

Heathland Lichens

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An assemblage of *Cladonia* species at Thetford Warren Lodge, Norfolk Breckland

Contents

Page

A brief introduction to the study of Heathland Lichens

Terminology, Diversity of lichens, Is it a lichen?	2
Identifying lichens: the major growth forms	3
Identifying lichens: features used in naming species	4
Ecology of lichens: pollution sensitivity and substrates	4
Ecology of lichens on soil	5
Literature on Lichens	6
Websites	8
Glossary	9
Naming of parts of <i>Cladonia</i>	11
Checklist of <i>Cladonia</i> and other heathland lichens in Beds, Cambs and Northants	12
Heathland and grassland lichens: a key to lowland <i>Cladonia</i>	13
A draft key to <i>Cladonia</i> squamules on soil at Cooper's Hill	23

A brief introduction to the study of Heathland Lichens

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These notes place lichens in their wider context of 'lower plants', and discuss the basics of lichen ecology, including the value of lichens in studying air pollution. I then go into a little more detail on the ecology of heathland lichens, especially the genus *Cladonia*.

Terminology and other lesser-known plants

- **Cryptogams** are plants which do not produce flowers or seeds, and which reproduce by spores, including ferns and horsetails, mosses, liverworts and other lower plants.
- **Lower plants** is an informal term for mosses, liverworts, fungi (including lichens), slime-moulds and algae.
- **Bryophyte** is a collective term for mosses and liverworts.
- **Lichens** are specialized fungi which exist in symbiosis with one or more species of microscopic algae. Some of the algae, and a few of the fungi, are capable of living independently of the lichen association.

Diversity of lichens compared with other plants

There are about 1700 species of lichen in Britain, a similar number to the 1800 native flowering plants and ferns, considerably more than the 900 or so mosses and liverworts; but far less than the 15,000 other fungi.

This booklet concentrates on lichens, especially those occurring on heathland soils. But in case you are not sure of the differences, the following brief notes on the other groups might be useful.

If you want a single guide to lower plants to give you an idea of 'what species look like', you might try **Jahns, H.M.** 1980. *Collins guide to the ferns, mosses and lichens of Britain and north and central Europe*. London: Collins. It has lots of pleasant photographs, and quite helpful in confirming identifications reached using other guides.

Phillips, R. 1980. *Grasses, ferns, mosses and lichens of Great Britain & Ireland*. London: Pan.

Has a smaller selection of lichens (because of its wider scope), and problems with colours (oddly, its moss and liverwort greens are good, but lichen greens and blue-greys are peculiar).

Both are attractive and give a rough idea of the range of lichens and mosses available, and are useful in confirming ID from other books. They are not really suitable for species identification except for the most distinctive species.

Is it a lichen?

This discussion of lower plants other than lichens is intended mainly as context. Having examined a few *mosses and leafy liverworts*, you are unlikely to confuse these with lichens. Most have a structure of leaves arranged along or around stems, which lichens do not. Most are brighter green and more translucent than the vast majority of lichens. *Thallose liverworts* do not have the stem-and-leaves form, and can be similar to lichens in shape. They can easily be distinguished in the following table:

Feature	Thallose Liverwort	Lichen
<i>Colour on outside</i>	Bright leafy green throughout, though some species have a brown or purplish tinge in part. Often glossy.	Wide range of colours, but rarely bright leafy green. Usually matt finish.
<i>Colour and texture inside</i>	Bright green throughout, sappy and oozing liquid when damaged	Coloured on the upper or outer surfaces, but brilliant white, dry and fibrous inside
<i>Surface pattern</i>	upper surface divided into tile-like or cell-like areas	Either no visible surface structure, or powdery, granular or minutely fluffy



A thallose liverwort, *Metzgeria furcata*, Forked Veilwort



A leafy lichen, *Peltigera lactucifolia*

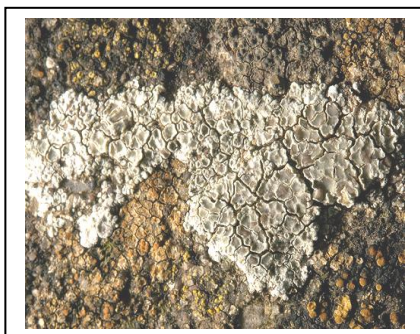
Identifying lichens: the major growth forms

Lichens are generally grouped into three main growth forms:

Crustose or crusty: Body of a lichen forming a thin crust over its substrate, which may be powdery or solid, thin (like a coat of water-colour paint) or thicker, with a smooth or a rough surface

Foliose or leafy: Leafy, the body of the lichen comprising a number of flat or curved scales or leafy structures which either stand up from, or are appressed to, the substrate

Fruticose or Shrubby: the body of the lichen made up of simple or branching structures which either stick up from, or dangle down from, the substrate



Crustose lichen, *Lecanora albescens*



Foliose *Parmelia sulcata*



Fruticose, *Evernia prunastri*

The dominant group of lichens which grow on soil and form an important part of heathland vegetation, is unusual in combining two forms: *Cladonia* begin as a low carpet of tiny leaf-like lobes called squamules, (or, in a few species, a thin crust of powder or granules), from which grow hollow upright structures called podetia which may be cup-shaped, simply pointed or branched and tree-like.



The main *Cladonia* podetia shapes: cups (*C. fimbriata*), simple spikes or antlers (*C. glauca*) and richly branched (*C. rangiformis*)

Identifying lichens: features used in naming species

Many lichen species can be recognised in the field with the naked eye. Many more can be distinguished with a hand lens. Crustose species in particular will often require microscopic examination. Spore characters, requiring x300 to x800 magnification, are very useful (and are used quite early in many published keys), but have been avoided here.

The lichen fungi are unique in producing a wide range of complex organic acids, some of which produce striking colour reactions when exposed to some simple chemical tests. The three commonest chemical tests are:

K, a solution of potassium hydroxide or sodium hydroxide (caustic soda) in water

C, calcium hypochlorite solution, cheap domestic bleach

P, para-phenylene diamine, a toxic and possibly carcinogenic chemical which is difficult to obtain.

Because of the dangers associated with P, on training courses I will supply only K and C.

Danger: K is strongly corrosive if splashed on the skin, and can do serious damage if it comes in contact with the eyes. If affected, wash thoroughly with plenty of water. C, domestic bleach, is also a danger to the eyes. Handle both chemicals with caution.

Ecology of lichens: pollution sensitivity and substrates

Along with mosses and liverworts, lichens are probably the most useful group to learn if you are interested in pollution monitoring. Unlike mosses and liverworts, which require high moisture levels in order to reproduce, lichens are richest on trees, rocks and walls in fairly bright sunshine, and parkland trees often have more species than those in dense woodland.

Habitats where the ground flora is sparse, such as heathlands, can be dominated by lichens of a few genera, especially *Cladonia* (cup-lichens, stag's-horn lichens, reindeer lichens). Elsewhere, they seldom form a major part of vegetation, and are found especially on trees, rocks, and walls; churchyard lichens are a study in themselves.

