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***Intralichen*, a new genus for lichenicolous '*Bispora*' and '*Trimmatostroma*' species**

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*Intralichen* gen. nov. is introduced for four dematiaceous hyphomycetes with mycelia growing inside the hymenia and thalline tissues of lichens or lichenicolous fungi and sporulating at the surface: *I. baccisporus* sp. nov., *I. christiansenii* comb. nov. (syn. *Bispora christiansenii*), *I. lichenicola* comb. nov. (syn. *Trimmatostroma lichenicola*), and *I. lichenum* comb. nov. (syn. *B. lichenum*). A key to the species is provided and all known hosts and reports of the species are summarized.

**Key words:** hyphomycetes, lichenicolous fungi, lichens, taxonomy.

### Introduction

The fungi obligately living on lichens have proved to be exceptionally rich in terms of numbers of species and the novelty of the genera involved. Over 1000 taxa are already known, and the actual number on Earth may be as many as 3-4000 (Hawksworth, 2001). In the early days of the revival of interest in these fungi that started in the 1970s, there was a tendency to 'squeeze' various species into clearly rather inappropriate genera rather than introduce many new generic names straight away. The result has been the necessity of gradually providing new generic names for such fungi as they become better understood. This contribution deals with one such case also bringing together some species hitherto placed under different generic names but which in practice appear to be closely related.

The appropriate generic placement of three dematiaceous lichenicolous conidial fungi which have immersed mycelia and conidiophores has been a matter of uncertainty since they were first described, notably two species referred to as *Bispora* (Hawksworth, 1979; Diederich, 1990) and one to *Trimmatostroma* (Hawksworth, 1979). The discovery of a fourth species

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sharing many features with these three fungi, including the lichenicolous ecology, but differing in conidium septation and cellular arrangement, leads us to the conclusion that these are probably closely allied. A new generic name is therefore introduced for this group here.

### Materials and methods

The specimens were studied macroscopically with a Nikon stereomicroscope with an eyepiece reticle at magnifications ranging up to 80 $\times$ . Microscopic characters were studied using hand-made sections or squash preparations with an Olympus BH2 microscope equipped with Nomarski differential interference contrast optics. The specimens were mounted in water, 10% KOH (K), Lugol's iodine (I), and erythrosin B-ammonia solution (0.5 g erythrosin B in 100 ml 10% aqueous NH<sub>3</sub>). Drawings were made using a drawing tube giving a 3200 $\times$  magnification. Average means of features measured are placed in italic type.

### Taxonomy

#### *Intralichen* D. Hawksw. & M.S. Cole, **gen. nov.**

*Etymology*: *intra* (within); *lichen*. From the growth habit of the mycelium of the fungi within lichen tissues.

Genus lichenicola ad hyphomycetes dematiatium pertinens. *Mycelium* immersum. *Conidiophora* immersa, micronemata, brunnea. *Cellulae conidiogenae* integratae, terminales, monblasticae. *Conidia* catenata, singularia vel aggregata, ellipsoidea ad subglobosa, 0-1 septata vel multicellularia, levia, brunnea.

*Mycelium* growing in the thalli or apothecia of lichens, branching through the tissues towards the surface and developing conidia as the surface is approached, smooth-walled, septate, constricted at the septa, hyaline to pale brown, cells elongated to torulose. *Conidiophores* micronematous, cells changing gradually as the hyphae approach the surface, there often becoming deeper brown and thicker walled. *Conidiogenous cells* integrated, terminal, monoblastic, first conidium with apical wall building at one locus, later conidia produced by ring wall building and maturation by diffuse wall building below the delimiting septum, not proliferating (Event 23 pattern of Hawksworth *et al.* 1995: 286). *Conidia* arising in unbranched chains, remaining single or aggregated, ellipsoid to subglobose, 0-1 septate, in some species forming a multicellular structure, smooth-walled, wall thickened or not, pale to dark brown.

