The status of *Leptodontium gemmascens* in Britain: an update

Richard Lansdown and **Fred Rumsey** summarise recent work on this charismatic moss.

Leptodontium gemmascens (Thatch-moss) is a scarce species which occurs in habitats that are rarely investigated by bryologists. It is known to occur in two habitat types: on decaying vegetation in heathy grassland and on thatched roofs (Porley, 2008; Lansdown, 2010). These two habitats, however, can be seen as different facets of the same habitat, and it may be considered 'a plant of acidic, base-poor substrates, characteristically growing on decaying organic matter in well-lit to partially shaded sites' (Porley, 2008). It is a small acrocarpous moss with one most distinctive feature – clusters of 15-40 gemmae on the leaves, on the tips of the excurrent nerves.

In 2008, Ron Porley published an account of the conservation status of *L. gemmascens* in Britain following detailed surveys and a transplant experiment. As a result of this work, R.V.L. was commissioned to survey *L. gemmascens* on selected National Trust properties (Lansdown, 2010, 2019a) which led to additional searches of suitable thatch and ultimately a survey by both authors of semi-natural habitats from which *L. gemmascens* has been recorded in Britain under the Natural England Species Recovery Programme. This account presents an updated assessment of the conservation status of *L. gemmascens* in Britain, based on the results of these surveys, together with a description of its ecology.

△ Figure 1. Decaying thatch supporting thousands of shoots of *L. gemmascens* on the shop at Selworthy in 2010, with the thatch collapsing in the hollow. The more orange moss is *L. gemmascens*. *All photographs Richard Lansdown*

A population considered likely to be *L. gemmascens* from Yorkshire appears somewhat intermediate between *L. gemmascens* and *L. proliferum* (Blockeel, 2017), which is otherwise known only from the Southern Hemisphere (Porley & Edwards, 2010). This population is treated in this article as *L. gemmascens*.

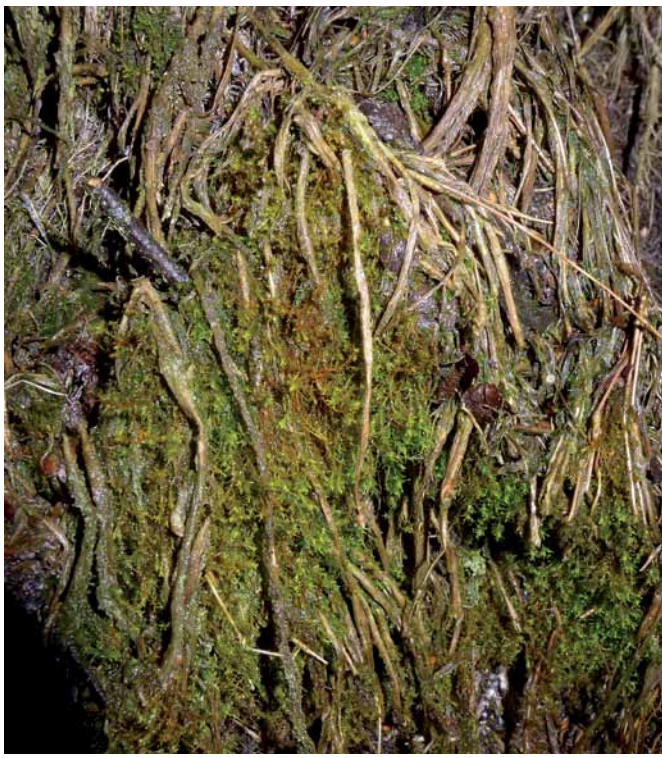
△ Figure 2. Distribution of *Leptodontium gemmascens* in Europe.

