A reinvestigation of *Microthelia umbilicariae* results in a contribution to the species diversity in *Endococcus*

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Abstract: A set of morphoanatomical characters and the amyloid reaction of the ascomatal centrum indicates that *Microthelia umbilicariae* Linds. belongs to *Endococcus* (Verrucariales). *Endococcus freyi* Hafellner, detected on *Umbilicaria cylindrica* (type locality in Austria), is described as new to science. The new combinations *Endococcus umbilicariae* (Linds.) Hafellner and *Didymocyrtis peltigerae* (Fuckel) Hafellner are introduced.

Key words: Ascomycota, key, *Lasallia*, lichenicolous fungi, *Umbilicaria*, Verrucariales, Pleosporales

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Introduction

The genus *Microthelia* Körb. dates back to the classical period of lichenology when for the first time sufficiently powerful light microscopes opened the universe of fungal spores and their characters to researchers interested in fungal diversity (KÖRBER 1855). Over the time, 277 species and infraspecific taxa have been assigned to *Microthelia*, now a rejected generic name against the conserved genus *Anisomeridium* (Müll.Arg.) M.Choisy.

In the second half of the 19th century also several lichenicolous fungi have either been described in *Microthelia*, namely by the British mycologist William Lauder Lindsay (1829–1880), or have been transferred to *Microthelia* by combination. A comprehensive revision of all taxa ever treated in *Microthelia* has been published by HAWKSWORTH (1985). Due to nomenclatural conflicts mentioned above, none of the species could be retained in that genus. For most of them HAWKSWORTH (l.c.) could make convincing proposals for better generic placements. For a set of additional taxa possible relationships have been discussed. Therefore, e.g. for *Microthelia umbilicariae* Linds., Hawksworth proposed a transfer to *Polycoccum*, a view repeated by HAWKSWORTH & DIEDERICH (1988), and the generic placement in that genus has been

accepted up to now. In the historical literature, on the other hand, an inclusion of that species in *Phaeospora* and *Leptosphaeria* had already been proposed (see below).

In a phylogenetic analysis, ERTZ et al. (2015) have shown that *Polycoccum* in the circumscription commonly applied contains at least two clades, *Polycoccum* s.str. and a second one, for which the widely neglected genus *Didymocyrtis* Vain. had to be resurrected as it was found to constitute the oldest available generic name. Furthermore, the authors could show that the taxonomic position of *Polycoccum* s.str. is different (Dothideomycetes–Trypetheliales–Polycoccaceae) from the previous concepts based on morphoanatomical characters, when it was treated in the branch Dothideomycetes–Pleosporales–Dacampiaceae (e.g., CANNON & KIRK 2007: 98, HYDE et al. 2013: 73–77).

In connection with these comparative studies of further polycoccoid lichenicolous fungi, also *Microthelia umbilicariae* invading occasionally *Lasallia* (*pustulata*) was among the candidates for an alternative and better taxonomic placement. Other than expected, morphoanatomical and biochemical characters have shown that the species belongs to *Endococcus*. Based on some additional collections, two of them rich enough to be distributed in the exsiccata “Lichenicolous Biota”, a detailed treatment of this species is presented below. Furthermore, an additional *Endococcus* species has been detected on *Umbilicaria* (*cylindrica*) which is described here as new to science. I am herewith able to present a further contribution to a better understanding of the species diversity of *Endococcus*.

Material and methods

Dried herbarium specimens cited together with the treatments of the species have been examined. External morphology was studied with a dissecting microscope (WILD M3, 6.4–40×). Anatomical studies of the thallus and the ascomata were carried out under the light microscope (LEICA DMRE, 100–1000x). Sectioning was performed with a freezing microtome (LEITZ, sections of 12–15 µm) but squash preparations were also used, especially for ascus analysis and staining experiments. Preparations were mounted in water. When necessary, contrasting was performed by a pretreatment with lactic acid-cotton blue (MERCK 13741). Amyloid reactions in hymenia were observed by the use of Lugol's reagent (I) (MERCK 9261). Sections and squash preparations were not pretreated with KOH (K) unless otherwise stated (K/I). Measurements refer to dimensions in tap water.

The photographs were taken with a light microscope ZEISS Axioskop equipped with a digital camera system AxioCam MTc5.

Abbreviations for institutional herbaria follow Index Herbariorum (HOLMGREN et al. 1990, THIERS 2019+). Abbreviations of nomenclatural authors are those proposed by BRUMMITT & POWELL (1992). Geographic units are defined and named according to HOLLIS & BRUMMITT (1992) or BRUMMITT (2001).

Taxonomic notes and discussions are based on the outline of lichenicolous fungi published by DIEDERICH et al. (2018).