*Type species*: *Intralichen christiansenii* (D. Hawksw.) D. Hawksw. & M.S. Cole (holotypus).

*Hosts:* In the thalli and hymenia of a wide range of lichens and more rarely lichenicolous fungi. Generally commensals, but can also be weakly pathogenic.

*Number of species:* Four are recognized here, but many others are to be expected.

*Distribution:* Recorded from Europe, North America, and Australasia, but probably world-wide.

### Key to species of *Intralichen*

1. Conidia 0-1-septate.....2
1. Conidia multicellular.....3
2. Conidia 1-septate, 5-8(-9) × 4-6 μm.....*I. christiansenii*
2. Conidia 0-septate, 3-4.5 × 2.5-4 μm.....*I. lichenum*
3. Conidia arising as elongated chains of cells, conidia 18-25 × 6-12 μm .....*I. lichenicola*
3. Conidia arising as subglobose aggregations of cells, conidia 6-12 × 5.5-9.5 μm.....  
.....*I. baccisporus*

### *Intralichen baccisporus* D. Hawksw. & M.S. Cole, **sp. nov.** (Figs. 1, 2)

*Etymology:* *baccus* (berry); *spora*. From the berry-like appearance of the conidia.

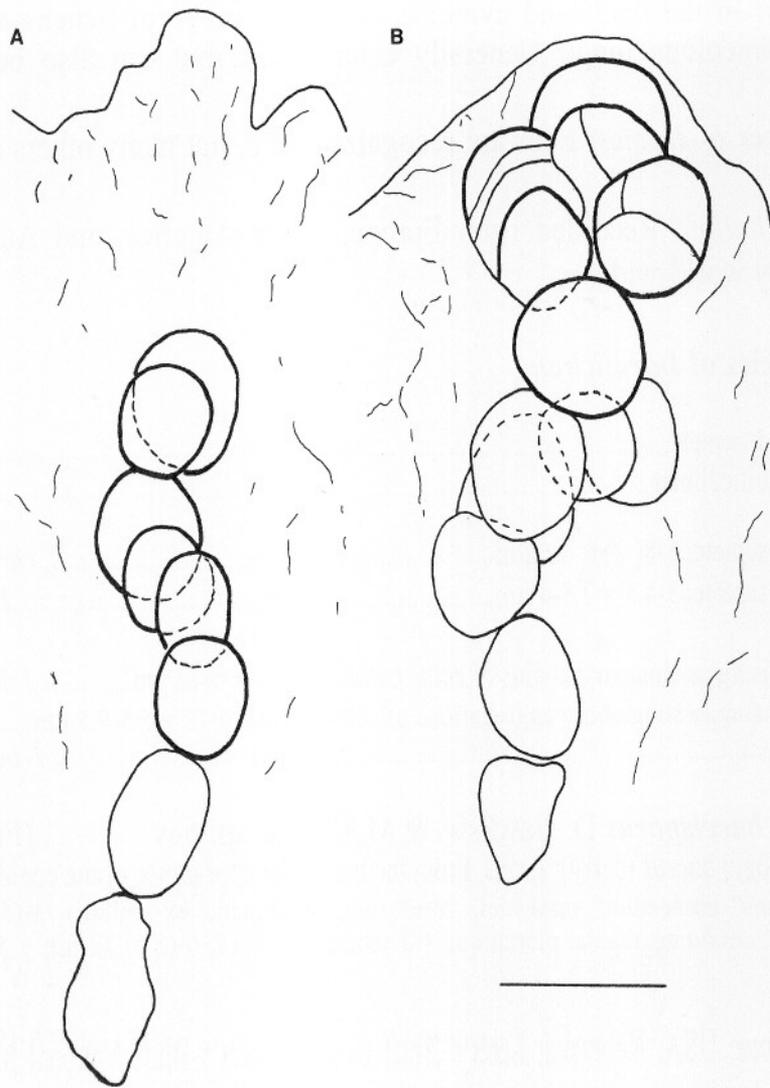
*Mycelium* immersum, ramosum, torulosum, hyalinum, ex cellulis 3-(5.5)-7 μm compositum. *Conidia* aggregata, plerumque 1-3 septata, brunnea, 6-(8.5)-12 μm × 5.5-(7)-9.5 μm.

