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THE BRYOPHYTES AND LICHENS OF CALCAREOUS SOIL¹

BY W. WATSON.

It is well known that some flowering plants are characteristic of calcareous soils whilst others are absent or extremely rare. The cryptogamic vegetation is similarly affected by the presence or absence of calcium carbonate. In the Oolitic districts of East Somerset, where the foxglove is absent, calcifuge mosses such as *Polytricha*, *Campylopi* and *Sphagna* do not occur, and the same phenomenon is shown in other calcareous tracts. A striking example of the effect of lime on vegetation is shown at Bugsworth in Derbyshire. The soil is siliceous, but is well limed owing to the transport of lime, by means of a narrow gauge railway, from Doveholes. In the vicinity of the railway, and especially where unloading for transport to the main line occurs, calciphilous bryophytes and other plants are abundant.

Many bryophytes and lichens are absent or very rare in calcareous districts. Some of the most pronounced and commonest calcifuge species are:

<i>Sphagnum</i> spp.	<i>Hypnum</i> fluitans	<i>Parmelia</i> saxatilis
<i>Polytrichum</i> spp.	<i>H.</i> exannulatum	<i>P.</i> physodes
<i>Dichodontium</i> pellucidum	<i>H.</i> revolvens	<i>P.</i> omphalodes
<i>Dicranella</i> heteromalla	<i>Aneura</i> multifida	<i>P.</i> sulcata
<i>D.</i> cerviculata	<i>Pellia</i> epiphylla	<i>Lecanora</i> parella
<i>D.</i> squarrosa	<i>Alicularia</i> scalaris	<i>L.</i> polytropa
<i>Campylopus</i> spp.	<i>Gymnocolea</i> inflata	<i>Pertusaria</i> dealbata
<i>Leucobryum</i> glaucum	<i>Leptoscyphus</i> anomalus	<i>Stereocaulon</i> spp.
<i>Rhacomitrium</i> spp.	<i>Cephaloziella</i> byssacea	<i>Lecidea</i> contigua
<i>Hedwigia</i> ciliata	<i>Lepidozia</i> setacea	<i>L.</i> crustulata
<i>Orthotrichum</i> rupestre	<i>L.</i> reptans	<i>L.</i> granulosa
<i>Aulacomnium</i> palustre	<i>Scapania</i> undulata	<i>L.</i> uliginosa
<i>Pterygophyllum</i> lucens	<i>S.</i> dentata	<i>Rhizocarpon</i> geographicum
<i>Hycomium</i> flagellare	<i>Sphaerophorus</i> spp.	<i>R.</i> confervoides

A few of these may be found on limestone heath where the top layer of soil is free from lime, or they may extend from a siliceous to a neighbouring calcareous substratum, but a full examination of such exceptions does not contradict but rather emphasise their calcifuge character. On "mixed" walls made up of both siliceous and calcareous stones, near the boundary between siliceous and calcareous outcrops, or when flint or an eruptive rock occurs in limestone, such exceptions may occur, but it is more usual to find that the calciphilous plant has invaded the siliceous substratum.

¹ Part of a thesis accepted for the degree of D.Sc. at the University of London.

There are many "indifferent" plants of all groups which are abundant both on calcareous and siliceous substrata. The following bryophytes and lichens may fairly be considered "indifferent":

Mosses :

Grimmia apocarpa	Catharina undulata	Plagiothecium silvaticum
Tortula muralis	Mnium undulatum	P. denticulatum
Fissidens bryoides	Neckera complanata	Amblystegium serpens
Bryum capillare	Porotrichum alopecurum	Hypnum riparium
B. caespiticium	Brachythecium rutabulum	H. cupressiforme
B. pallens	Eurhynchium praelongum	Hylocomium triquetrum
Thuidium tamariscinum	E. striatum	H. squarrosum
Dicranum scoparium		

Liverworts :

Plagiochila asplenoides	Aplozia riparia	Scapania nemorosa
Lophocolea cuspidata	Calypogeia fissa	Lejeunea cavifolia
Cephalozia bicuspidata		

Lichens :

