *Anas clypeata* and Tufted Duck. Breeding numbers were in steep decline before the 1980s but these two species, together with Gadwall *Anas strepera* and Pochard, still nested annually then whereas now they rarely do so, and the ducklings of Mallard *Anas platyrhynchos* are the only ones that reliably appear each year. The reasons behind the early stages of this decline were probably the invasion of tussocky grassland by trees and dense scrub and, possibly, a decline in numbers of Chironomid midges, which provide an important food source for ducklings. In more recent years the presence of a large population of Pike has been another important factor. The fish eat a significant proportion of ducklings that hatch and the corpses of pike, which are a familiar site on the lake surface in summer, have attracted an increasing population of Great Black-backed Gulls *Larus marinus*, which also take large numbers of ducklings. Predation by Pike is almost certainly responsible for the almost total loss of Little Grebe as a breeding species, and possibly also a recent decline in non-breeding numbers and may also have caused a steep decline in the breeding population of Great Crested Grebe *Podiceps cristatus*. The importance Chew Valley Lake had for breeding waterfowl has dwindled to virtually nothing, but one wholly unexpected feature of recent years has been the addition of Goldeneye *Bucephala clangula* to the list of birds nesting at the lake. When the first brood was seen in 2008 this was the first known occurrence of this species nesting anywhere south of Speyside, and breeding has occurred in several years since.

Plate 4: Lapwing *Vanellus vanellus*, a wader whose numbers have dramatically declined due to the increasing intensification of farming. ©Rich Andrews

Waders are a charismatic group of birds much loved by birdwatchers. The greatest diversity of species at inland waters is to be seen during the migration periods of spring and autumn. The latter period, which for some species begins in mid-June, sees the largest numbers, with juveniles often making up the vast majority of sightings, and has the greatest potential for rarities. It is a familiar complaint, confirmed by analysis of records (Rose, 2018), that wader passage at the lake is not what it used to be. There are several reasons for this. Some species are simply not as abundant as they used to be. An obvious example is Lapwing *Vanellus vanellus*, which has virtually disappeared from our area as a consequence of land drainage and agricultural intensification. Flocks of over 1,500 were a familiar site at the lake in the early 1980s, but any count over 100 is now noteworthy. We are less aware of the problems faced by species that breed in the far north, but Siberian species such as Little Stint *Calidris minuta*, Curlew Sandpiper *Calidris ferruginea* and Spotted Redshank *Tringa erythropus* have become much less regular. These declines may well reflect worsening breeding success caused by climate change, which is having particularly rapid effects on the tundra habitats used by these species.

Plate 5: Black-tailed godwit *Limosa limosa* is increasing at Chew.
©Rich Andrews

Changes at the lake itself have also worked against waders. A good wader year requires dropping water levels, but many areas where mud attractive to waders would previously have been exposed are now covered in reed and the water has to drop far lower than previously before optimum habitat is exposed. Many areas of mud have become, when exposed, less attractive to waders: soft mud, which was previously attractive to many species, has often been replaced with harder soil, which presumably supports fewer invertebrates. The news is not uniformly bad, however, and a few species have become more frequent. Black-tailed Godwit *Limosa limosa* is the main example, having become steadily more frequent to the point that it has now overtaken Lapwing as the lake's most numerous wader species.

This is thought to be because climate change has allowed an expansion in agricultural land, the species' favoured breeding habitat, in Iceland, but such positive examples are hard to find. Personally, I am perhaps unfortunate that I was first able to visit the lake regularly in the autumn of 1984, arguably the best yet for waders, setting a standard that has been hard to achieve since, although exceptional years such as 2011 and 2022 have come close.

Wader passage often coincides with sightings of terns and Little Gull *Hydrocoleus minutus* and in years of high-water level the chance of seeing good numbers of these charming birds was something to keep observers keen. Unfortunately, numbers of these birds have also declined, by a greater extent at Chew than at many comparable sites. Black Tern *Chlidonias niger* and Little Gull both breed around marshland pools in eastern Europe and are therefore particularly susceptible to the consequences of agricultural intensification. The occurrence of both has always depended on spells of easterly winds coinciding with their migrations, but Black Tern in particular has declined since the 1980's when flocks of over 100 were a not uncommon sight.

Plate 6: Great white egrets *Ardea alba* at Chew Valley Lake ©Rupert Higgins

Throughout the 1980s egrets were barely on the radar of any birder at Chew and their colonisation of the area has been one of the most striking ornithological phenomena of the last thirty years. The first species to be seen was Little Egret *Egretta garzetta* in 1990, when it was still a national rarity. Great White Egret *Ardea alba* was first seen in 2003, but the second individual was not seen until 2011, since when it has been an annual visitor and the count of 58 in September 2020 is to date the highest count made in Britain. Cattle Egret *Bubulcus ibis* was first recorded in 2007 and is now regularly seen in small flocks during the autumn. All three species may have lost their rarity value, but the sight of small feeding flocks continues to add an air of exoticism to late summer visits to the lake. All have benefitted from climate change, and a reduction in persecution.

The paragraphs above consider species for which the lake is of either national or local importance, but the fields, hedges and copses within the lake enclosure support a range of more familiar species. Conditions for most of these birds have not changed drastically at the lake, and the marked fluctuations of many species reflect wider trends. The disease *Trichomanes gallinae* has had a catastrophic effect on one species, and may be impacting another: roosts of over 200 Greenfinch *Chloris chloris* used to form in winter months in a small stand of conifers; it is now rare to see even a single Greenfinch at the lake. Chaffinch *Fringilla coelebs* numbers have declined almost as drastically and although the species is still widely distributed around the lake, its song is no longer a dominant part of the dawn chorus. The main drivers behind population changes, however, have doubtless been habitat loss and declining insect populations. These trends have impacted several species, perhaps most obviously Little Owl *Athene noctua*. Through the 1980s and 1990s this species was easy enough to find at the lake, but it gradually disappeared, and it is now some years since one was seen. Nest sites remain common enough in old trees around the lake and agricultural intensification in the wider landscape must be the cause. Another predator in general decline throughout our area is Kestrel *Falco tinnunculus*, probably due to loss of tall grassland to both scrub encroachment and agricultural intensification. Although single Kestrels still visit the lake, especially in late summer, they are no longer the everyday sight they once were.

Climate change is having ever more obvious impacts on our avifauna and is probably due at least in part for the loss of two species that previously bred around the lake, Willow Warbler *Phylloscopus trochilus* and Cuckoo *Cuculus canorus*. The former was once a prominent part of the spring soundscape but no longer nests around the lake; the latter may do so, but its appearances have become increasingly sporadic. Both will probably remain increasingly scarce passage migrants on their way to from the upland habitats to which they have largely retreated.

The fortunes of these more widespread species have not been uniformly negative. There are a few species that have benefitted from climate change, although none so obviously as the egrets discussed above. In the 1980s it was necessary to travel to the south coast to hear the explosive song of Cetti's Warbler *Cettia cetti*, although there were occasional records from the lake. Colonisation started in 1994 and although there have been temporary setbacks after cold winters this species is now frequent around the lake; the presence of singing males in even suboptimal habitat suggests that its favoured scrubby wetland sites are now fully occupied (Bailey, 2018).

 

Plate 7 (left): Marsh tit *Poecile palustris* have drastically declined at the Lake.
Plate 8 (right): Cetti's warbler *Cettia cetti* have dramatically increased. Both species are likely to be reacting to climate change to some degree. Both Plates ©Gary Thoburn

The reduction in levels of persecution and the ban on DDT have favoured a small number of species. It was possible to see Buzzard *Buteo buteo* from the lake in the 1980s, but it was surprisingly rare to see them actually over the lake. They first bred within the reservoir enclosure in 1994 and the population has gradually increased to around nine pairs. Raven *Corvus corax*, by contrast, remained a genuine rarity until 1990 and it was not until 2000 that it became a regular sight at the lake. Two pairs now breed in most years. Although yet to breed, Marsh Harrier *Circus aeruginosus* was an uncommon visitor until 2015, since when it has been an increasingly common sight, in keeping with the enormous rise in the UK population.

Woodland is not a significant habitat at the lake but there is sufficient for wider changes in bird populations to be apparent. These include drastic declines in sightings of Lesser Spotted Woodpecker *Dryobates minor* and Marsh Tit *Poecile palustris*, against which background the equally dramatic increase in Nuthatch *Sitta europaea* may seem puzzling but could be related to climate change. Numbers of Chiffchaff *Phylloscopus collybita* and Blackcap *Sylvia atricapilla* have both risen significantly; this may be due to the increased maturity of the lakeside plantations, but both species have become more numerous generally, again perhaps because of climate change.

What will the future hold for the lake's bird populations? It is foolish to assume that some of the trends discussed above will necessarily continue, and it cannot be guaranteed that the positive changes in the site's avifauna will be sustained. Recreational pressure is likely to become ever more severe and the point may soon be reached where it severely limits the lake's capacity to support large numbers of water birds. These same populations are also vulnerable to changes in pollution: although trends to date have been positive, a decline in water quality, for instance due to increased cultivation of maize, could cause a huge drop in numbers. Climate change will inevitably have a massive effect on the lake's birds. Chew is one of the few sites in southern Britain that continues to attract large numbers of Goldeneye, but for how long will they continue to migrate this far south? Changes in rainfall and water demand are also likely to have a severe impact. Low water levels in the autumn currently result in larger than usual numbers of birds at Chew, so we might in future enjoy increasingly frequent bumper years for waterfowl. Low water does, however, also allow willows to spread onto the shoreline, and this may limit habitat for several species. Frequent fluctuations in the water level may begin to have negative impacts on the lake's aquatic ecosystems and on the health of the reedbeds, on which the lake's huge breeding population of Reed Warbler *Acrocephalus scirpaceus* relies. Glossy Ibis *Plegadis falcinellus* may become a regular visitor, rather than an intermittent one, and other species from the south may appear. Marsh Harrier and Red Kite *Milvus milvus* may start to breed, but we may lose other breeding species. Predicting the future is probably foolish and it is doubtless wiser to consider the past and present: there is a wealth of information on the birds of Chew Valley Lake, on which I have only touched, and anyone wishing for more information is advised to look through The Birds of Chew Valley Lake, by Keith Vinicombe.

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Bristol and District Invertebrate Report 2022

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Introduction

2022 saw a return to more normal activities following two years of restrictions and concerns over the Covid19 pandemic. It also proved to be an exceptional year in terms of our weather patterns but also in respect to the changes to the insect fauna, especially with regard to migrant moths reaching our shores.

A long hot and dry summer may have led to hopes of a resurgence of familiar species, however, the annual Butterfly Conservation Big Butterfly Count, held across the country from 15 July to 7 August 2022, was not so encouraging. Gatekeeper, Comma, Common Blue and Holly Blue all did well compared to 2021, however the overall trend was of continued decline and overall numbers of butterflies nationally were the lowest since the survey started 13 years previously, being worse than 2021, the previous lowest. The relative scarcity of butterflies is of continued concern and probably reflects a similar situation across all our insect groups where unfortunately available data is more anecdotal.

The record-breaking heat in the UK during the summer of 2022, seemed to finally wake up many to the fact that human-induced climate change is happening and will have consequences for all of us, not just for our local environment but also for the crops and foodstuffs we import and take for granted. Greater recognition of the problem is one thing but finding ways to combat it is much more difficult. To most observers the impacts on vegetation and wildlife seem relatively minimal and transitory (compared say to the consequences of the arrival of *Hymenoscyphus fraxineus* the fungus native to Asia which causes Ash dieback and is predicted by some to eventually kill 80% of UK's ash trees). However, monitoring of invertebrate populations can show that dramatic changes are already taking place. In 2022, as well as the continued colonisation of our region by species previously found further south and the anecdotal reduction in abundance of many insects locally, we witnessed a remarkable late summer/autumn immigration of moth species from Europe and northern Africa. This was not accompanied by a more obvious good year for our regular immigrant butterflies such as the Painted Lady.

Maico Weites kindly arranged several BNS Invertebrate Section meetings – an online talk on butterfly monitoring jointly with the local branch of Butterfly Conservation in February and then field meetings at Stoke Park (May), Hanham Meadows (June) and Leigh Woods (August). These allowed members attending to see interesting species previously mentioned in these annual reports, such as the bristle-tail *Dilta chateri* at the Leigh Woods meeting.

Significant reports are listed below by relevant group of invertebrates. These records are not just from members of the Society but include other sightings I am aware of. My thanks to all those who have submitted records to myself and/or the Bristol Regional Environmental Records Centre (BRERC) especially Maico Weites, Rupert Higgins, Bob Fleetwood, Andy Pym and contributors to the Avon Insects *WhatsApp* group and others who have listed their sightings on open fora such as social media platforms.

