Rock of Ages Display as an Introduction to Lichens

Theresa Greenaway and Ray Woods
2013

Introduction to Lichens.

Lichens can be found almost everywhere, in towns as well as in the countryside and along the coast. Each lichen is made up of two (rarely three) completely different kinds of organisms, a fungus (the mycobiont) and one or two photosynthesizing partners (the photobionts), which are either a green alga or a cyanobacterium. The photobiont is completely surrounded by the fungus to form an organism – the lichen – which is very different in appearance from each partner when they live separately. The algae gain protection from desiccation and strong sunlight and in turn they provide the fungus with the carbohydrates it cannot manufacture itself.In Britain there are at least 1,800 species, 1,300 of which are found in Wales. This is an impressive 71% of the British total in 11% of the area. Some lichens are excellent indicators of air quality whilst others contain unique chemicals that may be of service to us in the future.

Size and Shape.

The lichen body is called a thallus. There are three main types of lichens. 'Crustose' lichens grow as a thin crust that cannot be removed from the substrate without damage. 'Foliose' lichens have a lobed, almost leafy structure and can be removed readily from the surface on which they grow. 'Fruticose' lichens are branched and shrubby. They are attached to the surface by a small plate called a holdfast.

Crustose and foliose lichens grow radially from a small propagule to form a more or less circular patch or thallus. The circular shape is often lost over time as parts of the lichen are eaten by invertebrates, meet up with a neighbouring lichen or encounter an unsuitable area of habitat. Lichens grow slowly. Crustose lichens in particular grow extremely slowly Many grow less than 0.5mm a year, with the zone of growth restricted to the margin of the colony. Eventually, some lichens may reach the size of a dinner plate, although most are much smaller, a few centimetres or less across.

Reproduction.

Lichens reproduce and spread by a number of different means. Like other, non-lichenised, fungi they can sexually reproduce by means of spores. These are produced in fruit bodies that are disc-shaped (apothecia), flask-shaped (perithecia) or elongated and slit-like (lirellae). Spores are spread by wind, rain or animals. In order to grow into a new individual, a spore not only has to land in a suitable place, but also has to encounter the correct photosynthesizing partner soon after germinating. A lichen fungus cannot survive for long by itself.

Many lichens also reproduce vegetatively . Small fragments (soredia or isidia) form on the surface of the lichen. These small fragments are made up of fungal hyphae and photobiont cells. They are readily detached from the parent lichen and, provided they land on a suitable surface, can grow into new lichens.

Where do lichens grow?

Lichens can grow and colonise a wide range of natural and man-made substrates including trees, rocks, soil, sawn wood and metal. They can survive in the Arctic tundra, on the tops of mountains, in hot deserts and tropical rain forests. They are found along rocky coasts, a few on rocks and even on the shells of barnacles at or below high water mark.

Although some species of lichen can grow on a wide range of surfaces, others are restricted to particular habitats. Saxicolous lichens are those that grow on rocks and rock-like man-made substances such as concrete. Naturally occurring rocks have been formed throughout Earth's history and are composed of many different chemicals, which give each kind of rock its own characteristics. Some rocks, such as granites, are chemically acid, whereas limestones and chalk are alkaline, or basic, in reaction. The Rocks of Ages exhibit in the NBGW has examples of rocks taken from all over Wales, from the Precambrian Era to the Carboniferous Period. Lichens have colonised all of these rocks, but each type of rock has its own characteristic lichen flora. A study of saxicolous lichens will therefore tell us a lot about the type of rock. The Rocks of Ages display in the NBGW is a good opportunity to observe the differences in lichen diversity on a range of rock types all in one place and to learn about the relationship between the rocks and the lichens that grow on them. Many of the rocks probably had no lichens on them when placed in the Botanic Garden. Others appear to have come complete with a covering of lichens that are probably still adjusting to life in a new area.

Precambrian Rock (Display 1)

This example of Precambrian rock is from Gwalchmai Quarry, Anglesey. It is granite, a hard, igneous, acid rock with a rough surface. Spores and vegetative propagules lodge easily on the rough surface, together with air-borne dust. Nutrients essential for lichen growth come from the rock itself, the dust and substances dissolved in rainwater.