Peltigera canina	Urceolaria scruposa	Buellia canescens
P. polydactyla	Cladonia pyxidata	Verrucaria muralis
Lecanora campestris	C. furcata	Dermatocarpon miniatum

Other common bryophytes and lichens which are almost "indifferent" but show a slight preference for limestone districts are:

Grimmia pulvinata	Anomodon viticulosus	Leptogium lacerum
G. apocarpa	Camptothecium sericeum	L. pulvinatum
Tortula ruralis	Eurhynchium rusciforme	L. scotinum
Bryum inclinatum	E. swartzii	L. tenuissimum
B. pendulum	Aneura pinguis	Dermatocarpon lachneum
Fontinalis antipyretica	Madotheca platyphylla	D. hepaticum

There are many plants which are never found except on calcareous rocks and soils and many others which show a decided preference for such habitats. These calcicole species are indicated in the following lists by an asterisk.

Many plants which are usually given as showing a preference for calcareous soil are probably calcicole species in a stricter sense than is generally understood. In many instances departures from their calcicolous character have been shown by a detailed study to be more apparent than real, and probably other ecological unconformities would yield similar results after fuller investigations.

In the Millstone Grit districts of the Pennines *Barbula tophacea* and *Encalypta streptocarpa* grow together on siliceous walls but only on damp mortared walls. When dry walling (i.e. building walls without the use of mortar) is practised in the same district one searches such walls in vain for either of these mosses.

Tortula ambigua and *T. aloides* usually occur in calciferous soil but are often present on Triassic sandstone of mortared walls in Somerset.

When limestone is sufficiently near to siliceous rock, the latter is often invaded by calcicolous species, a sufficient quantity of lime being imported by wind or water to enable them to exist, though often in a depauperate condition. On the boundaries between limestone and sandstone outcrops, as on Rushup Edge in Derbyshire, calcicolous plants such as *Encalypta streptocarpa* and *Collema multifidum* (= *C. melaenum*) occasionally occur on the sandstone. On flint and chert *Verrucaria integra*, *V. glaucina*, *V. nigrescens*, *Pannularia nigra* and other lichens occasionally spread from the surrounding calcareous rock. Where an eruptive rock occurs in limestone invasions from calcareous to siliceous rock or *vice versa* may sometimes occur, but mistakes in recording the habitat are more likely. Such an intermixture of rock occurs near the Sychnant brook on the Minera mountain of Denbighshire, and the notes made during my first examination of its bryophytic flora required careful revision later on when it was realised how deceitfully the rocks were intermixed. Similar care has to be taken in some parts of Derbyshire where toadstone occurs.

Weisia tenuis probably has a much more decided preference for lime-containing rocks than is generally thought. On a sandstone at Tinkerborough near Stafford I found it growing abundantly. On the same sandstone, *Barbula tophacea*, *Pellia fabbroniana*, *Amblystegium filicinum*, *A. serpens*, *Bryum capillare*, *Brachythecium rutabulum*, *Webera albicans*, *Tortula muralis* and *Barbula fallax* were present. The first three bryophytes are calciphilous and on testing the sandstone with weak acid a decided effervescence indicated the presence of carbonate of lime. Many sandstones on which this moss grows are distinctly calciferous and an ecologist requires some weak acid in his field equipment. Another calcicolous plant which is not uncommon in such a habitat is the crustaceous lichen, *Pannularia nigra*.

The occurrence of *Lophozia turbinata* and *Barbula cylindrica* by road-side ditches has, in several instances, been traced to the use of limestone for road-mending. In some other cases of deviation by these two plants from their normal calcareous habitat, the deviation could not be shown to be an apparent one.

The aberrant occurrence of some calcicole bryophytes on siliceous grassland may sometimes be traced to the frequent liming of the land.

Many calcicole plants occur on sand-dunes, but since comminuted shells are present there is sufficient lime for their requirements.