Material studied for comparison (T = type host):

Endococcus rugulosus Nyl. (type species of *Endococcus*)

Hosts: *Verrucaria macrostoma* (T), *Verrucaria nigrescens* agg. (1), *Verrucaria* spec. (2)

Austria: Steiermark (Styria), Zentralalpen, Murberge, Stolzalpe NE ober Murau, kurz SE der Kapelle, 47°07’10’’N / 14°11’25’’E, ca. 1180 m alt., GF 8851/3, Lichtung im Koniferen-Mischwald, bodennah an niederen Kalkschrofen, (1), 13. V. 1999, leg. J. Hafellner no. 53540 (herb. Hafellner). – Steiermark (Styria), [Gurktaler Alpen], „am Fuß der Seetaler Alpen“, 4 km S von Neumarkt, [kurz E von] Hohe Brücke, am S-Ufer des St. Veiter Baches, [47°02’20’’N / 14°25’40’’E], 760–800 m alt., GF 8952/4, Phyllitausbisse im Hangwald, auf feuchten Vertikalflächen, (2), 28. IV. 1989, leg. W. Obermayer no. 1940 (GZU). – Steiermark (Styria), Steirisches Randgebirge, Grazer Bergland, Rote Wand ca. 3 km E von Mixnitz, SW-Rücken, oberhalb der S-exponierten Abbrüche, 47°19’45’’N / 15°24’05’’E, ca. 1400 m alt., GF 8658/3, niedere Kalkausbisse, auf Neigungsflächen, (1), 30. X. 2005, leg. J. Hafellner no. 64544 (herb. Hafellner). – Steiermark (Styria), Steirisches Randgebirge, Grazer Bergland, Gösser E von Arzberg, etwas W vom Gipfel am oberen Rand der SW-exponierten Abbrüche, 47°15’00’’N / 15°32’05’’E, ca. 980 m alt., GF 8759, niedere Kalkschrofen und einzelne Bäume, auf Neigungsflächen niederer Kalkschrofen, (1), 4. VII. 2009, leg. J. Hafellner no. 74765 (herb. Hafellner). – Steiermark (Styria), Steirisches Randgebirge, Grazer Bergland, Gösser E von Arzberg, am W Rand der SW-exponierten Abbrüche, 47°15’00’’N / 15°31’55’’E, ca. 950 m alt., GF 8759, niedere Kalkschrofen an der Geländekante, auf S-exp. Neigungsflächen, (1), 13. IX. 2009, leg. J. Hafellner no. 74831 (GZU). – Steiermark (Styria), Steirisches Randgebirge, Grazer Bergland, Raabklamm NW von Weiz, orographisch linke Hänge S unter Schachen, markante S-exp. Felsrippe NW gegenüber vom Lehbauersteg, 47°14’15’’N / 15°33’05’’E, ca. 580 m alt., GF 8759/3, Kalkschrofen mit Felsrasen und einzelnen Rotföhren, auf Neigungsflächen der Schrofen auf den Felsgrat, (1), 11. IX. 2009, leg. J. Hafellner no. 74786 (GZU).

Endococcus stigma (Körb.) Stiz. (syn. *Discothecium stigma* (Körb.) Zopf, type species of *Discothecium*)

Hosts: *Acarospora* spec. (1, T, sub “*Lecidea lamprophora”*), *Acarospora fuscata* (2), *Acarospora freyi* (3)

Austria: Kärnten (Carinthia), Nationalpark Hohe Tauern, Schober-Gruppe, Klammer Scharte zwischen dem hintersten Gößnitztal und dem hintersten Gradental, [46°57’50’’N / 12°46’20’’E], 2930 m alt., GF 9042/2, auf Gneisfelsen, (1), 9. VII. 1988, leg. J. Hafellner no. 21818 & M. Walther (GZU, herb. Hafellner). – Kärnten (Carinthia), Ostalpen, Hohe Tauern, Kreuzeck-Gruppe, Knoten Berg NE vom Hochtristenhaus, [46°46’55’’N / 13°06’45’’E], 2150–2210 m alt., GF 9244/2, [N-seitige] Abbrüche aus Glimmerschiefer, (1), 15. VII. 1978, leg. J. Poelt (GZU). – Kärnten (Carinthia), Steirisches Randgebirge, Koralpe E von Wolfsberg, Seespitz, N-Rücken gegen den Sattel zur Kote 2005, sanft geneigte NW-Hänge in das Große Kar, 46°47’30’’N / 14°58’47’’E, ca. 2030 m alt., GF 9255/2, Fläche mit kleinen, losen Felsplatten (Plattengneis) in offener, alpiner Vegetation, auf kleinen Schieferplatten, (1), 11. X. 2008, leg. J. Hafellner no. 72644 (GZU). – Salzburg, Pinzgau, Hohe Tauern, Glockner-Gruppe, Bergkamm NW vom Kitzsteinhorn, E-Hänge der Hinteren Rettenwand ca. 2 km W ober der Krefelder Hütte, [47°12’35’’N / 12°40’50’’E], ca. 2600 m alt., GF 8742/3, kalkhaltiger Grünschiefer, auf E-exponierten Schrofen, (1), 20. VII. 1996, leg. J. Hafellner no. 38281 & H. Wittmann (GZU). – Salzburg, Hohe Tauern, [Glockner-Gruppe], W der Krefelder Hütte, über Kaprun, ca. 2250–2350 m alt., GF 8742/3, auf Kalkschiefer-Schrofen, (1), 31. VII. 1973, leg. J. Poelt (GZU). – Salzburg, Nationalpark Hohe Tauern, Ankogel Gruppe, Greilkopf, knapp N unter dem Westgrat, E ober der Hagener Hütte, [47°01’30’’N / 13°05’50’’E], 2500 m alt., GF 8944/4, alpine Matten über Glimmerschiefer, auf niederen Glimmerschieferschrofen, (1), 27. VIII. 1994, leg. J. Hafellner no. 32981 (GZU). – Steiermark (Styria), Niedere Tauern, Wölzer