*Holotypus:* USA: Nebraska: Scott's Bluff County, Scott's Bluff National Monument, south bluff on point of ridge south of Coyote Pass, on ridgetop with hard rocks and scattered *Pinus ponderosa* and *Juniperus* sp., 41°40'20" N, 103°42'51" W, elevation 1387 m, on thallus of *Caloplaca trachyphylla*, 4 July 1997, C. Wetmore 77657 A (MIN).

*Mycelium* growing throughout the medulla and hymenium of the host lichen, branching towards the surface and developing conidia as the surface is approached, torulose, smooth-walled, septate, constricted at the septa, hyaline, cells polyhedral, 3-(5.5)-7 × 3-(4)-4.5 μm. *Conidiophores* micronematous, integrated, cells changing gradually as the hypha approaches the surface, becoming brown and thick-walled. *Conidial ontogeny* as in *I. christiansenii*. *Conidia* aggregated in amorphous masses to 25 μm diam. on the surface of the lichen, separating from the hyphae that produced them, appearing most often where the thallus has been previously damaged, brown, individual conidia at first non-septate and 6-9 μm diam., then more elongate and 1-3 septate overall, 6-(8.5)-12 × 5.5-(7)-9.5 μm.

*Host:* In the medulla and hymenium of *Caloplaca trachyphylla*, occurring on the medulla where the cortex has been abraded or broken down.

*Distribution:* USA; only known to us from the holotype.



**Fig. 1.** *Intralichen baccisporus* (from holotype). **A.** Pre-erumpent conidia, younger. **B.** Pre-erumpent conidia, older. Bar = 10  $\mu$ m.

*Observations:* This species provides a link between *I. christiansenii* and *I. lichenicola* in that the conidia are produced in chains as in the former, but are up to 4-celled, but also appear to clump together to form multicelled propagules recalling the irregularly ellipsoid conidia of the latter. In the holotype, a single multicellular *Monodictys*-like conidium 42  $\mu$ m diam. was found, but was never seen clearly attached to a conidiophore; this most probably represented a different fungus so is excluded from the description here.

***Intralichen christiansenii*** (D. Hawksw.) D. Hawksw. & M.S. Cole, **comb. nov.**

$\equiv$  *Bispora christiansenii* D. Hawksw., *Bulletin of the British Museum (Natural History)*, Botany 6: 207 (1979).

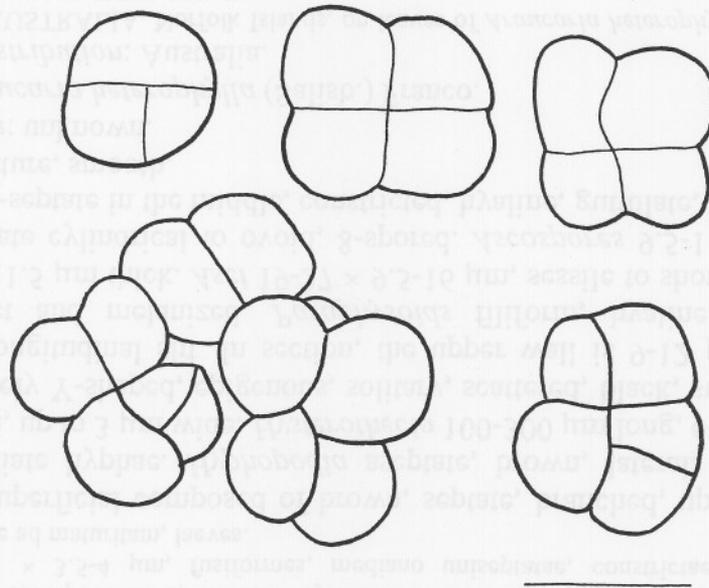


Fig. 2. *Intralichen baccisporus* (from holotype), conidia of various degrees of multicellularity. Bar = 10  $\mu$ m.