The lichens of calcareous walls are often very noticeable and characteristic and this is especially true for crustaceous lichens. On "dry" walls built up with both calcareous and siliceous stones some species may be erratic but usually the components of the wall are well differentiated by their drappings of lichens. Near Mam Tor in Derbyshire such a wall occurs. The siliceous stones are well marked by the presence of *Parmelia saxatilis*, *P. sulcata*, *P. physodes*, *Lecanora polytropa* and *Lecidea contigua*, whilst the limestone is clothed with

Placodium aurantium var. *plicatum* (= *Lecanora sympagea* of Crombie's Monograph), *Verrucaria calciseda*, *V. nigrescens*, *Thelidium immersum*, *Collema multifidum*, *Xanthoria parietina*, *Physcia caesia*, *Lecanora galactina* and *Aspicilia calcarea*.

The factors influencing the distribution of the higher plants are both chemical and physical and there is some doubt as to the relative importance of these factors. In regard to many bryophytes and lichens there seems little room to doubt that the chemical factor is much more important. Lichens with deeply-immersed reproductive bodies always occur on some form of limestone since siliceous rocks are less able to be attacked by an acid excretion. Many calcicole bryophytes and lichens are indifferent to the physical character of the substratum, they will grow on almost any rock or soil if calcium carbonate is present. *Hypnum molluscum* is a striking example of this indifference. It occurs most abundantly on damp and somewhat shady limestone soil, but also occurs on sandy, marly, or clayey soil, on calciferous sandstone and sand-dunes, or on igneous or metamorphic rocks and their products of decomposition. It occurs on Precambrian, Cambrian, Silurian, Devonian, Carboniferous, Permian, White Lias, Jurassic and Cretaceous lime-containing rocks or soil. In all cases which I have fully investigated the substratum has had lime contents. The only habitat in which I have found this moss and have been unable to prove the presence of lime is by some mountain streams, and even then its association with other bryophytes which are usually calciphilous renders the presence of lime probable. *Ditrichum flexicaule* and *Trichostomum tortuosum* have a similar varied habitat, and detailed examination of the substratum similarly reveals the presence of lime. In any case too much importance must not be attached to the exceptional occurrence of calciphilous bryophytes on a lime-free soil or rock.

The Chalk.

The Chalk has not been sufficiently studied to give a detailed account of its cryptogamic flora. General examination indicates that the difference between the distribution of the bryophytes and lichens on the older limestones and on the Chalk are slight, and that ecological classification would follow similar lines. The shade due to the close leafy canopy in the beechwood causes considerable differences between its ground flora and that of the ashwood. In the deepest shade the only plants present may be such saprophytic fungi as *Marasmius peronatus*, *Collybia dryophila*, *Boletus felleus*, *Cantharellus cibarius* and *Mycena pura*. In more open places and especially when rocks are abundant, the bryophytes and lichens are similar, particularly if places with similar light intensities are compared. A few calcicole species are seldom found except on chalk, the only frequent one being *Seligeria calcarea*. *S. paucifolia*, *Thuidium hystricosum*, *Weisia sterilis*, *Dicranum bonjeani* var. *calcareum*, *Cephaloziella baumgartneri*, *Lecidea obsoleta*, *Thelidium microcarpum*, *T. sparsulum* and *Polyblastia schraderi* are rare and mostly local plants.

The Older Limestones.

The ashwood association is characteristic of the Carboniferous limestone, and this has been particularly examined on the Mendip and in less detail in Derbyshire, Flintshire, Denbighshire, Wye Valley (with a Beechwood association) and Wharfedale. Limestones of other formations which have been studied include the Devonian limestone of S. Devon and small patches in W. Somerset, the Woolhope limestone, the Dolomitic Conglomerate flanking the Mendip, the Magnesian limestone of Yorkshire, the White Lias near Taunton, and the Jurassic limestones of E. Somerset.