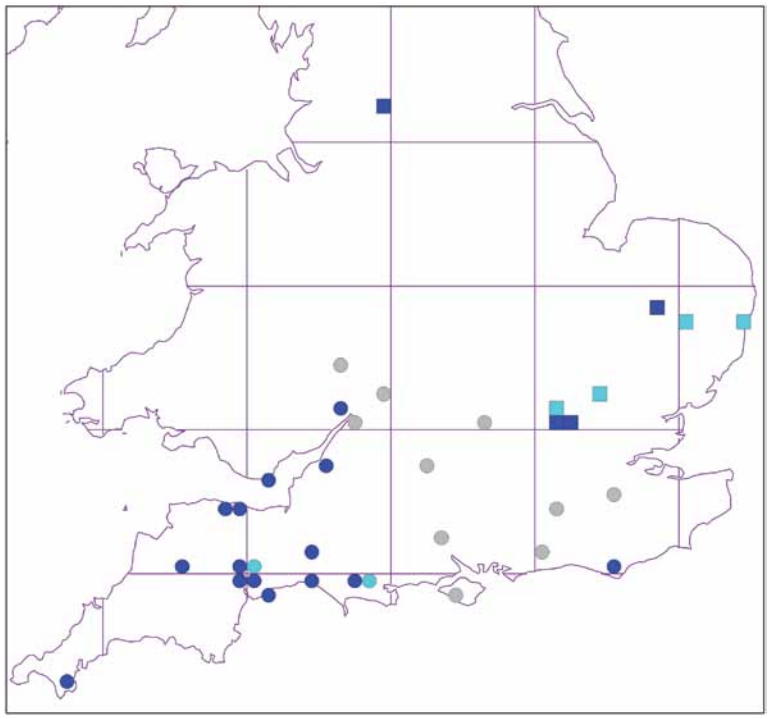
Distribution

L. gemmascens has a curious, disjunct distribution. It is known from seven countries in north-west Europe: Belgium, Denmark, Germany, Luxembourg, France, the Netherlands and the UK (Fig. 2), as well as Île Australia, Marion Island and Prince Edward Island, all in the Southern Hemisphere between South Africa and Antarctica. It has been suggested that populations in the Southern Hemisphere may have been introduced by humans (Porley, 2008). The main concentrations of records are from south-west England east through Belgium to the Ardennes, with scattered records north into Denmark and south to the French Pyrenees. Since the 1980s, increasing recognition of the potential for searches of thatch to locate new populations has resulted in a dramatic increase in the number of known populations. However, unlike recording of most bryophytes, where non-specific surveys can result in at least occasional new records, searches of thatch almost always require a specific focus and the patchy distribution of records may still indicate areas where individual bryologists have taken a particular interest in the species, such as in the Ardennes in France, Belgium, Luxembourg and Germany (Schneider *et al.*, 1998), the haute Adour in the Hautes-Pyrénées (Rogeon & Schumacker, 1984), as well as in northern and north-west France (Boudier, 1988; Lecointe & Boudier, 1989). Areas with few or no records may reflect areas with a lower number of thatched properties, where there has been a lack of targeted surveys, or possibly a genuine absence.

L. gemmascens is easily overlooked, both on thatch and in semi-natural conditions. On thatch, it generally occurs as solitary stems or a few scattered shoots until the upper thatch horizons are thoroughly weathered, when it can become much more noticeable (Fig. 1). It appears likely that the situation is similar in semi-natural conditions, where it is most frequently found in patches of fewer than 20 shoots but in some situations (e.g. Colden Clough, Yorkshire), can become very abundant (Fig. 3).

▽ Figure 3. *L. gemmascens* on decaying grasses at Colden Clough, S.W. Yorkshire.





◁ Figure 4. Distribution of *Leptodontium gemmascens* in Britain, showing hectads in which it was last recorded before 1990 (grey), between 1990 and 2009 (light blue), and from 2010 onwards (dark blue). Records from thatch are shown by circles and those in semi-natural habitats by squares.

In Britain records of *L. gemmascens* in semi-natural habitats are confined to an area from southern Hertfordshire, north and east to the East Anglian Brecks and the coast of Suffolk, with a single outlying site near Hebden Bridge in Yorkshire (Fig. 4, Table 1). In contrast, records of *L. gemmascens* on thatch extend from Surrey and Kent, west to south-west Cornwall, north to Herefordshire and east to Buckinghamshire. There is no overlap in these ranges.

Population dynamics

L. gemmascens has never been found with sexual structures and all reproduction appears to be by gemmae. Even a single shoot can produce large numbers of gemmae and therefore a population can go from very few to large numbers of shoots very quickly when conditions are suitable. Porley (2008) suggests that it behaves as a 'pluriennial' where a colony normally lasts a few years, and mortality is caused by competition or change of habitat (including renovation of thatch). In semi-natural habitats, *L. gemmascens* populations undergo massive fluctuations (Driver, 1982; Porley, 2008), such as at Wortham Ling, East Suffolk, where from being described as occurring 'in abundance over a wide area' in 1981 (Adams, 1982), it was reduced to 'a few plants' in 2003 (Fisk *et al.*, 2004) and no plants were found in 2019 (Lansdown, 2019b).