There are at least 25 different species of lichen on this Precambrian granite. Many of these are species characteristic of hard, acid rocks including: *Acarospora fuscata, Arctoparmelia incurva, Aspicilia caesiocinerea, Buellia aethalea, B.ocellata, Candelariella vitellina, Rhizocarpon geographicum, R. reductum, Xanthoparmelia loxodes* and *X. verruculifera*.

Other species indicate that the prominent tops of these rocks are favourite perches for birds. Bird droppings provide a rich source of nutrients, allowing species that require nutrient-rich conditions to grow on rocks that would otherwise be too nutrient-poor for them to survive. These lichens form distinct patches on the tops of the granite, and include the bright orange *Xanthoria* species as well as the grey or grey-green patches of *Physcia tenella*, *P. caesia* and *Phaeophyscia orbicularis*.

Species of interest

Although most lichens are shades of greenish or bluish grey, others are white, brown, black, reddish – even bright yellow or orange. These colours are caused by chemicals, often acids, produced by the fungal partner. The bright orange ***Xanthoria parietina*** (Yellow Wall Lichen) is an easily recognised species, common and widespread especially in nutrient-enriched sites. The boulder tops are favoured perches for birds where they regularly deposit their nutrient-rich droppings. The orange *Xanthoria* is commonest where the birds perch. If you look at the boulder tops you will see other nutrient-loving lichens such as the grey coloured ***Physcia*** species. ***Candelaria concolor*** the Lemon Lichen forms bright egg-yellow patches made up of lots of tiny narrow lobes. Until recently it was rare in Wales and was confined to trees near farm yards. Now it is widespread in the most intensive

agricultural areas and has even become a common lichen of street trees in Cardiff. It probably indicates high levels of ammonia in the air and may indicate a growing problem of nutrient enrichment of our environment.
The orange colour in these lichens is due to the chemical physcion. *Xanthoria parietina* is brighter orange in well-lit places. When growing in shade the lichen is yellowy-green. It is thought that the orange pigment protects the algae in the lichen from UV damage. Lichens contain many hundreds of unique chemicals whose uses have yet to be even guessed at.

Lecanora muralis occurs on nutrient-enriched acid rocks, but its tolerance to pollution has enabled it to grow on basic substrates as well – even on the concrete of city pavements, where its abundance and appearance has earned it the name of Chewing-gum lichen.

Cambrian rock (Display 2)

Slate from Penrhyn Quarry, Gwynedd dates from over 500 million years ago. Slate is a fine-grained, metamorphic rock. At least 20 different kinds of lichen are growing on these examples, but the most characteristic are the grey and grey-yellow circular colonies of *Buellia aethalea* and *B. ocellata*, two crustose lichens that are among the first to colonise well-lit siliceous rocks. There are some other lichens typical of acid rocks, such as the chocolate-brown crusts of the Brown Cobblestone Lichen *Acarospora fuscata* growing on the summit ridges*, Rhizocarpon reductum* and the yellow Map Lichen *R. geographicum* that occur on the sides, together with the grey lichens frequently found in places where birds perch such as the Little Ciliated Lichen *Physcia tenella, Physconia grisea* and the Mealy Shadow Lichen *Phaeophyscia orbicularis*.

Some other lichens – *Evernia prunastri*, Abraded Brown Shield Lichen *Melanelia subaurifera* and *Parmelina pastillifera* - found on this Cambrian slate are species more frequently encountered on trees. These three lichens spread by means of tiny fragments called soredia or isidia, which may well have been blown onto the rock from nearby trees.

Species of interest

Evernia prunastri has a long history of use in perfumery. Its common name is ‘oakmoss’, reflecting the time when lichens were thought to be mosses. Oakmoss has a slight musky scent which as well as providing a ‘woody’ note to some perfumes also helps to fix or stabilise other fragrances used in perfumery.

Ordovician rock (Displays 3, 4 & 5).

Dolerite (Display 3).The first example of Ordovician rock is dolerite from ARC Builth Quarry, Radnorshire. Fifteen species of lichens have been identified on this fine-grained, igneous rock. Its rather smooth surface is less favourable for propagules or wind-blown nutrients to lodge. This dolerite is a less acid rock, so lichens preferring a more basic substrate can become established, such as *Caloplaca citrina, C. holocarpa, Aspicilia contorta,* the Concentric Lichen *Rhizocarpon petraeum,* and *Verrucaria* species.