Dragonflies & Damselflies (Odonata)

A quiet year for reports of Odonata but a Lesser Emperor *Anax parthenope* at Villice Bay Chew Valley Lake, spotted by Rupert Higgins on 19 July 2022, might support the suggestion that this species is now breeding locally (as evidenced by egg-laying witnessed at Chew Valley Lake in 2006 by Rich Andrews) rather than just being migrant examples. The first sighting of this species in our region was in 2001 and the increasing sightings since may add to evidence of climate change impacting on our insect populations.

Plate 1: A pair of lesser emperors *Anax parthenope* ovipositing at Chew Valley Lake in 2006. ©Rich Andrews

Grasshoppers and crickets (Orthoptera)

The most notable record submitted in 2022 was that of a Large Marsh Grasshopper *Stethophyma grossum* recorded at Shapwick Heath on the Somerset Levels on 6 October by Dave Nevitt. Once considered extinct on the Levels this, our largest grasshopper, is otherwise only known from a few sites in southern England eg in East Anglia where reintroductions have been carried out to help save the species from becoming extinct in the country.

True bugs (Hemiptera)

The rhopalid bug *Stictopleurus punctatonervosus* is a new arrival to the UK and was reported from Portishead on 23 March by Dave Hawkins, 8 May at Kingsweston Down by Ray Barnett and 4 August at Lockleaze by Rupert Higgins, suggesting it has become rapidly established locally. *Eremocoris fenestratus* is a ground bug which was once confined to Juniper on the Chilterns and then thought to have become extinct in the UK before reappearing from 2010. Since then it has been expanding and our first record for the region was from Filton found by Andy Pym on 1 August.

Globiceps flavomaculatus (a member of that large family the Miridae) was first reported new to the region in the 2020 report found by David Hawkins, a further example was found on 10 July 2022 at Cleaves Wood, Wellow by Ray Barnett. *Pinalitus viscicola* (another mirid) is one of the small group of insects associated solely with Mistletoe and Rupert Higgins recorded it at Thornbury Church on 5 September. Finding these specialists is as much about being able to reach the Mistletoe! *Orsillus depressus* is a seed bug, introduced to the UK in the 1980s which feeds on cypress. It has been previously recorded in the region from Longwell Green, Maico Weites found one whilst beating cypress at Avon View Cemetery, Bristol on 14 May 2022.

Plate 2: The leafhopper *Acericerus heydenii* ©Maico Weites..

Amongst the planthoppers, *Ditropis pteridis* is widely distributed over the UK and can be abundant on its host plant Bracken but there are not many records from our region. Maico Weites recorded a large number of nymphs by sweeping bracken at Troopers Hill on 28 August 2022. *Acericerus heydenii* is a leafhopper associated with Sycamore. It was first reported in the UK in 2010 and has been expanding since. Our first records for the region are from Clevedon and from Troopers Hill where Maico Weites found it in late August 2022.

Butterflies (Lepidoptera)

In 2022 perhaps the most noteworthy occurrence was of a Long-tailed Blue *Lampides boeticus* at Sand Point on 23 October 2022 reported on social media by Cliff Smith. This species has now become of regular occurrence on the South East coast of England. There has been at least one report from our region in recent years and maybe this will become a familiar visitor in future. Of other migrants, there were occasional reports of Clouded Yellow *Colias croceus* eg 19 October 2002 seen by Howard Taffs in Clevedon but yet again a poor year for the Painted Lady *Vanessa cardui*. The sighting of a Monarch *Danaus plexippus* in Westbury-on-Trym on 4 August 2022 probably owes more to a captive release than a natural migrant.

Notable records of our resident species include Dark Green Fritillary *Speyeria aglaja* seen at both Walton Moor on 21 June by Howard Taffs and at Purdown, Bristol on 22 June 2002 per Larry Sweetland – a species at low densities locally. Also spotted was a Small Copper *Lycaena phlaeas* aberration *schmidtii* at Herriot's Pool, Chew Valley Lake by Margaret Webster on 1 September 2022. This striking form is white instead of copper coloured.

Moths (Lepidoptera)

2022 was a remarkable year for moth immigration to the UK and, by default, to our region. This really began in mid-May when reports started to come in of records of the Striped Hawk-moth *Hyles livornica* across the country. After having had records of just 5 in this region from the last 30 years, in 2022 there were moths reported at moth lights in Whitchurch, Keynsham, Clevedon and Weston-super-Mare. This pattern of unusual migrants appearing in large numbers was to be repeated around Bristol and Bath throughout the summer and autumn. It was not just migrants but also species which have only recently become established locally as breeding species, in particular Jersey Tiger *Euplagia quadripunctaria*, Clifden Nonpareil *Catocala fraxini* and Four-spotted Footman *Lithosia quadra* which had good years.

Of the other migrants (some of which may now be resident), the numbers of Convolvulus Hawk-moth *Agrius convolvuli* and the Vestal *Rhodometra sacraria* were well above the usual small sprinkling. Two examples of the Dark Crimson Underwing *Catocala sponsa* followed single examples in 2020 and 2021. Blair's

Mocha *Cyclophora puppillaria*, Ni Moth *Trichoplusia ni*, Gypsy Moth *Lymantria dispar*, Tree-lichen Beauty *Cryphia algae* and Dewick's Plusia *Macdunnoughia confusa* were all recorded at different sites across the region. However, the largest scale influx was of 'little brown jobs' – most thought to be the Beet Moth *Scrobipalpa ocellatella* (although very similar species may have been present in this population). Previously the Beet Moth has only been known as a resident from a few coastal sites in the South East of England but following this invasion new colonies may have become established locally, time will tell.

Other migrants which appeared in unusual numbers included Scarce Bordered Straw *Helicoverpa armigera*, Delicate *Mythimna vitellina*, White-speck *Mythimna unipuncta*, White-point *Mythimna albipuncta* with more normal numbers of Rush Veneer *Nomophila noctuella*, Rusty-dot Pearl *Udea ferrugalis*, Pearly Underwing *Peridroma saucia*, *Palpita vitrealis*, and Silver Y *Autographa gamma*. A Cosmopolitan *Leucania loreyi* was only the 2nd ever record for the region (one previously in 2006) and a Clancy's Rustic was just the 3rd ever record locally. The recent colonist Oak Rustic *Dryobota labecula* appeared at its presumed breeding site in Weston-super-Mare but seems also to have established in Clevedon now. Radford's Flame Shoulder *Ochropleura leucogaster* appeared once and *Uresphita gilvata* was only the third record locally and the first since 1895.

For many moth recorders across the country though, the highlight of the year was the unprecedented arrival of the Crimson Speckled *Utetheisa pulchella*. In the whole of the 20th century perhaps 100 were seen in the UK, a statistic blown out of the water by the numbers seen this year alone. A warm plume of air brought these stunning moths to the UK from northern Africa in October and this included one record from our region on 26 October by Wayne Tucker in Bath.

To cap the year there were four species recorded in the region for the first time ever: *Ethmia bipunctella, Pachyrhabda steropodes, Gypsonoma oppressana* and the Palm Moth *Paysandisia archon*. The latter is a South American species now established in Europe and likely to become so in the UK through the horticultural trade. The very attractive micro moth *Commophila aeneana* is very localised in the region even though the larvae feed on Ragwort. An example was spotted in Hartcliffe by Rupert Higgins on 5 June 2022.

Beetles (Coleoptera)

The Somerset Levels (including the wetlands that run behind Clevedon and Portishead and on up into South Gloucestershire) are, of course, of great importance for wetland wildlife. This includes our beetle fauna. A couple of specialist species from this habitat have been reported in 2022 eg the scarce soldier beetle *Cantharis fusca* seen on Nailsea Moor by Jean Oliver on 19 May 2022. The large diving beetles are another feature of such ecosystems but are more mobile and can fly distances at night, so occasionally turning up in moth light traps. *Dytiscus dimidiatus* is one such species and its national distribution includes a concentration in our local wetlands as well as in the wetlands of East Anglia and in Kent. Rich Andrews had one example at his light trap in Whitchurch on 27 March 2022.

Plate 3: Harlequin ladybird larva *Harmonia axyridis* ©Maico Weites

Ladybirds are a very familiar group to all naturalists and the arrival and explosion in abundance of the Harlequin Ladybird *Harmonia axyridis* is well known to most naturalists. Less well known are the much smaller members of the ladybird family, those usually not as well marked with spotting. In 2022 Larry Sweetland decided to investigate these beetles and has been rewarded with finding many of them in Fishponds and Eastville including *Rhyzobius lophanthae*, *R. chrysomeloides* and *R. forestieri* which are non-natives like the Harlequin. Also, *Nephus quadrimaculatus and Scymnus interruptus,* the latter another introduction. The former was also found in Bristol by David Hawkins in March. The tiny *Stethorus pusillus,* is used to control spider mites but also occurs naturally and Rupert Higgins found several in his Bishopston garden on 11 October 2022.

Another very small beetle found by Rupert Higgins was *Cytilus sericeus* which feeds on mosses as both adult and larva, it was found at the Three Brooks Local Nature Reserve on 12 May 2022.

The Minotaur Beetle *Typhaeus typhoeus* is a splendid-looking species a little like a miniature *Triceratops.* As dung beetles they dig a tunnel in which to lay their eggs, a tunnel which can go down 1.5m. Consequently, they need soils where the water table is below that depth, along with a good supply of rabbit, sheep or deer droppings. These conditions seem to be provided to the south west of Bristol as in 2022 Giles Morris reported one from Portbury Lane and Bob Fleetwood also came across one in Failand, both in early May.

On the BNS Field Meeting to Nightingale Valley, Leigh Woods on 6 August 2022, Maico Weites came across the eye-less leiodid beetle *Parabathyscia wollastoni* by sieving leaf litter. This species is rarely recorded as it is largely subterranean in habit and just over a millimetre long; it may be common, just under-recorded. This is now the third time Maico has found it in the Bristol area. Species more genuinely restricted include the weevil *Kalcapion semivittatum* recorded by Maico Weites as common across the city on Annual Mercury but nationally is largely restricted to the SE of England. *Sphinginus lobatus* (a much smaller relative to the familiar *Malachius bipustulatus*) has been known from Hampshire since the 1980s and is probably colonising the country, Ray Barnett swept one on Bristol Downs on 3 July 2022, the second record for the whole county of Gloucestershire. The Iris Weevil *Mononychus punctumalbum* is mainly a species of the south coast of England but is also known from our region, the BNS Field Meeting at Stoke Park on 28 May 2022 confirmed its presence, identified by Maico Weites.

It is thought that the small but striking false click beetle, *Microrhagus pygmaeus* which has pectinate antennae may be increasing nationally, an example was swept in Lower Woods, Wetmoor on 28 May 2022 by Ray Barnett.

The Rugged Oil-beetle *Meloe rugosus* was confirmed in good numbers (at least 28) on 27 October 2022 by Maico Weites along with Jen Greenwood and trainees from the Avon Wildlife Trust at Shirehampton.

Maico took a special interest in weevils this year as follows. *Ceutorhynchus chalybaeus* is a very localised small metallic weevil found feeding on Hedge Mustard in St George, Bristol on 8 May 2022. The Small Heather Weevil *Micrelus ericae* was a species Maico was expecting to discover on the heathland on Troopers Hill but it has proven elusive with it only being found on 31 July 2022, despite beating many a heather bush! *Zacladus exiguus* is a small black weevil with numerous bumps on the elytra and it specialises on smaller-flowered crane's-bill species such as Hedgerow Crane's-bill. Maico found it by sweeping in Eastville Park, Bristol on 28 May 2022 and again at Hanham Meadows during the BNS field meeting there on 11 June 2022.

Bees, wasps and ants (Hymenoptera)

The parasitic wasp *Stauropoctonus bombycivorus* has been recorded now two or three times in the last year or two in our region. The latest record was from Mike Bailey's moth trap in Timsbury on 17 July 2022. Although previously associated with

parasitising Lobster Moth, its sudden surge in numbers and distribution in England suggest it may also have other species on which it can prey.
The large black carpenter bees, *Xylocopa* species, are becoming more regular visitors to the country from Europe (a nest was discovered a couple of years ago in Oldbury-on-Severn). In 2022 one was seen at Chew Valley Lake (Stratford Hide) by Rupert Higgins on 12 August. Another species to look out for in coming years.

The Zig-zag Elm Sawfly *Aproceras leucopoda* continues to become widespread across the region such as at Chew Valley Lake on 24 June 2022 and Hallen Marsh on 4 July 2022, both by Rupert Higgins.

True flies (Diptera)

Plate 4: The soldier fly *Odontomyia tigrina* ©Rupert Higgins

Soldier flies are reminiscent of hoverflies but usually with more globular abdomens. Their larvae are associated with wet mud and hence the Levels are a stronghold for some species. It was surprising therefore for Jon Mortin to encounter *Odontomyia tigrina* in St Andrews Park in the heart of Bristol in 2022. Perhaps less surprisingly, Rupert Higgins also recorded it from Chew Valley Lake on 6 June 2022.