Much work has been done on the response of lichen species to air pollution. Most species are particularly sensitive to sulphur dioxide and to acid rain, and detailed scales of sensitivity have been published. In previous editions of Dobson's field guide, the 1-10 scale is shown, 1 being the most tolerant and 10 being the most sensitive (in fact, no species beyond 8 on the scale is at all frequent in our area). Only one species is known to prefer 'polluted' areas: *Lecanora conizaeoides* was globally rare, and confined to sulphureous areas around volcanoes, till the industrial revolution and burning of sulphur-rich fossil fuels provided abundant habitat for it. In the 19th and 20th century it was among the commonest lichens throughout lowland Britain and Europe. A few species are particularly sensitive to other pollutants, such as fluoride or heavy metals; and some species respond positively to these (see below).

With the advent of clean air legislation in the 1960s, pollution levels have gradually fallen. Since 2000, many species of more pollution-sensitive lichens have re-colonised central England, and others which used to be scarce are now widespread and common. The pollution-tolerant *Lecanora conizaeoides*, has declined, and is now absent from most natural surfaces, though still frequent on wood with the bark missing, and on timber structures.

Apart from air quality, the *substrate* (material on which a lichen is growing) is the main factor in determining what species are present in an area. Lichen substrates fall into three main types: soil, rocks and trees. Within each substrate type, the pH (acidity or base status) is crucially important, and in broad terms, different lichen assemblages may be described from acidic v. basic bark, and from acid (usually = siliceous = sandstone) v. calcareous rocks. The range of pH on bark varies from significantly acid to just beyond neutral: pine (3.4-3.8), birch (3.2-5.0), oak (3.8- 5.7), ash (5.2-6.6), elm (4.7-7.1). Different tree species are known to support different ranges of lichens, and in general the commoner trees support the most: oak (303 species), ash (230), elm (171), alder (72), hornbeam (42). In an unpolluted area a single old oak tree might have 50 species of lichen growing on it (as many as would be found in a good ancient woodland in Cambridgeshire!).

In the three counties, we have very few natural exposures of hard rocks, but buildings, especially churchyards, provide a very wide variety of excavated or imported rocks, and there are many manmade alternatives: cement, mortar and asbestos-concrete are the commonest 'calcareous rocks' over most of Britain. On a brick wall, a different set of species grow on the calcareous mortar compared with the neutral to acid bricks; but texture may also be important, and soft mortar hosts different species from hard brick faces. Again, within base-rich rocks, the flora of hard limestone is different from that of chalk or mortar, and granite supports different species from soft sandstone.

Nutrient availability is also important for lichens, especially nitrates. Places where birds perch will often be colonised by the bright orange *Xanthoria* species (note their occurrence on the ridge of roofs, and on farm buildings where manure or fertiliser splashes around). The table of local species indicates those which are particularly tolerant or demanding of high nutrient (eutrophic) conditions. Leaching of more unusual chemicals from one place can affect the lichens in another. Metals washing from leaded windows, copper lightning-conductors or rusty ironwork can all provide special niches for lichens which prefer metalliferous rocks.

Ecology of lichens on soil

Only about 150 of the 1700 British lichen species regularly grow on soil. Beware lichens which have fallen from somewhere else - in woodlands in particular, lichens from trees are often found lying on the ground, or even temporarily established on the soil. Because of their need for sunlight, lichens will not grow in the dense shade of flowering plants, so meadows and pastures have few or no lichens in them. The exception is the large leafy dog-lichens, *Peltigera*, which will grow over and among fairly short grass. Many more species will grow on bare soil or on mossy patches between flowering plants, where competition is weaker, coming mainly from mosses and liverworts.

Bare soil of any kind will potentially support some lichens, but they reach their greatest diversity on acidic soils such as sand and peat. Heathlands, moorlands and the drier parts of bogs can be particularly rich.

On lowland heaths, bare sand or peat which has been undisturbed for a few years is probably the richest habitat. When heather matures, it over-shades the lichens, and in humid semi-shade, mosses have a selective advantage. When over-mature heather, perhaps 40-50 years old, starts to collapse and lie down, and may die back from the middle, it creates gaps which lichens can colonise. Disturbance such as fire or soil stripping will also create spaces within which lichens can flourish.

On heathlands in particular lichens can be excellent habitat indicators. Where the dominant vegetation can be very species poor, perhaps a mosaic of heather, *Calluna vulgaris*, and wavy hair-grass, *Deschampsia flexuosa*, there may be 20-30 species of lichens, so it's possible to evaluate the habitat much more precisely.

Literature on Lichens

INTRODUCTIONS TO LICHENS

Probably the best starting point:

Baron, G. 1999. *Understanding lichens*. 92pp. Richmond Publishing.

A very clear short introduction to all aspects of lichens, with some useful colour photographs. Also has a clear and detailed evaluation of other books on lichens.

Even more attractive, but with a selection of species which is more relevant further west, is

Whelan, P. 2011. *Lichens of Ireland: an illustrated introduction to over 250 species*. Cork: The Collins Press.

A cheap and useful guide with excellent colour photos, good line drawings and straightforward text (but no keys) is:

Orange, A. 1994. *Lichens on trees*. (British Plant Life No. 3). Cardiff: National Museum of Wales.

LICHENS AND POLLUTION

The sensitivity of lichens to air-borne pollution is probably their best-known attribute, and the aspect which has attracted most research and general interest over the past 40 years.

Dobson, F.S. & Dalby, C. 1993. *Lichens and air pollution*. Field Studies Council/Richmond Publishing.

A 4-fold A5 laminated sheet dealing with lichens on trees, excellent colour paintings on one side, simple key on the other.

Richardson, D.H.S. 1992. *Pollution monitoring with lichens*. Naturalists' Handbook No. 19. Richmond Publishing.

Hawksworth, D.L. & Rose, F. 1976. *Lichens as pollution monitors*. Arnold: *Studies in biology* 66.

IDENTIFICATION

Two thorough introductory guides which do cover almost all the species to be found in the region:

Dobson, F.S. 2011 (6th edition: now in full colour, much better than earlier ones). *Lichens: an illustrated guide to the British and Irish species*. Richmond: Richmond Publishing.

The best introductory English-language guide to lichen identification so far produced. Reasonable keys and good descriptions, variable black and white photos, a few good colour photos of northern and western species you'll never find locally; tiny but extremely useful distribution maps, showing what is likely to occur. Names up to date. About 700 species included.

Duncan, U.K. 1970. *Introduction to British lichens*. Arbroath: Buncle.

Good keys, very stylised line drawings, and a highly indigestible introductory chapter with too many technical terms; the keys are well arranged and fairly easy to use once familiar with vocabulary. The *Cladonia* key still works pretty well. Very good lists of species by habitats. Names rather out of date (which may simplify identification: until the 1980s, there were far fewer genera of lichens, and most superficially similar species thus keyed out together). About 880 species. Still useful as a back-check on identifications using Dobson.

Hodgetts, N.G. 1992. *Cladonia: a field guide*. Peterborough: JNCC. 39pp.