Similarly, particularly on isolated thatched properties, there are periods of up to ten years following replacement of the thatch when there are no growing shoots of *L. gemmascens*. It appears likely that the gemmae must have some degree of dormancy for populations to persist when there are no growing shoots for long periods. It may be that one of the reasons why *L. gemmascens* typically occurs in areas with slightly raised humidity is because these

Table 1. Distribution of *Leptodontium gemmascens* in Britain. Records made since 2010 are given in bold, records from semi-natural habitats are marked with an asterisk (*)

Vice County	Site name	Most recent record
1 W. Cornwall	Helford	**2010**
3 S. Devon	Killerton Estate	2006
3 S. Devon	Broadclyst, Killerton Estate	2006
3 S. Devon	Penspool Cottage, Plymtree	2006
3 S. Devon	Killerton House	2006
3 S. Devon	College Cottage	**2018**
3 S. Devon	Forest Cottages	**2018**
3 S. Devon	Killerton House	**2018**
4 N. Devon	Jacobstowe	**2010**
5 S. Somerset	Barrington Court	**2010**
5 S. Somerset	Bossington	**2010**
5 S. Somerset	Holnicote Estate	**2010**
5 S. Somerset	Luccombe	**2010**
5 S. Somerset	Selworthy	**2010**
7 N. Wiltshire	Aldbourne	1984
9 Dorset	Briants Puddle	1994
9 Dorset	Hardy's Cottage	2005
9 Dorset	Branscombe	**2010**
9 Dorset	Shedbush Farm	**2010**
9 Dorset	Tolpuddle	**2010**
10 Isle of Wight	Calbourne	1964
11 S. Hampshire	Romsey	1917
13 W. Sussex	Amberley	1975
14 E. Sussex	Alfriston Clergy House	**2013**
16 W. Kent	Riverhead	1901
17 Surrey	Broadmore	1946
20 Hertfordshire	Patmore Heath*	1992
20 Hertfordshire	Nomansland Common*	1996
20 Hertfordshire	Barley Mo Farm*	**2019**
21 Middlesex	Fir and Pond Woods*	**2019**
23 Oxfordshire	Thame	1967
24 Buckinghamshire	Shabbington	1966
25 E. Suffolk	Dunwich Beach*	1998
25 E. Suffolk	Wortham Ling*	2003
26 W. Suffolk	Barnham Cross Common*	**2019**
33 E. Gloucestershire	Cheltenham	1917
34 W. Gloucestershire	Blaise Hamlet	**2010**
34 W. Gloucestershire	Hart's Barn	**2012**
36 Herefordshire	Castle Frome	1932
41 Glamorgan	Cosmeston	**2014**
63 S.W. Yorkshire	Colden Clough*	**2019**

conditions are necessary for gemmae to persist.

Long-distance dispersal was proposed by Rogeon & Schumacker (1984). However, there are very few animals which would come into contact with *L. gemmascens* in terrestrial habitats in a way which would enable dispersal of gemmae. In fact, the likelihood of such contact declines with the size and therefore the potential dispersal distance of animal dispersal vectors. Thus, all the known stands in semi-natural habitats in England are likely to be visited at times by small rodents and occasionally birds, such as dunnocks, which have a limited range, less often by medium-sized animals, such as rabbits, hedgehogs or carrion crows, and relatively very rarely by roe deer, badgers, pheasants, Canada or greylag geese or domestic livestock, with a wider range. It is possible that the primary dispersal vectors for gemmae of *L. gemmascens* are small rodents and less often rabbits. This might explain why it can be very local in its occurrence, such as at Patmore Heath, Hertfordshire, in 1981 where '*L. gemmascens* was found in an area approximately 50 × 50 m, but was inexplicably absent from apparently similar ground nearby' (Driver, 1982), as well as

its apparently very limited distribution at sites such as Barnham Cross Common, West Suffolk (Lansdown, 2019b).

Similarly, there are no mammal or bird species which are likely to carry gemmae between roofs except on a very local scale, as there are no vertebrates specialised to exploit this habitat, whilst at 30–50 µm long the gemmae are unlikely to be wind-borne. It is equally unlikely that gemmae arrive fortuitously just as the thatch becomes suitable for colonisation. It is much more likely that gemmae are introduced with new thatch and lie dormant until the thatch is sufficiently weathered for them to develop into shoots. Thatchers usually work on thatch which is weathered and often on thatch which is reaching the limits of its integrity. As a result, they are likely to come into frequent contact with *L. gemmascens* gemmae and it is likely that their clothes and equipment (such as ladders and scaffolding) carry large numbers of gemmae at any given time. It is also possible that gemmae remain on the lower horizons of the thatch when the upper horizons are replaced, thus speeding up re-establishment.