Spiders (Arachnida)

It is not just insects which can be accidentally imported into this country with the horticultural trade, there are several spiders which have arrived in the UK in this fashion. Adanson's House Jumper *Hasarius adansoni* was discovered in a Bath retail outlet on imported plants from the Netherlands on 10 September 2022 and reported via Rich Andrews. This species is native to sub-tropical regions but is now well established in greenhouses in many parts of the world. The same location also had

Uloborus plumipes present which similarly is associated with greenhouses and has been established in garden centres in the UK since 1992.

The Purse-web Spider *Atypus affinis* is an iconic species for British arachnologists as the only member of the mygalomorphs found here, the group which includes the large bird-eating spiders of South America. As a species which hides underground in a silken 'purse-web' it is rather elusive and difficult to find. On 8 September 2022 Michael Davis and Andy Pym confirmed its continued presence in The Gully, Avon Gorge when they also encountered the tangle-web spider *Episinus truncatus* a species of southern England and Wales of heathland or maritime grasslands where it can be found often under rock-rose – fitting the Avon Gorge habitat. *Marpissa mucosa* is a spider mainly found in the South East of England and associated with hiding under bark but also on dry stone walls, Michael Davis found it at the Avon Wildlife Trust Grow Wilder site in Frenchay, Bristol on 14 July 2022.

The jumping spider *Calositticus inexpectus* is associated with coastal shingle and amongst tidal litter on shell shingle and sand adjacent to saltmarsh. Primarily a species of the coasts of South-East England it has been recorded at the Severn Estuary before and was found near Clevedon on 7 June 2022 by Paul Chapman and Bill Urwin.

Harvestmen (Opiliones)

First recorded in the UK in 1999, *Opilio canestrinii* is now widespread across the country. It was unknown pre-1962 when first identified in Italy, since then it has spread across the continent but the area of the world where it is native is unclear. Andy Pym found an example in Filton on 1 August 2022.

Plate 5 : The harvestman *Opilio canestrinii*. ©Maico Weites

Pauropods, Centipedes & Millipedes (Myriapoda)

The British species of Pauropods, (small, pale creatures of leaf litter which resemble millipedes and are just a few millimetres long at most) can be recognised by their branched antennae. Maico Weites has found examples on Brandon Hill, Bristol but identification to species level is very challenging.

Strigamia maritima is a relatively common centipede known from coastal sites in Britain but there are very few records from our region (eg from Pilning and Portishead) but Maico Weites extended the known distribution locally when he found one on the beach at Clevedon on 15 May 2022.

Stosatea italica is a species of millipede known largely from the South East of England but also from our region (as reported in *Nature in Avon* for 2021, Volume 81, although incorrectly listed under centipedes). It was recorded at Narroways Nature Reserve on 8 May 2022 by Jon Mortin and also at Royal Fort Gardens, University of Bristol on 7 May 2022 and at Rownham Hill on 14 May 2022 by Maico Weites.

Plate 6: Bristly Millipede *Polyxenus lagurus* ©Maico Weites

Although not rare, the Bristly Millipede *Polyxenus lagurus* is a striking and distinctive species, Maico Weites found it on the railway bridge at Rownham Hill in relatively large numbers. It is associated with crumbling stone and so not uncommon on buildings.

Landhoppers (Amphipoda)

The Landhopper *Arcitalitrus dorrieni* has been reported on in previous years' Invertebrate Reports. Native to Australasia it is established in gardens around Bristol but also in local woodland eg Nightingale Valley, Leigh Woods as seen on 6 August 2022 by Maico Weites as part of a BNS Invertebrate Section Meeting).

Molluscs (Mollusca)

The preponderance of mud and silt in the Severn Estuary means records of marine molluscs associated with rocky shores are relatively few. Therefore, a sighting of a Sting Winkle *Ocenebra erinaceus* in Sand Bay on 30 April 2022 by Jon Mortin is noteworthy.

Terrestrial molluscs are not well recorded either so again a sighting of a Worm Slug *Boettgerilla pallens* at Boiling Wells, Bristol on 1 May 2022 by Jon Mortin is of note. Although not uncommon, it is poorly recorded. The slug uses worm tunnels to move around underground.

See elsewhere in this volume the report by Jon Mortin of the first living Pacific Oyster *Magallana gigas* for our region, from Clevedon Marine Lake in October 2022.

Weather report for 2022

Barry Horton

Introduction

We have a lot of weather and climate from 2022 to discuss but before we come down in scale to our own area I would like to put it into a global and regional context first.

For a starting example the World Meteorological Organisation has put out the following statement on their website https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate. "The past eight years are on track to be the eight warmest on record, fuelled by ever-rising greenhouse gas concentrations and accumulated heat. Extreme heat waves, drought and devastating flooding have affected millions and cost billions this year, according to the WMO Provisional State of the Global Climate in 2022 report." They go on to say "The rate of sea level rise has doubled since 1993. It has risen by nearly 10 mm since January 2020 to a new record high this year. The past two and a half years alone account for 10 percent of the overall rise in sea level since satellite measurements started nearly 30 years ago. 2022 took an exceptionally heavy toll on glaciers in the European Alps, with initial indications of record-shattering melt. The Greenland ice sheet lost mass for the 26th consecutive year and it rained (rather than snowed) there for the first time in September. The global mean temperature in 2022 is currently estimated to be about 1.15°C above the 1850-1900 pre-industrial average." They conclude there may be slight global cooling this year due to a rare triple-dip cooling La Niña event but this is a temporary affair**.** There will not be uninterrupted warming, year on year, but the upward temperature trend will continue.

At another website https://phys.org/news/2022-09-simulations-jet-stream-waviness-due.html it has been noted that the jet stream has become wavier than it used to be. Both peaks and valleys have become more extreme and this has led to changes in weather patterns - some places have grown wetter and some drier, and there have also been more extended hot and cold spells around the globe. In this new study the researchers suspected that the reason for the increased waviness is due to the asymmetric rise in global temperatures. Global warming is heating up the Arctic much faster than it is heating up more southern areas. The result is big changes in winds in the upper atmosphere. The researchers found that as conditions in the Arctic region grow warmer faster than regions to the south; the winds that circle the globe have become weaker. As the reader will see some of these events are largely mirrored in the local data from the Bristol weather station that has been in the area for close on 30 years.

To make the point in a local context about weaker winds as stated above, the following graph (Fig. 1) visualises the point by showing the recent increase in calm winds in Bristol. This could be related to the large scale jet stream changes mentioned above.

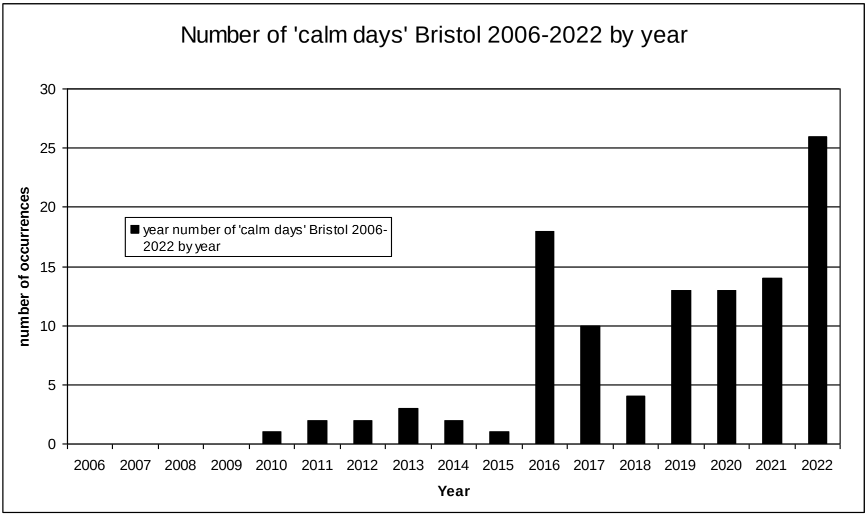

Fig. 1: Number of 'calm days', Bristol 2006-2022 by year

This year the global population will probably reach 8 billion people, and National Geographic, for example, estimates 8.7 million species of flora and fauna. In order to support that number we need to take our global and regional climate very seriously.

Closer to home in the Royal Meteorological Society's magazine 'Weather' there is a recent article stating that in the UK 2022 was the warmest on record. They go on to state that all months, other than December, were warmer than average (not entirely the case locally, as discussed later). Rainfall was mostly below average except the last three months of the year. The notable events of the year were the extreme heat in the summer of 2022 and the high winds in February. These last observations were reflected in the local data.

A recent public zoom meeting with the Woodland Trust stated that via 4 indicator species (plants and animals), using phenology, showed there was between an 8 to 9 day earlier onset of spring.

Of course our weather and climate are of vital importance to every living thing on the planet. All of nature has adapted or is adapting to the climate but most living things have a range of tolerances outside of which they will struggle with if the weather and climate shift too far and too rapidly. As I wrote last year 'sadly other world events have put climate issues into the background as other matters are deemed more prescient.' It seems we have not moved forward in tackling the only problem that affects every living thing on earth.

There has been an amateur weather station in Totterdown, Bristol since 1993 and it is from here the weather data has been collated and analysed in this article. You can look at the data and follow the weather as it is updated via the internet at http://www.bristolweather.org. The weather station is in Bristol's urban area and with that in mind, there are influences placed upon the data that would not be the case in a rural setting. Since 2005 the weather station data has largely been collected digitally but the author manually checks on the rainfall data and other local sites for comparison. The weather data used in this article comes from a variety of locally published historical sources. Some of the data is from as early as 1853 but there are time gaps and site differences which are too numerous to detail here. Broadly speaking the author has collated continuous records of rainfall and temperature for the Bristol area since 1882 and 1891; a period of 141 and 132 years, respectively. To see further information on the different date periods and the sources used see http://www.bristolweather.org/Historical.htm. There are also several other good web sources of weather data in the Bristol region. The 30 year averages used in the text are a standard Meteorological Office device to easily denote the 'longer term' weather 'normal'. This may not be a perfect method but it is well understood and widely used for comparison with the current data. The present 30 year period being used as the countrywide standard is 1991-2020.

Being an urban site near the heart of Bristol there are elevated temperatures especially at night and early morning when compared with a rural setting. Even though the site is not ideally situated, and is 'amateur', it is probably correct to say neither were many of the historical weather sites and all sites are vulnerable to human error and equipment drift or malfunction. Any long term data set is of value if in one place as comparisons with the past climate can be made.

Annual data

In 132 complete years of Bristol's average temperatures 2022 was the warmest at 12.7°C. Annual data has been collected since 1853 for Bristol but there are gaps before the 1890's so the continuous run from 1891 is used. The previous warmest year was 2014 when the average temperature reached 12.5°C. 2022 was 1.1°C above the 30 year average (1991-2020) of 11.6°C. The first 30 year continuous average temperature for Bristol (1891-1920) was 10.1°C. The first earlier 10 year average temperature (1853-1862) was 9.1°C.

The annual rainfall of 798.4 mm for 2022 was 87.4% of the 30 year average (1991-2020) for Bristol of 913.8 mm. The wettest month was November with 157.7 mm 157.0% above the 30 year average (1990-2020) of rainfall whilst the driest was July with only 17.5 mm of rain. There was measurable rainfall during the year for 4.2% of the time (371 hours). The first 9 months of 2022 produced 407.6 mm or rain whilst the last three months of the year produced 390.8 mm.

2022 was the least windy year with an average wind speed of 4.2 mph since records began in 2005. The average wind speed for the whole period is 5.4 mph. Notable was the increase of 'calm' days in 2022 (see Fig. 1). A calm day is when the average daily wind speed is less than 0.5 mph. The average number of calm days (2005-2022) is 1.4%, but in 2022 this was 7.1%.

There were 20 days of air frost, 3 days, (1 day with two occurrences), of thunderstorms and 3 days of small hail recorded. There was only 1 day of snowfall which was lying for 1 day at 09:00 GMT. With regard to sunshine it was very close to the yearly average for the percentage of maximum sunshine at 40.7% (maximum sunshine is calculated as a percentage of the possible - 100/% - for each day). The average (2005-2022) is 40.2%. The maximum daily temperature of 36.9°C on the 18th July was the highest recorded for Bristol. The lowest temperature of 2022 at -5.8°C recorded on 15th & 16th December was the lowest of any month since February 2012.

There is annual temperature data for Bristol dating from 1853 but in making the table below (Table 1) only the continuous data from 1891 has been used. What really brings home the recent rises in annual temperature for Bristol is the fact that there are no annual temperatures in the top 10 earlier than 1989. Put another way, none of the previous 98 continuous years of annual temperature data for the city are in the warmest top 10. It was increasingly looking like the highest annual temperature prior to 2022, set in 2014, was going to be broken as temperatures rise globally and sure enough it happened last year. I expect last year's record temperature will also not last very long either as carbon emissions continue to rise and wreak havoc with dynamic and delicate climate systems.

Year	Annual mean temperature °C	Rank
2022	**12.7**	**1**
2014	12.5	2
2020	12.4	3
2011	12.2	4
2018	12.1	5
2017	12.1	5
1989	12.1	5
1990	12.1	5
1997	12.1	5
2006	12.0	10

Table 1: 10 Highest annual mean temperatures, Bristol.

