# FURTHER DEVELOPMENTS OF THE FLORA AND FAUNA OF THE WILDLIFE GARDEN AT THE NATURAL HISTORY MUSEUM, LONDON: PART 2 – TWENTY ONE YEARS OF SPECIES RECORDING

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## ABSTRACT

This paper, Part 2 of a study following developments of the flora and fauna of the Wildlife Garden at the Natural History Museum (*The London Naturalist* No. 95, 2016), reports on groups omitted in part 1 and lists species new to the Garden in the past year. The groups covered by this paper are algae, fungi, plant galls, Collembola, Lepidoptera (butterflies), woodlice, amphipods, tardigrades and amphibians. As in part 1, the changes in species composition and abundance within the groups are discussed. The list of recorded taxa since 1995 stands at 3,290 of which two moths were new sightings to Britain.

## INTRODUCTION

### Background and aims of report

The background and aims of the Natural History Museum's Wildlife Garden (henceforth the Garden) have been fully described (Honey *et al*. 1998) and summarised (Ware *et al*. 2016). It is now twenty one years since the Museum's first living gallery opened to the public and since recording of species began there. The accounts are presented for the following groups: soil algae, fungi, plant galls, Collembola, Lepidoptera (butterflies), woodlice, amphipods, tardigrades and amphibians.In addition water samples analysed over the years have been discussed to assess changes in water chemistry that may have affected composition of aquatic flora and fauna (Ware *et al*. 2016).

### Habitat management and development since 2016

Habitat management continues to focus on enhancing plant communities to promote biodiversity within each habitat (see Figure 1) and to maintain a distinction between the

*Wildlife Garden heathland habitat. © The Trustees of the Natural History Museum, London*

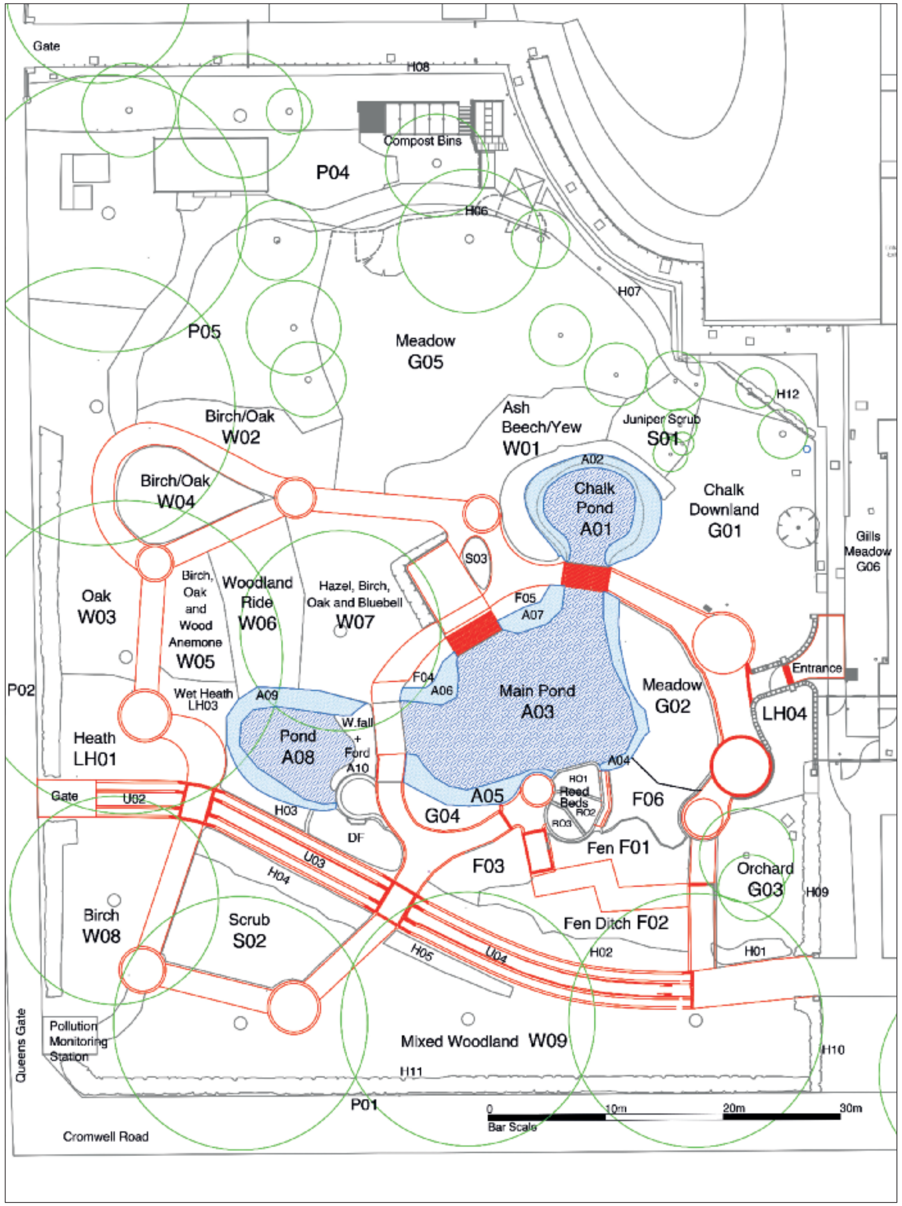


*Figure 1: Plan of Wildlife Garden with habitat areas and codes from 2012 onwards*



*Above: Hedge-laying (hedge H12) by Daniel Osborne. © The Trustees of the Natural History Museum, London*

*Below: The laid hedge nearly 10 weeks later. © The Trustees of the Natural History Museum, London*

different habitats in a relatively small area. For details see Ware *et al*. (2016). An additional hedge (H12) was laid in February 2017 by Daniel Osborne with help from volunteers Paula Entwisle, James Bautista and Nicola Mort. This transformed a previously unattractive aspect of the grounds and illustrates how a traditional and creative method of hedge management can produce benefits to wildlife using existing vegetation and at the same time enhance the landscape.

With over 400 species of vascular plants in addition to associated fauna, the Garden is an important resource for training in recording methods and species identification. The Garden continues to host training in wild flower identification led by the Species Recovery Trust, as well as training in recording and identification of other taxa led by different departments in the Museum. The Garden was awarded the London in Bloom Meadows Award in 2016.

## RECORDING METHODS

Data collection and surveys continue to be carried out by volunteers working with the Garden team, specialists who come in with the sole purpose of survey work and Museum scientists. Regular recording sessions are organized for staff and volunteers. Volunteers also help with sorting specimens, identification and entering records on to the Garden's database. The recording methods described previously (Leigh and Ware 2003; Ware *et al*. 2016) continue to be used. The methods below relate to the taxa discussed in this paper.

### Soil Algae

Soils were collected aseptically from various habitats during 2017 and stored in sterile plastic bags.

Heathland soils were collected from Merritown Heath, Dorset (surface and 10 cm) on 7 February 2017 by Danny Alder (formerly Senior Ecologist at Dorset County Council) and in the Wildlife Garden (surface and 10 cm) on 14 February 2017. Chalk soils were collected at Monk Sherborne, Hampshire (surface and 10 cm) on 26 January 2017 and in the Garden (surface and 10 cm) on 26 January 2017.

Five grams of soil were weighed aseptically and added to a sterile flask containing an inorganic growth medium (Bold's Basal medium – BBM). Duplicate cultures were made for each collection site (surface and 10 cm). The soils were incubated in a controlled environment growth chamber at 15ºC and 16:8 L:D cycle. Sub-samples of the soils were examined over several months with an Olympus microscope at a magnification of 400x and 1000x oil. Determinations were made by eye and confirmed with taxonomic keys.

### Fungi

The recording of the fungi was started in 1997 with at least one specialised visit a year between 1999 and 2002. Surveys have been carried out since 2003 at less regular intervals. Survey data are supplemented by casual observations throughout the year.

### Plant galls

Surveys of plant galls were carried out by Tommy Root in October 2013, July 2014 and July 2016. Additional records include those made by casual observations throughout the year.

### Collembola (Springtails)

The first Collembola record from the Natural History Museum came from flower pots in 1956 (the non-native *Sminthurinus domesticus*, recorded by Gisin). Subsequently they have been recorded from the Garden by the late Steve Hopkin in litter collections on 21 October 2003 and 17 March 2004, the author in a litter collection on 24 June 2015 and by litter collection and bark vacuuming on 2 December 2015, as incidental by-catches in Malaise traps in 2012-2013 and pitfall traps. Identifications followed Hopkin (2006), backed up by Fjellberg (1998; 2007).



### Lepidoptera (Butterflies)

Butterflies were recorded formally by Gay Carr during her regular bird, butterfly and dragonfly walks until her untimely death in 2015. These records were supplemented during regular weekly lunchtime recording sessions and by casual observations from volunteers and Museum staff. Butterflies are the most commonly recorded insects by volunteers while they carry out their conservation and gardening work. However some of the most common species, such as the 'whites' and speckled wood are probably under-recorded in much the same way that common birds, such as blackbirds and robins, are not 'recorded' each time they are observed in the Garden. Frances Dismore has taken on the butterfly and dragonfly walks since 2017.

### Isopoda (woodlice) and Amphipoda

Soil invertebrates are recorded through regular pitfall trapping and surveys of cryptic invertebrates by regular habitat searches, such as under logs, stones and leaves.

### Tardigrades

A survey was carried out by Phil Greaves in March 2015 when eight stations (areas with moss and lichen cover) were sampled, five of which yielded a combined total of 40 individuals. Further surveys were carried out in June 2016 and May 2017.

### Amphibians

These are recorded in the Garden using four different methods:

**Bottle trapping**: was used to survey for newts. There have been no records of great crested newts *Triturus cristatus* and it is unlikely that they will find their way to the Garden. Annual bottle trap surveys have been carried out since 2015 under the supervision of licence-holder Stephanie West. Approximately four traps were set around the edges of each of the three ponds and left overnight. All traps were checked at around 07:00 and any newts present were identified to species level, sexed and then released back into the same pond they were trapped.

**Torching**: was carried out at all three ponds during the evening when bottle traps were set. Using a high-powered torch (1 million candle-power), the light was shone into the water to reveal any newts. Although by using this method great crested newts could be identified from smooth and palmate newts, distinguishing between smooth and palmate newts in the water was more difficult.

**Egg searching**: marginal and overhanging vegetation in all three ponds was checked during the day and early evening for folded leaves where the newts may have laid their eggs. This was not as successful as the other methods.

**Terrestrial refugia search**: this method was used for all four amphibian species. Searches took place across the Garden under logs and log piles, in the compost bins and around the greenhouse under pots and shelving.

### Environment

Water samples are taken from each of the three ponds and the collection tank two or three times a year and analysed in the Mineralogy Department, by Gary Jones (until 2008) and since then by Stanislav Strekopytov.

## DATABASING RECORDS AND VOUCHER SPECIMENS

As previously reported (Ware *et al*. 2016) all records are entered on the Garden database managed by Nicky Reilly. Records are shared with other organisations including London's environmental records centre, GiGL (Greenspace Information for Greater London), the Woodland Trust's Nature's Calendar, Butterfly Conservation and the National Moth Recording Scheme. Voucher specimens are often retained for reference.

## DISCUSSION OF RESULTS

The total number of taxa recorded by August 2017 was 3,290. A total of 3,103 taxa have been identified to species level, the remaining 187 to genus level. The list includes 417 species of vascular plants recorded in the Garden over the last year. The species lists below are those discussed in the current paper (algae, fungi, plant galls, Collembola, Lepidoptera (butterflies), tardigrades, Amphipoda and Isopoda and amphibians). Additions to groups previously reported in part 1 (Ware *et al*. 2016) are included in Appendix 1. These additions include two 'notable' species bringing the total number of 'notable' species (including 8 UK Red Data Book species) recorded in the Garden to 44. The location of a particular habitat can be found on the plan of the Garden (Figure 1). Corrections to part 1 (Ware *et al*. 2016) are included in Appendix 2.

## FLORA AND FUNGI

### COMPARISON OF ALGAE INHABITING SOILS IN THE WILDLIFE GARDEN TO SOILS OF THE DONOR HABITAT

ELLIOT SHUBERT

### Introduction

Algae inhabiting soils have been studied for over 150 years at various habitats throughout the world. Generally, it is Cyanobacteria, diatoms and green algae that inhabit soils. Algae add nutrients to the soils by nitrogen fixation and excretion of organic compounds. Soil algae also improve the friability of the soils, which makes the soils more conducive for root establishment and growth. Most importantly, soil algae provide food for soil micro-organisms (e.g. bacteria, fungi, nematodes, insects, etc.).

### Results

A total of 24 algal taxa were identified (6 cyanobacteria, 5 diatoms, 12 greens and 1 euglenoid). There were similarities and differences between the control sites (original natural habitat) and the Garden sites (Table 1).

With respect to the control site at Monk Sherborne (chalk), there was variability of algal taxa (soil + chalk and chalk). More diversity was observed in the chalk layer (7 taxa) than the soil + chalk layer (5 taxa). Diatoms dominated the top layer and green algae dominated the chalk layer. The Monk Sherborne soils had a higher diversity of algae compared to the Garden site (12 taxa vs. 7 taxa); however, there were more cyanobacteria taxa at the Garden site (5 taxa vs. 3 taxa respectively). In addition, there were more



*Table 1: Algae in soils from the Wildlife Garden and from chalk and heath soil donor sites*

| Algae Group | Monk Sherborne: soil + chalk | Monk Sherborne: chalk |
|---|---|---|
| Cyanobacteria | *Oscillatoria limosa* | *Anabaena circinalis*<br>*Nostoc commune* |
| Diatoms | *Achnanthidium*<br>*Navicula*<br>*Nitzschia* | *Pinnularia borealis* |
| Greens | *Chlorococcum humicola* | *Ankistrodesmus*<br>*Desmococcus*<br>*Klebsormidium flaccidum*<br>*Oedogonium* |
| | **WLG chalk, surface** | **WLG chalk, 10 cm** |
| Cyanobacteria | *Anabaena* (no heterocyte)<br>*Cylindrospermum*<br>*Nostoc commune*<br>*Oscillatoria limosa* | *Anabaena* (terminal heterocyte)<br>*Cylindrospermum*<br>*Nostoc commune*<br>*Stigononema* |
| Greens | *Botryococcus*<br>*Chlorella* | *Botryococcus*<br>*Chlorella* |
| | **Merritown heath, surface** | **Merritown heath, 10 cm** |
| Cyanobacteria | *Chlorococcus* | *Aphanothece* |
| Diatoms | *Achnanthidium* | |
| Greens | *Botrycoccus*<br>*Chlamydomonas*-like<br>*Chlorella*<br>*Chlorococcum humicola*<br>*Coelastrum*<br>*Desmococcus*<br>*Desmodesmus* | *Chlamydomonas*-like<br>*Chlorella*<br>*Chlorococcum humicola*<br>*Desmococcus*<br>*Schroederia* |
| Other | *Moss protenema* | |
| | **WLG heath, surface** | **WLG heath, 10 cm** |
| Cyanobacteria | *Aphanothece/Gloeothece* | *Anabaena* |
| Greens | *Chlorococcum humicola*<br>*Gloeocystis*<br>*Klebsormidium flaccidum*<br>*Schroederia*<br>*Sphaerocystis* | *Chlorococcum humicola* (dom.)<br>*Klebsormidium flaccidum*<br>cf. *Palmodictyon*<br>*Schroederia* |
| Euglenoids | *Euglena* | *Euglena* (dominate) |
| Other | *Moss protonema* | |

Nostoc commune *showing the cells of the large colourless heterocysts about 7 micrometres in diameter and coloured cells about 5 micrometres in diameter. (c) Peter York*

green algae at the Monk Sherborne site (5 taxa) compared to the Garden's chalk downland site (2 taxa).