Intensive surveys in areas with concentrations of thatched properties show that it typically occurs as metapopulations, such as 56 roofs supporting *L. gemmascens* in the Ardennes (Schneider *et al.*, 1998) and approximately 60 roofs with populations in an area of 8 × 15 km in the Pyrenees (Rogeon & Schumacker, 1984). In Britain, surveys of properties on the National Trust Holnicote, South Somerset, Golden Cap, Dorset, and Killerton, South Devon, estates found *L. gemmascens* on 6 of 13, 7 of 13 and 9 of 27 roofs respectively. It is highly likely that *L. gemmascens* occurs as a series of dynamic metapopulations, defined by dispersal of gemmae (and on thatch, potentially linked to the work of individual thatchers). Some metapopulations may be very small and involve only one or two roofs, but others (such as the Killerton and Holnicote Estates, as well as the clusters of populations in the Ardennes) will be large and involve large numbers of buildings. In these larger metapopulations, it is very likely that different roofs will be at different stages of weathering and the different populations of *L. gemmascens* will be at different stages of establishment. Thus, at any given time, there will be relatively new thatch with no growing shoots, while other thatch will be approaching the end of its life, with abundant shoots bearing thousands of gemmae. In contrast, at least in England, populations in semi-natural habitats are now isolated, with little capacity for dispersal between sites or management units and often with declining dispersal potential within sites.

Ecology of *Leptodontium gemmascens* in semi-natural habitats

L. gemmascens appears to occupy a very specific microhabitat in terrestrial sites. As noted by Schneider *et al.* (1998), it occurs 'where certain [monocots] accumulate abundant biomass, but the dying leaves and leaf bases are not completely degraded, resulting in coarse detritus lasting several years'. It appears to be intolerant of direct shade, such as that caused by overhanging leaves, but requires fairly high humidity (it may be that this provides the conditions which enable decaying vegetation to persist rather than necessarily being a requirement of the plant). In terrestrial habitats, *L. gemmascens* can be described as typically occurring on gently sloping ground on decaying monocot remains, in situations where topography and, in some circumstances, other vegetation mean that dead plant material breaks down slowly, usually therefore developing a relatively thick mat or thatch (Figs 5, 6).

△ Figure 5. Fred Rumsey examining *L. gemmascens* in a hollow on Barnham Cross Common, West Suffolk.

▷ Figure 6. *L. gemmascens* growing on decaying vegetation at Barham Cross Common, West Suffolk.

The terrestrial habitats in which *L. gemmascens* has been recorded are typically described as acid grassland or heath, including heathland which can be assigned to the Genisto pilosae - Callunetum in the Ardennes (Schneider *et al.*, 1998). Schneider *et al.* also note that it occurs on the crest of banks in open woodland of the Hieracio-Quercetum petraeae, which is similar to the habitat in which it occurs in Yorkshire. In Britain, it often occurs in species-poor unmanaged *Festuca-Rumex* grasslands (NVC U1), as well as in species-rich Breckland heath and grasslands. It typically occurs on slowly decaying monocot debris in areas which support few other living plants. It has been recorded growing on the remains of a range of plant species (Table 2). It is also occasionally recorded

Table 2. Plant species on which *L. gemmascens* has been recorded growing.

	Dunwich Beach[1]	Fir & Pond Wood[2]	Patmore Heath[2]	Wortham Ling[2]	Ardennes[3]	Belgium[4]	The Netherlands[5]
Arrhenatherum elatius		√	√				
Carex arenaria				√			
Deschampsia cespitosa		√				√	√
Deschampsia flexuosa					√	√	
Elytrigia atherica	√						
Festuca spp.*			√	√	√		
Juncus effusus			√	√			
Molinia caerulea						√	
Rumex acetosella			√				

*Mainly *F. ovina* group, including *F. brevipila*, as well as *F. guestfalica* in the Ardennes (Schneider *et al.* 1998).

Sources: 1, Porley (2008); 2, Driver (1982); 3, Schneider *et al.* (1998); 4, BLWG (2014); 5, van Zanten (1995).

Table 3. Associated species which occur with *L. gemmascens* on decaying vegetation.