The following graph (Fig. 2) shows the continuous annual temperature record for Bristol from various local sites since 1891. This data set includes the current site from 1994. Looking at the annual data points it can be seen there is a fairly static picture, with annual variability, in the period up until the 1960's. Since the early 1970's however there appears to be a pretty consistent rise. Overlying the data on the graph is a linear regression trend line which is the continuous straight line. The change in temperature in the last 132 years on the regression line shows a total annual increase of temperature of 1.9°C over the whole period. This represents a rise of approximately 0.14°C every 10 years or 1.4°C every 100 years. Assuming such a rising linear trend from the past and simply extrapolating it into the future should be treated with caution as many factors, human and natural, may exert an influence on an artificial linear trend. Nevertheless it is fairly certain that a real temperature rise is taking place and action to mitigate this is urgent in the author's view.

It is interesting to take all the anomalies from the monthly average temperatures for 2022 (Table 2), and compare them with the 30 year average (1991-2020). Even with two months showing a lower than average temperature (January and December) the positive anomaly adds up to a total of 12.9°C.

With regards to the average monthly temperature, compared with the 30 year average (1991-2020), one can see from the graph (Fig. 3), and (table 2), that it tended to be the summer and autumn months that saw the largest positive anomalies. These were August (+2.7°C), October (+2.6°C) and November (+2.3°C).

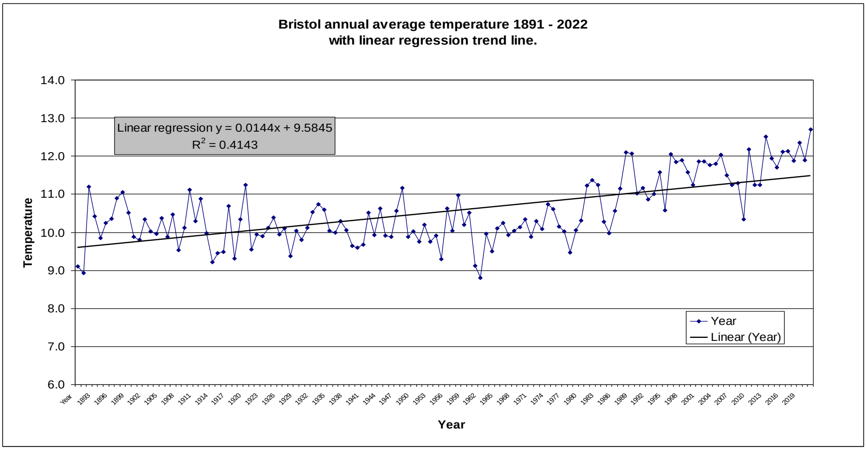

Fig. 2: Bristol Average temperatures 1891-2022

Month	Average monthly temperature (1991-2020) °C	Average temperature 2022 °C	Difference from average °C
JAN	5.7	5.6	-0.1
FEB	6.0	8.2	2.2
MAR	8.0	9.5	1.5
APR	10.6	10.7	0.1
MAY	13.7	14.6	0.9
JUN	16.6	16.6	0.0
JUL	18.5	20.0	1.5
AUG	18.1	20.8	2.7
SEP	15.5	16.0	0.5
OCT	12.0	14.6	2.6
NOV	8.1	10.4	2.3
DEC	6.1	4.8	-1.3
		accumulated difference °C	**12.9**

Table 2: monthly temperature anomalies for 2022 with averages.

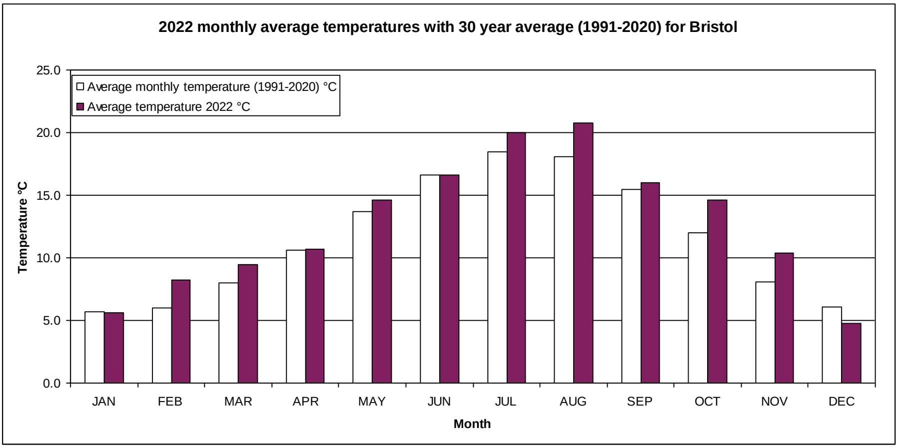

Fig 3: Bristol 2022 monthly average temperatures compares with 30 year average.

Regarding the annual rainfall the graph below (Fig. 4) shows that there is in fact continuous data for the city of Bristol going back to 1853. This is a good long period with which to be able to look back and analyse trends. However it should be noted that some UK sites go back into the 18th century and the Bristol record is from several different sites around the city so some care should be taken when drawing very specific conclusions about the rainfall and possible trends.

It is clear from the graph that despite the obvious inter annual variability of the annual rainfall there is an almost horizontal dotted linear regression trend line. This demonstrates that overall there is little movement (upward or downward) in the total annual rainfall record for Bristol over the longer term. We can see that the annual rainfall this past year was well within the normal range at 87% of the 30 year average with an annual rainfall of 798.4 mm for 2022. The 30 year average (1991-2020) for Bristol is 913.8 mm. The 10 year moving average applied to the graph shows two troughs in the early part of the data series and a longer trough in the mid 1900's (1940's to 1970's). Wetter periods in the 1880's and 1920's have been slightly replicated in the early 2000's but one is not trying to infer any cyclical pattern here.

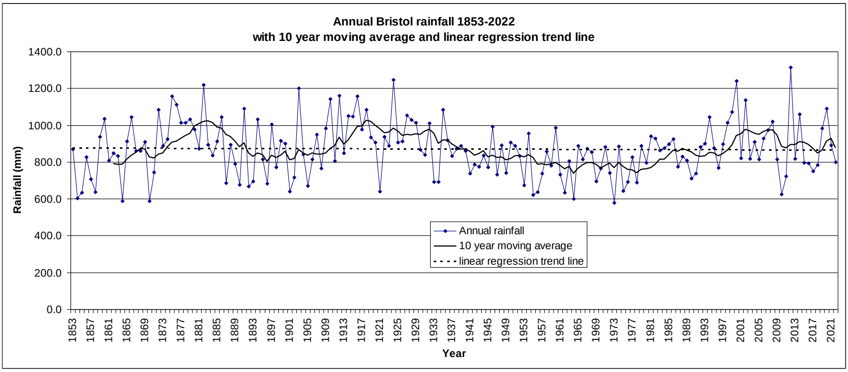

Fig. 4: Bristol annual rainfall 1853-2022 with 10 year moving average and linear regression line.

The graph below (Fig. 5) depicting the monthly rainfall for 2022 shows generally low rainfall amounts for the first 9 months of the year followed by the three wet months of October, November and December. The 30 year averages (1991-2020) for Bristol are shown for comparison and they depict a drying trend in the early part of the year and then increasingly wetter months, with an interruption for a drier September, until the end of the year.

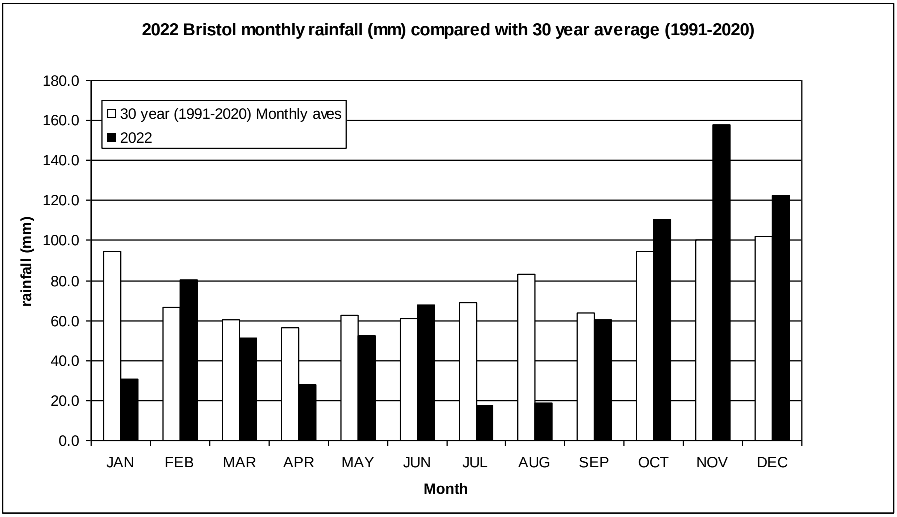

Fig. 5: 2022 Bristol monthly rainfall compared with 30 year average.

The annual average air pressure for the year 2022, as depicted in the graph below, (Fig. 6) was 1016 mb (millibars) which is close to the 28 year average of 1015 mb. The highest annual pressure at the current site was in 2003 at 1019 mb.

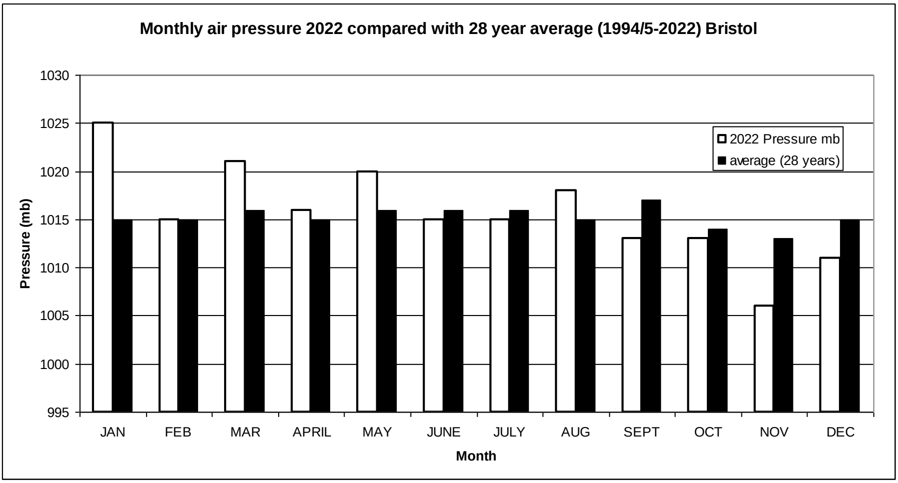

Fig. 6: Monthly air pressure Bristol compared with 28 year average.

The daily wind direction in the table below (Table 3) is broken down into 8 main compass points by month. One fairly consistent weather statistic is the annual wind directions for Bristol. In 2022 this follows the typical pattern of the South Westerlies (SW & WSW) being the dominant wind direction in our region. South Westerlies accounted for 44.1% of the total days with North Easterlies accounting for 18.6% of the total wind directions. This data is calculated automatically by the weather station's software.

2022	N	NE	E	SE	S	SW	W	NW	calm	Total
January	2	2	0	0	1	12	5	0	9	31
February	0	0	0	1	3	15	9	0	0	28
March	3	9	4	5	4	4	1	0	1	31
April	2	12	1	1	2	11	1	0	0	30
May	1	5	0	1	1	20	2	0	1	31
June	0	8	0	0	2	19	1	0	0	30
July	1	6	0	0	1	15	7	0	1	31
August	2	15	0	0	0	7	7	0	0	31
September	6	5	0	0	5	5	4	2	3	30
October	1	1	2	0	3	22	0	0	2	31
November	0	0	0	2	3	18	4	0	3	30
December	4	5	0	0	2	13	1	0	6	31
Totals	22	68	7	10	27	161	42	2	26	365
Percentage for year	6.0 %	18.6 %	1.9 %	2.7 %	7.4 %	44.1 %	11.5 %	0.5 %	7.1 %	100.0 %

Table 3: Daily and monthly wind direction by month 2022

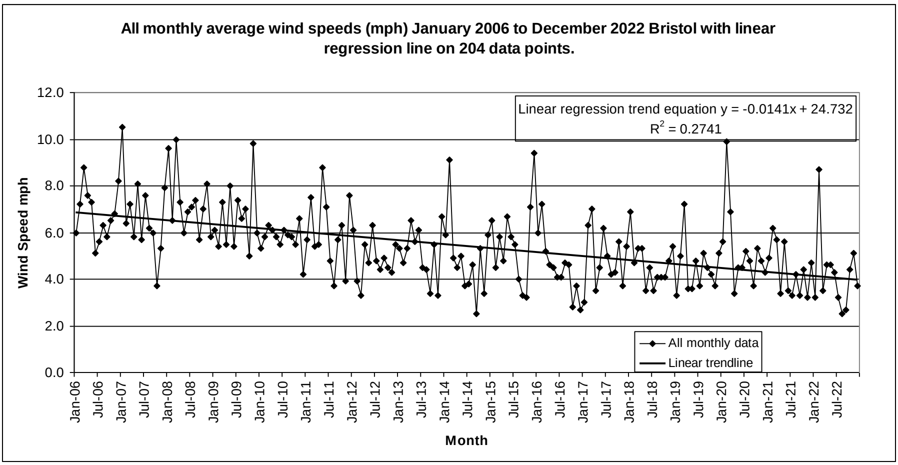

Fig. 7: Average monthly wind speeds mph Bristol 2006-2022

Figure 7 (above) shows an all months' average wind speed from January 2006 through to December 2022. As mentioned in the introduction there is evidence that changes to the jet stream are weakening the wind speeds.. One must be careful in interpreting local phenomena with a global influence but it is very marked how average wind speeds have fallen in the last 17 years and it will be interesting to see if this trend will continue.