*Description:* Hawksworth (1979: 207-209).

*Hosts:* In the hymenium of the apothecia or on the thallus of a wide range of lichens and some lichenicolous fungi. Causing discolourations, commensalistic to weakly pathogenic. Reported from: *Arthonia excentrica* (Alstrup and Hawksworth, 1990), *Bacidia* sp. (Hawksworth, 1986), *Buellia punctata* (Bricaud and Roux, 1990; Giersberg *et al.*, 1992), *Caloplaca aurantia* (Calatayud *et al.*, 1995), *C. castellana* (Aptroot and Alstrup, 1991), *C. cerina* (Hawksworth, 1979; Zhurbenko, 1998), *C. citrina* (Hawksworth, 1979), *C. decipiens* (Alstrup *et al.*, 1992), *C. tavaresianae* (Navarro-Rosinés and Roux, 1994), *C. trachyphyllina* (Alstrup and Olech, 1993; Cole and Hawksworth, 2001), *C. variabilis* (van den Boom, 1992), *Catillaria chalybeia* (Berger, 2000b), *Candelariella aurella* (Alstrup and Hawksworth, 1990), *C. hudsonica* (Alstrup and Hawksworth, 1990), *C. vitellina* (Hawksworth, 1979, host of type), *Carbonea intrusa* (Alstrup and Olech, 1993; Aptroot *et al.*, 1997), *Clauzadea immersa* (Alstrup and Olech, 1993), *Coriscium viride* (Alstrup and Hawksworth, 1990), *Hymenelia epulotica* (Hafellner, 2000), *Lecania erysibe* (Alstrup and Olech, 1993), *L. cyrtella* (Zhurbenko, 1998), *Lecanora* sp. (Hafellner, 1994b; Calatayud *et al.*, 1995; Zhurbenko and Hafellner, 1999), *L. carpineae* (Hawksworth, 1979), *L. chlarotera* (Bricaud and Roux, 1990; Alstrup and Olech, 1993; Giralt and Gomez-Bolea, 1998), *L. dispersa* (Hawksworth,

1979), *L. hagenii* f. *saxifragae* (Alstrup *et al.*, 2000), *L. polytropa* (Alstrup and Olech, 1993), *L. rupicola* ssp. *swartzii* (Berger, 2000a), *L. soralifera* (Diederich, 1986), *L. sienae* (Giralt and Gomez-Bolea, 1988), *L. cf. subrugosa* (Hafellner, 1994a), *Lecidea* sp. (Santesson, 1993), '*Lecidea*' *turgida* (Hafellner, 1996), *Lecidella elaeochroma* (Diederich, 1986; Diederich and Sérusiaux, 2000), *Lobaria amplissima* (Martínez and Hafellner, 1998), *Micarea leprosula* (Diederich, 1986), *M. lignaria* (Diederich and Sérusiaux, 2000), *M. lithinella* (UK: Suffolk: Westleton, Westleton Heath, 27 June, 1990, P.M. Earland-Bennett, herb. Hitch), *Opegrapha durieui* (Roux and Egea, 1992), *Phacopsis vulpina* (Alstrup and Hawksworth, 1990), *Physcia adscendens* (Santesson, 1993), *Polysporina* sp. (Hafellner, 2000), *Porpidia crustulata* (Alstrup and Olech, 1996), *Protoblastenia incrustans* (Alstrup *et al.*, 2000; Hafellner, 2000), *Pyrrhospora querneae* (Bricaud and Roux, 1990), *Ramalina calicaris* (Hawksworth, 1992), *Rinodina turfacea* (Alstrup and Hawksworth, 1990; Alstrup, 1991), *Scoliciosporum chlorococcum* (Diederich and Sérusiaux, 2000), *S. pruinatum* (Diederich and Sérusiaux, 2000), *Stereocaulon condensatum* (Alstrup and Hawksworth, 1990), *Strangospora pinicola* (Bricaud *et al.*, 1991; Diederich and Sérusiaux, 2000), and *Xanthoria elegans* (Alstrup and Cole, 1998). The report of this species associated with dark brown gall-like convex swellings on *Phaeophyscia orbicularis* (Hawksworth, 1979) refers to a *Tremella phaeophysciae* anamorph (P. Diederich, pers. comm.).