The ground flora of the actual wood contains such bryophytes as

Hypnum molluscum * sd	Porotrichum alopecurum a	F. incurvus o
H. cupressiforme a	Mnium undulatum a	F. decipiens * f
var. elatum * o	M. cuspidatum a	Ditrichum flexicaule * f
H. chrysophyllum * o	M. rostratum * a	Dicranum scoparium a
H. hispidulum var. sommerfeltii * o	M. affine a	D. majus o
	M. stellare o	Catharinea undulata a
Hylocomium triquetrum a	M. hornum a	Metzgeria furcata (usually on trees) a
H. squarrosum o	Bryum capillare a	Lophozia turbinata * f
Amblystegium serpens o	Encalypta streptocarpa * f	Plagiochila asplenioides and var. major a
Eurhynchium striatum a	Barbula fallax a	Chiloscyphus pallescens o
E. tenellum * f	B. cylindrica * a	Lophocolea cuspidata a
E. praelongum a	B. unguiculata o	L. bidentata o
E. crassinervium f	B. rubella o	Cephalozia bicuspidata a
E. confertum o	Trichostomum crispulum * o	Calypogeia fissa o
Plagiothecium denticulatum a	T. tortuosum * o	Scapania aspera * a
P. silvaticum a	Tortula subulata o	S. nemorosa o
Brachythecium rutabulum a	T. ambigua * f	Madotheca platyphylla f
B. velutinum o	Weisia crispa * o	Marchesinia mackaii * f
Thuidium tamariscinum a	Fissidens viridulus o	Lejeunea cavifolia o
Neckera complanata a	F. taxifolius o	
Camptothecium sericeum o	F. bryoides o	
Anomodon viticulosus a		

Lichens are not abundant in the well-shaded portions of the wood but the following occur on the shaded rocks and ground: *Collema auriculatum* * o, *C. granosum* * o, *C. pulposum* f, *C. ceranoides* * o, *Leptogium pusillum* o, *L. lacerum* o, *L. scotinum* o, *Stictina fuliginosa* o, *Peltigera canina* f, *P. polydactyla* o, *P. horizontalis* o.

The arboreal cryptogams are not included in the above list, nor in the following lists. Their abundance and diversity are influenced chiefly by the humidity and purity of the atmosphere.

In the wet or moist places of the wood the calciphilous plants *Amblystegium filicinum*, *Hypnum commutatum*, *Eurhynchium teesdalei*, *Orthotrichum rivulare*, *Barbula cylindrica*, *Weisia rupestris*, *W. verticillata*, *Pellia fabbroniana*, *Preissia quadrata*, *Lophozia turbinata*, together with the "indifferent" plants *Hypnum riparium*, *H. cuspidatum*, *Brachythecium rivulare*, *B. plumosum*, *Eurhynchium*

* = calcicole.

rusciforme, *Porotrichum alopecurum*, *Mnium punctatum*, *Fontinalis anti-pyretica*, *Aplozia riparia*, *Chiloscyphus polyanthus*, *Conocephalum conicum* and *Cephalozia bicuspidata*, are usually frequent.

Ash Scrub. In drier parts of the ash wood, in what is better described as ash scrub, and on more or less shaded limestone cliffs and screes, the bryophytes and lichens are similar and consist of such plants as:

Hypnum molluscum * a	Dicranum scoparium a	C. plicatile * o
H. cupressiforme a	Seligeria pusilla * lf	Peltigera polydactyla f
Eurhynchium circinatum * la	Fissidens decipiens * f	P. rufescens f
E. striatulum * o	Weisia tenuis * o	P. canina f
E. swartzii f	W. calcarea * o	Solorina saccata * f
Camptothecium sericeum a	W. crispata * o	Squamaria crassa * f
C. lutescens * o	W. tortilis * o	Placodium aurantium and
Neckera crispa * a	W. microstoma o	var. plicatum * f
Mnium rostratum * f	Zygodon stirtoni o	P. cirrochroum * o
M. stellare o	Z. viridissimus o	P. granulosum * r
M. undulatum f	Targionia hypophylla * o	Callophisma ochraceum * o
Thuidium philiberti * f	Reboulia hemisphaerica * o	C. tetrastichum * o
T. tamariscinum f	Aneura pinguis and var. den-	C. irrubatum * f
Anomodon viticulosus a	ticulata o	C. calvum * f
A. longifolium * l	Metzgeria pubescens * lf	C. erythrellum o
Bryum provinciale * lf	M. furcata (usually on trees) o	Leproplaca xantholyta * lf
B. capillare a	Lophozia turbinata * o	Diphrotora candicans * f
Pleurochaete squarrosa o	L. badensis * o	Candelaria vitellina o
Trichostomum tortuosum * a	Pedinophyllum interruptum	Pyrenodesmia variabilis * o
T. crispulum * a	* r	P. chalybaea * o
T. nitidum * f	Plagiochila asplenoides a	Lecanora galactina * a
T. mutabile * f	var. humilis f	L. campestris a
Orthotrichum anomalum	Lophocolea cuspidata a	Rinodina bischoffi var. im-
var. saxatile * f	Scapania aspera * a	mersa * r
O. cupulatum * o	Madotheca platyphylla a	Aspicilia calcarea * a
O. diaphanum o	Cololejeunea calcarea * o	A. prevostii * lf
Funaria calcarea * f	C. rossettiana * r	Urceolaria gypsacea * lf
Encalypta vulgaris * a	Frullania dilatata and F. ta-	U. scruposa o
E. streptocarpa * f	marisci (usually on trees) o	U. bryophila o
Barbula fallax a	Cladonia pyxidata and var.	Gyalecta exanthematica * f
B. rigidula * o	pocillum o	G. cupularis * f
B. sinuosa * o	Pannularia nigra * o	Lecidea lurida * a
B. revoluta * a	Synalissa symphorea * r	L. decipiens * o
B. rubella f	Collema auriculatum * f	L. testacea * l
Tortula intermedia * a	C. granosum * f	L. immersa * a
T. ruralis f	C. furvum * f	L. metzleri * l
T. muralis a	C. tenax and C. crispum f	Biatorina coeruleonigricans
T. aloides * f	C. pulposum f	* a
T. ambigua * f	C. granuliferum * a	B. candida * lf
Grimmia apocarpa a	C. multifidum * a	B. lenticularis f
G. pulvinata a	C. multipartitum * r	Buellia canescens f
G. orbicularis * o	Collemodium schraderi * f	Bilimbia aromatica * a
Ditrichum flexicaule * f	C. turgidum f	B. sabuletorum f

Dermatocarpon miniatum, and var. complicatum o	Verrucaria nigrescens * a	Thelidium immersum * f
D. hepaticum o	V. coerulea * o	Staurothele ebborensis * l
D. lachneum o	V. rupestris * o	Acrocordia epipolaea * f
	V. calciseda * a	

Exposed Limestone Rocks.

On exposed rocks and on calcareous walls the bryophytes and lichens are very characteristic and prominent constituents of the vegetation. Most of the species of the following list are found on limestone walls.

Grimmia apocarpa a	O. cupulatum * o	P. virella f
G. pulvinata a	Bryum pendulum f	Squamaria saxicola a
G. orbicularis * o	B. capillare a	Placodium murorum, form pulvinatum * a
Weisia viridula o	B. inclinatum a	P. aurantium * f
Trichostomum crispulum * o	B. murale * f	var. plicatum * a
T. nitidum * o	B. caespiticium f	Callopsisma citrinum * a
Encalypta vulgaris * f	Camptothecium sericeum sd	C. irrubatum * f
E. streptocarpa * f	Hypnum hispidulum, var. sommerfeltii * o	C. calvum * f
Tortula muralis a	Madotheca platyphylla o	Diphtratora candicans * f
var. rupestris * f	Plagiochila asplenioides, vars. minor and humilis r	Candelaria vitellina f
T. aloides * f	Pannularia nigra * a	Lecanora galactina * a
T. ambigua * o	C. furvum * o	L. crenulata * f
T. ruralis a	C. pulposum f	L. campestris a
T. intermedia * f	C. cheileum * a	Lecania erysibe f
Barbula rigidula * o	C. granuliferum * f	Aspicilia calcarea * a
B. fallax a	C. multifidum * f	Acarospora pruinosa * a
B. hornschuchiana f	C. polycarpon * o	Lecidea immersa * f
B. sinuosa * o	Collemodium turgidum f	L. ochracea * o
B. revoluta * a	Leptogium pulvinatum a	L. fuscobubens o
B. convoluta o	Xanthoria parietina a	L. sympathetica f
B. lurida * o	Physcia tenella a	Bilimbia aromatica * f
Orthotrichum anomalum, var. saxatile * a	P. caesia a	B. sabuletorum f
O. diaphanum f		Buellia canescens f

Limestone Grassland Association.