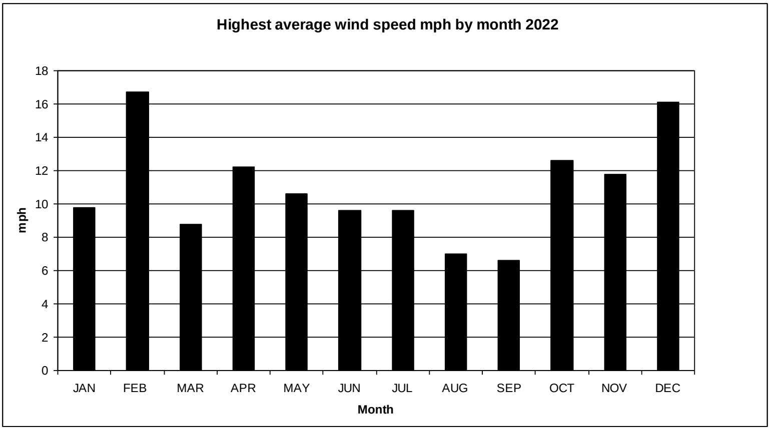

Fig. 8: Highest average daily wind speeds by month.

The above graph (Fig. 8) shows the highest average daily wind speed during each month. In 2022 it is seen that the highest daily wind speed occurred in the winter months of February and December with September 2022 being the least windy of the year.

The actual percentage sunshine for the year, against the maximum, was 40.7% in 2022. The average for the year is 40.2% making 2022 close to the longer term average starting in 2006. From the graph (Fig. 9) below it can be seen that August and October were the standout months in a positive sense whilst September was the dullest standout month with regard to the average maximum percentage sunshine.

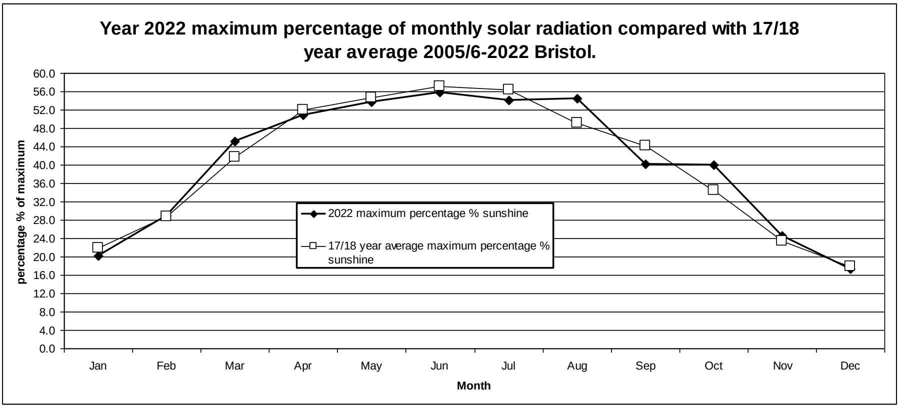

Fig. 9: Maximum monthly % of solar radiation for 2022 compared with longer term average

Seasonal data

Winter 2021/22 (December – February)

With an average winter temperature of 7.4°C it was the 5th warmest winter in Bristol in 132 years of data. It was 1.5°C above the 30 year average for the city. The total rainfall for the 3 winter months was 189.7 mm. The 30 year average (1991-2020) for the city is 260.7mm. This total makes 2021/22 the 47th driest winter out of 141 in the city.

Spring 2022 (March – May)

The spring of 2022 was the joint 4th warmest, with 2003, with respect to average temperatures with a mean temperature of 11.6°C. Continuous data for Bristol started in 1891. The total spring rainfall of 2022 was the 24th driest out of 141 years of data with 131.5mm. The 30 year average 1991-2020 is 179.5mm so 2022 represents only 73% of the average.

Summer 2022 (June – August)

The stark image of the grasses of the Downs, Bristol, (Fig. 10) looking decidedly pale and rather scorched in 2022 is a reminder of the general type of weather experienced this summer. Dry and hot would be the easy explanation but there is more detail than that to be gleaned from the rather exceptional summer conditions. It was the 3rd equal warmest summer in 132 years of complete data for Bristol. With an average temperature of 19.1°C it was 1.4°C above the 30 year average (1991-2020). The warmest summer was 1995 with an average temperature of 19.4°C, and 2018 had an average summer temperature of 19.2°C. 2022 was equal with 2003. The coolest summer was in 1954 when the average temperature only reached 14.4°C. The summer rainfall total was 104.3 mm which was only 49% of the 30 year average of 212.7 mm. It was the 10th driest summer in 141 years of data for Bristol.

Autumn 2022 (September – November)

The autumn was mild and wet. The mean temperature was 13.7°C which made 2022 the joint warmest autumn, with 2011, in 132 years of continuous data. The 30 year average temperature for the season in Bristol is 12.0°C. With a total rainfall of 328.9mm this autumn it was 24th wettest in 141 years of continuous data. The 30 year average for the season is 258.8 mm so 2022 had an excess above average of 70.1mm.

Fig. 10: A normal view of the Downs in the summer (year unknown but thought to be recent) (above) and the same view of the Downs in the summer of 2022 (below). ©Derek Catterall

Monthly data

January was a month of exceptionally light winds, dominated by high pressure, low rainfall, and high sunshine percentages. It was the 2nd calmest January since records began in 2006 at the South Bristol (Totterdown) weather site with an average wind speed of 3.2 mph see (Fig. 11). There were 9 calm days when the wind speed was less than 0.5 mph. The average wind speed for January (2006-2022) is 5.9 mph so the 3.2 mph of 2022 is a significant reduction.

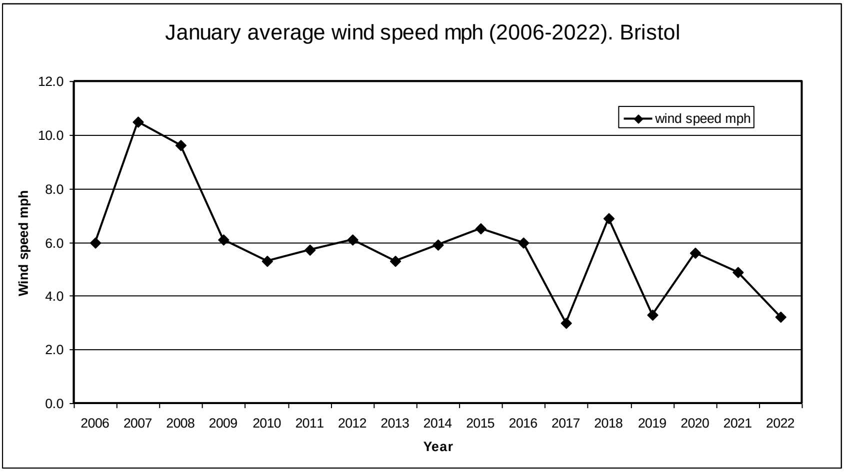

Fig. 11: January average wind speeds 2002-2022 Bristol.

The average daily pressure of 1025 mb at 09:00 for January was the joint highest for the month since the data started in 1994. The maximum daily pressure of 1041 mb on the 12th and 13th was the 3rd highest for the month of January in 29 years of data. The total monthly rainfall was 30.8 mm which is only 1/3rd of the 30 year average for Bristol. It was in fact the 20th driest January in 141 years of continuous data. It was the 3rd sunniest January with 22% of the maximum sunshine after 2012 (23.3%) and 2015 (23.2%). This data started in 2006. It should be stressed here that during the winter months there is an obstruction to the full sunshine being recorded at the Totterdown, Bristol weather station. Comparison with other previous solar radiation data from the same site is however valid. The mean temperature of 5.6°C for the month was just 0.1°C below the 30 year average. Interestingly the average minimum temperature was -0.9°C below average while the mean maximum temperature for the month was +0.6°C.

February was a mild month with no air frost or snow. It was also notable for three named storms around the middle of the month. It was mainly dull too. Rainfall was above average for the month and there were only 4 consecutive days without rainfall.

With a total rainfall of 80.5 mm it was 121% of the 30 year average for the month. Temperatures were above average and the mean temperature for the month was 8.2°C and, with 1998, it was the joint 2nd warmest since continuous data started in 1891. The average temperature was 2.2°C above the 30 year average for the city (see also table 2). 1990 was the warmest February with an average temperature of 8.8°C.

March The mean temperature of 9.5°C was 1.5°C above the 30 year average for Bristol and so continuing the warming trend. It was the 5th warmest March, with 1957, 1997 and 2000, since data was started in 1853 (with 1890 missing). The month's total rainfall was 51.1 mm which is 84.3% of the 30 year average (1991-2020). The March 2022 mean wind speed of 3.3 mph was the 2nd joint lowest for the month since data started in 2006. Also of note was the low incidence of South Westerly winds in March 2022 and in fact not since April 2019 have there been as few South Westerly winds and more South Easterly winds.The maximum wind gust of 32 mph on the 12th March was the joint 2nd lowest, with 2001, since this data started in 2006. The lessening of high wind speeds is discussed above. The highest daily temperature of 20.3°C on the 23rd of the month was the 10th highest in 86 years of data for Bristol.

April was dry month with average temperatures overall. The average temperature was 10.7°C which was 0.1°C above the 30 year average 1991-2020. The average minimum temperature was -0.3°C whilst the average maximum temperature was 0.4°C above the same 30 year average. Rainfall was just under 50% of the 30 year average for the month with a total of 27.9 mm. In fact the last six months, from November 2021 until the end of April 2022, have only produced 282.8 mm of rain in Bristol. The latest 30 year average (1991-2020) is 480.3 mm for the same period. This 2022 figure represents only 59% of the average rainfall.

May was yet another month with below average rainfall, the total being 52.5mm, just over 84% of the average. For the sixth month out of the last seven, monthly rainfall has been below the average for Bristol. Since November 2021 the total rainfall of 336.3mm is only 62% of the 1991-2020 average of 542.9mm.
The average temperature of 14.6°C for the month was +0.9°C above the 30 year average 1991-2020.

June was generally a quiet month with average temperatures the same as the 30 year average and with rainfall slightly above the 30 year average at 67.9 mm for the month. The landscape was becoming parched and gardens started to clearly show the picture of a prolonged dry spell of weather without ‘normal’ rainfall. It was the sunniest June, with 57.1% of the maximum sunshine, since 2018 when the month saw 63.0%. Nearly all wind directions (90%) were from the three directions NE (8 days), the SW (9 days) and WSW (10 days).

July The two notable items this month making the news on a larger scale as well as just locally, were the exceptional maximum temperature on the 18th of the month and the continuing lack of normal amounts of rainfall. The maximum temperature of 36.9°C on the 18th July was the highest ever recorded at any Bristol site from data starting in 1937 (Fig. 12). The previous record was 36.0°C recorded in the city on August 9th 2003. For the month overall it was the equal 7th warmest on record in 132 years of continuous data. The average temperature for 2022 was 20.0°C. The highest recorded in Bristol was 21.7°C in 1983. The low monthly rainfall of 17.5 mm was only 25.4% of the 30 year average 1991-2020. This was the driest July since 13.3 mm was recorded in 2016 and it was the 12th driest July since records began in 1853 (with 13 years missing data). In the last 9 months, since November 2021, the rainfall total was 420.7 mm. The 30 year average (1991-2020) is 672.6 mm so the 9 months in question represents only 63% of the 30 year average. The average wind speed for the month was 3.2 mph. This is the lowest for any July since the data started in 2005.The maximum daily pressure of 1033mb on 8th was the 2nd highest for the month since data started in 1995. The daily minimum pressure of 1009 mb on the 25th was the highest for a July.