Species of interest.

Placopsis lambii the Pink Bull’s Eye Lichen is an interesting species that favours damp, well-lit sites usually on acid rocks. Whereas most lichens have only one kind of photosynthetic partner, *Placopsis*

lambii has two, a green alga buried in the smooth white larger part of the colony and a cyanobacterium in brownish, wart-like lumps (cephalodia) towards the centre on the surface of the white thallus. The cyanobacterium can fix atmospheric nitrogen, providing essential nitrogenous compounds for the lichen. The fungus partner reproduces by means of microscopic spores formed in the coral pink button-like fruit bodies, whilst the lichen reproduces vegetatively by producing tiny packages of fungal tissue and green algal cells from the grey spotty patches.

Spotted Dolerite (Display 4) this Ordovician rock is from the Preseli Mountains. It is a 'bluestone' dolerite, containing spots or clusters of plagioclase feldspar, and is one of the rock types that make up Stonehenge. Its rougher surface supports a greater diversity of lichen species and growth types – an abundance of the larger 'leafy' (foliose) lichens such as *Xanthoparmelia conspersa* the Yellow Boulder Lichen*, X. verruculifera, Parmelia saxatilis* the Grey Crottle and *Flavoparmelia caperata* the Stone Crottle as well as crustose species. All of the foliose lichens seen here commonly reproduce by means of the small vegetative propagules that contain both fungal hyphae and algal cells. All of the 22 lichens identified on this rock are those requiring siliceous, acid substrates.

Many of the colonies are large and were probably already well-established on the boulders when brought to the Garden. Perhaps because they were already well-covered in lichens they have not been colonised by lichens typically seen where bird droppings have caused nutrient enrichment as is the case with many of the other rocks in the display. Studying lichens often reveals interesting issues such as this. Another interesting feature of this spotted dolerite is that three of the lichens found, *Acarospora smaragdula, Rhizocarpon oederi* and *Stereocaulon pileatum* are typical of metal-rich substrates, indicating that this rock contains metals such as iron.

Species of interest.

A few lichens were extensively used in the past to dye textiles such as wool and linen. Chemicals such as lichen acids are responsible for this and a range of colours was obtained from different species, including yellows, reds and even purple. ***Parmelia saxatilis,*** known as Grey Crottle in Scotland, produces a reddish brown colour and forms large colonies on the rocks here. It reproduces vegetatively by growing enormous numbers of fragile, rod-like branches from its surface. These break off readily and spread the lichen. The fungus also produces enormous quantities of tiny spores from the surface of the brown, dish-like structures called apothecia.

As well as growing on rocks, *Parmelia saxatilis* will grow on other substrates such as trees – and bones. Thalli growing on human bones were thought to have medicinal properties, and those growing on the skull of a hanged person were thought to be the most efficacious of all.

Rhyolite (Display 5)

This Ordovician Rhyolite is from north of Haverfordwest, Pembrokeshire. It is an igneous acidic rock derived from lava. The lichens found are typical of acid rock types, with the exception of *Ochrolechia subviridis*, which is usually a species of nutrient-rich, rough barked trees. Eleven species were recorded.

Species of interest
Two of the species found on these grits as well as on other acid rocks in the Rock of Ages display are the crustose lichens ***Buellia aethalea*** and ***B.ocellata***. Slow-growing but long-lived lichens such as these can help us to date rock exposures. By measuring the amount of growth in one year, an extrapolation can be made regarding the age of the lichen and perhaps give a date as to when the

rocks were first exposed. Species such as *Buellia aethalea* that are known to be early colonisers of exposed rock are the best suited to this method of dating, known as lichenometry. It has been used to estimate the rate of retreat of glaciers and the dates of ancient tsunamis.

Silurian rock (Display 6).

Aberystwyth grits from ARC Ystradmeurig Quarry, Cardiganshire. Aberystwyth grit is a quartz-rich sedimentary rock. Only eight species of lichens have been found on this rock, most of which are typically seen on acid substrates, although the presence of *Lecanora campestris* and *Xanthoria parietina* indicate some nutrient enrichment, probably derived from bird droppings.