With respect to the control site from Merritown Heath, there was variability of algal taxa (surface + 10 cm layer). More diversity was observed in the surface layer (9 taxa) than the 10 cm layer (6 taxa). Green algae were dominating throughout the layers. Less diversity was observed in the Garden heathland soils (9 taxa) compared to the Merritown Heath soils (11 taxa).

The Monk Sherborne soils were equivalent in diversity to the Merritown Heath soils (12 taxa vs. 11 taxa); however, the composition of the taxa was quite different (more green algae in the Merritown Heath soils). The heath soils in the Garden were more diverse than the chalk soils in the Garden (9 taxa vs. 7 taxa respectively).

There are not enough data to conduct a statistical analysis; however, when comparing algal taxa at the various sites, it is apparent that the community composition is very different.

## Discussion

It was expected that the algal flora at the control sites would be very similar to the Garden sites but this was not the case. There were a few similarities at both chalk control and Garden sites, such as the presence of *Anabaena*, *Nostoc* and *Oscillatoria*. There were also a few similarities at both the heath and Garden heath sites, such as the presence of *Aphanothece*, *Chlorococcum* and *Schroderia*. Otherwise, all sites were dissimilar.

Chalk is very different from heath soils; while chalk is high in carbonaceous material with an alkaline pH, heath soils are more fertile with a circumneutral pH. Thus, it is not surprising that cyanobacteria were more abundant at the chalk sites, because cyanobacteria prefer a high pH. Whereas, green algae were more abundant at the heath



sites because they use more nutrients and prefer a circumneutral pH.

I can only speculate that the Garden sites are different than the original sites of collection, because the sampled sites in the Garden have had five years of development and the microclimate is different compared to the original sites. Nevertheless, the chalk soils in the Garden are very different in algal community composition compared to the heath soils. The soils should be continuously monitored.

# FUNGI

BRIAN SPOONER

## Introduction and Background

Since its construction over a two-year period between 1993 and 1995, the Wildlife Garden has developed into a highly biodiverse site with a range of well-established habitats. It was a major transformation of the original grassy site in which there was comparatively little biodiversity but with mature trees, such as London plane *Platanus* x *hispanica*, Lombardy poplar *Populus nigra* 'Italica', lime *Tilia petiolaris* and hawthorn *Crataegus monogyna* cultivar, which remain and have protected (TPO) status. The site exhibits a range of carefully chosen habitats which reflect those found in the British Isles, including ponds, meadow, chalk grassland, hedgerow and woodland (Honey *et al*. 1998; Vickery 2004). The components of these new habitats (e.g. seeds, young trees and shrubs) were sourced remotely but of British origin, but now, in the succeeding 22 years, have developed into a highly successful, well-established mosaic with an enormous diversity of organisms, as is amply attested by the accounts and astonishing lists of recorded species which have appeared in the *London Naturalist* since 1998 (Honey *et al*. 1998; Ware 1999; Leigh and Ware 2003; Ware *et al*. 2016). Amongst this great diversity are, of course, the fungi, which are integral to every ecosystem. Their presence in the Garden, as elsewhere, is essential for the healthy growth of plants and hence of other organisms which are ultimately dependant on them, and the success of the Garden attests to the presence of a wide range of fungi. It is interesting and instructive then to record and monitor what fungi are present in the various habitats, some of them being introduced during the creation of the Garden, others either already present or soon colonising naturally. It is an enormous and ongoing task.

The lichenised fungi (lichens) have been discussed separately (Wolsey and Thüs, in Ware *et al*. 2016), so this article is concerned only with the non-lichenised species, especially those which are additional to the lists previously published, and with the so-called fungus-like organisms, which are not true fungi and are further discussed below. The opportunity to update some previous records has also been taken.

There are few records available for the site before 1995, either of fungi or of other organisms, though many fungi will certainly have been present and the species associated with those trees and shrubs which remain from earlier times will be amongst them. Recording began shortly after the Garden was opened to the public but concentrated initially on microfungi (Mordue, in Honey *et al*. 1998), particularly the powdery mildews (*Erysiphales*) and other plant pathogens of which just 25 species were reported. A few other, mostly larger, species were also listed but just seven in all, including two ectomycorrhizal toadstools, *Xerocomellus chrysenteron* and an undetermined species of

*Inocybe*. Amongst the powdery mildews recorded at that time were 11 referred to *Oidium* sp., i.e. the conidial or asexual states of the species involved, with just their host plants noted. Given that these fungi are strictly host-limited, with a single or occasionally two and rarely more species known from any given host, and following the publication of a monograph of these fungi by Braun and Cook (2012), most of these can now more confidently be referred to species and these appear in the accompanying species list. They include mostly common species, such as *Golovinomyces cynoglossi* on viper's bugloss *Echium vulgare* and *G. fischeri* on red campion *Silene dioica*, but also the less common, but apparently spreading, *Erysiphe howeana* on evening primrose *Oenothera biennis*. This was evidently first collected in Britain in Richmond in 1976, but remained undetermined at that time, and was otherwise first reported from Fifeshire in 1985, and then, on *O. glazioviana*, from Esher in 1996, with various records since then. A mildew on selfheal *Prunella vulgaris* was also recorded. This is of interest as there are few records of mildews from this host but must await re-collection and further study to identify with certainty as two species, *Golovinomyces biocellatus* and *Neoerysiphe galeopsidis*, potentially occur on *Prunella* but are more common on other hosts. They have both been recorded on *Prunella* in Europe although hitherto there appears to be only a single record of a powdery mildew on this host in Britain, of *N. galeopsidis* from Lancashire in 2002.

Since the 1998 account (Honey *et al*. 1998), the recording of fungi has continued with two extended accounts appearing in 2003, covering further microfungi (Mordue 2003) and others (Spooner 2003), which together enumerated an extended list of 40 or so larger fungi and many additional microfungi, bringing the total then known from the site to a little over 160 species. However, only two additional mycorrhizal toadstools were included and, again, the powdery mildews and rusts dominated the list, making up almost a third of the total and it might be assumed by a glance at the list that the Garden is dominated by pathogens! However, this merely reflects the host-specific nature of most of these fungi, the range of potential host plants that is available and that they are often more readily noticed due to their effects on the host. Many of the herbaceous plants are hosts to powdery mildews that form a whitish coating to the host leaves which is often most evident later in the season. Others occur on trees in the Garden, including species of maple *Acer*, hazel *Corylus*, spindle *Euonymus*, lilac *Syringa*, oak *Quercus*, ash *Fraxinus* and willow *Salix*. The mildew of London plane (*Platanus* x *hispanicus*), *Erysiphe platani*, a comparatively recent introduction to Britain, is also now present at the Garden as it is in much of the London area. Two other recorded mildews, *E. flexuosa* on horse chestnut *Aesculus* and *Phyllactinia carpini* on hornbeam *Carpinus*, are also recent arrivals in Britain.

*Bracket fungi* Trametes versicolor. © *The Trustees of the Natural History Museum, London*



Mycena galericulata. © *The Trustees of the Natural History Museum, London*

Fungi recording has continued since 2003 and the list of species has been extended during every visit. This is much as expected given the enormous diversity of fungi and will continue almost indefinitely. The total number of species present in the Garden is unknown but with a plant list of over 400 species (Ware *et al*. 2016) is likely to well exceed 2,000 species, many being representative of specialist niches yet to receive any serious study. These include, for example, the fungi of dung, of birds' nests, many soil fungi and aquatic species, and those known to occur as insect pathogens, many of which require specialist techniques to study. There are also many potential host plants which have not yet been much investigated. Saprotrophic microfungi on the many potential host plants also require further investigation. Excluding lichens, 280 species of fungi have now been recorded from the Garden, with 130 or so additions to the Garden list since 2003. They are representative of the two major groups to which most familiar fungi belong, the ascomycetes (Phylum: Ascomycota) and the basidiomycetes (Phylum: Basidiomycota), and can be referred to 76 families in 31 different orders. These phyla differ fundamentally in the method of spore production of their sexual stages, the former

Psythyrella corrugis. © *The Trustees of the Natural History Museum, London*

producing spores internally in asci, the latter externally on basidia. Ascomycetes, particularly, are extremely numerous, many having asexual stages (anamorphs, often referred to as hyphomycetes and coelomycetes) and the great majority of the microfungi belong here. Basidiomycetes include most of the more familiar larger fungi, the mushrooms and toadstools, brackets, clubs, crusts and jelly fungi.

A detailed, systematic study of fungi in the Garden has therefore not yet been possible. Although, as noted, we can be confident that, given the success of the Garden and number of plant species present, many fungi occur, the species involved can, by and large, be recorded only from their fruit-bodies. Apart from some perennial bracket fungi (of which, curiously, none have yet been recorded), most species, particularly the larger fungi, are generally seasonal in appearance. The development of their fruit-bodies will also rely on prevailing conditions; dry years will be less productive than damp ones and hence, to record the fungi at any given site is a long-term process. It is the autumn months that are most productive, particularly for toadstools (those such as the well-known mushroom with cap, stem and gills) which are most in evidence between September and December. Other fungi, however, such as the recently recorded St. George's mushroom *Calocybe gambosa*, are characteristic of spring and some, including many of the tiny ascomycetes,



may occur at any time of the year if conditions are favourable.

Over 70 species of larger fungi have been recorded. Recent records include toadstools such as lawyer's wig *Coprinus comatus* which is one of the larger, fleshy ink-caps, bonnet caps (species of *Mycena*) with simple, slender fruitbodies and white spores, the black-spored wood mushroom *Agaricus sylvaticus* and brown-spored species including *Psathyrella corrugis*, sometimes present in huge swarms. *Volvariella gloiocephala*, also found recently, is the only pink-spored toadstool yet recorded. Bracket fungi include the unmistakeable bright yellow or orange chicken-of-the-woods *Laetiporus sulphureus* and *Chondrostereum purpureum*, hairy above with purple underside, a common saprotroph of birch *Betula* and some other broadleaf trees, but also the cause of silver-leaf disease of plum trees. It is notable that of the ectomycorrhizal fungi, only ten species have been found to date though it seems certain that many more will be present and await discovery. Those recorded so far include several toadstools, such as two species of fibre cap *Inocybe*, two boletes, a *Hebeloma* and a web-cap *Cortinarius*, as well as two species of earthball *Scleroderma*. Two earth-stars, *Geastrum triplex* and *G. fimbriatum*, found amongst leaf litter have also been recorded recently, though both are amongst the more common of the British species. These iconic fungi are similar to puffballs but have an outer layer which splits at maturity into several lobes forming a star-shaped structure.

## Saprotrophs

Decaying plant parts from all the plant species found in the Garden will be host to a wide range of microfungi, often appearing in sequence during the decay process. These are mostly ascomycetes but other groups of fungi will be involved. Many of the larger basidiomycetes are also saprotrophs, occurring in plant litter, amongst grass, on soil in humus or on rotten wood. Amongst these larger fungi are some common species which

*Earth-star* Geastrum triplex. © *Frances Dismore*

Ramaria decurrens. © *Joe Beale*

perhaps surprisingly have not been noted before. They include the shaggy parasol *Chlorophyllum rhacodes*, generally common in such habitats, tawny funnel cap *Lepista flaccida*, sometimes in swarms in litter under trees, *Gymnopus dryophilus*, in broadleaf litter, and glistening ink-cap *Coprinellus micaceus*, common on rotten logs and stumps. Others include the bonnet-cap *Mycena haematopus* on rotten wood, *Stereum hirsutum*, one of the most abundant bracket fungi, found on decaying logs and stumps of both broadleaf trees and conifers, and the bright yellow or orange 'chicken of the woods', *Laetiporus sulphureus*. Also recorded recently are three of the so-called club or coral fungi, the common white *Clavulina coralloides* ('crested coral') and two species of Ramaria, *R. stricta* ('upright coral'), with pale tan or yellowish-brown coral-like fruit-bodies, and *R. decurrens*. The first, a fairly common saprotroph on various kinds of rotten wood, was first recorded in the Garden in 2006 and again in 2017. *Ramaria decurrens*, a similar and related but introduced species, first found in Britain in 1990 and now apparently spreading, was recorded in the Garden in 2017, again on woody debris. Amongst other species of note recorded recently is *Leratiomyces ceres*, the so-called 'redlead roundhead', recognisable by its orange, slimy cap and dark spores, an introduced species seen most frequently on wood-chip mulch, often in large troops, but occasionally now, as at the Garden, away from such mulch but associated with woody debris. Amongst the many ascomycetes might be mentioned *Xylaria polymorpha*, commonly known as dead-man's fingers due to its large, blackish, digit-like fruit-bodies, and the microfungus *Splanchnonema platani*. The former is generally frequent on rotten stumps in damp, shaded places, whereas the latter has tiny, flask-like fruit-bodies sunken in branches of *Platanus*, like many such fungi easily overlooked if not carefully searched for. This was first recorded in Britain at Kew only in 2003 and there are still only a handful of records of it.