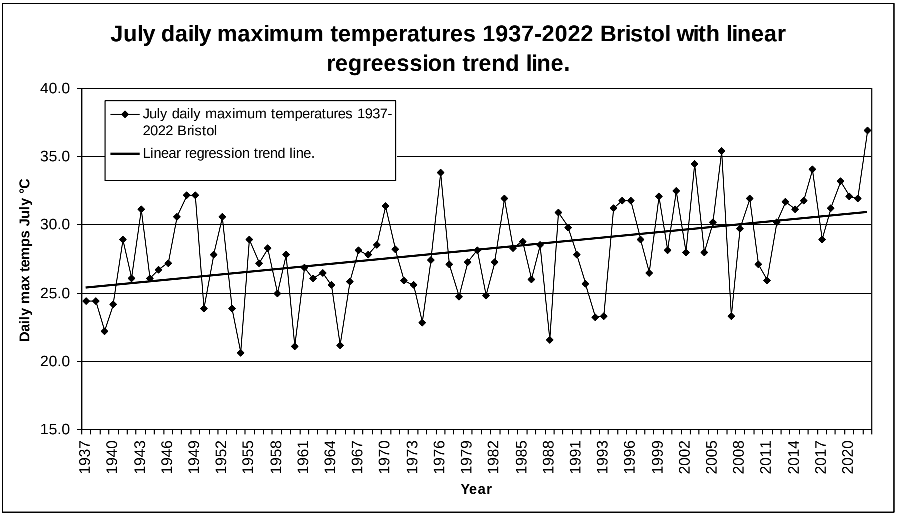

Fig. 12: July daily maximum temperatures 1937-2022 Bristol.

August The average temperature of 20.8°C was 2.7°C above 30 year average for Bristol and was the equal 2nd warmest, with 1997, in the last 132 years. It was the warmest month of the year. The warmest August was 21.3°C in 1995. As well as being a warm month it was also a sunny month. It was the driest August with only 18.9 mm of rainfall since 2003 when only 13.1 mm was recorded. It was the 7th driest August since continuous data began in 1877. 2022's August rainfall was only 22.8% of the 30 year average for the month. It was the least windy August on record when data started in 2005. The average wind speed for the whole month was only 2.5 mph.

The highest daily maximum temperature of 34.9°C on 12th of August was the 2nd highest for the month since this data started in 1937. The highest was 36.0°C on August 9th 2003. The lowest daily maximum temperature of 20.2°C on 17th August was the highest since this data began in 1960. The highest daily average temperature of 27.0°C on 12th August 2022 was the 2nd highest since the data started in 1993.

September After a notable summer of record breaking temperatures and very dry conditions it was perhaps with some relief that some weather conditions returned to something approaching the 'normal' for this time of the year. Temperatures were broadly in line with the month's 30 year average (1991-2020), being +0.5°C above the average of 15.5°C at 16.0°C. After the two previous months of low rainfall September was much closer to the 30 year average for the city with 60.5 mm. This represents 95% of the average. The highest daily wind speed of 6.6 mph on 30th was the 2nd lowest of all monthly data since this particular parameter started in July 2005. The lowest, also in a September (2014) was 5.5 mph.

October After a significantly dry and hot summer during October we at last got some substantial and welcome rain. The main story for the weather in October in Bristol was however the very high average temperatures for this time of the year. It was in fact the warmest on record in Bristol since 1891 with an average temperature of 14.6°C. This is 2.6°C above the 30 year average for Bristol (1991-2020) of 12.0°C. For only the 3rd time in 12 months the monthly rainfall was above the 30 year average (1991-2022). With a rainfall of 110.7 mm in October 2022 it was the wettest month since October 2021. Looking at the recent records for Bristol it is indicating that October is becoming one of the wettest months of the year, just behind November and December. The wind direction on 22 out of 31 days was predominately from the SW or WSW which also contributed to the high temperatures as there was little wind from colder directions.

November was a warm month and temperatures were well above average for the time of the year. With an average of temperature of 10.4°C November 2022 was 2.0°C above the 30 year average (1990-2020) of 8.4°C. It was the 3rd warmest November after 2011 (10.9°C) and 2015 (10.8°C) in 132 years. November's rainfall was 157.7mm which represents 156.9% of the 30 year average. It was the wettest November since 2012 when 169.7mm was recorded. There was a noticeable lack of winds from an Easterly or Northerly direction again contributing to the mildness.

December was a month of two very distinct halves (Fig. 12). The first part was dry, cold and calm and the second half of the month was wet, mild and windy. The average monthly temperature of 4.8°C was 1.3°C below the 30 year average for the month and was the coldest month of 2022. The rainfall of 122.4 mm was 120.2% of the 30 year average for the month. 118.3 mm fell in the last 14 days of December. It was the least windy December since 2016. There were 12 consecutive days which had temperatures below 0.0°C. Out of the 288 hours of that period 147 were below 0.0°C, therefore of the 12 days approximately 50%. The lowest daily minimum temperature of -5.8°C recorded on the 15th and 16th of December was the lowest since February 2018, when there was the so called 'Beast from the East'. It was the lowest for a December temperature since -7.5°C was recorded in 2010. The lowest daily maximum temperature of -0.3°C was the lowest since March 2018. It was the coldest December since 2010 and the coldest month since February 2018.

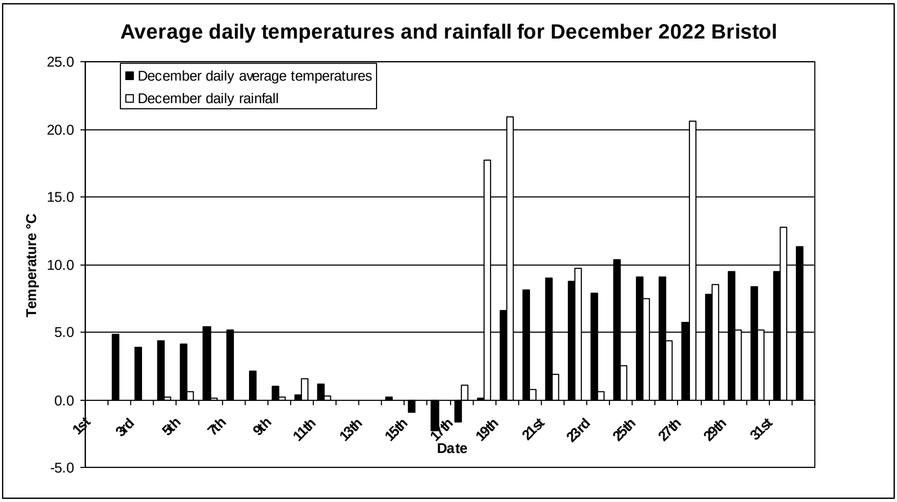

Fig. 13: Average daily temperatures and total daily rainfall for December 2022. (**N.B.** Note the dramatic change around the middle of the month).

Some notable events in 2022

Here there is an attempt to filter out some individual data into singularities which it is felt are best suited to being in a section of their own. No system of trying to move events away from the monthly timeline is perfect and this one is no exception.

Pressure

In March the highest pressure of the month, of 1041.9 mb on the 18th, was the highest March pressure for this site since data started in 1994.

For the 4th consecutive April the wind direction was predominantly from a north easterly direction.

The low pressure at any time, in the month of May, of 1000.8mb on the 23rd, was the equal second highest since detailed records of pressure began in 2005.

The lowest pressure of 978.2mb on the 16th of November 2022 was the lowest of any month since January 2021.

Rainfall

Interestingly the first three months of 2022 were the driest since 2012 which in fact became the wettest year on record from data starting in 1853. There was no measurable rainfall from the 4th to the 21st July and only 7 hours of rainfall in the whole month.

Snow and Frost

For the whole of 2022 there was only one day of snowfall and only one day when snow was observed as laying over 50% of the ground at 09:00 GMT. Both these events were in December. There were 20 days of air frosts in 2022 with a total of 178 hours duration (Fig. 14).

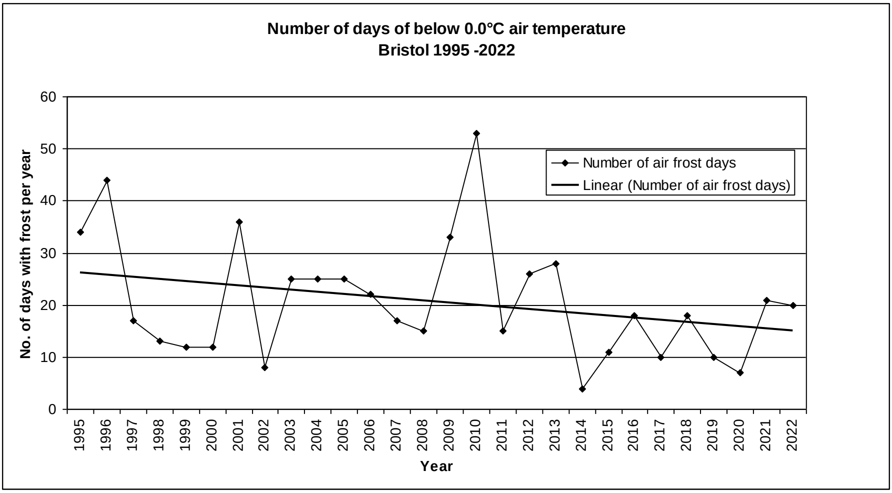

Fig. 14: Days of frost in Bristol 1995 – 2022

Solar radiation

With 54.5% of the maximum sunshine it was the sunniest August since 2007 when the sunshine was 60% of the maximum.

It was the dullest September (with a full month of data), since this data started in 2005. With only 40.2% of the maximum sunshine possible it was approximately 4% below the average for the month. The 1 hour daily maximum of Solar incidence at the surface in WM/2 (Watts per square metre) of 623.5 WM^2, which occurred jointly on the 14th and 18th of September, was the lowest for the month since the data started in 2005.

October was a sunny month and with an average of 6.80 MJ/m^2 (MilliJoule per square metre) for the whole month when the average is 5.80 MJ/m^2 it was the highest solar radiation for an October since this data began in 2005.

Temperature

There were three notable daily temperature extremes in January. The highest daily minimum temperature of 12.8°C on the 1st was the highest since this data started in 1960. The highest daily maximum temperature of 14.8°C, also on the 1st, was the highest since this data started in 1937. The highest daily average on this exceptional day of 13.8°C was the highest since this particular parameter started in 1994.

The lowest minimum temperature of 1.6°C on the 11th of February was the 4th highest since this data started in 1938. The average minimum temperature for the month of 5.4°C was the 3rd highest since the data started in 1894. The lowest daily maximum temperature of 7.3°C on the 24th was the equal 2nd highest, with 2014, since this data started in 1960. The highest was 8.0°C in February 2000.

The low temperature of -0.7°C on the 3rd was the lowest in April since -1.8°C was recorded on 2nd of April 2013.

In May, at 10.8°C the average minimum temperature was the second highest since continuous data started in 1894.

The author makes no apology for entering the following piece in both the monthly data section and the notable events section. The maximum temperature of 36.9°C on the 18th July was the highest ever recorded at any Bristol site from data starting in 1937. There were 3 consecutive days when the maximum temperature rose above 30°C. The highest daily mean temperature of 27.9°C on the 19th was the joint highest of any month since this data started in 1993. The highest minimum temperature on the 19th of 22.2°C was the highest of any month since the data started in 1960.

Noteworthy was the average maximum temperature for October of 18.3°C which was 3.2°C above the 1991-2020 30 year average.

The highest daily maximum temperature of 18.9°C on the 12th was the equal highest for November with 1946. This data started in 1937.

The lowest daily average temperature of -2.3°C on the 15th of December was the lowest since March 2018.

Wind

On the 18th February storm Eunice arrived and unusually at this site in Bristol there were 4 occasions with wind gust speeds at 50 mph or above. It was a windy month generally and was the windiest of all months since February 2020. The maximum gust average for the month was 30 mph and this is equal 11th highest in 321 months of records starting in 1995. Also notable was that there were no predominate daily winds from any of the Easterly, Northerly, North Easterly or North Westerly directions. It was the dullest February since 2017 with only 28.9% of the maximum for the month. On the 18th the highest gust of the day recorded was 51 mph at 10:50 hours. The 10 minute average wind speed of 30 mph at 11:30 on the 18th was the 8th highest of all months starting in 2005/6. The previous highest in February was 31 mph in 2008.

There were 15 days in August when predominately the wind direction was from the NE. This is the highest for this direction in August also since the data started.

There were 6 days in December when it was 'calm' which is more than for any month since this data started in 2006.

Conclusion

2022 has been a year full of climatic interest. Not, unfortunately, all good. Record temperatures are not good if they continue to rise as animals and plants cannot necessarily adapt as quickly as the temperature might change. Prolonged dry spells create real problems for food production, nature’s survival and sustainability. We need to find ways to address the source of these drivers that are making the planet more fragile. No longer is there an everlasting abundance – there probably never was!

We have yet another COP in 2023, ‘Conference of the Parties (COP 28)’, this time in United Arab Emirates (UAE). Let us hope the mounting evidence of man’s influence on the Climate overrules fossil fuel production and vested interests. Then perhaps a serious effort can be made to curtail carbon releases and increase biodiversity. Along with ending warring nations and the destructive power associated with the battlefield, perhaps we can manage a sustainable survival and a future for all of nature and humankind.