Tauern, Planneralpe, nach NE abfallende Geländerippe NE der Karlspitze, bei den großen Blöcken am Grat (Hunnengrab), [47°23’45’’N / 14°10’40’’E], ca. 1950 m alt., GF 8651/1, auf Granatglimmerschieferschrofen, (2), 21. VII. 1988, leg. J. Hafellner no. 20511 (herb. Hafellner). – Tirol (Tyrol), Osttirol, Nationalpark Hohe Tauern, Glockner-Gruppe, Ködnitztal NE ober Kals, kurz N ober der Lucknerhütte, 47°02’35’’N / 12°41’30’’E, ca. 2300 m alt., GF 8942/3, niedere Kalkschieferschrofen und Rasen am Westhang, Lesesteinmauer, auf Glimmerschiefer, (1), 4. IX. 1998, leg. J. Hafellner no. 46863 (GZU). – **Italy**: Trentino-Alto Adige, Südtirol, [Ostalpen, Ötztaler Alpen], Langtauferer Tal E des Reschenpasses, E von Melag, [46°50’10’’N / 10°39’40’’E], 1920 m alt., Fe-hältige Blöcke, (3), 18. IV. 1984, leg. J. Hafellner no. 12387 (GZU). – Trentino-[Alto Adige], Prov. Trento, [Südalpen], Catena dei Lagora, N-exponierte Hänge des Berges Tognazza S vom Passo di Rolle, 46°17’35’’N / 11°47’15’’E, ca. 2050 m alt., auf Porphyrblöcken, (1), 26. X. 1984, leg. J. Hafellner no. 41627 (GZU). – Trentino-[Alto Adige], Prov. Trento, [Südalpen], Val di Moena S von Cavalese, [46°15’40’’N / 11°27’15’’E], 1100–1200 m alt., an Silikatblöcken, (1), 27. X. 1984, leg. J. Poelt (GZU). – Friuli-Venezia Giulia, Prov. Udine, [Südalpen], Karnische Alpen, Monte Crostis N von Comeglians, am Grat W vom Gipfel, [46°34’20’’N / 12°53’20’’E], ca. 2240 m alt., alpine Matten und Schrofen, auf niederen Silikatschrofen, (1), 17. VIII. 1994, leg. J. Hafellner nos. 36792, 36795 (GZU). – **Sweden**: Torne Lappmark, Umgebung von Abisko, wenig S über dem Torneträsk, unterhalb der Naturvetenskapens Station, [68°21’10’’N / 18°50’00’’E], ca. 360 m alt., auf einem Schieferblock, (1), 19. VII. 1967, leg. J. Poelt no. 4707 (GZU). – **Switzerland**: Kanton Tessin, [Westalpen], Adula Alpen, Val Piora, E-exponierte Abhänge S des Passo del Camoghe über dem Ritomsee, [46°32’20’’N / 08°40’15’’E], 2050–2150 m alt., auf Amphibolitfelsen, (1), 30. VIII. 1984, leg. H. Mayrhofer no. 4411 (GZU).

Endococcus propinquus (Körb.) D.Hawksw.

Hosts: *Porpidia tuberculosa* (1, T), *Porpidia crustulata* (2), *Porpidia macrocarpa* (3), *Porpidia cinereoatra* (4), *Porpidia* spec. (5), *Stenhammarella turgida* (6)