A handy booklet which includes almost all the British species. Well illustrated with quite helpful simple line drawings. It divides *Cladonia* into several groups, then presents carefully-arranged short descriptions, rather than a formal dichotomous key. Main difficulty is the *Key to main groups* on page 9. This is rather tricky to use at times, because of variability within species; it also suffers a printing error: the groups 1-7 begin on pages 12, 14, 15, 20, 28, 31 and 35 (each is listed as a page later in the booklet).

A definitive handbook to all the British lichens is now available:

Smith, C.W., Aptroot, A., Coppins, B.J., Fletcher, A., Gilbert, O.L., James, P.W. & Wolseley, P.A. 2009. *The lichens of Great Britain and Ireland*. London: Natural History Museum & British Lichen Society.

Over 1050 pp., few illustrations. Thorough keys, many requiring good microscope, and measurement of spore sizes. Helpful descriptions and identification notes, including useful indications of what might be confused with what in the field. All 1700+ species included.

The previous edition,

Purvis, O.W., Coppins, B.J., Hawksworth, D.L., James, P.W. & Moore, D.M. 1992. *The lichen flora of Great Britain and Ireland*. London: Natural History Museum & British Lichen Society.

May be found second-hand quite cheaply, and is still useable.

OVERSEAS IDENTIFICATION GUIDES

There is a rich literature on lichens in other parts of the world, and some guides cover a high enough proportion of the British flora to be useful here.

Although aimed at a very different part of the world, there is a surprising overlap, the following is so well illustrated to be worth consulting:

Brodo, I.M., Sharnoff, S.D. & Sharnoff, S. 2001. *Lichens of North America*. Yale University Press, New Haven and London.

A large and lavish book, 795pp., 286 x 250mm, extremely well illustrated throughout in colour, with large, sharp and well-printed photographs; includes about 800 species, and overlaps by about 50% with the British flora.

Van Haluwyn, C., Asta, J., Boissiere, J-C., Clerc, P. and Gaveriaux, J-P. 2012. *Guide des Lichens de France: Lichens des sols*.

A well-illustrated pocket guide to lichens growing on soil in France

Wirth, V. 1987 (and other editions). *Die Flechten Baden-Wurttembergs*. Stuttgart: Ulmer.

The German equivalent of Dobson's field guide, with larger and usually clearer photographs of around 1000 species. Even if you read no German, it can be a help in confirming identifications (or, when all else fails, to flick through the pictures!).

SPECIALIST WORKS ON CLADONIA

Ahti, T., Stenros, S, and Moberg, R. 2013. *Nordic Lichen Flora, vol 5, Cladoniaceae*. Uppsala: Nordic Lichen Society. 116pp. In English.

An attractive and technically superb slim volume of keys, descriptions and colour photos, the most up-to-date and comprehensive guide. Fairly easy to use. Of the British species, it omits *only* *C. mediterranea*, *C. firma*, and *C. stereoclada*, none of which is likely to occur in central England. It includes many species which do not occur in Britain, and raises to species level several lichens which have been treated as subspecies in British keys.

Burgaz, A.R. and Ahti, T. 2009. *Flora liquenologica Iberica: Cladoniaceae*. Madrid: Sociedad Espanola Liquenologica. 111pp.

An A4 booklet with keys, descriptions and line drawings of the Spanish and Portuguese *Cladonia*. Illustrations and descriptions useful.

Hennipman, E., 1969. *De Nederlandse Cladonias*. Wetenschappelijke Mededelingen KNNV no. 79.

53pp plus 22 plates of excellent drawings. In Dutch.

A short softback booklet, with a key and short descriptions. It omits quite a few species which occur in Britain, but with the best drawings of squamules that I have seen.

Thomson, J.W., 1967. *The lichen genus Cladonia in North America*. Toronto: Toronto University Press. 172 pp.

A thorough monograph to North American *Cladonia*, with keys, descriptions and small black and white photographs of 116 species and subspecies. Rather dated but still useful. It provides details and photographs of microcrystal techniques for investigating lichen chemistry which are rarely explained elsewhere.

ECOLOGY AND BIOLOGY

Gilbert, O.L. 2000. *Lichens*. Harper-Collins, *New Naturalist* series. 288 pp.

A thorough and highly readable overview of lichen history, biology, ecology and habitats. Conveys much of the excitement of lichenology, and especially, the pioneering work on the British lichen flora during the latter half of the 20th century, by one of the most active participants.

Hawksworth, D.L. & Hill, D.J. 1984. *The lichen-forming fungi*. London: Chapman & Hall.

Nash, T.H. 1996. *Lichen biology*. Cambridge: Cambridge University Press.

Two readable accounts of what makes lichens interesting and unusual. The first has a strong British bias; the latter is more up-to-date but global in outlook (written by an American).

Kershaw, K.A. 1985. *Physiological ecology of lichens*. 293pp. Cambridge University Press.

An analysis of the environment in which lichens grow, the factors affecting species distributions, and role of lichens in plant communities.

Bates, J.W. and Farmer, A.M. 1992. *Bryophytes and lichens in a changing environment*. 404pp. Oxford University Press.

A collection of papers by a range of specialists on mosses and liverworts as well as lichens, looking at their responses to a wide range of pollution impacts, and to changes due to agriculture.

Hawksworth, D.L. & Seaward, M.R.D. 1977. *Lichenology in the British Isles 1568-1975*. Richmond Publishing.

A thorough historical review, with a very useful county-by-county index to 2695 publications.

Websites

Using a search engine to find photographs of a lichen you have named tentatively can be very helpful. Unfortunately, not all photographs are correctly named, and *Cladonia* are among the most often misidentified of all lichens. So, although you will find some wonderful photos by searching on www.flickr.com or www.wildaboutbritain.co.uk you cannot rely on them to be named correctly. Thankfully, there are some websites which are generally reliable.

Alan Silverside's is fairly comprehensive, and has especially good descriptions as well as excellent photographs: <http://www.lichens.lastdragon.org/>

Two regional websites from areas with rich lichen communities are helpful:

<http://wales-lichens.org.uk/content/species-communities>

<http://www.irishlichens.ie/>

The British Lichen Society's website is full of useful information, as well as quite a few useful photographs: <http://www.thebls.org.uk/>

Some non-British websites have excellent photos and are very useful because of the overlap of species: <http://www.stridvall.se/la/galleries.php#lichens>

http://www.sharnoffphotos.com/lichens/lichens_home_index.html

The latter North American website has numerous photos of each species and among the best photographs of lichens ever produced. It's essentially the website of the book by Sharnoff *et al.* (above)

My own *Cladonia* photographs, many taken locally, are arranged in species albums at:

<https://www.flickr.com/photos/cladoniophile/sets/?&page=2>

<http://www.huh.harvard.edu/collections/lichens/guide/guidetoliterature.html#illustrations>

A very good global literature guide, with links for downloading many free keys.