Obituary: Lesley Nicola Cox

29th June 1950 – 10th December 2022

Lesley Cox was the Honorary Secretary of the Bristol Naturalists' Society from July 2014 to October 2022 and the huge gap that her loss leaves in the affairs of the society bears testimony to the tireless work that she did over those eight years.

She did much to raise the profile of the BNS, ensuring that this small and ancient Society punched well above its weight. She was always much more than just the Secretary to the Council and, with her cheerful face present at every indoor meeting, for many she was the face of the BNS. In September 2017 she instituted the monthly Natty News feature in the Bulletin, with a thoroughly researched selection of interesting and topical items from the world of science and nature. The many comments since its disappearance are a sure indicator of this feature's popularity.

When Richard Bland's Phenology articles came to an end, it was Lesley who immediately arranged a new series of reports on Bristol Weather. Numerous photos in the Bulletin came from her friends and contacts; she was a great networker and worked very hard to improve the Society's links with the University of Bristol. She was also secretary of the Ornithology section for those eight years, though continuing ill health prevented her from attending as many field meetings as she would have liked. Lesley was always quick to spot a new face at meetings and many members have commented on how much they valued Lesley's friendly welcome to the Society when they first joined.

Despite her cheerful and friendly nature, Lesley was essentially a very private person and many of us who had worked with her on Council for years had to wait until her funeral before finding out much about her life outside the Society.

Lesley was born in Bristol but spent her early years in Cardiff before her family moved back to Westbury-on-Trym when she was six. The family house backed onto the Blaise Castle Estate and she came to love the woods and their wildlife. She was educated at Colston's Girls' School, where she developed a love of sport, especially cricket. Her attachment to cricket was life-long, playing for the Somerset Wanderers and becoming the South-West Representative for the Women's Cricket Association. After school she took a gap year working as a volunteer in deprived areas of Manchester. At the University of Bristol she read Sociology and Politics before finding a job in adult education. Her positive attitude, great sense of humour and belief in her students helped many to reach university themselves.

In 1980 Lesley and her cousin, Fil Hughes, moved to Stoke Gifford where they shared a love of dogs and music. Soon afterwards Lesley was diagnosed with Crohn's Disease which caused numerous bouts of ill health and forced her to retire from work. She soon transferred her energies to the BNS!

Lesley's health deteriorated badly during the Covid lockdowns and she was finally admitted to Southmead in June 2022 where she was diagnosed with Motor Neuron Disease. Needing 24 hour care, she was moved to a nursing home. Lesley was courageous throughout this difficult time and bore the ravages of MND with fortitude and a strong spirit. Thankfully she did not suffer for long.

Lesley had a real love for the natural world and always fought strongly for what she thought would make the world a better place. She was a real force of nature and she will be sorely missed.

Giles Morris

SOCIETY ANNUAL REPORT 2022

1 Society Organisation

The year 2022 saw a gradual return to normality for Bristol Naturalists' Society following the Covid pandemic with a fairly full programme of field meetings whilst Zoom continued to be used for most talks and Council meetings. December saw our first "in person" talk since the pandemic giving a welcome opportunity for members to meet face to face.

The Annual General Meeting took place using Zoom on 16th March 2022. The following members were appointed to serve on the BNS Council for the years 2022/2023

Officers

President: Ray Barnett [3rd year of 3-year term]
Hon. Secretary: Lesley Cox
Hon. Treasurer: Mary Jane Steer
Hon. Membership Sec: Margaret Fay
Hon. Librarian: Jim Webster
Hon Bulletin Editor: David Davies
Hon. Archivist: vacant
Hon. Publicity Sec: Alex Morss
Hon. Proceedings Receiving Editor: Dee Holladay

Members:
Tim Corner
Robert Muston
Steve Nicholls

Section Reps:
Geology: Richard Ashley
Invertebrates: Maico Weites
Ornithology: Giles Morris
Botany: David Hawkins

At the subsequent Council meeting Giles Morris was elected as its Chairman. Due to the illness and eventual death of Lesley Cox, the Hon. Sec., the duties of the Secretary were undertaken by other members of Council. Lesley who did a lot for the BNS is very much missed, as is Clive Lovatt a long-standing member of Council who died just before the AGM and whose Obituary was included in the last issue of "Nature in Avon". A tribute to Lesley Cox is included in this edition. Robert Muston stood down from Council during the year due to ill health and sadly died in January 2023.

At the 2022 AGM changes to the membership structure were approved. A "Young Naturalist" membership was instituted to replace the more restricted "Student Membership", at a reduced rate, for young persons between the ages of 16 and 25.

Council also approved the adoption of a Safeguarding Policy and appointed Richard Ashley and Tim Corner as its Safeguarding Officers.

During the year there was fairly substantial expenditure, as can be seen from the accounts, on the creation of a new and vibrant website. Council approved this expenditure on the basis that it would be more effective in recruiting new members. So far this decision seems to have been justified. After a long period when membership was in slow decline, 2022 saw a substantial number of new members joining. Thanks must go to Dee Holladay and David Hawkins for all the hard work that they put into liaising with the website developers and getting the new website up and running.

Thanks are also due to David Davies for his unremitting hard work producing "Naturalist News" on a regular basis and to Dee Holladay and her team for producing the excellent 2021 edition of "Nature in Avon". Dee has been the editor for 8 years and she now hands over to fellow botanist and naturalist Dawn Lawrence. Dee deserves our sincere thanks for all the hard work she has put in over these 8 years to maintain the high quality of this annual publication.

It is worth stressing that without committed people like these the BNS could not function and that volunteers are its lifeblood.

2 Society Events

The continued use of Zoom for our talks has had both advantages and disadvantages and will probably continue to be used in conjunction with "in person" meetings that allow the very important social interaction between members. Our new website has allowed members to access links to recorded meetings when they cannot attend on the night.

The following Society talks were held during 2022:

January: The Private Life of Bees, speaker: Phil Savoie; The wildlife filmmaker and photographer explored the many species of bee and their importance in pollination, lavishly illustrated with outstanding photographs.

February: Snakes in the Heather Project, speaker: Owain Masters; An account of the work of this project in mapping and conserving the Smooth Snake.

March: Society AGM & The Greenland Shark, speaker: Paul Cox of the Shark Trust; a fascinating story about a species that is probably the longest living of all vertebrates.

October: The 1st Clive Lovatt Memorial Lecture, by Nick Wray on the Evolution of Flowers had to be cancelled due to the illness of the speaker.

November: Beasts Before Us, speaker: Dr Elsa Panciroli; a wonderfully accessible account of the research showing the importance of the early mammals.

December: Planet Insect, speaker: Steve Nicholls; having talked about the importance of the Class Insecta to the planet, Steve showed the first episode of his spectacular film series highlighting the group.

The December was an "in person" meeting with wine and mince pies. The others were held by Zoom.

3 Grants and Legacies

BNS Council approved two grants this year. A grant of £500 to be made to Hannah Jones for preparing a book of photographs of different species of Whitebeam trees. It was also agreed that a grant of £500 be made to Bristol University student George Greiff for a research project on bryophilous fungi.

The Society was honoured and grateful to be remembered in legacies left by sadly departed members: a legacy of £1,000 from the estate of Ralph and Kathleen Williams and a legacy of £2,000 from the estate of Mr Christopher Taylor.

4 The Library

The year began with the library tentatively restarting, as the Covid restrictions were slowly lifted, opening up to members by email appointment only. The appointment system worked smoothly, but the number of visits reduced from an already low pre-Covid level.

Then the sad and unexpected death of Clive Lovatt deprived the library committee of a Chair, botanical expert and archivist.

Our committee now consists of seven enthusiast members, who are actively considering the best options for the long-term future of the library, which is currently an undervalued but still fantastic asset of the BNS.

Jim Webster Hon. Librarian

5 Annual Section Reports for 2022

Botany Section

The Botany Section held twelve field meetings (and no indoor meetings in 2022). Following some resignations in recent years, as well as the sudden and unexpected passing in early March of long-time member Clive Lovatt – who was section President for a number of years, and Secretary before that – a new committee took shape: Rupert Higgins, Nicky Hodges and John Thompson joined the incumbents Helena Crouch, David Hawkins (Secretary) and Jenny Greenwood. In light of the fact that we failed to convene for a section AGM in 2022, the new committee would be sworn in/re-elected at our AGM in January 2023.

As has become tradition in recent years, we took part in the Botanical Society of Britain and Ireland's (BSBI) annual New Year Plant Hunt at the beginning of January. We split into two groups to cover more ground, finding numerous species in flower (the target of the search). Clive even showed his group the recently discovered Sea Stork's-bill *Erodium maritimum* growing as a pavement weed in Clifton Wood. February – which would be Clive's last meeting – saw us exploring Portishead Marina and Portbury Wharf, gleaning a first vice-county record for Greater Mexican Stonecrop *Sedum praealtum*.

After a sad lacuna, a few of us regathered for a hastily planned walk around Lower Failand in late April. Spring was in full swing, with violets adorning the lane-banks and birds and caterpillars noted along the way. In May we investigated the ancient woods and grassland of part of Blaise Estate, while early June saw us on Lawrence Weston Moor examining the flora of the species-rich wet meadows – with water vole field signs as a bonus. A highlight from June's second meeting around Oldbury Power Station was Narrow-leaved Bird's-foot-trefoil *Lotus tenuis*, but July's trip up the narrow and dripping Frome Valley was garlanded by the decidedly minute gametophytes of the rare Killarney Fern *Trichomanes speciosum*; a good torch and a desire to snout into rock crevices were necessary to espy this curiosity!

Towards the end of August we sought relief from the scorched landscape by escaping to Backwell Lake, which inhabits an exceedingly rich part of the map: Helena Crouch – BSBI Vice-County Recorder for VC6 (North Somerset) – remarked on how, after this meeting, the total species count for the OS map grid square now stood at 'an impressive 450 species, which is currently the highest monad total in VC6'. In September, Middle Hope afforded an opportunity to study the important Somerset Hair-grass *Koeleria vallesiana*, among many other delights. We stayed coastal in October, wandering the saltmarshes of the southern Clevedon foreshore and catching up with the local speciality Tree Medick *Medicago arborea*, a long-established – and rather impressive – unusual garden escape nestled in the cliffs.

In November we turned our attentions to bryophytes, combing through the remnant acid grassland and woods of Rodway Hill for mosses and liverworts – from the showy Bristly Haircap moss *Polytrichum piliferum* to the miniscule epiphytic liverwort Fairy Beads *Microlejeunea ulicina*. The highlight of this meeting may, nonetheless, have been vascular, as Bird's-foot *Ornithopus perpusillus* was encountered still in flower. December witnessed more bryological action, as the walls, trees, verges and clinker of the Cumberland Basin revealed their mosses, some tipped with frost.

Two further field meetings had been planned but had to be cancelled: following Clive's death, the March field meeting was called off (a number of us attended his funeral); Kenn Moor in August was postponed until 2023 due to one of the summer's extreme heatwaves.

Joint meetings with Gloucestershire Naturalists' Society (Oldbury) and Somerset Rare Plants Group (Backwell Lake) added variety and maintained our collaboration with these sibling outfits. Meanwhile, as well as various committee members taking on the duties of organising and leading meetings, we benefitted once again from the expertise of Neill Talbot as a guest leader (Blaise Estate).

Overall, attendance was consistent and generally higher than in preceding years. Lockdown has perhaps changed habits and reshuffled people's priorities, while a new Society website and more meetings in and close to Bristol itself undoubtedly help. We can now pretty reliably expect double digits for our field meetings, while more than twenty is a reasonable eventuality too.

In addition to meeting reports, the Bulletin also held discussions of notable records and curios. Special mention should go to Dylan Peters, who made countless interesting discoveries throughout the year, many of which were featured.

Grateful thanks go to all BNS members who sent in records and queries – whether vascular plants, bryophytes, lichen or fungi – and especially to everyone who contributed material that was reproduced in the Bulletin.

Clive was fond of repeating an adage of J.W. White, found in his seminal *The Bristol Flora* (1912): 'Finality in field botany is fortunately unattainable.' Further to this, I always find that our collective knowledge has no finitude either – its horizons appear boundless.

David Hawkins, Hon Secretary

Geology Section

A brief AGM of the Geology Section was held by Zoom immediately prior to the Society AGM on 16th March 2022. The Annual Report for 2021 was approved and in the absence of any other nominations Richard Arthur was elected as President and Richard Ashley agreed to continue as Secretary and Field Secretary.

No indoor talks were held during the year, but three field meetings were organized by BNS:

February 10th Saltford - A Geological Ramble, Leader Simon Carpenter This was based on a new walking trail guide produced by Simon that will be of great benefit to visitors interested in the geology of the area.

May 10th Velvet Bottom and Charterhouse, Leader Richard Arthur The aim of this meeting was to study the colonisation of toxic mine waste by pioneer plants / animals and how life is controlled by and dependent on geology. A notable feature of this meeting was the finding by the leader of a piece of Galena that had been missed by the old miners. They did not miss much!