## Mycorrhizal species

Most of the plant species present in the Garden will have some sort of mycorrhizal partner, for the woody species these mainly being ectomycorrhizal, as exemplified by many agarics, various other basidiomycetes, and at least some ascomycete species. Some trees and shrubs, however, notably *Acer* (Aceraceae), *Platanus* (Platanaceae) and *Fraxinus* as well as *Syringa* and *Ligustrum* (all Oleaceae) amongst genera present in the Garden, lack such associates and instead are endomycorrhizal, associated with species of *Glomus* (Glomeromycota), which have tiny, underground fruit-bodies sometimes known as 'pea truffles', universal partners of almost all herbaceous plants and of some trees and other



*Dead man's fingers* Xylaria polymorpha. © *Frances Dismore*

woody plants. Although only ten ectomycorrhizal species have yet been recorded in the Garden, others will surely occur, associated with host genera such as *Betula*, *Populus* and *Salix*, but can be recorded only when their fruit-bodies appear. Since 1998, *Hebeloma leucosarx*, two *Inocybe* species, *Laccaria amethystina* and *L. laccata*, and another bolete *Xerocomellus rubellus*, have been recorded, as well as a specifically unidentified *Cortinarius*. The two earth balls, *Scleroderma areolatum* and *S. verrucosum*, are also recent records.

## Pathogens

As noted, these are represented especially by the powdery mildews (Erysiphales: Ascomycetes) but also by the rusts (Pucciniomycetes), smuts (Ustilaginomycetes) and some of the ascomycetes which may cause leaf spots or other symptoms, including galls. Gall-causers, represented for example by *Taphrina*, have been separately discussed under Plant Galls, but are given below in the overall fungus list. Three rust fungi, *Puccinia annularis* on wood sage *Teucrium scorodonia*, *P. behenis* on red campion *Silene dioica* and *P. oxalidis* on pink sorrel *Oxalis corymbosa*, are additions that have been recorded recently. Also recorded now is *Microstroma album*, a pathogen of *Quercus* leaves, forming tiny, white flecks on the leaf underside, a basidiomycete now placed in Microstromataceae.

## Slime moulds and other fungus-like species

Apart from the main groups of fungi so far noted, there are various smaller groups yet to be recorded in the Garden, for example the above-mentioned endomycorrhizal 'pea truffles' (Glomeromycota), which form tiny underground fruit-bodies, the chytrids (Chytridiomycota and similar fungi), which include saprotrophs, some plant parasites and aquatic species, and the Mucorales (Zygomycotina), often known as pin moulds. Also much under-recorded are the so-called 'fungus-like organisms', which though often remarkably fungus-like in character are not true fungi but belong, in fact, to different Kingdoms. They include the slime moulds or myxomycetes (Kingdom: Protozoa) which have amoeboid stages in their life cycle but at maturity form sporangia which are rather fungus-like in appearance. They are hence traditionally recorded amongst the fungi and are attractive to look at. Many species are common, to be found in various habitats on substrates such as decaying leaves and rotten wood, though some may be found only from bark culture, which is a rather specialist study. Just five species, all fairly common and widespread in Britain, have so far been recorded from the Garden, three of them since the previous lists were published, viz.: *Perichaena corticalis* on bark of sweet chestnut *Castanea*, *Physarum cinereum* on plane *Platanus* and *Stemonitis fusca* on a rotten coniferous log. Other species are sure to occur.

Also fungus–like are some members of Kingdom Chromista, i.e. the downy mildews (Peronosporales) and the blister rusts (Albuginales), plant pathogens which include some quite common species in Britain. The former generally cause yellowing of the leaves with a greyish-white development of conidia on the leaf underside, whilst the latter form whitish, pustular fruit bodies on the host leaves and stems. Curiously, only one species of each of these groups has yet been recorded in the Garden: *Plasmopara umbelliferarum* (Peronosporales), common on many umbellifer species recorded on *Angelica*, and *Albugo candida* (Albuginales) which is frequent on many species of Brassicaceae and has been recently found on *Sisymbrium*. These fungus-like organisms have likely been overlooked as several are common pathogens of host plants that are well established in the Garden.

## FAUNA

### INVERTEBRATES

### PLANT GALLS

TOMMY ROOT

Cecidology, the study of plant galls, covers a wide range of gall-inducing species from a varied set of groups. Galls are formed by insects (from six orders), mites, fungal agents, nematode worms, bacteria, phytoplasma, other plants and possibly viruses.

As with all gall surveys, the species present is determined firstly by the floral assemblage, then the availability of inducing organisms. In addition to natural distribution, other factors affecting the availability of inducing organisms can be the mobility of the organisms, life cycle requirements (some inducing species require more than one host species for their life cycle), non-native introduced host species and non-native gall inducers.

From three surveys (October 2013, July 2014 and July 2016), 32 galls induced by 31 known species have been recorded as follows:

- 17 insect galls comprising: 13 Hymenoptera (11 wasp-induced, 2 sawfly), 2 Hemiptera, 2 Diptera
- 9 mite-induced galls
- 4 fungal galls
- 1 gall type induced by another plant
- 1 unknown inflorescence – speculated to be either viral or phytoplasma.



#### Hymenoptera

Of the 11 wasp-induced galls, ten were found on pedunculate oak *Quercus robur* and one on dog rose *Rosa canina*. Wasps producing galls on *Rosa* only require one host due to an involtine life cycle – one phase only producing male and female wasps. Of those found on *Q. robur* the majority of species practise a cyclical parthenogenic life cycle. These wasps have a sexual phase early season (male and female wasps hatch) and an asexual phase later (asexual females only). Gall inducement is caused by liquids accompanying egg-laying.

Three of the wasp-induced gall species found within the Garden, *Andricus grossulariae*, *Andricus kollari* and *Andricus lucidus*, all utilize Turkey oak *Quercus cerris* for the sexual phase of their development. This species is not present in the Garden but is known to grow in nearby Kensington Gardens. The sexual phase of these species results in smaller more discrete galls compared to the larger, showier asexual phase galls. Asexual *A. grossulariae* and *A. lucidus* are both spikey, with *A. lucidus* having thinner, more densely packed spikes. *A. kollari*, the oak marble gall, is famous for once being a major source of tannins used in ink. All three are non-native introductions. A fourth species, the ramshorn gall *Andicus aries*, is also a recent non-native species; however, only one asexual phase is currently known.

The other oak wasp galls were all asexual phase common species. *Andricus foecundatrix*, the artichoke gall, present in 2014 and 2016, are always a pleasure to find due to their unique appearance. Common spangle galls *Neuroterus quercusbaccarum* were present in high numbers in 2013 and 2014 with many a leaf underside covered in these small round galls. I could not find any in the 2016 visit. *N. quercusbaccarum* seems to be having a rather poor 2016. Infection rates have been low at all sites I have visited and I have had to look hard to find even a few, although in most surveys I have found at least some.

Two sawfly galls were found. One leaf roll gall *Blennocampa phyllocolpa* on dog rose

Andricus foecundatrix – *artichoke gall on* Quercus robur. © *Tommy Root*

and a red, bean-shaped swelling induced by *Pontania proxima* in the leaves of *Salix alba* x *S. fragilis*. Sawfly galls tend to be simple and the two species found were very representative of sawfly gall morphology.

## Diptera

Only two Diptera-induced galls were found. Diptera galls often tend to be more discreet than hymenopteran. Common species *Dasineura plicatrix* (thicken leaf veins on bramble *Rubus fruticosus* agg.) and *Dasineura fraxini* (mid-rib leaf pouch on ash *Fraxinus excelsior*) were found within the Garden; however there are a huge number of Diptera galls in the UK and further species might be found by targeting herbaceous plants in particular, such as common nettle, the host plant of *Dasineura urticae*.

## Hemiptera

Hemiptera galls are induced in reaction to the saliva of the gall-inducing species. Swollen leaf rolls or pouches are both common forms of Hemiptera gall. Swellings are often accompanied by colours such as red, purple or yellow. Looking inside the gall can sometimes help, with identification factors such as insect colouration and sticky, waxy gall interior or woolly aphids. Two very common species were found: *Pemphigus spyrothecae* on Lombardy poplar *Populus nigra* 'Italica' (swollen, twisted leaf petioles with grey, woolly aphids) and *Psylopsis fraxini* on ash (swollen leaf roll, often tinged purple, with white aphid wool inside).

## Mites

Inducement of mite galls results in reaction to saliva and a leaf with several galls can be the result of one or many mites. Whilst a few other types of gall can be found, many mite galls are in the form of leaf pustules and are often accompanied by tiny hairs known as erinea. Most of the mite galls present within the Garden were very common species. I very rarely see spindle *Euonymus europaeus* without the folded swollen leaf margins induced by *Stenacis convolvens* or holm oak *Quecus ilex* without leaf pustules induced by *Aceria ilicis* – the Garden was no exception. An interesting absence were galls occurring on field maple *Acer campestre* where there are a few common species that are usually quite easy to find. I have speculated that this absence may be down to the isolation of the Garden and the lower mobility of gall mites.

## Fungal

Fungal galls tend to be either leaf spots (usually black or orange) or exaggerated growth or swelling accompanied by powder (dependent on the life cycle stage). Only common species were found in the Garden. Spot fungus galls on the leaves of common mallow *Malva sylvestris* and Lombardy poplar were found.

*Sphaerotheca macularis* on meadowsweet *Filipendula ulmaria* has a stark, bleak appearance and was found within a marshy area (F01 and F02). *S. macularis* galls meadowsweet stems and shoots resulting in thickening, distorted growth and a covering of thick, white fungal mycelium. *Taphrini pruni* results in galls commonly known as 'pocket plums'. The fungal agent causes plums and sloes to shrivel and dry. In the process, the stone within fails to form, resulting in a pocket. Galled sloes were found within the Garden.



*Mistletoe* Viscum album *on* Malus *host 'Brownlees' Russet*. © *Tommy Root*

## Plant galls induced by another plant

Mistletoe *Viscum album* causes distinct swelling within the host plants they parasitize. These swellings serve as a conduit for the transfer of host nutrients to the mistletoe and as a gall is always named after the organism that caused it, *Viscum album* counts as a *bona fide* gall. Mistletoe was found within the Garden growing on a *Malus* host – one of several common host trees for this species and it is also present on willow *Salix alba* x *S. fragilis* in the Garden. Vectors for spread of *V. album* tend to the mistle thush *Turdus viscivorus*, blackcap *Sylvia atricapilla* or deliberate human introduction. Mistletoe was introduced to the Garden in 2009, however a small seedling was recorded on rowan *Sorbus aucuparia* in 2017 which is likely to have been spread by mistle thrush which feed on the rowan berries in the Garden (Ware *et al*. 2016).

## Unknown inflorescence

A distorted catkin found on sallow *Salix caprea* was found. Distorted catkins on *Salix* are quite common. However, as the field of cecidology is still relatively new, some areas remain understudied. Expert knowledge of inflorescence galls seems to be such an area and it is still unknown as to the gall-inducing agent that causes these galls to form. It is thought that such galls are induced by either phytoplasmas or viruses. The only known phytoplasma gall occurring on clover causes very similar exaggerated growth. Vectors for the spreading of such agents are known to be insects of the order Hemiptera.

## COLLEMBOLA

PETER SHAW


### Abstract

This work represents the first attempt to synthesize a list of Collembola found in the Wildlife Garden of the Natural History Museum. Forty four species are recorded, with a bias (23/44) towards surface-active forms. Three (*Katianna schoetti*, *Sminthurinus reticulatus* and *Desoria trispinata*) are invasive non-natives and one (*Stenaphorura denisi*) appears to be the first record inside London.


### Introduction

Collembola (springtails) have long been classed as 'Apterygota', wingless insects, but this phylogeny is no longer defensible. Molecular and comparative anatomical work agrees that these classify close to the Diplura, and it is not clear that their last common ancestor with insects either had six legs or lived on land. They are mainly found in moist habitats due to their poor control of water loss, though there are exceptions. Most Collembola are creatures of the litter layer, with others preferring plant surfaces or filter-feeding from the surface film of ponds and puddles. Due to small size (max. 6 mm in the UK), generally dull colours and dark habitats, they are habitually overlooked. Even Owen (2010) who tried to name all animals in her garden, getting 2,673 species, omitted the Collembola. Despite this, they combine ubiquity with densities exceeding 10,000 per square metre, making them probably the most numerous hexapods on the planet (Frampton and Hopkin 2001).

### Results

So far 44 species of Collembola have been recorded from the Garden, as listed in Table 2. Most species were collected from soil/litter but *Deuterosminthurus pallipes*, *Entomobrya albocincta* and *Willowsia platani* were only found in the Malaise traps. The community seems to be dominated (23/44) by epigeic species, the (relatively) large and colourful species that run around on the surface of soil, tree bark and plant leaves. Nine species were predominantly of the litter layer, eight were euedaphic (deep soil) species and the remaining four were aquatic/waterside species.

Three of these species are not keyed out in Hopkin (2007) and are probable invasives, in particular *Katianna schoetti* is an Australasian species (P. Greenslade pers. comm.) but which has turned up on garden plants in Sheffield, Cornwall and Surrey (Ardron 2009; Bird 2015) and is probably widespread but overlooked throughout the UK. Its not being keyed out in Fjellberg's work, or any other European key, makes this species especially unlikely to be recorded. *Sminthurinus reticulatus* has a distinctive dorsal pattern and can be confirmed from a good photograph, was first recorded in the UK in 2006, and seems to be expanding its range northwards. *Desoria trispinata* is keyed out in Fjellberg (2007) but can easily be mis-keyed to a dark form of *Isotoma viridis* using Hopkin (2007). It seems scarce but is probably widely overlooked. It is hard to know what to do with the old record of *Sminthurinus domesticus* from flower pots in 1956 – this species appears confined to intensive horticultural environments and may well have been lost from the site decades before the Garden reached its current form.



*Left: Springtail* Orchesella cincta. © *Peter Shaw*
*Right: Springtail* Stenaphorura denisii. © *Peter Shaw*

### Discussion

This Collembola species list, 44 taxa, is relatively rich for such a small area. As a comparison, the grounds of Whitelands College (where the author is based) are about ten times larger, have been studied intensively by the author and his student projects since 2004 and has a list of 42 Collembola. At least one very common species remains outstanding; *Orchesella villosa* is large, distinctively patterned, very common in leaf litter around London and further afield, but has not yet been found in the Garden. *Tomocerus vulgaris* and *Pogonognathellus* (=*Tomocerus*) *longicornis* are also common species that one would expect in the Garden. Deeper in the soil, species of *Friesea*, *Mesaphorura* and *Protaphorura* are probably present but remain undiscovered. The final list of Collembola in the Garden is therefore likely to exceed 50 species.