In the actual grassland few bryophytes or lichens occur but they become more frequent in moist or wet parts, and when the surface is rocky they become abundant. On "calcareous heath" they are often very abundant, but consist of plants which are indifferent to lime conditions or may even be calcifuge. Sphagna, Polytricha, Campylopi, Dicrana, Rhacomitria, Dicranellae, Plagiothecia, Diplophylla, Lophozia, Lepidozia and other plants which may be abundant on such heaths are rarely found in calcareous districts. If present, their rhizoids do not penetrate to the calcareous substratum, and the plants really live on non-calcareous soil.

The commonest mosses on dry calcareous pasture (e.g. Brean Down (Carboniferous limestone), slopes of Castleton, are (*after the name indicates that the species shows a preference for a calcareous substratum):—*Fissidens decipiens* * (form of grassy ground), *Dicranum scoparium*, *Barbula fallax*,

Weisia crispata *, *Ceratodon purpureus*, *Trichostomum crispulum* *, *Bryum capillare*. *Camptothecium lutescens* *, *Brachythecium rutabulum*, *B. glareosum* *, *Eurhynchium swartzii*, *F. pumilum*, *Hypnum molluscum* *, *H. cupressiforme*, *Hylocomium squarrosum*. Where the ground becomes more stony *Ditrichum flexicaule* *, *Funaria calcarea* *, *Encalypta vulgaris* *, *E. streptocarpa* *, *Tortula ambigua* *, *T. aloides* *, *Bryum caespiticium*, *Neckera crispa* *, *Anomodon viticulosus*, *Camptothecium sericeum* *, *Hypnum chrysophyllum* *, *H. hispidulum* var. *sommerfeltii* *, occur, but all these are more frequent on the actual rock or its soil-cap.

Other plants which are frequent in damper places are *Barbula cylindrica* *, *Webera albicans*, *Bryum pallens*, *Thuidium recognitum* *, *T. philiberti* *, *Hypnum cuspidatum*.

Some calcicole plants of limestone grassland such as *Weisia tortilis* and *Cylindrothecium concinnum* are less frequent or local in distribution.

Polytricha, Rhacomitria, Dicrana, Dicranellae, Mnia, Weberae and Plagiothecia are commoner on siliceous grassland, but *Dicranum scoparium*, *Mnium stellare*, *M. hornum*, *Plagiothecium denticulatum* and *P. undulatum* have been met with in abundance on some Carboniferous limestone pasture (Castleton). The hepatics of grassland are not abundant. *Lophocolea cuspidata*, *L. bidentata* and *Plagiochila asplenoides* are the liverworts most frequently found, and show little preference for calcareous or siliceous soil.

Lichens are occasionally found, usually on bare places but sometimes amongst short grass, *Cladonia sylvatica* and *C. furcata* often being plentiful on wind-swept summits. The following lichens are occasional members of this association: *Collema pulposum*, *C. crispum*, *Collemodium turgidum*, *Leptogium tenuissimum*, *L. lacerum*, *Peltigera canina*, *P. rufescens*, *P. polydactyla*, *Cladonia pungens*, *C. furcata*, *C. sylvatica*. None of these, with the probable exception of the Collemaceous plants, can be considered as calcicolous plants.

Association of Limestone Pavements.

A limestone pavement near Bwlch Gwyn in Denbighshire is an excellent example, and has been particularly studied in compiling the following list of bryophytes and lichens.

<i>Seligeria calcarea</i> * f	<i>Fissidens decipiens</i> * f
<i>S. pusilla</i> f	<i>Tortula intermedia</i> * a
<i>Trichostomum crispulum</i> * a	<i>T. muralis</i> a
var. <i>nigroviride</i> * f	var. <i>rupestris</i> f
<i>Ditrichum flexicaule</i> * a	<i>Barbula lurida</i> * a
var. <i>densum</i> * f	<i>B. rigidula</i> * a
<i>Dicranoweisia cirrata</i> o	<i>B. cylindrica</i> * f
<i>Grimmia apocarpa</i> a (in dry places the apical portion of the leaf has little chlorophyll)	<i>B. fallax</i> f
<i>G. pulvinata</i> a	<i>B. tophacea</i> * o
	<i>B. hornschurchiana</i> o
	<i>B. revoluta</i> * o