Brief Glossary of technical terms about lichens

'Introductory' books about lichens probably use more obscure and technical language than any other branch of natural history. This is partly because the structures of lichens do not have analogues in everyday life, and partly because lichens are a diverse group, with very varied life strategies. The simple key provided today tries to avoid most obscure terms. This list is intended to soften the blow of trying to read one of the standard works for the first time. Fortunately, all the recommended texts include their own comprehensive glossary, too.

Apical	At or toward the tip
Apothecia	Fruits, especially disc-shaped ones
Calcareous	Made of, or rich in, chalk or limestone, so with an alkaline pH and fizzing in acids
Cilia	Hairs or bristles sticking out from the lichen body; usually, at random angles (if mainly on the underside and downward-pointing, probably referred to as rhizines or rhizinae)
Cortex medulla)	The smooth outer surface of the body of most lichens (cf. the inner part, the
Crustose	Body of a lichen forming a thin crust over its substrate, which may be powdery or solid, thin (like a coat of water-colour paint) or thicker, with a smooth or a rough surface
Eutrophic	Enriched with nutrients, especially nitrates
Foliose	Leafy, the body of the lichen comprising a number of flat or curved leafy structures which either stand up from, or are appressed to, the substrate (q.v.)
Fruits	The structures associated with production of fungal spores by the lichen. They are often flat or convex discs, sometimes with a distinct margin or rim. In some species they are immersed in the surface of the lichen, and open as small pores
Fruticose	Shrubby, the body of the lichen made up of simple or branching structures which either stick up from, or dangle down from, the substrate (q.v.)
Granular	Texture of caster sugar or slightly finer
Isidia	Tiny warty or finger-like outgrowths of the smooth surface of a lichen; under high magnification, the surface of isidia is smooth, formed of the same material, the cortex, as the rest of the lichen surface. This smooth cortex distinguished them from soredia, which are powdery
Lecanorine	A fruit which looks like a jam tart: a flat disc (usually coloured) in the middle, and a rim or margin, usually the colour of the body of the lichen, around the edge
Lecideine	A fruit in which the margin, if present, is the same colour and texture as the disc of the fruit, usually black all over
Leprose	Powdery, and tending to break up
Lirellae	Fruits (apothecia) which are linear or crack-like, usually black and charcoal-like on a pale background
Medulla	The inner part of a lichen, which you see if you scratch the surface. In most species, the medulla is white, and made mainly or entirely of fungal fibres, whereas the outer layer, the cortex, is coloured and has algal cells arranged within it
Perithecia	Fruits, especially those immersed in the body of the lichen and opening as tiny pores in the surface
Placodioid	A lichen which is crustose in the middle but has small lobes around the edges
Podetia	Structures sticking up from the basal part of the lichen, usually hollow and often bearing fruits at their tip when mature, e.g. the cups or antlers of <i>Cladonia</i> , arising from a bed of basal squamules (q.v.)
Pruina	A bloom or frosting of white powder on the surface of a lichen
Rhizines	Root-like hairs on the underside of a lichen lobe; also called rhizinae

Simple	Unbranched
s.l.	<i>sensu lato</i> , in the broad sense, meaning a species which includes two or more very similar species in aggregate. The opposite is s.s.
Soralium	A well-defined patch of fine or coarse powder on the surface of a lichen (plural soralia), a form of vegetative reproduction, cf. isidia
Soredia	The powder or granules which make up soralia
Spores	The microscopic spherical or oval reproductive cells which are released by the fruits of lichens; they are actually the propagules of the fungal partner, and contain no algal component
Squamules	Small leaf-like or scale-like structures, either at the base of structures which stick up, or attached to such structures
s.s.	<i>sensu stricto</i> , in the strict sense, meaning a single narrow species distinguished from others in a group of closely similar species, the segregate out of an aggregate. The opposite is s.l.
Substrate	The material on which a lichen is growing, usually bark, rock or soil, occasionally mosses or other lichens
Thallus	The body of the lichen, usually excluding the fruits

British Lichen Society

Finally, anyone seriously wishing to study lichens should join the dedicated national society. It publishes a renowned international journal, *The Lichenologist*, which still includes some useful papers on identification, and important bibliographies such as *Literature on lichens and air pollution*, and a regular *Bulletin*, which is written in a popular style, includes series such as *New and interesting British lichens*, and *Recent records*.

Enquiries should be addressed to The Secretary, British Lichen Society, c/o The Natural History Museum, Cromwell Road, London SW7 5BD, or via the Society's website: <http://www.argonet.co.uk/users/jmgray/>.