Although Collembola are generally animals of soil/litter (Hopkin 1997), there is a well-defined group of species that are habitually found in arboreal/canopy habitats (Shaw 2015). In the UK this group is dominated by the Symphypleona (globular springtails), along with species in the genera *Entomobrya*, *Vertagopus*, *Willowsia* and *Orchesella cincta* (Bowden *et al*. 1976; Hopkin 2007). It is worth noting that the (common, widespread) species *Entomobrya intermedia* would key to *E. nivalis* in Hopkin (2007), though recent barcoding has established these two species to be validly isolated (South 1961; Faria 2015). These proved to be the dominant species in the Garden based on the collections to date. This is probably an under-representation of deep soil species on site, as all the collectors involved were careful to take shallow soil samples with a predominance of litter. None of the species are scarce, though *Stenaphorura denisi* seems to be a species of arable soils with no previous records within the London area. The waterside areas are well populated with *Isotomurus* species (*I. unifasciatus* and *I. fucicolous*, easily identified by their colour patterns). Only one *Sminthurides* species was found hopping on the water surface (*S. malmgreni*) but these tiny animals often occur in mixed-species communities so other *Sminthurides* may be expected.

| Species | Hab | NC | Comment |
|---|---|---|---|
| *Anurida granaria* | Eu/W | 1 | In P05; widespread species, always hypogean, often very wet sites. |
| *Brachystomella parvula* | L | 1 | In G02; common, an early colonist of disturbed soils. |
| *Crytopygus thermophiles* | Epi | 2 | In P05 and on compost bins; common on bare sites in the south of UK. |
| *Desoria tigrina* | L | 1 | Collected by Steve Hopkin 2004. |
| *Desoria trispinata* | L | 4 | Widespread across the Garden, probably a newly expanding invasive species but is not keyed out in Hopkin (2007). |
| *Deuterosminthurus pallipes* | Epi | 7 | Almost all in Malaise collections, peaking June-July 2013 with many hundreds of individuals. Both yellow and purple colour morphs of this common species were present. |
| *Dicyrtomina saundersi* | Epi | 3 | On plant surfaces in P05 and G05; very common across southern UK. |
| *Dicyrtoma fusca* | Epi | 3 | In hedge H05, G05 and on bark of 'bee tree'. |
| *Entomobrya albocincta* | Epi | 1 | Only collected in the Malaise traps; an incorrigible tree climber. |
| *Entomobrya intermedia* | Epi | 4 | In A05 and A10 and in Malaise traps; common and a known tree climber. |
| *Entomobrya multifasciata* | Epi | 1 | On the compost bins; a common widespread species with a penchant for clustering in bark crevices. |
| *Entomobrya nicoleti* | Epi | 5 | G02, W01, A09, H05; a common species of tall vegetation, most often found in long grass. |
| *Folsomia manolachei* | L | 1 | In W09; probably common but easily confused with *F. quadrioculata*. |
| *Folsomia quadrioculata* | L | 1 | In P05; common in acid soils but unusual in an urban setting. |
| *Heteromurus nitidus* | Eu | 2 | In the meadow grass; a common species of deep litter, also typical of caves and tombs. |
| *Hypogastrura purpurescens* | Epi/L | 7 | Widespread across the Garden. |
| *Isotoma viridis* | Epi/L | 2 | Compost bins. |
| *Isotomiella minor* | Eu | 2 | LH01 and W09; a common species of deep litter. |
| *Isotomurus fucicolus* | W | 2 | Waterfall A10; a widespread species of wet places. |
| *Isotomurus maculatus* | W | 1 | In a Malaise trap; oddly as this is a water-loving species. |
| *Isotomurus unifasciatus* | W | 4 | By waterfall and pond; formerly the pale form of '*Isotomurus palustris*', now recognised as a common species in its own right. |
| *Katianna schoetti* | Epi | 2 | Not keyed out in standard keys but this Australian invasive turns up commonly on garden plants in the southern UK. |
| *Lepidocyrtus cyaneus* | Epi/L | 4 | On compost, in Malaise traps and in turf; widespread common and almost certainly a species complex. |
| *Lepidocyrtus lanuginosus* | Epi/L | 1 | A10; a common species especially in tree canopies. |
| *Lepidocyrtus violaceus* | Epi/L | 1 | In the hedge; apparently uncommon but may be in the *L. cyaneus* species complex. |
| *Megalothorax minimus* | Eu | 3 | Tiny, widespread soil-dweller. |



| Species | Hab | NC | Comment |
|---|---|---|---|
| *Monobella grassei* | L | 1 | In P05; a species of southern leaf litter. |
| *Neanura muscorum* | L | 1 | W09; a common species of woodland leaf litter. |
| *Neelus murinus* | Eu | 1 | In A01; probably common. |
| *Orchesella cincta* | Epi | 3 | Very common, a known tree climber. |
| *Paratullbergia callipygos* | Eu | 2 | H05 and P05; common in woodland leaf litter. |
| *Parisotoma notabilis* | L | 9 | Ubiquitous in the garden as it is in the UK. |
| *Pseudosinella alba* | Eu | 6 | P04, P05, H05, W09; common in woodland leaf litter. |
| *Sminthurides malmgreni* | W | 1 | In P05; common on pond surfaces. |
| *Sminthurinus domesticus* | Epi | 1 | 1 old record by Gisin (1956). |
| *Sminthurinus elegans* | Epi | 3 | Widespread and common. |
| *Sminthurinus niger* | Epi | 1 | W09; common. |
| *Sminthurinus reticulatus* | Epi | 7 | Was classed as a colour form of *S. elegans* but seems to be a distinctive invasive line. |
| *Stenaphorura denisi* | Eu | 1 | In meadow turf, G05; uncommon or overlooked. |
| *Tomocerus minor* | L | 5 | Widespread and common. |
| *Vertagopus arboreus* | Epi | 1 | Collected by Steve Hopkin - common up trees. |
| *Vertagopus cinereus* | Epi | 1 | In Malaise traps; a tree climber. |
| *Xenylla maritima* | Epi | 4 | Common inland in bark crevices despite its name. |
| *Willowsia platani* | Epi | 6 | All in Malaise traps, January-September 2013. |

*Table 2. Collembola recorded from the Garden. Nomenclature follows Fjellberg (1998; 2007). Abbreviations: Hab – main habitat; NC – Number of collections; Epi – Epi-edaphic (living on the soil surface or on plant surfaces); Eu – Euedaphic (deep soil-dwelling); L – Litter (predominantly in the leaf litter layers); W – Wet (waterside/waterlogged habitats and pond surfaces).*

## LEPIDOPTERA – BUTTERFLIES

CAROLINE WARE

The Garden (0.5 ha) was designed, and is managed, to promote biodiversity with a mosaic of habitats and plant communities that include a range of host plants in areas of shade and sun to benefit a diversity of invertebrates, including butterflies. However the physical isolation of the Garden from larger sites, such as Kensington Gardens and Hyde Park (*c.*750 m to the north) and surrounding garden squares such as Queen's Gate Gardens, with little connectivity between them, does somewhat limit the abundance of species. Or does it? With appropriate planting and management a small site in central London can produce habitat to support a number of butterflies. For example, in its short life-span the William Curtis Ecological Park, a site of 0.8 ha, recorded 23 species between 1977 and 1986, with 17 species known to breed there (Freed 2001). The London Wildlife Trust's Camley Street Nature Park (0.8 ha) has recorded 11 species over the last ten years and the Centre for Wildlife Gardening (0.22 ha) 16 species. Gillespie Park, Islington (3.4 ha) has recorded 24 species and the Gunnersbury Triangle (2.5 ha) has recorded 21 species, although 14-16 would be more typical in one year. Camley Street, Gillespie Park and

Gunnersbury Triangle additionally benefit from their positions alongside wildlife corridors – canal (Camley Street) and railway line (Gillespie Park and Gunnersbury Triangle).

By the end of 1997 just over two years since the Garden opened, 15 species of butterfly had been recorded there (Honey *et al*. 1998). This number increased by five (Essex skipper, common blue, orange tip, purple hairstreak and silver-washed fritillary) in 2002 (Leigh and Ware 2003) and a further three (small copper, ringlet and small heath) have been recorded since 2003. There have also been several records of escapees from the Museum's annual Butterfly House exhibition, including the clipper *Parthenos sylvia*.

Of the 23 species of butterfly recorded in the Garden, three have been recorded just once, whereas 18 have been recorded at least twice since 2000. The individual species, sightings and availability of host and nectar plants in the garden are discussed below. Order and nomenclature follows Agassiz, Beavan and Heckford (2013).

## Hesperiidae (Skippers)

**Essex skipper *Thymelicus lineola* and small skipper *Thymelicus sylvestris***

Both small and Essex skipper are seen occasionally during July, with small skipper sightings in 1996, 2006 and 2007 and Essex skipper in 2000 and 2015. Since these species are similar (the distinguishing features of the antennae are difficult to see, unless close up) it is possible that there are misidentifications between the two. With help from Warren (2017) identifications should be determined with more confidence from the current year. Of the two species, small skipper was the most commonly recorded and more widely distributed in Hertfordshire and Middlesex (Wood 2016; 2017). Grasses, including Yorkshire-fog *Holcus lanatus*, timothy *Phleum pratense*, meadow foxtail *Alopecurus pratensis* and false brome *Brachypodium sylvaticum*, are host plants for the small skipper. Essex skipper uses cock's-foot *Dactylis glomerata*, common couch *Elytrigia repens*, timothy, Yorkshire-fog and meadow foxtail (Freed 2001), all of which are present in the Garden, as are knapweeds and thistles, these skippers' favourite nectar plants.

*Large skipper* Ochlodes sylvanus. © *Russell Ritchin*



**Large skipper *Ochlodes sylvanus***

The large skipper was first recorded in the Garden in 1996. It has since been recorded in 2011, 2013 and 2015. From a distance it can be confused with the small and Essex skippers. This skipper is found to be more frequent in gardens than the Essex and small skippers (Wood 2016). Its larval food plants, cock's-foot and false brome, are plentiful in the Garden's grassland and woodland habitats respectively.

## Pieridae (Whites and yellows)

**Orange tip *Anthocharis cardamines***

The orange tip butterfly was first recorded in the Garden in 2005 and next in 2010, since when it has been recorded annually with the exception of 2016. Usually seen in April and May in the Garden's grassland, woodland and pond side habitats, it was our first recorded butterfly of the year in 2013. Two of its larval food plants, cuckoo flower *Cardamine pratensis* and garlic mustard *Alliaria petiolata*, are abundant in these habitats. It has often been observed nectaring on bluebell.

**Large white *Pieris brassicae* / Small white *Pieris rapae***

Both large and small whites are doing well in London and the wider recording area (Williams 2016; Wood 2016) and not surprisingly they appear to be the most commonly seen butterflies in the Garden. However, there are differences in frequency of sightings. The large white, first recorded in 1997, was not seen again until 2001, 2005, 2008, 2014 and 2015. The small white, first recorded in 1996 and 1997, was subsequently recorded annually from 2000 to 2016 with the exception of 2007 and 2010. Larvae have been found on garlic mustard and charlock *Sinapis arvensis*. They use a variety of nectar plants and are most commonly seen in grassland areas.

**Green-veined white *Pieris napi***

Green-veined white is the second most commonly seen pierid after the small white. Interestingly it relies on wild cruciferous plants rather than the cultivated garden varieties (Wood 2016) so will not be disappointed in the Museum's Wildlife Garden. In addition to the host plants it shares in common with large and small whites, the green-veined white also uses cuckoo flower.

**Brimstone *Gonepteryx rhamni***

The brimstone is seen in the Garden more usually in late spring, April and May, and was recorded during these months from 1999 to 2006 and from 2011 to 2017. Sightings in 2016 were more frequent than in any other year. In 2012 and 2013 it was also recorded in July and August. It is a species that apparently responds well to the planting of buckthorn in gardens (Wood 2017; Williams 2016) and these species (buckthorn *Rhamnus cathartica* and alder buckthorn *Frangula alnus*) are present in fen (F01 and F03) and in hedgerow (H07 and H08). Two of its favourite nectar plants, primroses *Primula vulgaris* and wild daffodils *Narcissus pseudonarcissus*, are abundant in north and central woodland areas (W01-W07), although in very recent years, wild daffodil has finished flowering in the Garden by mid-March before the brimstone is usually seen here. Later flowering nectar favourites include thistles *Cirsium* spp. that are present throughout the Garden.

## Nymphalidae (Vanessids, fritillaries and browns)

**Speckled wood *Pararge aegeria***
First recorded in 1995 and 1998 and annually since 2000, the speckled wood is the most commonly recorded butterfly in the Garden, often seen in pairs as sparring males 'dancing' in the dappled shade around woodland edges. It was the first butterfly of the year in the Garden in 2006 and 2007 (Table 3). Sightings were most frequent in 2016. It is widely distributed in shady areas throughout London (Wood 2017), where it often feeds off honeydew from aphids on trees. Its larval food plants include false brome, one of the most common grasses in the Garden along woodland edges and hedge-banks, and Yorkshire-fog and cock's-foot.

**Small heath *Coenonympha pamphilus***
The small heath was first sighted in the Garden on 16 July 2014 by Gay Carr during one of her last bird and butterfly walks. It has not been recorded here since. However due to its superficially moth-like appearance and erratic flight pattern it could easily be overlooked. Its food plants, fescues, bents *Agrostis* spp. and meadow-grasses, are abundant in different habitats throughout the Garden.

**Ringlet *Aphantopus hyperantus***
The ringlet was first sighted in the Garden in July 2013 and again in July 2015. Overall, however, this butterfly is increasing its distribution in London (Wood 2016) and we could expect to see it more frequently in the future. Four of its food plants, cock's-foot, false brome, tor grass *Brachypodium pinnatum* and tufted hair-grass *Deschampsia cespitosa*, are common in the Garden.

**Meadow brown *Maniola jurtina***
First recorded in the Garden in July 1996, the meadow brown has since been seen on just five occasions, most recently in 2016. As with the gatekeeper, its larval food plants are grasses, including Yorkshire-fog, bents and meadow-grasses. It visits similar flowers to the gatekeeper for nectar.