*Distribution:* Austria (Berger, 2000a, Hafellner, 1994a, 2000), Belgium (Diederich, 1986), British Isles, Denmark, Finland, Germany, and Italy (Hawksworth, 1979), Canada (Alstrup and Cole, 1998), Canary Islands (Hafellner, 1996; Martínez and Hafellner, 1998), Corsica (Hafellner, 1994b), Denmark (Alstrup, *et al.*, 1992), Germany (Giersberg *et al.*, 1992), France (Bricaud and Roux, 1990; Bricaud *et al.*, 1991), Greenland (Alstrup and Hawksworth, 1990), Iceland (Berger, 2000b), Italy (van den Boom, 1992), Luxembourg (Diederich, 1986), New Guinea (Aptroot *et al.*, 1997); Norway (Santesson, 1993), Poland (Alstrup and Olech, 1996), Portugal (Roux and Egea, 1992; Roux and Navarro-Rosinés, 1992), Siberia (Zhurbenko, 1996, 1998; Zhurbenko and Hafellner, 1999), Spain and the Canary Islands (Giralt and Gomez-Bolea, 1988; Navarro-Rosinés and Roux, 1994; Calatayud *et al.*, 1995; Hafellner, 1996; Martínez and Hafellner, 1998), Spitsbergen (Alstrup and Olech, 1993), Svalbard (Aptroot and Alstrup, 1991; Alstrup and Elvebakk, 1996), Sweden (Alstrup, 1991; Santesson, 1993), Ukraine (Hawksworth, 1992; Kondratyuk and Khodosovtsev, 1997), and the USA (Cole and Hawksworth, 2001).

*Observations:* This fungus, the only member of the genus yet to be obtained in pure culture, has proved to be widespread and able to grow on a wide range of hosts. However, small differences occur between collections that may or may not prove to be significant and cultural and molecular studies may eventually show that additional new species should be recognized.

***Intralichen lichenicola*** (M.S. Christ. & D. Hawksw.) D. Hawksw. & M.S. Cole, **comb. nov.**

≡ *Trimmatostroma lichenicola* M.S. Christ. & D. Hawksw., in Hawksworth, *Bulletin of the British Museum (Natural History)*, Botany 6: 264 (1979).

*Description:* Hawksworth (1979: 264-266).

*Hosts:* In apothecia of *Caloplaca* sp. (Zhurbenko, 1996), *Caloplaca holocarpa* (Alstrup and Hawksworth, 1990), *Candelariella aurella* (Santesson, 1998), *C. hudsonica* (Alstrup and Hawksworth, 1990), *C. vitellina* (Diederich and Sérusiaux, 2000; Hawksworth, 1979; host of type), *Lecanora fuscescens* (Alstrup and Hawksworth, 1990), *L. polytropa* (Alstrup and Hawksworth, 1990), *L. symmicta* (Alstrup and Søchting, 1986), *Pleurosticta acetabulum* (Diederich and Sérusiaux, 2000), *Psoroma hypnorum* (Alstrup and Hawksworth, 1990), and *Toninia cumulata* (Alstrup and Hawksworth, 1990; Øvstedal, 1986).