	Barley Mo Farm[1]	Barnham Cross Common[1]	Fir and Pond Wood[1]	Patmore Heath[2]	The Netherlands[3]
Aulacomnium androgynum		√	√	√	√
Bryum rubens	√	√	√		
Campylopus pyriformis	√	√	√	√	
Ceratodon purpureus	√	√	√	√	√
Cladonia spp.*	√	√	√		√
Dicranella heteromalla					√
Dicranum scoparium		√			√
Placynthiella icmalea					√

*Including *C. chlorophaea senso lato* and *C. fimbriata*. Sources: 1, Lansdown (2019a); 2, Driver (1982); 3, van Zanten (1995).

on other substrates, including on a burnt stump of *Crataegus monogyna* at Patmore Heath (Driver, 1982), gorse stems (Adams, 1982), rot holes in trees (Porley, 2008), decaying oak leaves, rotting fragments of deciduous branches (Schneider *et al.*, 1998) and even on rabbit dung (Porley, 2008). It is clear that the process of decay of vegetation is more important than the species of plant involved.

L. gemmascens occurs on the sands of the Brecks at Barnham Cross Common (Lansdown, 2019a) and on soils over the boulder clay in Hertfordshire and Middlesex (Driver, 1982). In France, it is described as occurring over siliceous parent rocks: Ordovician, Silurian, Devonian slates, Permian volcanic, Carboniferous greywacke and sandstone (Schneider *et al.*, 1998). In Britain, terrestrial populations may be limited to the region with a more continental climate, and, in fact, Breckland is in the driest part of Britain (Rothera, 2000). It occurs from near sea-level in Cornwall and West Sussex to 1000 m altitude in the Pyrenees (Rogeon & Schumacker, 1984). It has been recorded with a wide range of species, some of which may also occur on decaying vegetation (Table 3), while others often occur in the same habitats as *L. gemmascens* but on other substrates (Table 4).

In England, *L. gemmascens* typically grows in habitats which are or have been grazed by horses (Barley Mo Farm, Hertfordshire) (Fig. 7) or cattle (Barnham Cross Common), many also by rabbits

Table 4. Associated species in the same habitat as *L. gemmascens*.

	Barley Mo Fm.[1]	Barnham Cross Common[1]	Fir and Pond Wood[1]	Patmore Heath[2]	The Netherlands[3]
Lophocolea bidentata			√		
Lophocolea heterophylla					√
Ornithopus perpusillus		√			
Oxyrrhynchium speciosum					√
Plagiothecium laetum/ curvifolium					√
Polytrichum juniperinum	√	√			
Rumex acetosella	√	√	√	√	

Sources as Table 3.

◁ Figure 7. Heavily horse-grazed habitat at Barley Mo Farm, Hertfordshire, supporting *L. gemmascens* in a hollow in the bank on the right.

(Barnham Cross Common, Patmore Heath). However, as noted by Schneider *et al.* (1998), many sites where it occurs have been grazed by stock in the past but have been ungrazed by livestock for some time. Porley (2008) suggests that active grazing may prevent the build-up of decaying plant material necessary for the establishment of *L. gemmascens*. This would suggest that rotation of livestock with 'fallow' periods might be the most effective management for the conservation of *L. gemmascens*.

Ecology of *Leptodontium gemmascens* on thatch

Historically, thatch was the roofing material of the poor, rather than the expensive and desirable material that it is today. As a consequence, thatched roofs would often occur in complexes, with most roofs in a village thatched. Thatch was also very carefully managed to maximise its life-span and thereby reduce costs. Where possible, small parts of a single roof face (referred to here as a 'face') or only the upper horizons would be replaced but in some cases the owners would not be able to replace the thatch when needed and it would degrade beyond repair, requiring complete replacement. If thatch is managed on a relatively short rotation (typically replacing a single face or the entire roof at intervals of 10–15 years) only the upper layer of a multi-layered thatch weathers and the lower layers may persist for hundreds of years. As a result, most villages would include thatch of varying ages and stages of weathering, as well as some thatches of which the lower horizons might be hundreds of years old. It is feasible that these lower long-lived horizons also bear dormant gemmae.