Naming of parts of *Cladonia*



Bed of small squamules



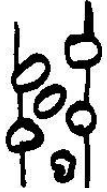
Large squamule



Squamules and podetium



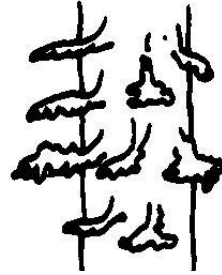
Fine powder



Smooth granules



Rough granules



Squamules



Tapering to base



Short stalked conical



Wine-glass



Tall wine-glass



Narrow cup



Very narrow

Proliferating from margin



Proliferating from middle of cups



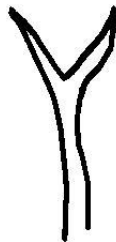
Simple Spike



Simple with groove



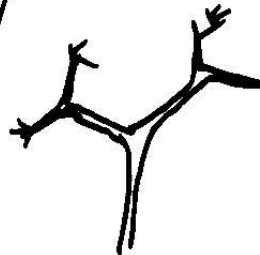
Stout, branched



Slender perforated axil



Widely branched



Branch tips all turned to one side



Checklist of *Cladonia* and other heathland lichens in Beds, Cambs and Northants

Brian Eversham

October 2013

Genus	Species	UK	BCNP	Habitats	Fruits	Cups	Points	Surface
<i>Cladonia</i>	<i>polydactyla</i>	c	o	hwtp	R	Y	Y	f
<i>Cladonia</i>	<i>diversa (coccifera)</i>	c	r	hdp(tw)	R	Y		scg
<i>Cladonia</i>	<i>floerkeana</i>	c	r	hp(td)	R		Y	mg, sq
<i>Cladonia</i>	<i>macilenta</i>	c	fc	tw(hpdr)	R		Y	f-mg
<i>Cladonia</i>	<i>digitata</i>	f-c	vr	thp	R			sq
<i>Cladonia</i>	<i>arbuscula</i>	fc	vr	hpd	N		Y	s
<i>Cladonia</i>	<i>ciliata</i>	O	vr	hpd	N		Y	s
<i>Cladonia</i>	<i>c. ciliata</i>	o-r		hpd	N		Y	s
<i>Cladonia</i>	<i>portentosa (impexa)</i>	C	r	hpd	N		Y	s
<i>Cladonia</i>	<i>uncialis</i>	f-c		hp	N		Y	s
<i>Cladonia</i>	<i>ochrochlora</i>	O	o-r	wt(sh)	B	Y	Y	mg, sq
<i>Cladonia</i>	<i>ramulosa (anomaea)</i>	O	r	swth, thatch	B	Y	Y	smg, sq
<i>Cladonia</i>	<i>cariosa</i>	o	r	hd	B		Y	smg
<i>Cladonia</i>	<i>squamosa</i>	C	o	shpd	B	Y	Y	sq
<i>Cladonia</i>	<i>s. subsquamosa</i>	fc	r	shpd	B	Y	Y	sq
<i>Cladonia</i>	<i>chlorophaea</i>	vc	vc	twshdpr	B	Y		mg
<i>Cladonia</i>	<i>fimbriata</i>	vc	vc	stw(hdpr)	B	Y		f
<i>Cladonia</i>	<i>humilis</i>	f	o-r	sd	B	Y		f, s base
<i>Cladonia</i>	<i>pyxidata</i>	C	c	swtdr	B	Y		cg
<i>Cladonia</i>	<i>cervicornis verticillata</i>	O	r	hp	B	Y		
<i>Cladonia</i>	<i>strepsilis</i>	O	r	ph	N			sq
<i>Cladonia</i>	<i>coniocraea</i>	vc	vc	t(hp)	B		Y	mg, sq
<i>Cladonia</i>	<i>crispata</i>	f	r	hpd	B		Y	s, sq
<i>Cladonia</i>	<i>furcata</i>	f-c	r	hpsd	B		Y	s, sq
<i>Cladonia</i>	<i>glauca</i>	f	r	hptd	B		Y	f, sq
<i>Cladonia</i>	<i>gracilis</i>	f	r	shpd	B		Y	s
<i>Cladonia</i>	<i>rangiformis</i>	f	o	sd calc	B		Y	s
<i>Cladonia</i>	<i>subulata</i>	f-c	o-r	hswpd	B		Y	f
<i>Cladonia</i>	<i>caespiticia</i>	o	vr	s, woods	B			sq
<i>Cladonia</i>	<i>parasitica</i>	o-r	r	t	B			sq
<i>Cetraria</i>	<i>aculeata</i>	f	r	hpr				
<i>Baeomyces</i>	<i>roseus</i>	f	vr	hp	pink			
<i>Baeomyces</i>	<i>rufus</i>	f	vr	hp	B			

Status: c = common, f = frequent, o = occasional, r = rare, v = very

Habitat: main habitats first, less common habitats in brackets

h = heaths, p = peat, d = dunes, s = soil, w = wood (inc fences, rotting wood)

t = trees (live) r = rocks

Fruits: R = red, B = brown, N = none

Surface (texture of podetia): s = smooth, f = fine powder, mg = medium granules,

cg = course granules, sg = smooth granules, sq = squamules

Heathland and grassland lichens: a key to lowland *Cladonia*

Brian Eversham

v.1.6

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Note: some species key out in several places, as they are very variable in their growth form. Basal squamules of species which produce podetia, and very young specimens of most species, may be difficult or impossible to identify. Plants growing in shade or in very damp places often proliferate more, are brighter green, and have more squamules.

Rarely, species usually found growing on trees may survive and grow if they fall onto the ground.

- 1** Podetia (upright hollow structures, pointed or branched or cup-shaped) absent, whole plant consists of basal squamules, which may be leaf-like or scale-like, creeping, overlapping or held upright **2**
- 1a** Podetia present, as erect points, antlers, complex branched structures, or cups. **4**



Cladonia species with squamules only (*C. foliacea*), cups or antlers (*C. fimbriata* and *C. ochrochlora*) and complex branched podetia (*C. portentosa*)

2 THREE CHOICES

- 2a** Squamules rounded, up to 1cm wide, grey-green, rounded, forming loose mats. White fine-powder beneath, orange toward base underneath. K+ yellow, P+ orange.

Cladonia digitata

- 2a** Squamules elongate, up to 1cm long or tall, with deeply incised edges, recurved tips to the lobes, and undersides white or pale yellowish, but not powdery. ***Cladonia foliacea***

- 2c** Squamules smaller, with rounded, crisped or incised edges, usually darker green, often forming patches or carpets. Not white-powdery beneath. **3**

3 THREE CHOICES

- 3a** Squamules 5mm x 2mm, cushion-forming, with incised edges. Fruits often present, pink-brown rather gelatinous blobs on short white stalks, looking rather like tiny mushrooms. K-, P+ red ***Cladonia caespiticia***

- 3b** Tiny squamules with frilly or densely incised edges, often so small as to appear like granules to naked eye. K+ yellow, P+ orange. On trees, logs and stumps.

Cladonia parasitica

- 3c** Variable, but not as above. Squamules often rounded with more or less incised edges. Often growing on soil, more or less flat against the ground.

Immature specimens of *Cladonia* species which produce podetia



Cladonia caespiticia, *C. parastica* and squamules of a species which produces podetia (*C. polydactyla*)

- 4 Red fruits present on tips of podetia branches or round edges of cups 5
- 4a Fruits brown or absent 9



Two red-fruiting species, *Cladonia diversa* and *C. floerkeana*, and a brown-fruiting species, *C. ramulosa*

- 5 Cups present on podetia, either widening gradually from the base, or more rapidly at the top of the stalk. 6
- 5a Podetia not widening into cups, simple or branched spikes or club-shaped 7
- 6 Podetia short and broad. Cups wider than deep, often with large red fruits all around the edges. Usually simple, often rather irregular or lopsided, sometimes with one upper tier. Red fruits often large and joining up. Whole podetia covered in smooth-surfaced rounded granules, and yellowish tinge to the green colour. K-, P- ***Cladonia diversa***
(=*coccifera* s.l.)
- 6a Podetia slender, much taller than wide. Cups narrow, often with smaller cups or points arising from their edges. Fruits small. Surface of podetia covered with fine, flour-like powder, white or greyish. K+ yellow, P+ orange-red ***Cladonia polydactyla***



Two red-fruiting cup-forming *Cladonia*: *C. diversa* (left) and two forms of *C. polydactyla* (centre and right)

7 Surface covered in granules, not fine powder. Often with squamules over much of podetia, which are usually rather stout and blunt. Usually K- P- Illustration p. 14 and below.

Cladonia floerkeana

7a Surface of podetia covered in fine, flour-like powder. Upper parts of podetia usually without squamules, often narrowly tapering. K+ yellow, P+ orange-red **8**

8 Podetia tall and slender, usually simple and unbranched.

Cladonia macilenta

8a Short and/or branched, often dividing into several branches at one point, and often with irregular narrow cups developing on some podetia, each usually with points around its edges. Illustrations p. 14.

Cladonia polydactyla



Two red-fruited antler-shaped *Cladonia* species, *C. floerkeana* (left) and *C. macilenta* (right). For *C. polydactyla*, see page 14.