**Gatekeeper *Pyronia tithonus***
The gatekeeper has expanded into London from suburban gardens relatively recently since the early 1990s (Freed 2001). It was first recorded in the Garden in 1996 and subsequently in 2001, 2008, 2009 and 2015 and 2016. Its larval food plants are grasses, including cock's-foot, bents *Agrostis* spp., fescues *Festuca* spp. and common couch. These are abundant in the Garden, as are some of its favourite nectar plants.



**Silver-washed fritillary *Argynnis paphia***
There has just been just one recorded sighting of the silver-washed fritillary – in July 2000 on the chalk downland habitat (G01). Observations have slowly increased in London (Williams 2004). In west London it has been recorded in Barnes at the London Wetland Centre, Wimbledon Common and Paddington but has not been seen again in South Kensington. This species lays its eggs on the bark of tree trunks, where its larval food plant, common dog-violet, grows close by.

**Red admiral *Vanessa atalanta***
First recorded in the Garden in 1996, the red admiral has since been recorded annually (with the exception of 2001, 2002 and 2005). It is the most commonly recorded vanessid in the Garden, where it can be seen throughout the year until early autumn and as late as December in 2014. Its larvae have been found feeding on nettles *Urtica dioica* in the Garden which are abundant in sunny aspects as well as shade as managed for nettle-dependant lepidoptera.

**Painted lady *Vanessa cardui***
First recorded in the Garden in 1996, further sightings were not made until 2000, 2006, 2007, 2009 (a year of large migration to this country) and 2011. Its larval food plants, including common mallow *Malva sylvestris* and nettles, are common in the Garden, as are several suitable sources of nectar

**Peacock *Inachis io***
The peacock was first recorded in the Garden in 1996 and annually between April and September from 2000 to 2004, and in 2008, 2010, 2012, 2013 and 2015. Peacocks over-winter in woodland areas and also in garden sheds and similar dark and sheltered places. It is often the first butterfly of the year to be seen in the Garden as it has been on four occasions (Table 3). Larval food plants include common nettle and hop *Humulus lupulus* which are abundant here, as are some of its favourite nectar plants.

**Small tortoiseshell *Aglais urticae***
Once a common sight throughout the country, the small tortoiseshell has declined by 73% over the past forty years (Brereton *et al*. 2015). It was first recorded in the Garden in 1999 being the first butterfly of the year on 14 March and recorded again that year in December. It has subsequently been observed in the month of July in 2003, 2011, 2015, 2016 and in 2017 in late May, suggesting an upturn in the fortunes of the small tortoiseshell in the Garden as in the wider area (Wood 2017). Its larval food plant, common nettle, is plentiful.

**Comma *Polygonia c-album***
With red admiral and peacock, the comma is one of the three most commonly seen vanessids in the Garden. Its larval food plants, nettles and hops, are abundant here, as is one of its favourite nectar sources, brambles.

*Common blue* Polyommatus icarus. © *The Trustees of the Natural History Museum, London*

## Lycaenidae (Hairstreaks, coppers, blues and metalmarks)

**Small copper *Lycaena phlaeas***

There has been one sighting of the small copper, in May 2010, on the chalk downland (G01). Williams (2016) reported low and zero counts in urban green spaces in 2015 and it has not been recorded in the local tetrad since 2010-11 (Wood 2016). Its host plants, common sorrel *Rumex acetosa* and sheep's sorrel *Rumex acetosella*, are present in meadows G04 and G05 and heathland LH04 respectively.

**Purple hairstreak *Favonius quercus***

First recorded in August 2000, the purple hairstreak was seen here once more, in June 2009. This species can be easily overlooked as it flies high in the leaf canopy of oak and ash, feeding on aphid honeydew. As it also tends to fly in the evening this may be another reason for under-recording. Sightings have also been made nearby in Holland Park, Brompton Cemetery and in Buckingham Palace Garden (Tim Freed, pers. comm.).

**Holly blue *Celastrina argiolus***

One of the earliest on the wing, the holly blue has been the first butterfly of the year recorded in the Garden in seven out of twenty one years. First recorded in 1996, and since then annually, this double-brooded butterfly is frequently seen between April and August nectaring on flowers in grassland, fen and pond margins, scrub and edges of woodland habitats. This species was especially frequent in 2015 and 2016. Holly *Ilex aquifolium*, its main first-brood host plant, is abundant with several mature trees present in the Garden as well as hedgerow holly which occurs in the northern and sunnier part. Mature flowering ivy *Hedera helix*, the second-brood food plant, is present on the lime *Tilia cordata* in the centre of the Garden. Holly blue is one of the more common and widespread urban butterflies (Wood 2016).



**Common blue *Polyommatus icarus***

First sighted in 2000, the common blue has subsequently been recorded in 2003, 2006, 2008, 2009, 2015 and 2016. Two males were observed in 2015 in grassland G07 (a recent extension to grassland habitats). This species did especially well in Hertfordshire and Middlesex in 2015 (Wood 2016). Its food plants, common bird's-foot trefoil *Lotus corniculatus*, black medick *Medicago lupulina*, common restharrow *Ononis repens* and clovers *Trifolium* spp., are common on the chalk downland habitat and, apart from common restharrow, are present in most grassland habitats throughout the Garden.

*Table 3. First butterfly of the calendar year in the Wildlife Garden: 1996 to 2016*

| Year | Species | Day and month |
|---|---|---|
| 1996 | Peacock | 26 April |
| 1997 | Holly blue | 06 April |
| 1998 | Holly blue | 13 May |
| 1999 | Small tortoiseshell | 14 March |
| 2000 | Red admiral | 15 March |
| 2001 | Peacock | 22 April |
| 2002 | Green-veined white | 04 March |
| 2003 | Holly blue | 03 January |
| 2004 | Small white | 22 April |
| 2005 | Brimstone | 21 April |
| 2006 | Speckled wood | 27 April |
| 2007 | Speckled wood | 22 April |

| Year | Species | Day and month |
|---|---|---|
| 2007 | Red admiral | 22 April |
| 2008 | Small white | 26 April |
| 2008 | Holly blue | 26 April |
| 2009 | Holly blue | 06 April |
| 2010 | Comma | 13 January |
| 2011 | Holly blue | 25 March |
| 2012 | Peacock | 27 March |
| 2013 | Orange-tip | 30 April |
| 2014 | Holly blue | 01 April |
| 2015 | Peacock | 08 April |
| 2016 | Brimstone | 02 April |

## ISOPODA AND AMPHIPODA

DUNCAN SIVELL

Isopods and amphipods have been relatively well-studied in the Wildlife Garden with only a few changes to the species lists published in Leigh & Ware (2003).

The Amphipoda are represented by one aquatic (*Crangonyx pseudogracilis*) and one terrestrial (*Arcitalitrus dorrieni*) species. The latter is non-native, originating from Australia, and commonly referred to as the 'landhopper'. *Arcitalitrus dorrieni* is common in woodland areas of the Garden, particularly near the sheds. What impact this species has on native fauna is unclear. In the Garden *A. dorrieni* occurs alongside good populations of woodlice and millipedes (e.g. other detritovores), so food competition does not appear to be a concern. However, it should be noted that habitat management in the Garden supplies an abundance of deadwood and decaying organic matter that may preclude effects of competition. The status of *A. dorrieni* in Britain has recently been reviewed by Gregory (2016).

The aquatic amphipod *Cragonyx pseudogracilis* is also a non-native, originating from North America, but has been in Britain since 1930 and is now a widespread and common species (Dunn 2013). Its dispersal mechanism is not well-understood but is obviously effective, allowing it to colonise isolated sites (Fryer 1993). The presence of *C. pseudogracilis* in the Garden ponds is, therefore, not unexpected. *Cragonyx pseudogracilis* probably benefits from the lack of native *Gammarus* amphipods in the Garden, which might otherwise provide some competition.

Two aquatic isopods, *Asellus aquaticus* and *Proasellus meridianus*, have been recorded in the Garden, (Leigh & Ware 2003) reporting large populations of both species. Waterlouse records of recent years have all been *A. aquaticus* (Ware *et al*. 2016), however, which suggests that *P. meridianus* has been overlooked or has dramatically declined. These two species can be confused for one another but *P. meridianus* does tolerate a narrower range of water qualities than *A. aquaticus* (Gregory 2009) and changes to the ponds' water supply could explain a decline in *P. meridianus*. Further investigation is recommended.

Ten species of woodlice (terrestrial isopods) have been recorded in the Garden to date. The 'famous five' woodlice (pill, striped, shiny, rough and pygmy) are all common; the shiny *Oniscus asellus* and rough *Porcellio scaber* woodlice can be especially abundant in the woodland areas. One species of special interest is *Porcellio laevis*, a large woodlouse recently listed as Nationally Scarce (Lee 2015). *P. laevis* was first recorded in 1998 and then not seen again until 2015, so the Garden population appears to be very sparse. A general decline in *P. laevis* records at the national level has raised further concerns about the status of this woodlouse in Britain (Harding 2016). It would be good to gain a better understanding of this species' ecology within the Garden, though it would have to be found more frequently for such a study to be viable.

Continued recording of isopods in the Garden is recommended with more emphasis placed on targeting smaller species. A good number of larger woodlouse species occur in the Garden and if smaller species are similarly represented there should be a few more isopods to add the Garden list.

## TARDIGRADA

PHIL GREAVES

The Tardigrada are a phylum of microscopic, multicellular invertebrates that are major constituents of the fauna that inhabit mosses and lichens (other constituents include the nematode worms, bdelloid rotifers and mites). They are characterised by a cylindrical body with four pairs of stumpy legs terminating in claws, and have the common name of 'water bears' from their slow bear-like gait. Tardigrades are remarkable for their ability to form a resistant structure, called a tun, in response to drought conditions; the tun is also exceptionally resistant to extremes of temperature and ionizing radiation.

Within the UK there are very few workers on this phylum and relatively few surveys



*The tardigrade* Macrobiotus *cf.* hufelandii. © *Phil Greaves*

have been published on their distribution within the British Isles. Tardigrades in urban environments in particular have been poorly studied both within the British Isles and globally; studies that have been published are generally short-term surveys. The survey of tardigrades within the Wildlife Garden, which was commenced in 1998, is therefore of significance.

Samples consisting of mosses and lichens from a variety of locations and substrates within the Garden have been sampled at six timepoints (1998, 2001, 2014, 2015, 2016 and 2017) and tardigrades extracted by soaking the sample for 24 hours in tap water followed by collecting of live tardigrades on a 45 µm sieve. Identification is by high-power microscopy, using a variety of published keys. Only one species (*Macrobiotus echinogenitus*) was identified from the 1998 samples (most probably as mosses had not widely established to support a diverse tardigrade community at that time). A further three species (*Macrobiotus* cf. *hufelandi*, *Hypsibius convergens* and *Ramazzottius oberhaeuseri*) were identified from more extensive samples taken in 2001. In 2015 *M.* cf. *hufelandi* and *R. oberhaeuseri* were again recovered along with the carnivorous *Milnesium tardigradum* from three different locations, indicating that this species has successfully colonised the Garden. A total of 12 samples were taken and extracted in June 2015 and from these a total of 87 individual tardigrades have been recovered. No additional species were identified but the ongoing presence of *Macrobiotus* cf. *hufelandi*, *Hypsibius convergens*, *Ramazzottius oberhaeuseri* and *Milnesium tardigradum* was confirmed. *Macrobiotus echinogenitus*, present in 1998 and 2001, has not been seen since but sampling over a more extended period of time is required to confirm if it is now absent from the Garden.

The species list of tardigrades thus stands as:

- *Macrobiotus echinogenitus* (possibly replaced by incoming species)
- *Macrobiotus* cf. *hufelandi* (note this is a species complex which requires eggs for full speciation; unfortunately to date eggs have not been recovered from samples).
- *Hypsibius convergens*
- *Ramazzottius oberhaeuseri*
- *Milnesium tardigradum*

## VERTEBRATES

### AMPHIBIANS

LARISSA COOPER

The Wildlife Garden is home to four species of amphibian; common frog *Rana temporaria*, common toad *Bufo bufo*, smooth newt *Lissotriton vulgaris* and palmate newt *Lissotriton helveticus*. The first three species were initially introduced into the chalk pond margins (A02) of the Garden in July 1995 (Honey *et al*. 1998). By March 1997 there were reports of frogspawn, an adult male common frog and an adult common toad in the main pond (A03). During the same survey five male and two female smooth newts were recorded in the main pond (A03) along with ova on marginal vegetation. As is still occasionally the case, a few juvenile newts had been found in pitfall traps in 1996 and 1997 (Honey *et al*. 1998). In 1998 and 1999 spawn of both frogs and toads (collected from local ponds) were introduced into the main pond following the advice of Atkins and Herbert (1997). In the following years the quantity of frogspawn seen each year has increased from five clumps in 2000 to 15-30 in 2002. By 2003 sightings of all three species of amphibian were a common occurrence around the Garden (Leigh and Ware 2003).

#### Newts

The population of smooth newts recorded within the Garden has steadily increased. Two surveys were conducted in 2014 by Sean Hanna using egg searching and torching methods. The first on 16 April recorded two females, one male and eggs on a small water mint *Mentha aquatica* leaf in the top pond A08, three females and one male in the main pond (A03) and three females in the chalk pond (A01). The second survey on 1 May recorded three males and six females in the top pond (A08), eight males and 12 females (plus one unidentified) in the main pond (A03) and two females in the chalk pond (A01). These numbers were actually lower than the total (42) reported in a survey in April 2002 (Leigh and Ware 2003). This could in part be due to predation from birds, including the resident moorhens which have been observed taking newts from the chalk stream in G01, or perhaps a natural stabilisation of the population.

In 2015, as part of the training programme for the Museum's Identification Trainers for the Future scheme, newt surveys were carried out in the Garden on 20 April using three methods: torching, egg searching and bottle trapping. During this survey a second species of newt, palmate newt, was discovered. Using the torching method, one male and one female palmate newt, one male and two female smooth newts together with 4 females (species not distinguished) were seen in the main pond (A03). In the chalk pond (A01) ten female newts were seen but not identified to species. The following morning two female palmate newts and one male smooth newt were found in the bottle traps in the chalk pond (A01).