Devonian rock (Display 7)

Sandstone from Heol Senni Quarry, Breconshire. This sandstone is a rather porous and relatively softer rock, providing crevices for moisture, debris and reproductive bodies to accumulate. The chemical nature of the Devonian sandstone means that it lies between the more acidic rocks such as granite and dolerite and the very basic limestones. This enables lichens with both acidic and more basic preferences to colonise, which has resulted in the identification of a total of 37 lichen species, more than any other rock type in the Rocks of Ages display.

Species of interest
Mosses are also a conspicuous feature of this Devonian sandstone, becoming established in damp crevices. These small plants hold moisture and trap debris, contributing to nutrient increase and small pockets of soil formation. Species of the cup lichen *Cladonia* can grow among the mosses, including ***Cladonia fimbriata*** the Fringed Cup Lichen. The fruit bodies of this lichen are borne on cup-shaped structures (podetia) resembling minute golf tees. Some *Cladonia* species have recently been found to contain substances that might cure the feared prion protein induced "Mad Cow" disease.

Baeomyces rufus the Brown Mushroom Lichen is a lichen that can grow on peaty or sandy soils as well as on rock. It makes large, powdery greenish crusts, and unusually, the stalked fruiting bodies look like tiny brown mushrooms-hence its English name.

Lichens may be parasitized by other fungi or even other lichens. The black fruit bodies of the fungus ***Sclerococcum sphaerale*** can be seen on this sandstone growing on the surface of the White Coral-crusted Lichen ***Pertusaria corallina***.

Some of the largest colonies of crust-forming lichens must have occurred on the boulders before their installation in the Garden since their size at over 15cm in circumference suggests they are over 100 years old.

Lower Carboniferous rock (Display 8) Limestone from Tarmac Cornelly Quarry, Pyle, Glamorganshire. 9 species

Lower Carboniferous rock (Displays (9 & 10) Carboniferous – Limestone from RMC Halkyn Quarry & Tarmac NW Quarry, Clwyd. 11 & 9 species respectively.

Carboniferous limestone is a difficult rock for many lichens to colonise. It is so rich in lime that only those species that can tolerate lime can hope to get established. In the high rainfall of Wales the limestone surface is rapidly dissolved by the rain which is acidic. Some of the acids come from carbon dioxide in the air, the levels of which we are increasing by burning fossil fuels. This burning process also produces nitrogen oxides which react to form nitric acid. Large parts of Wales are still

badly affected by un-naturally acidic rain. Limestone is also often short of other nutrients so making colonisation difficult.
Lichens themselves also produce acids that may also gradually dissolve the rock. Some dissolve channels just under the rock surface and are only visible when they produce their fruits on the surface or if the rock is broken. These rocks may have more lichens on them than is at present apparent. Lichens can occasionally cause visible biodeterioration in a fairly short time. Over a longer timescale the processes involved, together with the release of nutrients from dead lichens and the accumulation of wind-blown dust, contribute to soil formation.

Upper Carboniferous (Display 11)

Upper Carboniferous – Sandstone from Redland Hafod Fach Quarry, Abercam, Gwent. 23 species. All represented elsewhere in the display.

Conclusions

The Rocks of Ages display at the NBGW demonstrates just how varied lichen communities can be on different types of rock. Lichens make up a highly successful group of organisms and studying them, as well as fascinating, is also challenging. They are interesting for many and diverse reasons, from their use in atmospheric pollution assessment, perfumery and dyeing to their role in soil formation. The leafier sorts harbour innumerable small invertebrates such as mites, and are pecked off by birds to use in nest building and those with cyanobacteria fix nitrogen from the air and contribute significantly to nutrient cycles.

As well as this, lichens add a lot of interest to rocks of all kinds simply by enhancing the appearance of the rock surface with their shapes and colour. Historically, only a few lichens have been known by common names, and the vast majority of them today are still only known by their scientific, Latin names. But as hopefully more and more people learn to enjoy looking at and studying lichens, an increasing number will be given common names, in Welsh and English.

Over seventy one different sorts of lichen have been identified from the Rocks of Ages display. As well as those positively identified, a number of others were simply too small and young to identify or could not be identified without removing material to the laboratory. The display has been in place for just over fifteen years. How many more lichens will we be able to identify in future?