9 Podetia often clearly growing from a bed of squamules (beware specimens where only podetia have been collected!). Podetia may be cup-shaped, or simple and unbranched, or antler-like or fairly densely branched. Often at least a few squamules present on lower parts of podetia, and surface often powdery or granular in part. **10**

9a Squamules absent. Whole plant repeatedly much-branched from base to tips and 'tree-like'. Tips of podetia slender. Podetia never with any cups, nor with squamules, powder or granules on the surface. **30**



A moderately branched species of *Cladonia*, *C. furcata*, and two much-branched species, *C. ciliata* subsp. *tenuis* and *C. arbuscula*

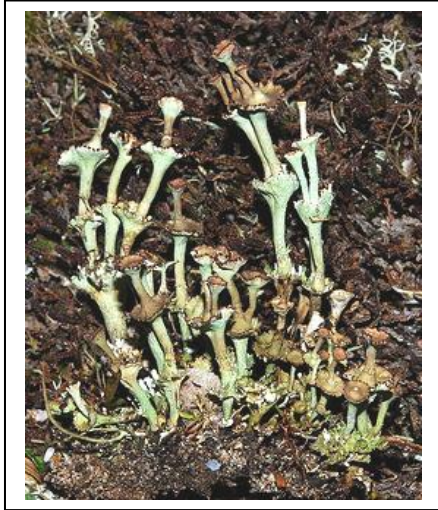
10 Podetia widened toward their tips, forming cups or 'wine-glasses'. **11**

10a Podetia not widened into cups: simple or branched spikes or club-shaped. **20**

- 11** Podetia dark green-brown, neat and regular, with 2-4 tiers of cups, each arising from the middle of the previous layer. Surface smooth, no powder or granules. Up to 5cm tall.

Cladonia cervicornis verticillata

- 11a** Podetia usually pale green- grey or yellowish, often partly powdery or granular. If cups are proliferating, the upper ones arise from margins of lower cups, never from middle. **12**



Cup-forming podetia which proliferate from the middle of each layer, *C. cervicornis verticillata* (left), and from the edges, *C. chlorophaea s.l.*(right)

12 THREE CHOICES

- 12a** Surface of podetia covered in fine, flour-like powder. Upper parts of podetia (cups) usually without squamules. Usually regularly wineglass- or goblet-shaped, often narrowing suddenly into a slender stalk. Cups usually simple, rarely proliferating, though sometimes with little spikes round edges of cups. **13**
- 12b** Surface covered in larger, rough granules, not fine powder. Often with squamules over much of podetia, sometimes on cups too. Cups sometimes irregular, often more or less triangular, tapering more gradually into the slender stalk. Often proliferating, with smaller cups arising form edges of larger ones. **14**
- 12c** Surface of podetia smooth, not powdery or granular, sometimes with a few squamules, and often with a network of white lines, with darker or green raised areas in between, like crazy paving. Cups usually rather narrow, and whole plant often tall and slender. **26**



Cup-shaped podetia with surface powdery (*Cladonia fimbriata*), coarse granules (*C. pyxidata*) and smooth (*C. gracilis*)

13 THREE CHOICES

13a Cups very short, 5-7mm. Tapering to a very short narrow stalk, the basal 1-2 mm of which is smooth (lacking fine powder). ***Cladonia humilis***

13b Cups often taller, up to 15mm, with a longer slender stalk. Cup contracting rapidly into slender stalk, so golf-tee or champagne-goblet shaped. Whole podetia covered in fine powder, right down to the base. Illustrations pp. 4, 13, 16. ***Cladonia fimbriata***

13c Often taller, up to 6cm. Cups usually narrow and with one or more spikes developed on the edge of the cup. Usually some podetia simple or antler-like without cups. **23**

14 Podetia short and broad. Cups wider than deep, often with wide red fruits all around the edges (in field, look around for similar cups with fruits). Usually simple, often rather irregular or lopsided, sometimes with one upper tier. Whole podetia covered in smooth-surfaced rounded granules, and yellowish coloured. Illustrations p. 14. ***Cladonia diversa***

14a Podetia variable in shape, may be tall and slender. Cups variable, often with wine-glass shape (tapering to a slender stalk), or narrowly triangular, and often with 2 or more tiers. Surface of podetia covered with fine, flour-like powder, or coarser granules, often with squamules up the stalk, white or greyish. **15**

15 Squamules present up the podetia, often on outside and round rim of cups. **16**

15a Squamules mainly at base. Cups covered in fine powder or granules, or eroded and whiteish in upper parts. **18**



Cladonia squamosa with squamules over podetia; *C. chlorophaea* with squamules mainly at base

16 Cups wide, much wider than stalk, with a hole in middle, and often with holes or gashes down rest of podetia. Either K- P-, or sometimes K+ yellow, P+ orange (var. *subsquamosa*)

Cladonia squamosa

16a Cups narrow and podetia tall and almost parallel-sided. Cups and podetia with or without holes. K-, P+ red. **17**

17 Podetia up to 4cm tall, unbranched, usually straight and ending in narrow, regular little cups without holes. Podetia finely powdery over much of surface, with a few bare patches and a few scattered squamules. Lowest part with a smooth continuous surface for a few mm at base. Squamules usually rounded, blue-green when dry, brighter green when wet, often with white powdery edges and undersides. Illustration pp. 13, 18. ***Cladonia ochrochlora***

17a Podetia up to 3cm, often branched once or twice, cups often very irregular and lop-sided and with holes. Surface largely eroded and bare, with scattered smooth-surfaced or

flattened granules, not powdery. Squamules usually yellowish-green, long and narrow with cut edges, fragile and easily broken when dry. K-, P+ red. ***Cladonia ramulosa***



Cladonia ochrochlora and two forms of *C. ramulosa*, one with abundant fruits, the other strongly branching

18 THREE CHOICES

18a Cups funnel-shaped, tapering fairly rapidly into fairly slender parallel-sided stalks. Often proliferating from margins. Granules rough-surfaced, medium-size. Podetia 1-2.5cm, occasionally 4cm tall. Illustration p. 17 ***Cladonia chlorophaea s.l.***

18b Cups rather triangular, tapering fairly evenly from top of cup to base. Seldom proliferating. Covered in often-dense, coarse, smooth-surfaced, granules. Podetia 0.5-1.5cm, rarely 3cm tall. **19**

18c Cups very variable, often proliferating irregularly or a mix of cups and antlers, often very irregular and lop-sided. Surface largely eroded and bare, with scattered smooth-surfaced or flattened granules, not powdery. K-, P+ red. Illustration above. ***Cladonia ramulosa***
(If podetia have long slits or gashes up the side, and K+yellow, cf. *Cladonia cariosa*, couplet 24)

19 Basal squamules usually small, separate, sometimes dense, rounded or elongate, often becoming erect. On acid soils and rocks. ***Cladonia pyxidata***
 Basal squamules thick, spreading, joining together and overlapping, radiating toward the edges to form a rosette. On chalk and limestone soils rocks and on mortar.