*Main pond with reflection of Museum. © Russell Ritchin*

Palmate newts were not recorded in the repeat survey by ID trainers in 2016. However 28 newts which were not identified to species and one male smooth newt were seen when torching in the top pond (A08). In the main pond (A03) two unidentified newts were seen when torching and eight smooth newts were trapped in bottle traps (three males, five females). In the chalk pond (A01) 11 unidentified newts and one smooth newt were recorded using the torching method and 11 smooth newts (nine males and two females including a heavily gravid female) were trapped in the bottle trap. The lower numbers of palmate newt is likely to be due partly to the difficulty of accurately identifying between the two species when torching but is also perhaps indicative of lower numbers of palmate newt.

The question is, however, where has the population of palmate newt originated from? There are a few possibilities. Firstly, it is possible that they arrived with plant material such as that introduced from Slop Bog in 1999 and 2006 as this species was recorded there (National Grid Reference SU077018) on the 6 April 2004 (Occurrence record 394758797, National Biodiversity Network, 2017). However, it is unlikely that the species

*Photo 21: Newt survey 2017*

would have gone unidentified for over 11 years. They could also have been accidentally introduced as eggs on aquatic plants, for example from our aquatic plant supplier, Bennett's Water Lily Farm, in Weymouth DT3 4AF. There are five records in total within 1 km of the site all recorded in 2003 and are part of the ARC rare species database and can be found on the NBN (Occurrence records 394723072, 394723056, 394723695, 394723081, 394723060).

The third possible source of introduction via plant material is with heathland turfs donated in 2012 from Merritown Heath, Dorset (Ware *et al*. 2016). Whilst we have been unable to locate any current records for palmate newt at the donor site, there are records on the NBN for areas closely surrounding Merritown Heath; one record on Parley Common on 01 April 2006 (Occurrence record 394679828, National Biodiversity Network 2017) and one record at Ramsdown recorded on 06 April 2007 (Occurrence record 394764720, National Biodiversity Network, 2017). These records, combined with the habitat suitability, make it fairly likely palmate newt would be found in Merritown Heath and therefore could have been inadvertently introduced with the heathland plants.

Another option is that they have colonised from the local area but this is extremely unlikely given the built environment and main roads surrounding the Museum. The closest record found on the National Biodiversity Network is in Sheen Mount, Richmond recorded on 1 January 1988 (Occurrence record 221295963, National Biodiversity Network 2017).



There is of course a chance that the palmate newts were not an accidental introduction at all. Across the country there are incidences of well-meaning members of the public releasing species into the wild for various reasons and it is possible that palmate newts were released into the Wildlife Garden ponds without a member of staff being aware.

When carrying out general amphibian surveys by searching logs, plant posts and compost bins, both species of newt can be found across the Garden. They are easily found under logs in the immediate habitats around the pond such as the bog (LH03) and scrub (S02), (the latter forming a very important refuge for all the Garden's amphibians due to low human disturbance) and amongst log piles in the woodland habitats around the edge of the Garden. Both species are also very common around and in the compost bins (P04), especially in winter months, and also around the Garden shed area (P05) with ten palmate newts recently discovered taking refuge under the shed itself by volunteers Willie Ross and Peter Alsbury.

## Common frog and common toad

There is a large population of both common frog and common toad of all ages around the Garden. Both are regularly seen across all habitats throughout the year, in particular in woodland habitats and compost bins during winter months where they are likely to be seeking places to hibernate. In early summer juveniles of both species are frequently seen in the grassland habitats as they migrate from the ponds. Although both species are commonly observed by all who work in the Garden, they are in fact under-recorded as formal observations because they are so frequently seen. Predators such as carrion crows *Corvus corone* and even the visiting common buzzard *Buteo buteo*, have been observed taking common frogs, showing their importance in the food-chain in the Garden.

### Spawning dates of common toads and common frogs

Due to on-going biological recording within the Garden, there is a full dataset for the dates of the first frogspawn of the year for the period 1999-2016 (Table 4). The majority of the dates fall between the 12 and 23 March (Figure 2) where the average mean temperature recorded for London at Heathrow Airport weather station is 9.3ºC (Met. Office

*Table 4: First spawning dates for both common toad* Bufo bufo *and common frog* Rana temporaria

| Year | Common Toad *Bufo bufo* | Common Frog *Rana temporaria* | Year | Common Toad *Bufo bufo* | Common Frog *Rana temporaria* |
|---|---|---|---|---|---|
| 1998 | 05 Mar | | 2008 | 06 Mar | 03 Mar |
| 1999 | | 15 Mar | 2009 | | 14 Mar |
| 2000 | | 13 Mar | 2010 | 23 Mar | 23 Mar |
| 2001 | | 12 Mar | 2011 | 25 Mar | 22 Mar |
| 2002 | | 12 Mar | 2012 | | 12 Mar |
| 2003 | | 18 Mar | 2013 | 16 Apr | 08 Apr |
| 2004 | 20 Mar | 15 Mar | 2014 | 25 Mar | 25 Mar |
| 2005 | | 19 Mar | 2015 | 18 Mar | 23 Mar |
| 2006 | | 31 Mar | 2016 | 14 Mar | 23 Mar |
| 2007 | | 28 Feb | 2017 | | 13 Mar |

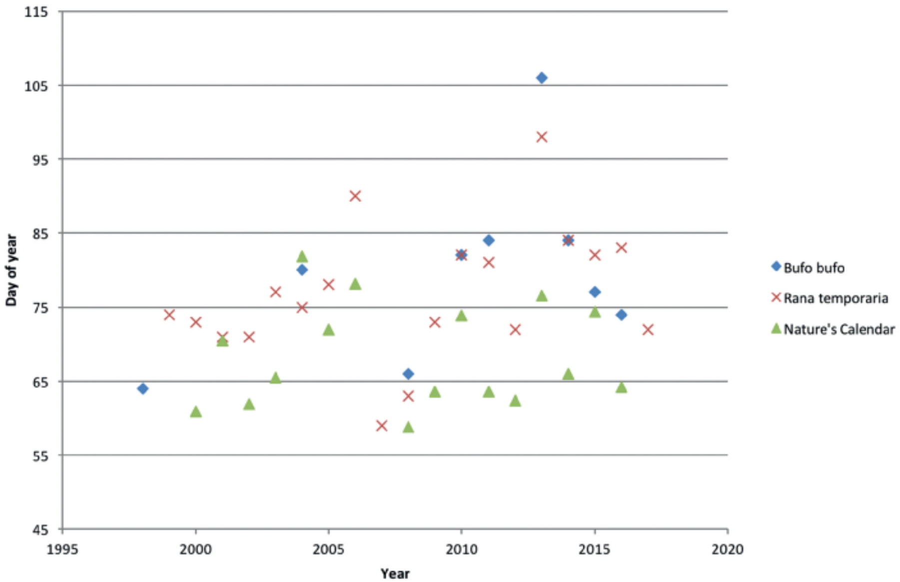


*Figure 2: First spawn dates of common toad (diamonds) and common frog (crosses) in the Wildlife Garden and common frog spawn dates from Nature's Calendar (triangles) (naturescalendar.woodlandtrust.org.uk) shown as days after 31 December (e.g. 23 March = day 84)*

2017). There are three years which fall outside this pattern – 2007, 2008 and 2013. In 2007 and 2008 the first sightings of spawn seen were particularly early: 28 February and 3 March respectively. In both years the average temperature for London on those dates was similar to the spawning dates in 1999 to 2006, 2009 to 2012, and 2014 to 2016 – the mean temperature being around 9ºC. It is possible that the warmer temperatures in 2007 and 2008 during late February and early March are part of the reason of the early spawning.

The opposite is the case for 2013 when the first spawn sightings for common frog were delayed until 8 April. Again, the mean temperature on 8 March was close to 9ºC. However, the mean temperature for 23 March 2013, the latest date we usually find the frogspawn, was just 2ºC, and was a particularly cold March overall, which may have delayed spawning.

There are fewer records for common toad first spawning dates. Recorded spawn dates usually range from 14-25 March. However, there are two records which sit outside of this range and show interesting variations. In 2008 which was a warmer than average year, common toads spawned earlier than usual on 6 March and for 2013, which was colder than average, the common toads spawned in mid-April.

Multiple studies looking at data from a range of spawning sites for the common frog have reported that spawn dates are correlated with temperatures, with the first spawn date generally advancing over time as temperatures rise (Tryjanowski *et al*. 2003; Scott *et al*. 2008; Carroll *et al*. 2009; Phillimore *et al*. 2010). Scott *et al*. (2008) suggests that spawn date can advance as much as 5.4 days for every one degree Celsius rise in temperature and it seems that common frogs are influenced by the more immediate temperatures, whilst Reading (1998) discusses common toads being influenced by the temperature over the 40 days prior to spawning. Using data from the Garden alone would not necessarily show any direct correlation between spawn dates and temperature under statistical analysis, such as in the study by Beebee in 1995, but for future studies it will be useful to combine with other data such as the Woodland Trust's Nature's Calendar.



## ENVIRONMENT

## ANALYSIS OF POND WATER

STANISLAV STREKOPYTOV

### Water Chemistry

Pond water was periodically sampled in 5–7 locations over the period of 2005–2015. Samples were frozen within 24 hours and kept at –18ºC until the analysis. Immediately after thawing they were filtered through 0.22µm membrane filters. Anion concentrations were determined by ion chromatography (from 2009 using Dionex-3000 system), cation concentrations by inductively coupled plasma optical emission spectroscopy (ICP-OES). Concentrations of heavy metals and other trace elements were checked by inductively coupled plasma mass spectrometry (ICP-MS) in March and August 2015 and no unusually high concentrations of any elements were found. Samples for the ICP-OES and ICP-MS analyses were acidified with 1% high purity nitric acid.

Before 2009 the ponds were reportedly re-filled with the mains water similar in its composition to Thames Water supply in Kensington area (Table 5). From 2009 the source of water to top up the ponds was reportedly the Museum's borehole (Ware *et al*. 2016), which significantly affected the composition of water in the ponds. Given that the major source of mineral salts for the pond water is the mains or borehole water fed into the ponds, the concentration of chloride can be taken as an indicator of salinity and, therefore, of the feed/evaporation balance over the years. There was no obvious increase in salinity over the summer months, with the possible exception of 2007, but rather cyclic changes over the period of several years. Salinity was at its minimum (*c*.40 mg/l $Cl^-$) between July 2012 and January 2015. The concentration of sulphate does not differentiate mains water and the borehole water, so while the borehole water contains more sodium it is not in the sulphate form as suggested earlier (John 2016), but probably balanced by bicarbonate ions. Comparing Ca/Cl and nitrate concentrations for sampling point WG5 (chalk pond) shows that the events of high nitrate levels (up to 18 mg/l) coincide with high Ca/Cl (up to 2.4, w/w) (Figure 3). The relationship between the calcium and chloride concentrations is very indicative of the type of feed water: mains water has a Ca/Cl (w/w) ratio of about 2.5 and borehole water about 0.2, mainly due to the differences in calcium concentrations: about 110 mg/l (Anon. 2017) and 6–16 mg/l, respectively. Concentration of nitrate is likely to be about 30 mg/l in the mains water and only 1-2 mg/l in the borehole water (Table 5). It is, therefore, possible that high Ca/Cl marks the input of the mains water carrying excessive nitrate and orthophosphate. Of all the sampling points nitrate level has always been the highest in the chalk pond and the temporal patterns of phosphate and nitrate concentrations closely followed each other as well as Ca/Cl (Figure 3, Table 6). Mains water and borehole water have also very

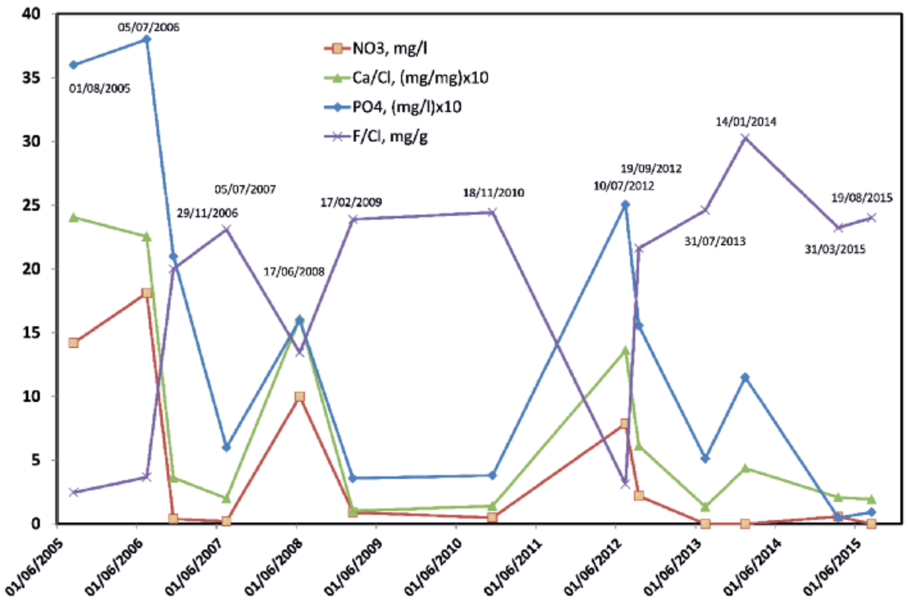


*Figure 3. Trends of hydrochemical parameters in chalk pond (WG5) between August 2005 and August 2015.*

different levels of fluoride (0.12–0.14 mg/l and 1–2.4 mg/l, respectively) and F/Cl is, indeed, following the trend opposite to that of Ca/Cl. The pattern is most pronounced in the chalk pond (although Ca/Cl is fairly constant across the ponds) so a complex biogeochemical interplay involving dissolved fluoride, carbonate, orthophosphate and solid calcium carbonate could potentially contribute to observed trends. More frequent sampling would be needed to look into these processes. We conclude that the use of the mains water and the borehole water to feed the ponds has not necessarily been happening as reported (switch of supply in 2009) but potentially followed a more complex pattern. Feeding the ponds with the mains water could possibly explain all the observed events of high nitrate and orthophosphate concentrations.