Weathering of thatch is strongly influenced by local conditions. A simple rectangular roof on a property which is isolated from other buildings or trees and in a level area or on a hill will weather very slowly, will typically be dry most of the time and will support few, if any, mosses or lichens. In contrast, thatch on a complex roof with abundant angles and sheltered areas, which is in a building complex with adjacent tall trees, surrounded by woodland and in a narrow valley will weather very quickly. In the latter case, hollows in the thatch and drip lines running down from chimneys will remain almost permanently moist and eventually the whole face will become colonised by a wide range of bryophytes and lichens (Fig. 8). *L. gemmascens* only grows on thatch in specific circumstances; often becoming established on thatch which is weathered but not rotten, often occurring on a biofilm. It typically appears to establish as solitary shoots, becoming more abundant, then coalescing into tufts and ultimately swards as the thatch weathers. Roofs which are so degraded that the thatch is starting to collapse and the spars protrude may support thousands of plants (Fig. 9). There is therefore an 'arms-race' between establishment of *L. gemmascens* and thatch maintenance. *L. gemmascens* appears not to develop until thatch is at least five years old (Porley, 2008), but shoots typically establish when a thatch is ten or more years old (Hedderson *et al.*, 2003a), becoming more abundant as the thatch weathers, reaching an optimum when thatch is breaking down and

△ Figure 8. A cottage on the National Trust Killerton Estate, South Devon, with a dense cover of mosses, dominated by *Dicranum scoparium* and with sparse *L. gemmascens*.

the roof is beyond repair. In contrast, the aim of thatch maintenance is to replace thatch before weathering starts to compromise the integrity of the roof.

There is no evidence to suggest that *L. gemmascens* is particular about the type of material used in the thatch, which is generally common reed (*Phragmites australis*) (often referred to as 'water-reed' by thatchers) or wheat straw, although other materials are used (Porley, 2008; Hedderson *et al.*, 2003a). Superficial comparison of data from the 2010 survey suggests that there are different vegetation associations:

- Some roofs are dominated by *Cladonia* lichens, often with *Campylopus introflexus*.
- Some roofs are dominated by pleurocarpous mosses.
- Some roofs are dominated by acidophilous mosses, including *Ceratodon purpureus* and *Bryum pallescens*; this often appears to be linked to the use of wire netting.
- Some roofs support a diverse flora, including liverworts (such as *Colura calyptrifolia* in Glamorgan), acrocarpous mosses, pleurocarpous mosses and a range of lichens, typically dominated by *Cladonia* spp., but often also with species such as *Evernia prunastri* and *Flavoparmelia caperata*.

However, there was no strong evidence for an association between *L. gemmascens* and any particular one of these vegetation types (Table 5), or any particular species (Table 6). *L. gemmascens* occurred on 26 (35%) of the 74 faces surveyed. It did not necessarily occur on the most species-rich faces nor apparently particularly often with any other group of bryophytes or lichens.

However, there does appear to be a very strong effect of location on the occurrence of all species on faces. Thus, only one of the 74 thatch faces surveyed in 2010 supported navelwort (*Umbilicus rupestris*), whereas it was one of the typical species of one group of vegetation on faces surveyed by Hedderson *et al.* (2003b). Similarly, in the 74 faces surveyed in 2010 *Orthotrichum* species were virtually limited to the roofs on the Holnicote Estate. It also seems that age is likely to have a strong influence on the vegetation of faces, as well as exposure and humidity.

Porley (2008) suggested that leachate of

Table 5. The relationship between *L. gemmascens* and other taxa on thatch (Lansdown, 2010).

	Faces on which taxon occurred	Faces supporting *L. gemmascens*
Lichens	43 (58%)	12 (46%)
Pleurocarpous mosses	38 (51%)	14 (54%)
Acrocarpous mosses	35 (47%)	18 (69%)
Campylopus introflexus	18 (24%)	9 (36%)

Table 6. Species recorded on the same roof face as *L. gemmascens* (Lansdown, 2010).

Species	Golden Cap Estate	Alfriston Clergy House	Holnicote Estate	Bossington Estate	Blaise Castle	Barrington Court	No. of sites
Amblystegium serpens		1			1		2
Barbula unguiculata		1					1
Brachythecium rutabulum		1			1		2
Bryum capillare	1	1	3			1	6
Bryum moravicum					1		1
Bryum pallens			2				2
Bryum radiculosum		1					1
Campylopus introflexus	2	1	3	1			6
Cladonia spp.	1	1	3	1			6
Cratoneuron filicinum		1	2		1		3
Cryphaea heteromalla		1					1
Dicranoweisia cirrata		1	2		1		4
Dicranum scoparium			3				3
Evernia prunastri		1		1			2
Flavoparmelia caperata				1			1
Frullania dilatata			2				2
Hypnum andoi				1			1
Hypnum cupressiforme var. *lacunosum*			1				1
Hypnum cupressiforme var. *resupinatum*	2	1	4	1		1	9
Kindbergia praelonga			1				1
Leptodontium flexifolium				1			1
Orthotrichum diaphanum		1					1
Orthotrichum sp.			1				1
Orthotrichum stramineum		1					1
Parmelia sulcata		1	1				2
Peltigera sp.			1				1
Syntrichia montana		1					1
Syntrichia papillosa		1					1
Umbilicus rupestris			1				1
Total species	1	17	5	7	5	2	