Austria: Kärnten (Carinthia), [Eastern Alps], Nationalpark Hohe Tauern, Ankogel Gruppe, am Westgrat des Greilkopf E ober der Hagener Hütte, [47°01’35’’N / 13°05’55’’E], ca. 2500 m alt., GF 8944/4, alpine Matten über Glimmerschiefer, auf niederen Glimmerschieferschrofen, (1), 27. VIII. 1994, leg. J. Hafellner no. 33024 (herb. Hafellner). – Kärnten (Carinthia), Nationalpark Hohe Tauern, Schober-Gruppe, Gradental W von Döllach, SW der Graden Alm, [46°58’05’’N / 12°48’50’’E], ca. 1750 m alt., GF 9042/2, auf großen Gneisblöcken im lichten Lärchenwald, (1), 10. IX. 1988, leg. J. Hafellner no. 21888 & M. Walther (herb. Hafellner). – Kärnten (Carinthia), Hohe Tauern, Kreuzeck-Gruppe, Schwarzsteinwände (Südwände des Schwarzsteins) E der Hochtristen, N der Turgger Alm, [46°47’55’’N / 13°09’10’’E], 1950–2150 m alt., GF 9244/2, auf Grünschieferblöcken, (2), 17. VII. 1978, leg. J. Hafellner no. 4139 (GZU). – Kärnten (Carinthia), [Südalpen], Karnische Alpen, Raudenspitz E ober dem Hochweißsteinhaus, Bergkuppe NE vom Öfner Joch, 46°38’30’’N / 12°44’50’’E, ca. 2100 m alt., GF 9342/3, paläozoische Glimmerschiefer, auf niederen Schrofen, (1), 17. VIII. 1996, leg. J. Hafellner no. 39284 (GZU, under the name of the host). – Steiermark (Styria), [Eastern Alps], Eisenerzer Alpen, Leobner N von Wald am Schoberpaß, Sattel zwischen dem Gipfel und der Leobner Mauer, 47°29’50’’N / 14°39’00’’E, ca. 2000 m alt., GF 8553/2, lückige Windheiden über paläozoischem Schiefer (Blaseneckporphyroid), auf Lesesteinen, (2), 31. VII. 1997, leg. J. Hafellner no. 42514 (GZU). – Steiermark (Styria), Niedere Tauern, Schladminger Tauern, Großsölktal, 1,5 km NW vom Sölkpaß, W ober dem Unteren Kaltenbachsee, [47°16’40’’N / 14°03’55’’E], ca. 1980 m alt., GF 8750/1, schattig-feuchte, N-exponierte Abbrüche, auf steilen Felsschrofen, (6), 2. IX. 1993, leg. A. Wilfling no. 2853 & M. Möslinger (GZU). – Steiermark (Styria), Niedere Tauern, Schladminger Tauern, Eisenhut ca. 8 km NW von Baierdorf, am kurzen W-Rücken unterhalb des Gipfels, 47°14’06’’N / 14°02’57’’E, ca. 2400 m alt., GF 8750/3, auf Glimmerschieferblöcken, (1), 2. VIII. 2011, leg. M. Sebernegg & A. Atanassova, det. J. Hafellner (GZU). – Steiermark (Styria), Niedere Tauern, Wölzer Tauern, Hohenwart-Massiv [W von Pusterwald], E-Hänge des Hohenwart oberhalb der Mittagwand, im Bereich des Marmorzuges, [47°19'45"N / 14°14'25"E], ca. 2220 m alt., GF 8651/3, Schrägflächen schwermetallhaltiger Silikatschrofen, (4), 18. VIII. 1993, leg. M. Möslinger no. F68, J. Hafellner & A.