*Table 5. Composition of water from the mains and from the Museum's borehole. [a] Anions are as determined in tap water in the Museum in December 2013, cations are ranges of concentrations from the 2016 Thames Water report for Kensington (Anon. 2017).*

| Sample | $F^-$, mg/l | $Cl^-$, mg/l | $NO_3^-$, mg/l | $SO_4^{2-}$, mg/l | $PO_4^{3-}$, mg/l | Na, mg/l | Mg, mg/l | Ca, mg/l |
|---|---|---|---|---|---|---|---|---|
| Mains water, 2013-2016[a] | 0.10 | 36.4 | 24.7 | 46.2 | 4.65 | 26-37 | 5-5.1 | 106-111 |
| Borehole water, July 2013 | 1.1 | 42.9 | 1.4 | 39.1 | 0.48 | 86.4 | 2.5 | 6.3 |



| Date | $F^-$, mg/l | $Cl^-$, mg/l | $NO_3^-$, mg/l | $SO_4^{2-}$, mg/l | $PO_4^{3-}$, mg/l | Na, mg/l | Mg, mg/l | Ca, mg/l |
|---|---|---|---|---|---|---|---|---|
| **main pond** | | | | | | | | |
| 1.viii.2005 | 0.12 | 44.3 | 0.2 | 44.5 | 2.0 | 37.8 | 5.1 | 92.9 |
| 5.vii.2006 | 0.48 | 54.6 | 1.29 | 41.0 | 1.3 | 59.6 | 5.9 | 83.4 |
| 29.xi.2006 | 0.70 | 60.0 | 0.4 | 27.0 | 2.8 | 86 | 4.5 | 54.0 |
| 5.vii.2007 | 1.81 | 83.8 | 0.07 | 45.5 | 1.3 | 157 | 4.1 | 26.6 |
| 17.vi2008 | 0.76 | 51.1 | <0.07 | 38.0 | 1.1 | 81.9 | 5.1 | 70.7 |
| 17.ii.2009 | 1.11 | 60.0 | 0.28 | 45.6 | 1.32 | 103 | 3.78 | 27.6 |
| 18.xi.2010 | 1.66 | 84.4 | 0.10 | 44.6 | 1.62 | 166 | 3.43 | 23.5 |
| 10.vii.2012 | 0.355 | 48.5 | <0.1 | 32.6 | 1.50 | 50.4 | 4.00 | 54.5 |
| 19.ix.2012 | 0.938 | 50.1 | <0.1 | 42.0 | 1.23 | 81.4 | 3.25 | 25.8 |
| 31.vii.2013 | 1.00 | 40.6 | <0.1 | 28.1 | 0.89 | 76.6 | 2.32 | 15.5 |
| 14.i.2014 | 0.801 | 36.4 | <0.1 | 21.5 | 1.14 | 60.4 | 2.49 | 18.2 |
| 31.iii.2015 | 1.38 | 68.1 | <0.1 | 34.3 | 0.56 | n.a. | 4.67 | 35.9 |
| 19.viii.2015 | 2.16 | 99.5 | <0.1 | 52.0 | 1.23 | n.a. | 5.44 | 27.0 |
| **chalk pond** | | | | | | | | |
| 1.viii.2005 | 0.11 | 44.5 | 14.2 | 50.4 | 3.6 | 39 | 5.2 | 107 |
| 5.vii.2006 | 0.17 | 46.4 | 18.1 | 49.0 | 3.8 | 39.9 | 6.5 | 105 |
| 29.xi.2006 | 1.60 | 80 | 0.1 | 56.0 | 2.1 | 154 | 6.7 | 29.0 |
| 5.vii.2007 | 2.09 | 90.5 | 0.2 | 67.8 | 0.6 | 175 | 5.8 | 18.2 |
| 17.vi.2008 | 0.68 | 50.6 | 10.0 | 49.5 | 1.6 | 76.5 | 5.7 | 81.5 |
| 17.ii.2009 | 2.33 | 97.4 | 0.90 | 80.0 | 0.36 | 182 | 4.77 | 10.0 |
| 18.xi.2010 | 2.07 | 84.5 | 0.50 | 67.0 | 0.38 | 179 | 3.76 | 11.9 |
| 10.vii.2012 | 0.146 | 46.6 | 7.86 | 52.7 | 2.51 | 33.0 | 4.11 | 63.4 |
| 19.ix.2012 | 0.786 | 36.4 | 2.20 | 35.7 | 1.55 | 61.1 | 2.59 | 22.3 |
| 31.vii.2013 | 1.31 | 53.2 | <0.1 | 45.1 | 0.51 | 94.7 | 2.56 | 7.17 |
| 14.i.2014 | 0.850 | 28.1 | <0.1 | 22.4 | 1.15 | 52.7 | 1.90 | 12.3 |
| 31.iii.2015 | 2.14 | 92.3 | <0.1 | 77.9 | 0.05 | n.a. | 5.73 | 19.3 |
| 19.viii.2015 | 2.24 | 93.2 | <0.1 | 78.1 | 0.09 | n.a. | 5.64 | 18.1 |

*Table 6. Changes of water composition in the main pond (A03) (point WG1, near reed beds) and in the chalk pond (A01) (point WG5) in 2005-2015 (n.a. - not analysed)*

## SPECIES LISTS

The species below are full lists for the groups reported above unless otherwise indicated.

### SOIL ALGAE

Species recorded during the current survey (excluding donor sites – Table 1)

**Cyanophyceae: Blue-green algae**

*Anabaena* sp. (no heterocyte)
*Aphanothece/Gloeothece* sp.
*Cylindrospermum* sp.
*Nostoc commune*
*Oscillatoria limosa*
*Stigononema* sp.

**Chlorophyceae: Green algae**
*Botryococcus* sp.
*Chlorella* sp.
*Chlorococcum humicola*
*Gloecystis* sp.
*Klebsormidium flaccidum*
Cf *Palmodictyon* sp.
*Schroederia* sp.
*Sphaerocystis* sp.

**Euglenophyceae**:
*Euglena* sp.

## FUNGI
### ASCOMYCETES
**Ascodichaenaceae**
*Ascodichaena rugosa*

**Cladosporiaceae**
*Cladosporium herbarum*
*Cladosporium macrocarpum*

**Clavicipitaceae**
*Epichloe sylvatica*

**Cucurbitariaceae**
*Cucurbitaria berberidis*

**Dermateaceae**
*Diplocarpon rosae*
*Drepanopeziza salicis*
*Drepanopeziza triandrae*
*Mollisia aquosa*
*Mollisia palustris*
*Pseudopeziza trifolii*
*Trochila ilicina*
*Trochila laurocerasi*

**Diaporthaceae**
*Diaporthe arctii*
*Diaporthe eres*
*Phomopsis crustosa*
*Phomopsis epilobii*
*Phomopsis* sp.

**Diatrypaceae**
*Anthostoma gastrinum*
*Diatrype stigma*
*Eutypa flavovirens*
*Eutypa lata*
*Eutypella tetraploa*

**Didymellaceae**
*Ascochyta equiseti*
*Ascochyta podagrariae*
*Boeremia hedericola*
*Phomatodes nebulosa*

**Dothideaceae**
*Scirrhia* cf. *rimosa*

**Entomophthoraceae**
*Erynia neoaphidis*

**Erysiphaceae**
*Blumeria graminis*
*Erysiphe adunca* var. *adunca*
*Erysiphe alphitoides*
*Erysiphe aquilegiae* var. *ranunculi*
*Erysiphe berberidis*
*Erysiphe buhrii*
*Erysiphe convolvuli* var. *calystegiae*
*Erysiphe convolvuli* var. *convolvuli*
*Erysiphe cruciferarum*
*Erysiphe euonymi*
*Erysiphe euonymicola*
*Erysiphe euonymi-japonici*
*Erysiphe flexuosa*
*Erysiphe hedwigii*
*Erysiphe heraclei*
*Erysiphe howeana*
*Erysiphe knautiae*
*Erysiphe lonicerae*
*Erysiphe penicillata*
*Erysiphe ranunculi*
*Erysiphe syringae*
*Erysiphe thalictri*
*Erysiphe trifolii*
*Erysiphe trifoliorum*
*Erysiphe ulmariae*



*Erysiphe urticae*
*Erysiphe viburni*
*Golovinomyces artemisiae*
*Golovinomyces biocellatus*
*Golovinomyces cichoracearum* var. *cichoracearum*
*Golovinomyces cynoglossi*
*Golovinomyces depressus*
*Golovinomyces fischeri*
*Golovinomyces macrocarpus*
*Golovinomyces orontii*
*Golovinomyces sonchicola*
*Golovinomyces sordidus*
*Golovinomyces sparsus*
*Golovinomyces verbasci*
*Neoerysiphe galeopsidis*
*Neoerysiphe galii*
*Oidium* sp.
*Phyllactinia betulae*
*Phyllactinia carpini*
*Phyllactinia fraxini*
*Phyllactinia guttata*
*Podosphaera aphanis*
*Podosphaera clandestina*
*Podosphaera dipsacacearum*
*Podosphaera epilobii*
*Podosphaera erigerontis-canadensis*
*Podosphaera ferruginea*
*Podosphaera filipendulae*
*Podosphaera fugax*
*Podosphaera fusca*
*Podosphaera leucotricha*
*Podosphaera macularis*
*Podosphaera pannosa*
*Podosphaera plantaginis*
*Podosphaera spiraeae*
*Podosphaera tridactyla*
*Sawadaea bicornis*
*Sphaerotheca epilobii*

**Glomerellaceae**
*Colletotrichum dematium*

**Gnomoniaceae**
*Cryptodiaporthe salicina*
*Cryptosporella platanigera*

**Helotiaceae**
*Bisporella sulfurina*
*Bloxamia leucophthalma*
*Eubelonis albosanguinea*
*Hymenoscyphus caudatus*
*Hymenoscyphus scutulus*

**Hyaloscyphaceae**
*Dasyscyphella nivea*
*Lachnum controversum*
*Protounguicularia barbata*
*Unguicularia millepunctata*

**Hypocreaceae**
*Trichoderma harzianum*
*Trichoderma viride*

**Leptosphaeriaceae**
*Leptosphaeria purpurea*

**Massarinaceae**
*Helminthosporium velutinum*

**Mycoporaceae**
*Mycoporum quercus*

**Mycosphaerellaceae**
*Cercospora malvarum*
*Cercospora zebrina*
*Cymadothea trifolii*
*Physalospora* sp.
*Ramularia epilobiana*
*Ramularia filaris*
*Ramularia pratensis*
*Ramularia rhabdospora*
*Ramularia scrophulariae*
*Ramularia superflua*
*Septoria angelicae*
*Septoria epilobii*
*Septoria leucanthemi*

**Nectriaceae**
*Dialonectria episphaeria*
*Nectria aquifolii*
*Nectria cinnabarina*

**Orbiliaceae**
*Hyalorbilia inflatula*

**Phacidiaceae**
*Phacidium multivalve*

**Phaeosphaeriaceae**
*Ampelomyces quisqualis*
*Eudarluca caricis*
*Phaeosphaeria eustoma*
*Phaeosphaeria herpotrichoides*
*Phaeosphaeria pontiformis*

**Phyllachoraceae**
*Phyllachora dactylidis*

**Phyllostictaceae**
*Guignardia aesculi*
*Phyllosticta philoprina*

**Pleomassariaceae**
*Splanchnonema platani*

**Pleosporaceae**
*Dendryphion comosum*

**Rhytismataceae**
*Lophodermium arundinaceum*

**Taphrinaceae**
*Taphrina populina*
*Taphrina pruni*
*Taphrina sadebeckii*

**Torulaceae**
*Torula herbarum*

**Valsaceae**
*Cytospora platani*
*Cytospora salicis*

**Venturiaceae**
*Hormotheca robertiani*
*Venturia inaequalis*
*Venturia maculiformis*
*Venturia rumicis*

**Xylariaceae**
*Annulohypoxylon multiforme*
*Daldinia concentrica*
*Hypoxylon fuscum*
*Hypoxylon howeanum*
*Hypoxylon rubiginosum*
*Rosellinia arcuata*
*Xylaria hypoxylon*
*Xylaria polymorpha*

**Xylariomycetidae**
*Dinemasporium cytosporoides*

## BASIDIOMYCETES

**Agaricaceae**
*Agaricus silvaticus*
*Chlorophyllum rhacodes*
*Coprinus atramentarius*
*Coprinus comatus*
*Coprinus sp.*
*Lepiota cingulum*
*Lepiota cristata*
*Lepiota subincarnata*
*Leucoagaricus serenus*

**Auriculariaceae**
*Auricularia auricula-judae*
*Auricularia mesenterica*
*Exidia nucleata*
*Exidia thuretiana*

**Bolbitiaceae**
*Conocybe striaepes*

**Boletaceae**
*Xerocomellus chrysenteron*
*Xerocomellus rubellus*



**Botryobasidiaceae**
*Botryobasidium aureum*

**Coleosporiaceae**
*Coleosporium tussilaginis*

**Coniophoraceae**
*Coniophora puteana*

**Dacrymycetaceae**
*Dacrymyces stillatus*

**Fomitopsidaceae**
*Laetiporus sulphureus*

**Geastraceae**
*Geastrum fimbriatum*
*Geastrum triplex*

**Gomphaceae**
*Ramaria stricta*

**Helinomydaea**
*Hebeloma leucosarx*

**Hydnangiaceae**
*Laccaria amethystina*
*Laccaria laccata*

**Hydnodontaceae**
*Subulicystidium longisporum*

**Hyphodermataceae**
*Hyphoderma praetermissum*

**Inocybaceae**
*Inocybe fuscidula*
*Inocybe griseolilacina*
*Inocybe* sp.

**Lyophyllaceae**
*Calocybe gambosa*
*Lyophyllum decastes*

**Marasmiaceae**
*Marasmius epiphyllus*
*Marasmius rotula*

**Melampsoraceae**
*Melampsora epitea*
*Melampsora larici-populina*

**Meruliaceae**
*Bjerkandera adusta*
*Byssomerulius corium*
*Chondrostereum purpureum*
*Mycoacia fuscoatra*
*Phlebia rufa*

**Microstromataceae**
*Microstroma album*

**Mycenaceae**
*Mycena adscendens*
*Mycena galericulata*
*Mycena galopus* var. *nigra*
*Mycena sanguinolenta*
*Mycena vitilis*

**Niaceae**
*Merismodes anomala*
*Merismodes fasciculata*

**Omphalotaceae**
*Gymnopus dryophilus*

**Peniophoraceae**
*Peniophora incarnata*
*Peniophora lycii*
*Peniophora rufomarginata*

**Phanerochaetaceae**
*Terana coerulea*

**Phragmidiaceae**
*Phragmidium bulbosum*
*Phragmidium sanguisorbae*
*Phragmidium violaceum*

**Physalacriaceae**
*Cylindrobasidium laeve*
*Flammulina velutipes*

**Polyporaceae**
*Cerrena unicolor*
*Polyporus picipes*
*Trametes pubescens*
*Trametes versicolor*

**Psathyrellaceae**
*Coprinellus disseminatus*
*Coprinopsis lagopus*
*Lacrymaria lacrymabunda*
*Parasola leiocephalus*
*Psathyrella corrugis*
*Psathyrella multipedata*
*Psathyrella* sp.