zinc may be toxic to many mosses and prevent establishment of *L. gemmascens*. In surveys of more than 100 roofs (Porley, 2006; Lansdown, 2010; our unpublished data), *L. gemmascens* was recorded growing beneath wire netting on completely netted roofs only twice, on a single roof on the Killerton Estate and at Blaise Hamlet, West Gloucestershire. At both sites, there was a tree overhanging and almost touching the roof. It appears likely that in these circumstances

△ Figure 9. Dense *L. gemmascens* on very decayed thatch of the shop at Selworthy, with other mosses including *Campylopus introflexus*, *Hypnum cupressiforme* var. *resupinatum* and *Cladonia* lichens.

the proximity of the tree in some way negates or reduces the influence of the netting. In contrast, *L. gemmascens* frequently occurs on thatch where the ridge has been netted (e.g. all populations on the Killerton Estate), although none of the populations on these roofs is large and most involve only a few scattered shoots or tufts. This suggests that even only netting the ridge may suppress but not prevent growth of *L. gemmascens*.

Survey of *L. gemmascens* on selected National Trust properties led to some tentative conclusions about the conditions in which it occurred on thatch (Lansdown, 2010):

- *L. gemmascens* typically occurred where trees or other structures increased the shade or shelter of the thatch.
- *L. gemmascens* was never the only moss species on the roof.
- *L. gemmascens* has rarely been recorded on roofs which were fully covered with chicken wire netting and only twice on partially netted roofs.
- The largest populations occurred on roofs that had not been replaced or substantially repaired for at least ten years.
- The largest populations occurred where there was a complex of thatched roofs in a small area (generally separated by less than 5 km).
- The largest populations were in valleys.

Most occurrences and absences of *L. gemmascens* can be explained by three fairly simple factors: local humidity profiles, competition from other bryophytes and lichens and the presence or absence of wire netting.

Conservation

The transplant experiment

Fears that replacement of the thatch on the roof of Alfriston Clergy House, in East Sussex, might cause the loss of a known population of *L. gemmascens* resulted in seven sheaths of thatch bearing *L. gemmascens* being transplanted from donor colonies on the north face to the east face on 25th October 2005. Each transplant was marked with an electronic chip and a white plastic tag, and the area containing the transplants was covered with plastic netting to hold the tags and sheaths in place. The surface horizons of thatch on the south, north and west faces were replaced in 2005, but the lower horizons were retained. In 2006, the transplants were monitored and *L. gemmascens* was present at each of the places where sheaths had been transplanted (Porley, 2008). On 20th May 2008 the transplants were

again monitored, all the tags were in place and all chips were working, but no *L. gemmascens* was located (a small piece of material was removed and when examined under a microscope was shown to include gemmae). On 23rd March 2010, the transplants were again monitored, and all chips and tags were in place and all chips were working, but no *L. gemmascens* was located, in spite of a very detailed inspection of the lower 2 m of the face. Inspection of the north face of the roof showed two small populations of *L. gemmascens*, both within 3 m of the eastern tip of the eaves, one of which had abundant gemmae. A total of 15 species of moss was recorded from the same area but this declined to 2–3 species over the rest of the face, suggesting that a limited area of the eastern end of the north face was particularly suitable for bryophytes.

Transplantation of *L. gemmascens* onto the east hip appears to have been unsuccessful; any *L. gemmascens* which did colonise or survive transplantation on the east face appears to have been out-competed by *Campylopus introflexus*. However, *L. gemmascens* successfully recolonised the north face without assistance and in spite of the entire face being replaced. It therefore seems likely that *L. gemmascens* can survive replacement of the entire roof either from gemmae on the roof itself, from other nearby sites or from the clothing or equipment of the thatchers. The limited distribution of *L. gemmascens* and the other 14 bryophyte species on the north face of the roof is probably caused by increased humidity in that area, resulting from the presence of a tree immediately adjacent to the thatch.