July 31st Manor Farm and Aust, Leader Simon Carpenter This provided an opportunity to collect fossils from the late Triassic rocks including the famous bone bed.

In addition to these meetings members had the opportunity, under reciprocal arrangements, to attend field meetings organised by Bath G.S. and WEGA to Lilstock, Pen Hill, the Forest of Dean (2), Penarth and the Lake District. Publicity was also given in Naturalist News to the events of the Mendip Rocks Festival jointly organised by the Mendip Society and the Somerset Earth Science Centre.

Members of the Geology Section also carried out a considerable volume of private fieldwork including the preparation of papers for publication in Nature in Avon and other journals. Notable was the making of an excavation in a field called Ringhill near Hinton Charterhouse that exposed rocks of the Chalfield Oolite Formation and the Frome Clay. Fossils and rocks from this excavation are currently being studied with the intent to write a paper for publication.

The Secretary has also been involved in making arrangements with North Somerset Council and the potential contractors for the geological study and recording of Triassic and Jurassic rocks likely to be exposed during the construction of a by-pass around the village of Banwell in North Somerset.

Thus in spite of the paucity of formal meetings the Geology Section is still very much alive and active in pursuing the science of geology.

Richard Ashley, Hon Secretary

Invertebrate Section

The Invertebrate Section had an eventful 2022 with one online meeting and three field meetings.

Our first event was a joint online meeting with Butterfly Conservation, organised by Peter Bright. Here we were informed on the results of butterfly monitoring along several transects in and around Bristol and there was successful recruitment of new transect walkers so we can get more data in the years to come!

The Invertebrate Section held its first field meeting of 2022 on 27 May at Stoke Park. Stoke Park comprises a mixture of grasslands as well as woodland, and some small water bodies. We met at Romney Avenue from where a group of about 13 people set off to scour the place for invertebrates. We found a myriad of mirid bugs in the grasslands, damselflies and dragonflies along the ponds, and specialist beetles that feed on the reeds, bur-reeds and irises embracing the pond, such as *Donacia marginata* and Iris Weevil *Mononychus punctumalbum*. The latter is not a common species in the UK and this was the highlight of the trip for me personally.

Our second section field meeting was held at the Hanham Meadows led by the ever enthusiastic Peter Smithers. In 2014 six acres of meadows were created at the Hanham Hall Estate and so far not many invertebrate records had been made here. This was an opportunity to add some more sightings to the list. Six of us set out into the meadows to see what we could find. Peter was very organised and had placed numerous pitfall traps in the meadow the day prior and these had captured plenty of ground beetles and rove beetles for us to inspect. Swiping the vegetation resulted in nets full of insects typical of species-rich grassland. We ended our meeting where one should, at the pub.

On 6 August we had by far our busiest section meeting, nearing twenty attendees! This is an unusual number of people for our meetings but it is great to see that so many people are interested. The summer had been incredibly dry. There was not much in flower and the soil was rock hard but luckily Nightingale Valley was remarkably damp and we decided this would be the best place to start our walk. Some of our top finds were the bristletail *Dilta chateri* (this species was only described in 1995 based on specimens from Wales), a White-letter Hairstreak (*Satyrium w-album*), and two Common Sexton Beetles (*Nicrophorus vespilloides*) in the process of burying a shrew. Together we recorded at least 60 invertebrate species during this meeting.

I would like to thank all those who helped with organising these meetings an d those who attended. Hopefully see you again during our 2023 meetings!

Maico Weites, President

Ornithology Section

Along with the rest of the Society, the Ornithology Section has been very saddened by the death of Lesley Cox, following a debilitating illness. She was a tireless worker as Secretary of the Ornithology Section, and she will be much missed.

Mel Parker has taken over the role of Honorary Secretary for the Section. Giles Morris continued his excellent work as Honorary President of the section, aided by committee members Mike Johnson and Alastair Fraser. We would also like to thank Mary Hill for all her work for the section over the years as she has stepped down from the committee.

2022 was as busy as ever for the section. As the threat of Covid continued to recede, members have been pleased to be able to attend the regular field meetings around the region. The indoor meetings took place over Zoom for the 2022 season.

We had a number of very interesting talks via Zoom, including Richard Bashford telling us about the Birds of Poland, Dr Gavin Siriwardena of the BTO, speaking about Farmland Bird Research in February, while after our AGM Giles Morris updated us about the Portbury Wharf Nature Reserve in March. In November, Neil

Gartshore talked about birding in Spain, and focused on marshes, mountains and migration. Ken Smith gave a talk entitled 'Bars and Spots' in December, illuminating the varying fortunes of Greater and Lesser Spotted Woodpeckers in Britain.

Our field meetings offered members visits to a good selection of local venues and a wide variety of habitats:

January	RSPB Greylake
February	Newport Wetlands
March	Forest of Dean
April	Sand Point
May	Dawn Chorus at Blaise; RSPB Ham Wall; Durlston and The Purbeck Coast, Dorset (Joint Coach trip with Bristol Ornithological Club); Watercress Farm, Wraxall
June	Upton Cheyney - A BBS square; Velvet Bottom
July	Chew Valley Lake
September	Sand Point
October	Wain's Hill, Clevedon
November	WWT Slimbridge
December	RSPB Ham Wall *(cancelled due to bad weather)*

Thanks to the stalwart committee members who lead the walks, come rain or shine. We are always looking for new walk leaders, so if you would be prepared to lead a walk around your local patch or favourite birding site we would love to hear from you.

Members continue to contribute to various Ornithological surveys:

RSPB:	Annual Garden Birdwatch
BTO Surveys:	Breeding Bird Survey, Waterways Breeding Bird Survey, Garden Bird Survey, Wetland Bird Survey
Local Surveys:	The Avon Winter Birds Survey

The Bird Survey at Westonbirt Arboretum has been put on hold.

We hope to encourage more members to participate in these surveys, as these observations make an invaluable contribution to the monitoring of British bird populations.

Mel Parker, Secretary

6 Membership

We have been very pleased with the impact of our new website on our recruitment of new members. The updated website introduced online membership applications which attracted an additional 51 members joining the Society online. As a result, after several years of declining membership, this year saw an increase of over 40 to take our total membership back over the 400 mark to 410. Equally pleasing has been the increase in younger members attending both talks and field meetings.

Sadly, there were seven deaths reported during the year, three of whom were particularly long-standing members. As well as Clive Lovatt, who became a member in 1977, two other members passed who had been with the Society for close to 50 years, they were Mr John C Phillips of Backwell and Mr M J Pinker of Horton who joined in 1975 and 1974 respectively.

7 Thanks

As always our sincere thanks go to Bristol City Council's Culture & Creative Industries department for the Museum's continued support of our Society Library, located within the Bristol Museum and Art Gallery.

Finally, our thanks go to all those members of The Bristol Naturalists' Society who gave so willingly of their time and energy over the course of the year to support the aims and aspirations of the Society.

BNS Treasurer's Report – Year End 2022

Membership increased during the year, and attendance at meetings in person in recent months have been encouraging.

The Society made the following grants in December 2022, and welcomes applications for 2023:
£500 to Hannah Jones towards a book of photographs of different Whitebeam trees
£500 to George Greiff towards a project on bryophilous fungi

We also received two generous legacies:
April 2022 £1000 from the estate of Ralph and Kathleen Williams
May 2022 £2000 from the estate of Christopher Taylor

The COIF fund investments continue to provide a useful additional income.

A key item of expenditure during the year was on the development of the new website. This is proving to be very successful, and several new members have been recruited online. However, it is essential that Section leaders continue to ensure that their pages are kept up to date.

The Society is in a healthy financial situation and is well placed to meet development costs such as the website. However, costs such as room hire have increased while membership rates have stayed steady for several years. Council may wish to consider a small increase in membership subscriptions for 2024.

After several years in post I am retiring as Treasurer at this AGM, but will continue as Acting Treasurer until a successor can be found. Any expressions of interest in taking on this role would be welcomed.

Mary Jane Steer, Hon. Treasurer

ACCOUNTS for the Year to	31/12/2022						
(Profit and Loss)							
	2022		2021			2020	
	(Year to date)		(Full year)			(Full year)	
INCOME							
	£	%	£	%		£	%
Membership Fees	8,506	54	7,503	20		7,989	73
Advance payments made in previous year	570	4	965	3		725	6
Advance payments made for coming year	0	0	-570	-1		-965	-4
Gift Aid	1,478	9	1,504	4		1,486	13
Donations/Legacies	3,035	19	15,065	39		213	2
Trading	85	1	48	0		10	0
Interest(Skipton Building Society)	118	1	20	0			
Interest(COIF Charity Funds)	2,038	13	1,490	4		1,099	10
App/Dep COIF Charity Funds	0	0	794	2			
University of Bristol refund	0	0	11,527	30		0	0
TOTAL	**15,830**	100	**38,346**	100		**11,007**	100
EXPENDITURE							
Administration							
Printing & stationery	0	0	0	0		39	2
Post & telephone	132	2	80	20		65	3
Council meetings	0	0	144	37		210	9
Insurance	96	1	96	25		140	6
Capital Items (Library Computer)	0	0	0	0		682	28
Website	7,294	97	70	18		1,282	53
TOTAL	**7,522**	100	**389**	100		**2,418**	100
SURPLUS of Income over Running Costs	**8,308**		**37,957**			**8,589**	
Charitable Activities							
Meetings (Speakers' Fees & Room hire)	518	6	355	5		913	11
Bulletin Production	3,720	44	3,063	41		3,092	38
Avon Bird Report Printing	2,025	24	2,019	27		1,466	18
Proceedings (Nature in Avon) Printing	1,845	22	1,711	23		1,529	19
Publicity	0	0	0	0		0	0
Library (books & periodicals)	269	3	411	5		894	11
Bristol Tree Forum - RLB memorial tree	0	0	0	0		295	4
TOTAL	**8,377**	100	**7,558**	100		**8,190**	100
SURPLUS of Income over Running Costs							
and Charitable Activities	**-69**		**30,398**			**399**	
GRANTS (from Capital)							
Grants Awarded	1,000		62			1,500	
TOTAL	**1,000**		**62**			**1,500**	
CASHFLOW FOR 2022	**-1,069**		**30,336**			**-1,101**	

BALANCE SHEET 2022	31/12/2022			
ASSETS	**2022**	**2021**		**2020**
	(year to date)	(year end)		(year end)
	£	£		£
Lloyds Bank	8,762.97	2,520		1,393
Skipton Building Society	20,750.90	40,632		40,612
COIF funds sum invested	80,000.00	68,000		40,000
Creditors	0.00	-570		-965
	109,513.87	110,583		81,040
LIABILITIES	None	None		None
NET ASSETS - General fund	**109,513.87**	**110,583**		**81,040**
inc £60,000 Barry Harper Memorial Fund				
RECONCILIATION				
2021 Final Balance	110,582.90	81,041		82,616
2022 Cashflow	-1,069.03	29,543		-1,575
2022 Final Balance	**109,513.87**	**110,584**		**81,041**
MEMBERSHIP SUBSCRIPTIONS				
	2022	**2021**		**2020**
Received in previous year	570.00	965		725
Received in current year	8,505.97	7,503		7,983
Pre-payments for following year	0.00	-570		-965
Total	9,075.97	7,898		7,743
Recent Valuation of COIF Funds				
COIF Fixed Interest Sum invested	34,228	20,000		
COIF Fixed Interest Valuation 31/12/2021	32,678	20,228		
COIF Fixed Interest Valuation 30/06/2022	28,980			
COIF Fixed Interest Valuation 31/12/2022	28,586			
COIF Fixed Interest unrealised Profit/Loss	-5,642	228		
COIF Ethical Sum invested	34,359	20,000		
COIF Ethical Valuation 31/12/2021	38,468	20,359		
COIF Ethical Valuation 30/06/2022	34,000			
COF Ethical Valuation 31/12/2022	33,689			
COIF Ethical unrealised Profit/Loss	-670	359		
COIF Global Equity Income Fund invested	12,000			
COIF Global Eq. In. Fund Valuation 30/06/2022	11,184			
COIF Global Eq. In. Fund Valuation 31/12/2022	11,426			
COIF Global Eq. In. Fund unrealised Profit/Loss	-574			

Instructions for authors

The editor welcomes original papers or short notes on the natural history and geology of the greater Bristol region for consideration for publication in *Nature in Avon*.

Text should be submitted by email in Word. Please send all illustrations as separate files (they may also be embedded in the Word file to indicate placing). These files may be sent separately in emails or by Dropbox (or similar application) links.

The Deadline for submission is March 31 and publication is in June. Recent issues, subject to a 2-year moratorium, are available for download on the BNS website at www.bristolnats.org.uk.

Historical issues of *Nature in Avon* and its predecessor *Proceedings of the Bristol Naturalists' Society* can be found on the Biodiversity Heritage Website at www.biodiversitylibrary.org.

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VOLUME 82 (2022)

CONTENTS

Rerum cognoscere causas – Virgil

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