**Pterulaceae**
*Radulomyces confluens*

**Pucciniaceae**
*Puccinia annularis*
*Puccinia arenariae*
*Puccinia behenis*
*Puccinia brachypodii*
*Puccinia brachypodii* var. *poae-nemoralis*
*Puccinia caricina* var. *ribesii-pendulae*
*Puccinia coronata*
*Puccinia magnusiana*
*Puccinia malvacearum*
*Puccinia oxalidis*
*Puccinia pulverulenta*
*Puccinia punctata*
*Puccinia urticate*
*Puccinia variabilis*
*Uromyces geranii*
*Uromyces pisi-sativi*
*Uromyces rumicis*

**Pucciniastraceae**
*Pucciniastrum agrimoniae*
*Pucciniastrum epilobii*

**Russulaceae**
*Lactarius torminosus*

**Schizoporaceae**
*Hyphodontia sambuci*

**Sclerodermataceae**
*Scleroderma areolatum*
*Scleroderma verrucosum*

**Sistotremataceae**
*Sistotrema oblongisporum*
*Trechispora nivea*

**Stereaceae**
*Stereum hirsutum*

**Strophariaceae**
*Kuehneromyces mutabilis*
*Leratiomyces ceres*

**Strophariceae**
*Hypholoma fasciculare*

**Tremellaceae**
*Sirotrema pusilla*
*Tremella mesenterica*

**Tricholomataceae**
*Clitocybe dealbata*
*Lepista flaccida*
*Lepista nuda*
*Lepista saeva*

**Tubariaceae**
*Tubaria dispersa*
*Tubaria furfuracea*

**Urocystaceae**
*Urocystis ranunculi*

## PLANT GALLS

### ACARI

**Eriophyidae**
*Acalitus brevitarsus*



*Aceria aceriscampestris*
*Aceria crataegi*
*Aceria fraxinivora*
*Aceria ilicis*
*Aceria macrocheluserinea*
*Aceria tenella*
*Eriophyes laevis*
*Eriophyes pyri*

**Phytoptidae**
*Phytoptus avellanae*

### ASCOMYCETES

**Erysiphaceae**
*Sphaerotheca macularis*

**Taphrinaceae**
*Taphrina populina*
*Taphrina pruni*

### BASIDIOMYCETES

**Pucciniaceae**
*Puccinia malvacearum*

### DIPTERA

**Cecidomyiidae**
*Dasineura fraxini*
*Dasineura plicatrix*
*Hartigiola annulipes*
*Wachtliella rosarum*

### HEMIPTERA

**Acanthosomatidae**
*Elasmucha grisea*

**Aphididae**
*Pemphigus spirothecae*

**Naucoridae**
*Ilyocoris cimicoides*

**Psyllidae**
*Psyllopsis fraxini*

### HYMENOPTERA

**Cynipidae**
*Andricus aries*
*Andricus grossulariae*
*Andricus lignicola*
*Andricus lucidus*
*Andricus quercuscalicis*
*Cynips divisa*
*Cynips longiventris*
*Diplolepis nervosa*
*Diplolepis* sp.
*Neuroterus anthracinus*
*Neuroterus numismalis*
*Neuroterus quercusbaccarum*

**Tenthredinidae**
*Blennocampa phyllocolpa*
*Pontania proxima*

### COLLEMBOLA

**Bourletiellidae**
*Deuterosminthurus pallipes*

**Brachystomellidae**
*Brachystomella parvula*

**Dicyrtomidae**
*Dicyrtoma fusca*
*Dicyrtomina saundersi*

**Entomobryidae**
*Crytopygus thermophiles*
*Entomobrya albocincta*
*Entomobrya intermedia*
*Entomobrya multifasciata*
*Entomobrya nicoleti*
*Heteromurus nitidus*
*Lepidocyrtus cyaneus*
*Lepidocyrtus lanuginosus*
*Lepidocyrtus violaceus*
*Orchesella cincta*
*Pseudosinella alba*
*Willowsia platani*

**Hypogastruridae**
*Hypogastrura purpurescens*
*Xenylla maritima*

**Isotomidae**
*Desoria tigrina*
*Desoria trispinata*
*Folsomia manolachei*
*Folsomia quadrioculata*
*Isotoma anglicana*
*Isotoma viridis*
*Isotomiella minor*
*Isotomurus fucicolus*
*Isotomurus maculatus*
*Isotomurus unifasciatus*
*Parisotoma notabilis*
*Vertagopus arboreus*
*Vertagopus cinereus*

**Katiannidae**
*Katianna schoetti*
*Sminthurinus domesticus*
*Sminthurinus elegans*
*Sminthurinus niger*
*Sminthurinus reticulatus*

**Neanuridae**
*Anurida granaria*
*Mnobella grassei*
*Neanura muscorum*

**Neelidae**
*Megalothorax minimus*
*Neelus murinus*

**Poduridae**
*Podura aquatic*

**Sminthurididae**
*Sminthurides malmgreni*

**Tomoceridae**
*Tomocerus minor*

**Tullbergiidae**
*Paratullbergia callipygos*
*Stenaphorura denisi*

## LEPIDOPTERA

**Hesperiidae (Skippers)**
*Thymelicus lineola* Essex skipper
*Thymelicus sylvestris* Small skipper
*Ochlodes sylvanus* Large skipper

**Pieridae (Whites and yellows)**
*Anthocharis cardamines* Orange tip
*Pieris brassicae* Large white
*Pieris rapae* Small white
*Pieris napi* Green-veined white
*Gonepteryx rhamni* Brimstone

**Nymphalidae (Vanessids, fritillaries and browns)**
*Pararge aegeria* Speckled wood
*Coenonympha pamphilus* Small heath
*Aphantopus hyperantus* Ringlet
*Maniola jurtina* Meadow brown
*Pyronia tithonus* Gatekeeper
*Argynnis paphia* Silver-washed fritillary
*Vanessa atalanta* Red admiral
*Vanessa cardui* Painted lady
*Inachis io* Peacock
*Aglais urticae* Small tortoiseshell
*Polygonia c-album* Comma

**Lycaenidae (Coppers, blues and metalmarks)**
*Lycaena phlaeas* Small copper
*Neozephyrus quercus* Purple hairstreak
*Celastrina argiolus* Holly blue
*Polyommatus icarus* Common blue

## AMPHIPODA

**Talitridae**
*Arcitalitrus dorrieni* Landhopper

**Crangonyctidae**
*Crangonyx pseudogracilis*



## ISOPODA

**Armadillidiidae**
*Armadillidium vulgare* Pill woodlouse

**Asellidae**
*Asellus aquaticus* Two-spotted waterlouse

**Oniscida**
*Oniscus asellus* Shiny woodlouse

**Phylosciidae**
*Philoscia muscorum* Striped woodlouse

**Porcellionidae**
*Porcellio scaber* Rough woodlouse
*Porcellio laevis*
*Porcellio dilatatus*

**Trachelipodidae**
*Trachelipus rathkii*

**Trichoniscidae**
*Haplophthalmus danicus*
*Trichoniscus pusillus* Pygmy woodlouse
*Androniscus dentiger* Rosy woodlouse
*Trichoniscoides albidus* (To be confirmed as voucher specimen not retained)

## TARDIGRADA

**Macrobiotidae**
*Macrobiotus echinogenitus*
*Macrobiotus* cf. *hufelandi*

**Hypsibiidae**
*Hypsibius convergens*
*Ramazzottius oberhaeuseri*

**Milnesiidae**
*Milnesium tardigradum*

## AMPHIBIA

*Bufo bufo* Common toad
*Rana temporaria* Common frog
*Lissotriton helveticus* Palmate newt
*Lissotriton vulgaris* Smooth newt

## Conclusion

The Wildlife Garden was created as an outdoor classroom, combined with a living laboratory, designed to replicate the major lowland habitats of Britain. Biological recording started as the Garden was being created and was one of the stipulations of the grant provided by English Nature at the time. The Garden is now considered to be one of the most intensively recorded areas in London with a history of 21 years of biological recording.

This is the second of two papers updating our knowledge of wildlife within the Garden. In Part 2 we assess a smaller set of taxonomic groups than in Part 1 (Ware *et al*. 2016) but these cover a wide spectrum of flora and fauna, ranging from fungi to amphibians to Collembola, and we also report on water chemistry.

As in part 1, our results highlight the richness of the Garden flora and fauna and provide insights into how wildlife has developed over time. The records include some interesting additions and omissions, most likely explained by the relative isolation of the Garden for some species and the more effective dispersal abilities of others.

Amphibians, butterflies, larger woodlice and Collembola are all well represented in the Garden. It is notable that a relatively quick survey of Collembola has produced more springtail species than a longer term, intensive study of a much larger college grounds elsewhere in London. The richest group reported here are the non-lichenised fungi but, even at 290 species, this seems to be only scratching the surface. Significantly more fungi species are presumed to be present within the Garden. The number of plant galls

Setacera aurata *NHMUK 010863229. © The Trustees of the Natural History Museum, London*

recorded has tripled since the previous update (Leigh & Ware 2003) while the number of tardigrades has remained fairly stable; one new species arriving and a previously recorded species requiring confirmation. The amphipod fauna also remains stable with one terrestrial and one aquatic species continuing to be recorded.

Soil algae have been reported on previously (Leigh & Ware 2003) but in this paper we compare the biology of chalk and heathland soils recently brought into the Garden with the donor sites they came from. The results show that both soil types have lost algae species while the chalk has seen an increase in cyanobacteria. How soils might change and adapt over time is an interesting topic for further study.

We also report on species from other taxonomic groups that have been found in the Garden since Part 1 was published (Appendix 1). The voucher of the shore fly *Setacera aurata* is the third British specimen and only British male in the NHM, a reminder of how the Garden contributes to the Museum collections.

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## APPENDIX 1

Additional records for groups discussed and listed in Part 1 (Ware *et al*. 2016)

### FRESHWATER ALGAE
**Zygnemataceae**
*Spirogyra jugalis*

### BRYOPHYTES
**Mniaceae**
*Rhizomnium punctatum*

### LICHENISED FUNGI
**Teloschistaceae**
*Xanthoria calcicola*

**Verrucariaceae**
*Verrucaria bulgarica*

**Vezdaeaceae**
*Vezdaea leprosa*

### VASCULAR PLANTS
Nomenclature follows Stace (2011)
**Asteraceae**
*Tragopogon pratensis* Goat's-beard
*Senecio aquaticus* Marsh ragwort

**Poaceae**
*Elytrigia repens* Common couch

**Rosaceae**
*Rosa micrantha* Small-flowered sweet-briar

**Veronicaceae**
*Linaria purpurea* Purple toadflax

**Convolvulaceae**
*Calystegia pulchra* Hairy bindweed

**Urticaceae**
*Parietaria judaica* Pellitory-of-the-wall

### HEMIPTERA (True bugs)
**Pentatomidae**
*Rhaphigaster nebulosa*

*Mottled shieldbug* Raphigaster nebulosa. © *Russell Ritchin*

### HYMENOPTERA
**ANTHOPHILA (Bees)**
**Apidae**
*Nomada panzeri*

**Melittidae**
*Macropis europaea* Notable A

### COLEOPTERA (Beetles)
**Cantharidae**
*Malthinus seriepunctatus*

**Coccinellidae**
*Coccidula scutellata*

**Chrysomelidae**
*Plagiodera versicolora*
*Bruchidius villosus*

**Curculionidae**
*Anthonomus rubi*
*Cionus alauda*
*Hypera meles* Notable A

**Elateridae**
*Melanotus* cf. *villosus*

**Scarabaeidae**
*Hoplia philanthus*

**Scirtidae**
*Scirtes hemisphaericus*

**LEPIDOPTERA (Moths)**
**Gelechiidae**
*Helcystogramma rufescens*
*Platyedra subcinerea*

**Geometridae**
*Perizoma alchemillata*
*Scopula imitaria*

**Gracillariidae**
*Acrocercops brongniardella*

**Heliozelidae**
*Antispila treitschkiella*

**Noctuidae**
*Abrostola triplasia*
*Lenisa geminipuncta*
*Helotropha leucostigma*
*Mythimna albipuncta*
*Leucania obsoleta*

**Notodontidae**
*Clostera curtula*

**Oecophoridae**
*Stathmopoda pedella*

**Roeslerstammiidae**
*Roeslerstammia erxlebella*

**Tortricidae**
*Acleris comariana*
*Notocelia cynosbatella*

**DIPTERA (True Flies)**
**Limoniidae**
*Dicranomyia chorea*

**Ptychopteridae**
*Ptychoptera contaminate*

**Culicidae**
*Anopheles plumbeus*

**Ceratopogonidae**
*Culicoides pictipennis*

**Chironomidae**
*Cricotopus sylvestris*

**Empididae**
*Clinocera stagnalis*
*Empis tessellata*

**Dolichopodidae**
*Poecilobothrus nobilitatus*

**Platypezidae**
*Agathomyia antennata*

**Lonchopteridae**
*Lonchoptera furcata*

**Lonchaeidae**
*Lonchaea chorea*

**Agromyzidae**
*Phytomyza calthophila*

**Ephydridae**
*Notiphila venusta*
*Setacera aurata*

**Fanniidae**
*Fannia sociella*

**Calliphoridae**
*Melanomya nana*
*Pollenia pediculata*

**Tachinidae**
*Gymnocheta viridis*



**OLIGOCHETES (Earthworms)**
**Lumbricidae**
*Satchellius mammalis*

**ARACHNIDA**
**ARANEAE (Spiders)**
**Segestriidae**
*Segestria senoculata*

**AVES (Birds)**
**Sylviidae**
*Sylvia communis* Whitethroat

## APPENDIX 2

Corrections to Part 1 (Ware *et al*. 2016)

Page 139
**MYRIAPODA**
**CHILOPODA (Centipedes)**
**Schendylidae**
*Schendyla dentata* (not *dentate*)

**DIPLOPODA**
**Blaniulidae** should read
*Blaniulus guttulatus*
*Choneiulus palmatus** Notable (Nationally Scarce)

Page 156
*Tilia cordata* small-leaved lime should read *Tilia petiolaris* silver pendant lime