- Trichostomum tortuosum * a
 T. mutabile v. cophocarpum * o
 Weisia calcarea * o
 W. verticillata * o (moist)
 W. tortilis * o
 W. tenuis * o
 Zygodon mougeotii o
 Bartramia pomiformis o
 Encalypta streptocarpa * a
 E. vulgaris * o
 Funaria calcarea * o
 Orthotrichum anomalum v. saxatile * a
 Bryum capillare a
 var. ferchelii * f
 var. rosulatum o
 Mnium stellare o
 M. rostratum * a
 Orthothecium intricatum o
 Neckera complanata o
 N. crispa * a
 var. falcata * a (drier places)
 Camptothecium lutescens * o
 C. sericeum f
 Brachythecium velutinum o
 Amblystegium serpens o
 A. filicinum * (moist places) o
 Hypnum hispidulum var. sommerfeltii * o
 H. cupressiforme f
 var. tectorum f
 H. molluscum * a
 Targionia hypophylla * o
 Conocephalum conicum (moist places) o
 Reboulia hemisphaerica * o
 Aneura pinguis o
 Riccia lescuriana o (in hollows where
 water stands)
 Pellia fabbroniana * (moist places) o
 Metzgeria pubescens * l
 Lophozia badensis * o
 L. turbinata o
 L. ventricosa r
 Plagiochila asplenioides o
 Pedinophyllum interruptum * l
 Diplophyllum albicans r
 Scapania aspera * f
 Madotheca platyphylla o
 Frullania tamarisci f
 Collema granuliferum * f
 C. flaccidum * o
 C. multifidum * f
 C. auriculatum * o
 C. furvum * o
 C. crispum o
 C. pulposum f
 Leptogium lacerum f
 L. pulvinatum f
 Synalissa symphorea * r
 S. intricata r
 Solorina saecata * f
 Pannularia nigra * a
 Peltigera canina f
 Xanthoria parietina a
 Squamaria crassa * f
 Placodium aurantium * f
 var. plicatum * f
 P. murorum, form pulvinatum * o
 Diphratora candicans * f
 Lecanora campestris * a
 L. galactina * f
 Aspicilia calcarea * a
 A. prevostii * r
 Lecidca immersa * a
 Biatorina coerulea nigricans * a
 Bilimbia aromatica * o
 B. sabuletorum o
 Acarospora pruinosa * f
 Verrucaria integra * f
 V. rupestris * f
 V. nigrescens * f
 V. calciseda * f
 Thelidium immersum * o
 Trentepohlia aurea f

Many slight variations in the actual habitats of these plants are shown, some occurring on the rock faces, others on the crumbling sides of the fissures, others only in the moister places. Such mosses as *Tortula intermedia*, *Encalypta vulgaris*, *Camptothecium sericeum*, occur on the exposed faces of the rock, whilst *Fissidens decipiens*, *Barbula cylindrica*, etc. prefer less exposed and damper situations. The only hepatic which occurs at all commonly on the exposed surfaces is *Frullania*, but the lichens are more frequent there than in any

other situation. Where light-intensity becomes small lichens are absent and few bryophytes occur. In a general way the bryophytes and lichens of limestone pavements are similar to those found on calcareous rocks and walls, and a list of bryophytes and lichens from limestone cliffs would largely consist of the same species as have been given above for the limestone pavement.

A few lichens are able to excrete some acid juice beneath the developing reproductive bodies, so that the apothecia lie in small pits. These pits are well developed in *Thelidium immersum*, *T. incavatum*, *Lecidea immersa*, *Verrucaria calciseda*, *V. integra*, *V. rupestris* and *Aspicilia prevostii*. In these lichens, the acid excretion pits the rock so deeply that only the tops of the apothecia can be seen. A smaller amount of pitting also occurs in *Lecidea metzleri*, *L. contigua* form *calcareo*, *Rhizocarpon calcareum*, *Arthopyrenia foveolata* and *Rinodina bischoffii* var. *immersa*.