Wilfling (GZU). – Steiermark (Styria), Niedere Tauern, Wölzer Tauern, Hohenwart-Massiv W von Pusterwald, am Steig zum Pölseckjoch, E unter dem Gipfel, [47°19'45"N / 14°14'30"E], ca. 2200 m alt., GF 8651/3, NE-exponierte intermediäre Marmorschrofen, (5), 18. VIII. 1993, leg. A. Wilfling, J. Hafellner & M. Möslinger (GZU). – Steiermark (Styria), Niedere Tauern, Wölzer Tauern, Aufstieg vom Kleinen Zinken zum Hohen Zinken, 2,5 km N von Lachtal, 2 km NW der Klosterneuburger Hütte, [47°16'20''N / 14°21'00''E], ca. 2140 m alt., GF 8752/1, SE-exponierte Marmorschrofen, auf feinkristallinem, kompaktem Marmor, (6), 7. XI. 1994, leg. A. Wilfling no. 2675, 2447 & F. Wilfling (GZU). – Steiermark (Styria), Niedere Tauern, Triebener Tauern, am oberen Ende der schmalen Rinne zwischen Hochleitenspitze und den Gamskögeln, [47°22'00''N / 14°32'45''E], ca. 2300 m alt., GF 8653/1, auf Gneisblöcken, (5), 18. III. 1990, leg. J. Hafellner no. 51800 (herb. Hafellner). – Steiermark (Styria), Niedere Tauern, Triebener Tauern, Griesmoar Kogel SW von Wald am Schoberpaß, am N-Rücken halbwegs zwischen dem Sattel zum Himmeleck und dem Gipfel, 47°25'15''N / 14°36'10''E, ca. 1950 m alt., GF 8553/4, niedere Ausbisse aus Glimmerschiefer, stellenweise mit Ca-Spuren, in alpinen Matten, auf Steilflächen von Glimmerschiefer, (5), 20. VIII. 2002, leg. J. Hafellner no. 59173 & J. Miadlikowska (GZU). – Steiermark (Styria), Niedere Tauern, Seckauer Tauern, Seckauer Zinken N von Seckau (SW von Mautern), auf dem Gipfel kurz W vom Gipfelkreuz, 47°20'20''N / 14°44'10''E, ca. 2395 m alt., GF 8654/3, Blockwerk quarzreichen Schiefers, auf S-exp. Neigungsflächen von Blöcken, (1), 5. X. 1997, leg. J. Hafellner no. 43791 & J. Kocourková (GZU). – Steiermark (Styria), Ostalpen, Gurktaler Alpen, NW-exponierte Abbrüche zwischen Kornock und Rinsennock über der Winkleralm, W der Turracherhöhe, 46°54'47–56''N / 13°51'07–18''E, 2160–2180 m alt., GF 9049/3, auf Silikatschrofen, (1), 12. IX. 1985, leg. H. Mayrhofer & J. Poelt, det. J. Hafellner (GZU). – Steiermark (Styria), Gurktaler Alpen, Kirbisch ca. 11 km SW von Murau, oberhalb von St. Lorenzen, NE-exponierte Hänge knapp unter dem Gipfel, 47°03'05''N / 14°03'05''E, ca. 2100 m alt., GF 8950/1, niedere Schrofen und Blockwerk aus paläozoischen Schiefern zwischen Zwergstrauchheiden, auf Neigungsflächen der Schrofen, (3), 24. VIII. 2003, leg. J. Hafellner no. 62436 (GZU). – Steiermark (Styria), Ostalpen, Seetaler Alpen, Zirbitzkogel E von Neumarkt, am Rücken von der Tonnerhütte zum Zirbitzkogel, 47°03'50''N / 14°33'40''E, ca. 2250 m alt., GF 8953/1, W-Hänge mit Silikatblockwerk und offenem Caricetum curvulae, auf Gneisblöcken, (1), 8. VII. 1985, leg. J. Hafellner no. 84268 (GZU). – Steiermark (Styria), Steirisches Randgebirge, Gleinalpe, Speikkogel S von St. Michael, oberste N Abhänge kurz N unter dem Gipfel, 47°13'40''N / 15°02'55''E, ca. 1980 m alt., GF 8756/3, Blockschutthalde und umgebende Zwergstrauchheiden, auf teilweise überdeckten, bergfeuchten Gneisblöcken, (1), 12. VIII. 2000, leg. J. Hafellner no. 57887, 57894, 84267 & A. Hafellner (GZU). – Ibid., (3), 12. VIII. 2000, leg. J. Hafellner no. 57892 & A. Hafellner (GZU). – Steiermark (Styria), Sausal, Demmerkogel ca. 9 km W von Leibnitz, am Fuß der E-Hänge im hintersten Teil des Kroisgrabens unterhalb von Kitzeck, 46°47'20''N / 15°26'10''E, ca. 400 m alt., GF 9258/2, Mischwald, an der Steigböschung auf kleinen Ausbissen eines paläozoischen Schiefers, (2), 25. III. 2000, leg. J. Hafellner no. 60927 (GZU). – Tirol, Osttirol, [Eastern Alps], Nationalpark Hohe Tauern, Glockner-Gruppe, Dorfertal N von Kals, kurz S der Maireben Alm, 47°02'15''N / 12°37'30''E, ca. 1620 m alt., GF 8941/4, subalpine Weiderasen mit niederen Schieferblöcken, auf niederen Schieferblöcken, (2), 15. VII. 1997, leg. J. Hafellner no. 47033 (GZU). – **France**: Korsika, Dept. Haute-Corse: Forêt de Vizzavona, kurz NE unter der Paßhöhe des Col de Vizzavona, ca. 1150 m alt., Buchenwald, auf kleinen Felsblöcken am Ufer eines Bächleins, (2), 3. XI. 1993, leg. B. Wieser (GZU). – **Germany**: Bayern (Bavaria), Niederbayern, Bayerisch-Böhmischer Wald, Höllerbachgespreng am Großen Falkenstein bei Zwiesel, c. 900–1100 m alt., auf Granit, (1), 4. X. 1971, leg. J. Poelt no. 10576 (GZU). – **Great Britain / United Kingdom**: Scotland, Westerness (V.C. 97), N side of Loch Sunart, Resipola, ravine of Allt Mhic Chiarain, 50–150 m alt., on siliceous rock, (1), 19. VI. 1992, leg. B. Coppins, P. W. James & J. Poelt no. Sc92/448a (GZU). – Scotland, Westerness (V.C. 97), N side of Loch Sunart, 4–5 km W of Strontian, woodland S of the road W of Woodend, 0–40 m alt., on siliceous rocks, (1), 14. VI. 1992, leg. B. Coppins, P. W. James & J. Poelt no. Sc92/118a (GZU). – **Italy**: Friuli - Venezia Giulia, Prov. Udine, [Southern Alps], Carnic Alps, Monte Fleons (Raudenspitz), slopes NE above Giogo Veranis (Öfner Joch),