Conservation in Britain

The specific microhabitat requirements of *L. gemmascens*, its poor dispersal capacity, particularly in terrestrial habitats, and habitat fragmentation, combined with significant population fluctuations, mean that the likelihood of its loss from a semi-natural site is very high. Where formerly there was probably a high degree of connectivity between sites, combined with a greater abundance of potential dispersal vectors, such as wild boar, now the fragmentation of potentially suitable sites means that recolonization is very unlikely. However, it is unlikely that the sites where *L. gemmascens* has been found are the only ones where it occurs in terrestrial habitats, even though searches of potentially suitable Breckland heath sites in 2019 failed to find any additional populations (Lansdown, 2019b). The discovery of the plant near Colden Clough, in S.W. Yorkshire, is particularly incompatible with any concept of a restricted distribution, unless this record actually represents an introduced occurrence of *L. proliferum*.

Without active, targeted searches, *L. gemmascens* is unlikely to be found at additional sites. One way in which to increase the likelihood of populations being found in semi-natural habitats would be to organise bryological surveys of potentially suitable sites with particular emphasis on areas where there are known populations, either on thatch or in semi-natural habitats.

Of the sites in which *L. gemmascens* occurs in semi-natural habitats, all but three are Sites of Special Scientific Interest (SSSIs) and one of those is a Local Nature Reserve, while Dunwich Beach, East Suffolk, is also a National Nature Reserve. However, this level of protection is no guarantee that *L. gemmascens* will prosper. It appears to have been lost from two SSSIs (Patmore Heath and Wortham Ling) since 1990 and it persists at the other sites because of actions beyond the positive influence of SSSI management; by rabbits at Barnham Cross Common and ants at Fir and Pond Woods, Middlesex.

All but three of the known populations of

L. gemmascens on thatch are on National Trust properties and all of these, except Alfriston Clergy House, are in Devon, Dorset and Somerset on estates where the Trust has a policy of conservation of *L. gemmascens* which includes minimising use of wire netting. Elsewhere in Britain, there is no such policy and most properties are fully netted. Whilst it is currently highly unlikely that the Trust will change their policy in the south-west, if it becomes clear in the future that the costs of not netting thatch are excessive, the Trust could decide to extend netting throughout their holdings, in which case *L. gemmascens* populations would almost certainly decline to only a handful of roofs. In contrast, if the Trust were to establish a policy of using an inert netting material throughout their holdings, *L. gemmascens* might increase significantly and spread over a much wider area. It is clear that the conservation status of *L. gemmascens* in England is highly dependent upon the support of the National Trust. The most effective means of conserving *L. gemmascens* on thatched roofs on National Trust holdings may be to adopt a pragmatic approach, where roofs are not netted and are patched where possible, but typically maintained on a 10–15 year cycle with entire faces or roofs replaced before the lower layers start to degrade. Adoption of this approach across the holdings of the National Trust would be very likely to lead to re-establishment of *L. gemmascens* across its former range. Another way to enhance the conservation status of *L. gemmascens* on National Trust properties would be to replace the roofs of porches and gateways with thatch, as well as installing thatched shelters on structures such as information boards. A further method of increasing the distribution and abundance of *L. gemmascens* might be to increase the movement of its thatchers. In fact, it is clear that if all thatched properties owned by the National Trust were managed by the same thatchers and none were completely netted, the entire holding would function as one very large metapopulation and *L. gemmascens* could expand its distribution much more widely in Britain. If thatched properties in a complex (functioning as a metapopulation) are managed so that at any given time there are thatched roofs at different stages of weathering, in the absence of other adverse influences, it is almost certain that *L. gemmascens* would survive indefinitely.

If all populations are taken into account, *L. gemmascens* cannot currently be considered threatened in Britain. However, populations on thatch are clearly not natural and are dependent upon the continued active conservation commitment of the National Trust who accept that the avoidance of the use of wire netting results in a potential shortened lifespan of thatch on their properties. Red list assessments employing the IUCN criteria should not allow non-native populations to affect the threat status of a taxon (Craig Hilton-Taylor pers. comm.). Adopting this approach, *L. gemmascens* should be classed as Vulnerable D2 (IUCN 2012) because it is currently known to occur only at four sites: Barley Mo Farm, Fir and Pond Wood, Barnham Cross Common and Colden Clough (although the last may not be this species). Populations may also be considered to be 'Severely Fragmented' as there is no obvious or logical means of dispersal between these sites.

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