*Distribution:* Greenland, Norway, and Spain (Alstrup and Hawksworth, 1990); Luxembourg (van den Boom *et al.*, 1996; Sérusiaux *et al.*, 1999; Diederich and Sérusiaux, 2000), Norway (Alstrup and Søchting, 1986; Øvstedal, 1986; Santesson, 1998), Siberia (Zhurbenko, 1996), Svalbard (Alstrup and Elvebakk, 1996), and Sweden (Santesson, 1993).

*Observations:* This species is evidently much rarer than, for example, *I. christiansenii* which was recognized at the same time.

***Intralichen lichenum*** (Diederich) D. Hawksw. & M.S. Cole, **comb. nov.**

≡ *Bispora lichenum* Diederich, *Mycotaxon* 37: 302 (1990).

*Description:* Diederich (1990: 302-304).

*Hosts:* Reported from apothecia and more rarely thalli of *Arthonia* sp. (Diederich, 1990), *Candelariella xanthostigma* (Diederich, 1990), *Evernia mesomorpha* (Cole and Hawksworth, 2001), *Opegrapha* sp. (Aptroot *et al.*, 1997), *O. atra* (Diederich, 1990; host of type), *O. plectocarpoidea* (Diederich, 1990), *Scolicosporum chlorococcum* (Alstrup, 1993), *Strangospora moriformis* (Hawksworth, 1994), *S. pinicola* (Diederich, 1990), and *Trapelia placodiodes* (Hawksworth, 1994).

*Distribution:* Belgium (Diederich and Sérusiaux, 2000), British Isles (Hawksworth, 1994), Denmark (Alstrup, 1993), Luxembourg (Diederich,

1990), New Guinea (Aptroot *et al.*, 1997), and the USA (Cole and Hawksworth, 2001).

*Observations:* We considered whether the epithets 'lichenum' and 'lichenicola' were so similar in spelling that they should be treated as homonyms under Art. 53.3 of the *Code* (Greuter *et al.*, 2000) and a new epithet proposed for the later of the two, 'lichenum'. However, the case is not dissimilar to that of *Senecio napaeifolius* and *S. napifolius* which is given as an example of names not likely to be confused (Ex. 10); both were accepted as they had different derivations, as is the case with 'lichenum' (of lichens) and 'lichenicola' (living on lichens).

### Discussion

The genera *Bispora* and *Trimmatostroma* primarily include bark and wood-inhabiting saprobic fungi which have largely superficial colonies and not ones where the mycelium and conidiophores are immersed in host tissues. Further, in *Bispora* the conidia in the type and most species placed there have a characteristic broad pigmented band at the septum, while in *Trimmatostroma* the conidiophores are compacted into dense sporodochia and the conidia are extremely irregular, multicellular and often branched. The type and other species in these genera are well-illustrated in Ellis (1971).

Hawksworth (1979) used both these generic names for lichenicolous species with hesitation and because more appropriate genera had not been described; the two genera were used for different species because of the differences in the conidia. The discovery of *Intralichen baccisporus*, which shares some features of the lichenicolous species he described in these two genera, and which has a similar ecology and biology, indicates that these fungi are closely allied, although molecular data should be used to determine this when sufficient material can be obtained or the species cultured. As no generic name is available it is appropriate to introduce one here rather than to describe the new species in either of the two previously used genera.

We did not consider the lichenicolous genus *Sclerococcum* appropriate for these fungi as in that genus the species characteristically form compacted sporodochia on the surface of the lichen hosts (Hawksworth, 1975, 1979). In addition, the conidia in *Sclerococcum* do not form from immersed torulose conidiophores, and in the type species are produced from a multicellular meristem-like locus. *Monodictys* was also considered inappropriate as in the type and similar species the conidia are formed superficially, and are large and multicellular (Ellis, 1971); some lichenicolous species placed in that genus have less complex conidia, such as *M. anaptychiae* (Hawksworth, 1979), and will eventually also require transfer to separate genera.

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