46°38’30’’N / 12°44’50’’E, ca. 2100 m alt., palaeozoic micaschists, on low outcrops, (1), 17. VIII. 1996, leg. J. Hafellner no. 39233 (GZU). – Emilia Romagna, Prov. Parma, Apennino, Lago Lagoni S above Corníglio, just E above the lake, 44°23’25’’N / 10°02’50’’E, ca. 1450 m alt., beech forest on gentle slope with big boulders, on boulders of sandstone in the shade, (5), 24. VII. 2001, leg. J. Hafellner no. 58363 (GZU). – **Spain**: Asturias, Prov. Oviedo, Parque Nacional de Muniellos S von Cangas de Narcea, Las Chabolas, c. 1150 m alt., Silikatblockwerk in lockerem Mischwald, auf Silikatblöcken, (1), 5. IX. 1980, leg. J. Hafellner no. 9785 (herb. Hafellner). – **Sweden**: Bohuslän, Uddevalla commune, Skredsvik par., ca. 1 km NE of Cederslund along road Skredsvik to Munkedal, alt. ca. 80 m alt., open Pinus forest, on NW-facing vertical rock faces, gneiss, (1), 27. VIII. 1992, leg. J. Hafellner no. 30432 (GZU, under the name of the host).

Polycoccum trypethelioides (Th.Fr.) R.Sant. (heterotypic synonym of *Polycoccum sauteri* Körb., the type species of *Polycoccum*)

Hosts: *Stereocaulon condensatum* (T), *Stereocaulon alpinum* (1), *Stereocaulon* spec. (2)

Franz Josef Land archipelago (Russian Federation): Ziegler Island, north-western part, c. 600 m WNW of the camp, SW of a small lake, 81°04’22’’N / 56°15’50’’E, 58 m alt., moist flat area dominated by mosses and *Phippsia algida*, (2), 10. VIII. 1996, leg. H. Pauli no. 1-54a, det. J. Hafellner (GZU). – **Austria**: Tirol (Tyrol), [Ostalpen, Rhätische Alpen], Samnaun-Gruppe, Furgler W ober Serfaus, am Grat zwischen dem Furgler Joch und dem Gipfel, [47°02’40’’N / 10°30’50’’E], 2800–2900 m alt., GF 8929, Windheiden im unteren Teil des Grates, auf Rohboden, (1), 2. IX. 1991, leg. J. Hafellner no. 30184 (herb. Hafellner).

Didymocyrtis peltigerae (Fuckel) Hafellner

Host: *Peltigera canina* (T), *Peltigera praetextata* (thallus) (1), *Peltigera rufescens* (thallus) (2)

Austria: Steiermark (Styria), [Eastern Alps], Nördliche Kalkalpen, Ennstaler Alpen, Gesäuseberge, Reichenstein-Massiv ca. 7,5 km SE von Admont, Schneide zwischen Totenköpfl und Pfarrmauer, S-Hänge N über der Mödlinger Hütte, 47°32’50’’N / 14°33’00’’E, 1950 m alt., GF 8453/3, kurze Felsrippe in alpinen Rasen, Triaskalk, auf Moosen und Pflanzenresten, (2), 22. IX. 2007, leg. J. Hafellner no. 69811, L. Muggia & A. Hafellner (herb. Hafellner). – Steiermark (Styria), [Eastern Alps], Niedere Tauern, Wölzer Tauern, Kasofen 2 km N von Pusterwald, Marmore direkt im Gipfelbereich, [47°19’30’’N / 14°22’55’’E], ca. 1890 m alt., GF 8652/3, auf Erde und Moosen, (2), 17. IX. 1993, leg. A. Wilfling no. 616 & M. Möslinger, det. A. Wilfling (GZU). – Tirol (Tyrol), [Eastern Alps], Stubaier Alpen, c. 2 km S of Kühtei, soil deposit north below of the concrete dam of the storage lake "Speicher Finstertal". 47°12’N, 11°02’E, alt. c. 2300 m alt., (2), 4. VIII. 1996, leg. et det. P. Scholz (Triebel, Microfungi Exsiccati 282) (GZU). – **Sweden**: Uppland, Estuna par., Norr Malma, Bybacken, on a mossy rock in an oak forest, (1), 30. IX. 1959, leg. et det. J. Santesson no. 13603 (Santesson, Fungi Lichenicoli exs. No. 68) (GZU).

Results

Endococcus Nyl., Mémoires de la Société Impériale des Sciences Naturelles de Cherbourg 3: 193 (1855).

Type: *Endococcus rugulosus* Nyl. (holotype) (see note 1 further below!)

= *Discothecium* Zopf, Nova Acta. Abhandlungen der Kaiserlichen Leopoldinisch-Carolinischen Deutschen Akademie der Naturforscher 70(2): 131 (1897).