Cladonia pocillum



Two *Cladonia* with very coarse granules on cups: *C. pyxidata* (left) and *C. pocillum* (right)

20 THREE CHOICES

- 20a** Surface of podetia covered in fine, flour-like powder. Upper parts of podetia usually without squamules and tapering to a sharp-looking point. **21**
- 20b** Surface covered in larger granules, with either a rough or a smooth surface, not fine powder. Often with squamules over much of podetia, which are often less tapered and rather blunt. **24**
- 20c** Surface of podetia smooth, with neither powder nor granules, and often with a network of white lines, with darker or green raised areas in between, like crazy paving. Squamules usually few and mainly near the base. **26**
- 21** Podetia simple and unbranched, or branching into 1-3 simple points near apex. Basal squamules green. Podetia K-. Fruits almost never present. **22**
- 21a** Podetia often branched several times, often with 5 or more points, sometimes widening into small cups. Basal squamules bluish grey-green on upper surface. Podetia K+ yellow. Red fruits developing. Illustration p. 14. ***Cladonia polydactyla***
- 22** On wood. Podetia short (up to 15mm) and simple, often all curving one way, usually squamulose in lower half and tapering in upper half. Podetia usually arising separately at intervals from a bed of dense small squamules. ***Cladonia coniocraea***
- 22a** Usually on heathy soil or peat. Podetia usually taller (2-6cm), with a few squamules at base and a long, often branched, tapering point. Often forming dense stands or thickets of podetia which touch each other. ***Cladonia glauca/subulata*** **23**



Simple or sparsely branched spikes: *Cladonia coniocraea* (left), *C. cariosa* (2nd), *C. subulata* (3rd), *C. glauca* (right)

- 23** Podetia usually with a single longitudinal groove up one side. P-. ***Cladonia glauca***
- 23a** Podetia without a longitudinal groove. P+ orange-red ***Cladonia subulata***
- 24 THREE CHOICES**
- 24a** Podetia with vertical slits or gashes, may look ragged or shredding, or podetia branch then join together. Often with clusters of brown fruits. Podetia with smooth-surfaced granules. K+ yellow. Sandy heaths, dunes. Illustrated above. ***Cladonia cariosa***
- 24b** Podetia sometimes with a few holes at the tips, or where branches have broken off, but not with long slits. Surface of podetia with smooth-surfaced granules, often flattened and looking like paving slabs, and with pale eroded areas. Pale brown fruits often abundant. Illustration above couplet 18. ***Cladonia ramulosa***
- 24c** Podetia sometimes with a few holes at the tips, or where branches have broken off, but not with long slits. Surface with rough granules or abundant squamules. K-.or K+yellow **25**

25 THREE CHOICES

25a Podetia often rather thick, unbranched or branching once or twice, hardly tapering. With coarse and fine rough-surfaced granules and variable cover of squamules. Developing red fruits. On heaths, moors and dunes. Illustration pp. 14, 15. ***Cladonia floerkeana***

25b Usually irregularly branched, either as tapering antlers or widening to form cups. Covered with squamules over most of surface right to apex. K- or K+yellow. On heaths, dunes and rotting wood. Often developing brown fruits. Illustration p. 17. ***Cladonia squamosa***

25c Unbranched or with one or two branches. Mostly covered in fine powder. Rarely fruiting. Almost always on wood. **22**

26 Most branches with a hole in the angle where they split off the main stem. Tips of most podetia with a hole opening to the hollow interior, often surrounded by short spiny branches. P- **27**

26a Axils and tips all or mostly without holes. (Beware damaged podetia - if the end snaps off, it leaves a hole). P+ red or P-. **28**

27 THREE CHOICES

27a Usually tall and slender, up to 5cm, well branched, with 3-4 or more branches from each fork. Tips of podetia open, usually ending in either 3-6 short points radiating like a star round the hole, or in narrow irregular cups with a hole in the middle. Most branches with a hole in the angle. At least a few basal squamules usually present, sometimes on podetia too. Grey-green, brown-grey or olive-green with irregular pale lines. K- KC- P-.

Cladonia crispata* var. *cetrariiformis

27b Often fairly short, 2-4cm, well branched, slender, up to 1mm diameter, mostly forking with only 2 branches at each division. Some branches often with small holes in their angles, but rarely with a star-shape at the tips, and never forming cups. Squamules usually small and confined to base, sometimes very few. Grey-green, brown-grey or olive-green with irregular pale lines. K- or K+ yellow, P+ red ***Cladonia furcata***

27a Pale yellowish green, often mottled with white, K-, KC+ yellowish, P-. Podetia relatively short (usually 1-2cm, up to 4cm), spikey, fairly simple (branched 1-2-3 times, usually as a 2-pronged fork), stout (usually 2-3mm diameter, sometimes wider), and looking rather bloated or swollen, never forming cups. Squamules absent. ***Cladonia uncialis***



Smooth-surfaced, branched *Cladonia*: *C. crispata* (left, from above and side), *C. furcata* (with red fruiting bodies of the moss *Polytrichum piliferum*), *C. uncialis*

28 Branches spreading at a wide angle, often about right-angles. Surface white with neat and regular patches of green. Often forming tangled spiky spreading mats, up to 5cm tall. K+ yellow. Often in grass on chalk or limestone soils. ***Cladonia rangiformis***

- 28a** Branches usually less widely spreading. Often brown-tinged, and not white with regular green patches (though often mottled green and white). Usually K-. Often more upright and with parallel stems. May be on acid soils, growing directly on soil or among mosses. **29**



Cladonia rangiformis (left) and *C. subrangiformis* (right)

29 THREE CHOICES

- 29a** Podetia short and rather stout, mostly lying down, twisted and curved. Olive or dark brown, with a few raised white circular patches erupting from lower surface and basal parts. Often little-branches, and with most branches at about right-angles to main stem. with short, spine-like final branchlets. K- or K+ pale yellow, P+red. In short calcareous turf in grassland, often just a few scattered podetia. Illustration p. 20. ***Cladonia subrangiformis***
- 29b** Podetia tufted and mostly upright, 2-4cm, with branches regularly forking in pairs, at an acute angle. Some branches often with a small opening in the axil. Often with scattered peeling squamules. K- or rarely K+ yellow, P+orange-red. On acid heaths, bogs, dunes, and acid soils in woods. Illustrations pp. 15, 20. ***Cladonia furcata***
- 29c** Usually taller, up to 6cm, more upright, slender and less branched. Axils never perforate. Podetia often end in narrow cups with smooth insides and a few spines around their edges. Few squamules. Often olive-brown or bronzed. K- P-. Acid soils on heaths, in woods, sometimes on rotting logs etc. ***Cladonia gracilis***



Cladonia gracilis (two forms, left and middle), and *Cetraria* (=Coelocaulon) *aculeata* (right)

- 30** Whole lichen deep rich brown, its surface smooth and slightly glossy. Main stems often flattened, solid or with a small hollow in the middle. Often with tiny bristles or short spines on the surface of the branches. Twisted and matted highly branched structures lying over moss or heathy/peaty soils. Illustration above. ***Cetraria (=Coelocaulon) aculeata***
- 30a** Whole lichen grey or white, often with a bluish, yellowish or greenish tinge, sometimes brown at the tips. Matt finish, not glossy. Stems hollow, with the wall much thinner than the hole in the middle. No bristles or short spines on surface of branches. Usually growing upright from a base at soil level, and either simply forked or tree-like (beware broken and trampled specimens) **31**