Type: *Discothecium stigma* (Körb.) Zopf [syn. *Tichothecium stigma* Körb.] (holotype) (see note 3 further below!)

= *Pseudoendococcus* Marchand, Énumération méthodique et raisonnée des familles et des genres de la classe des Mycophytes (Champignons & Lichens): 143 (1896) [nomen nudum, sub *Pseudo-Endococcus*].

Type: not indicated (see note 4 further below!)

Full descriptions: TRIEBEL (1989: 90–91); KAINZ & TRIEBEL (2004: 648).

Key characters for identification of the genus: Vegetative hyphae inconspicuous, intrathalline. Ascomata black, sphaerical to ovoid to ellipsoid, solitary or in groups but never in dense herds or laterally fusing, with apical ostiolum and ostiolar region often somewhat flattened, with dark brown to blackish peridial wall composed of few layers ± tangentially flattened hyphal cells with ± evenly pigmented hyphal walls. Hamathecium consisting of persisting crown of periphysoids, interascal filaments lacking in ascomata containing mature asci. Asci verrucarialean, ventricose to clavate (not cylindrical), ascal wall bitunicate with an exoascus secreting hemiamyloid gelatinous matrix which is gradually pervading the hymenium with time, endoascus with distinct ocular chamber when young, 4- to 8-spored. Ascospores brown in various shades, narrowly fusiform to broadly ellipsoid, usually 1-septate, with two ± equal cells, with rounded or acute ends, with thin to moderately thick walls, perisporal sheath frequently demonstrable in careful preparations but in most species inconspicuous, perispore rarely conspicuous but often forming a sculpture visible in LM with increasing age. Gelatinous cap surrounding the exoascus and hymenial gel I(Lugol)$_{dilut.}$ + bluish, I(Lugol)$_{conc.}$ + pale orange-red, K/I + blue.

Frequently confused genera: *Polycoccum*, *Didymocyrtis*, *Sphaerellothecium*.

Number of accepted species: *c.* 45 (compare DIEDERICH et al. 2018: 364–365). – A search of the MycoBank database yielded 79 legitimate names for taxa that have been treated at a certain point in the past as belonging to *Endococcus*.

Species identification: HAWKSWORTH (1979), CLAUZADE et al. (1989: 45–46); both keys including only a limited set of species recognized at that time; no comprehensive key available.

Notes: 1. Together with the protologue of the genus two species are mentioned (NYLANDER 1855), "*E. rugulosus* (Leight. sub Verruc.)" and "*E. perpusillus* Nyl.", both lacking species descriptions. Whereas *Endococcus rugulosus* can be interpreted as a new name replacing *Verrucaria rugulosa* Borrer ex Leight. [1851] non Flörke [1808], *E. perpusillus* Nyl. has not been validly described earlier than 1857 (NYLANDER 1857). Therefore, there is no need to designate a lectotype but *E. rugulosus* de facto constitutes the holotype as it was the only validly described species at the time when the new genus was introduced.

2. For a long time the name *Endococcus rugulosus* has been applied in a broad sense for *Endococcus* species with thick-walled dark-brown ascospores with rounded ends and within a certain range of variation in size (*c.* 12–17 × 5–8 µm). Apart from the type host *Verrucaria macrostoma*, TRIEBEL (1989) included strains invading several only distantly related hosts including species of *Amygdalaria*, *Aspicilia*, *Ionaspis*, *Myriolecis*, *Placopsis*, and *Rhizocarpon*. Since the critical notes published by SÉRUSIAUX

et al. (1999), the name *E. rugulosus* is used in a restricted sense only for a strain invading species of the *Verrucaria nigrescens* group, occasionally also other Verrucariaceae.

3. When ZOPF (1897) introduced the new genus *Discothecium*, the only species assigned to the genus was *Discothecium stigma* (Körb.) Zopf. *D.* constitutes a younger heterotypic synonym of *Endococcus,* nevertheless it was used instead by various authors (e.g. VOUAUX 1913, KEISSLER 1930). The type host for the type species is given in the protologue as *Psora lamprophora*. TRIEBEL (1989) was able to show by direct comparison with other specimens of this rare saxicolous lichen species that this was a misidentification and the areoles on which the ascomata of the *Endococcus* had developed most likely belong to a sterile thallus of an unnamed *Acarospora* species. This is now generally accepted, as there is an *Endococcus* with exactly fitting characters (8-spored asci, ascospores with attenutated ends, etc.) regularly found on various *Acarospora* species.

4. The generic name *Pseudoendococcus* Marchand (sub *Pseudo-Endococcus*) was introduced together with *Pseudorimularia* Marchand (sub *Pseudo-Rimularia*) and *Pseudomycoporon* Marchand (sub *Pseudo-Mycoporon*), all of them without a generic description and without mentioning any species that should belong to these genera, which at the same time were assigned to a new family Pseudoverrucariaceae Marchand (sub Pseudo-Verrucariacés) (MARCHAND 1896). Therefore, *Pseudoendococcus* constitutes an invalidly published genus name (ICN Article 38.1.).