31 THREE CHOICES

- 31a** Podetia brown-tinged or olive-green, tall (up to 6cm), slender and branched only a few times, often with open axils and sometimes ending in narrow cups. A few squamules usually present (look carefully!). Often producing brown fruits. **Back to 26**
- 31b** Podetia short (usually 1-2cm, up to 5cm), fairly simple (branched 1-3 times, usually as 2-pronged fork, with holes in the axils), stout (about 3mm thick), looking swollen. Yellowish green, often mottled with white. Squamules absent. Fruits very rare. Illustration p. 20. ***Cladonia uncialis***
- 31c** Often even taller (up to 15cm), repeatedly and finely branched. Pale, often greyish or yellowish white. Squamules and fruits absent. **32**
- 32** Tips of branches pointing in all directions, their final divisions being mostly 2-branched. Whole plant seems to form loose 'heads'. Greyish white. ***Cladonia portentosa***
- 32a** Tips of branches mostly curved over in one direction, looking as if blown by the wind, sometimes lining up neatly like a comb. Final divisions 2- 3- or 4-branched. Greyish or yellowish, sometimes tinged purplish. **33**
- 33** Tips mostly 3-4 branched, and whole branches bending in direction which tips face. Rather stout main stems. Green-grey-white, usually with a yellowish tinge. ***Cladonia arbuscula***
- 33a** Tips mostly 2-forked. Main branches more or less vertical, and only fine tips curve in one direction. Whole plant often rather slender. **34**
- 34** Whole lichen greyish-white, with no green or yellow tinge, often tinged purplish at tips. ***Cladonia ciliata var. ciliata***
- 34a** Whole lichen greenish-grey to yellowish-white. ***Cladonia ciliata var. tenuis***



Finely branched *Cladonia* species:
C. portentosa (top left)
C. arbuscula (above)
C. ciliata (left)

Not to be confused with moderately branched species such as *C. furcata* (below left) and *C. rangiformis* (below) which usually have at least a few squamules.



A draft key to *Cladonia* squamules on soil at Cooper's Hill, Bedfordshire

Brian Eversham

v.1.0

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Most lichenologists regard *Cladonia* as a difficult genus, because most species are quite variable, their shape changing as they grow, and being affected by degree of shading, moisture etc. Their structure is also more complicated than in most lichens, because most species start growing as a bed of squamules, from which gradually develop podetia. Published keys all rely on the structure of the podetia, and often use the colour of the fruits too. Hence on many surveys, in the absence of well developed podetia, '*Cladonia* squamules' is recorded, rather despondently.

Prompted by heathland restoration experiments at Cooper's Hill nature reserve, where identifying colonising species would be useful, I've attempted to produce a key to squamules. As you will see, many of the characters used are rather vague and comparative, and quite a few groups of species cannot currently be separated. However, I think the exercise is useful, if only to show that there are some useful identification features in the squamules. At some point I'll try producing illustrations, but the subtle shades of green are probably beyond the available colour printer.

Note that this key was written with the species-list of Cooper's Hill in mind, and that in other parts of Britain, additional species will be found.

- | | | |
|-----------|--|-----------------------------|
| 1 | Undersides K+ yellow on white parts | 2 |
| 1a | Undersides K- | 4 |
| 2 | Undersides K+yellow turning orange. Squamules to 2mm, indented, forming compact masses. Not orange-brown at base. <i>C. squamosa</i> subsp. <i>subsquamosa</i> | |
| 2a | Undersides K+yellow, not turning orange. Squamules often scattered, deeply incised. Often orange-brown, K+ purple, at base. | 3 |
| 3a | Squamules blue-grey, incised, elongate. | <i>Cladonia macilenta</i> |
| 3b | Squamules grey-white, often shorter, incised. | <i>Cladonia polydactyla</i> |
| 3c | Squamules pale green, sometimes with white powder on upper surface, elongate, forming cushions when young, | <i>Cladonia cariosa</i> |
| 4 | Squamules orange-brown, K+ purple, at base underneath. | 5 |
| 4a | Squamules entirely white underneath, K-. | 6 |
| 5 | Squamules yellow-grey or yellow-green, to 2mm, rounded, sparingly indented. | <i>Cladonia diversa</i> |
| 5a | Squamules grey-green, inconspicuous. | <i>Cladonia floerkeana</i> |
| 6 | Squamules large, 3-5mm or larger | 7 |
| 6a | Squamules small, usually 1-2mm | 9 |
| 7 | Squamules elongate, up to 10mm, with upturned ends, bright yellow-green, underside white or yellowish. | <i>Cladonia foliacea</i> |
| 7a | Squamules 3-5mm, more rounded, not yellow-green. | 8 |

- 8 THREE CHOICES**
- 8a** Squamules commonly 5mm, grey to bright green-grey, white underneath, rounded, sparingly incised, often forming carpets. *Cladonia humilis*
- 8b** Squamules 2-3 (-5)mm, neatly rounded, with rounded-indent ed edges, usually abundant, deep green, olive or even brownish, often greyish underneath. *Cladonia cervicornis verticillata*
- 8c** Squamules 2-3mm, rounded, scattered, bright emerald green or slightly brownish, white underneath. *Cladonia furcata*
- 9** Squamules yellow-green or yellow-grey, pale. **10**
- 9a** Squamules grey-green or brown-green, not strikingly pale. **11**
- 10** Squamules rounded or sparingly indented, often orange-brown near base underneath. *Cladonia diversa*
- 10a** Squamules elongate, indented, tufted, fragile, white throughout underneath. *Cladonia ramulosa*
- 11** Squamules distinctly brownish **12**
- 11a** Squamules green or grey-green, never brownish **14**
- 12** Squamules 2-3 (-5)mm, neatly rounded, with rounded-indent ed edges, usually abundant, deep green, olive or even brownish, often greyish underneath. *Cladonia cervicornis verticillata*
- 12a** Squamules usually smaller, sometimes scattered, often more elongate, more deeply or irregularly incised. **17**
- 13** Squamules scattered, rounded. *Cladonia furcata / pyxidata*
- 13a** Squamules often clumped, elongate. *Cladonia crispata/gracilis/subulata*
- 14** Squamules rounded or elongate, without deep indentations. **15**
- 14a** Squamules deeply indented or incised or with finger-like lobes. **16**
- 15** Squamules 2-3 (-5)mm, neatly rounded, with rounded-indent ed edges, usually abundant, deep green, olive or even brownish, often greyish underneath. *Cladonia cervicornis verticillata*
- 15a** Squamules usually smaller, sometimes scattered, often more elongate, *Cladonia furcata / pyxidata*
- 16** Squamules indented, scattered, inconspicuous, often brown-tinged. *Cladonia crispata/gracilis*
- 16a** Squamules of various shapes, usually forming a continuous carpet. **17**
- 17 THREE CHOICES**
- 17a** Squamules elongate and incised. *Cladonia fimbriata/glauca/subulata*
- 17b** Squamules more rounded, more or less incised, forming a thin carpet. *Cladonia chlorophaea/floerkeana*
- 17c** Squamules indented, forming compact mats or cushions. *Cladonia squamosa*