5. HAWKSWORTH (1979) presented a kind of revision of *Endococcus* but the generic concept applied in that publication is rather formal. As the author did not use hyphal wall chemistry for a better circumscription of *Endococcus* (and *Muellerella*), several taxa of superficially similar genera with phaeodidymosporous species are not clearly separated. Only a minority of the species treated treated by HAWKSWORTH (1979) definitely belongs to *Endococcus*.

6. It was TRIEBEL (1989) who for the first time offered a clear and consistent concept of the genus *Endococcus,* but the genus was assigned to Dothideales which under the insights gained in the meanwhile is apparently not the correct placement.

7. In specimens assigned to *Tichothecium stigma* (i.e. *Endococcus stigma*), SANTESSON (1960) has observed a wide variability in the iodine-reaction of the ascomatal centrum, ranging from I- to I+ blue then red (hemiamyloid) to I+ permanently blue (euamyloid). This might depend on a variable amount of ascal gel produced, the concentration of the reagent arriving at the structures to be tested, and the type of iodine-reagent applied (iodine, Lugol, Melzer) which was often not specified in the past but proved to be essential (see the assessment by BARAL 1987). The diagnostic reactive portion of the hymenial gel is that secreted by the outermost layer of the ascal wall and therefore the reactivity of the hymenial gelatinous matrix should be tested near ascus tips.

8. In spite of several contributions to a better understanding of various *Endococcus* species described in the past (e.g. MATZER 1993, SERUSIAUX et al. 1999, TRIEBEL 1989, this publication) and additional, previously not

distinguished species successively described as new (e.g. ALSTRUP 1993, ALSTRUP et al. 1994, BRACKEL & KOCOURKOVÁ 2006, DAVID & ETAYO 1995, ETAYO 2002, ETAYO & BREUSS 2001, ETAYO & SANCHO GARCIA 2008, HAFELLNER 1994, HAFELLNER et al. 2002, HAFELLNER et al. 2008, HALICI et al. 2007, HAWKSWORTH & ITTURIAGA 2006, KNUDSEN 2008, KOCOURKOVA & KNUDSEN 2011, SERUSIAUX et al. 1999, ZHURBENKO & PINO-BODAS 2015, ZHURBENKO et al. 2012, this publication), the genus is still in urgent need of a critical revision.

Additional species to be assigned to *Endococcus* and invading thalli of lichenized fungus species pertaining to the Umbilicariaceae:

Endococcus umbilicariae (Linds.) Hafellner **combinatio nova**

MycoBank number: MB 833719

≡ *Microthelia umbilicariae* Linds., Transactions of the Royal Society of Edinburgh 25: 538 (1869).
≡ *Phaeospora umbilicariae* (Linds.) Arnold, Flora (Regensburg) 57: 151 (1874).
≡ *Leptophaeria umbilicariae* (Linds.) Sacc. & D.Sacc., Sylloge Fungorum 17: 731 (1905).
≡ *Polycoccum umbilicariae* (Linds.) D.Hawksw., Bulletin of the British Museum for Natural History 14(2): 171 (1985).

Type: Norway, without locality, separated from material collected as commercial "Pustulatous moss" (holotype in E) n. v. (restudied by HAWKSWORTH 1985: 171).

Host of type: *Lasallia pustulata* (thallus)

Icon.: LINDSAY (1869: plate XXIII Fig. 31 [coloured drawings of habit, cross section of infected thallus], plate XXIV Fig. 3 [coloured drawings of part of hymenium with indication of some details including one mature ascus with ascospores]); this publication Fig. 1 (photographs of ascus, ascospores).

Description (based on the protologue and own observations): Ascomata black, immersed to later protruding with the upper portion, smooth, with subconical to rounded ostiolar region and distinct apical ostiole, 200–300(–350) µm wide in longitudinal section. Ascomatal wall brown throughout, 40–50 µm thick, in longitudinal section with several layers of polygonal hyphal cells gradually tangentially flattened towards the centrum. Hamathecial filaments developed as periphysoids, forming a circumostiolar crown, 20–30 µm long, some with ramifications, consisting of only few cells, cells 5–10 µm long, lumina 1–2 µm wide, with gelatinized walls and outer delimitation therefore indistinct; interascal filaments not discernable in mature ascomata (for some time persisting empty ascal walls may be misinterpreted as hamathecial elements). Asci ventricose to broadly obclavate, 8-spored (some with reduced spore numbers together with aborted spores), (50–)60–75 × 20–26 µm, fissitunicate, verrucarialean, i.e. cap of ascal gel surrounding exoascus hemiamyloid, $I(Lugol)_{dilut.}$ + bluish, $I(Lugol)_{conc.}$ + pale orange-red, K/I + persistently blue; endoascus I(Lugol) -, in young asci with broadly conical ocular chamber. Ascospores dark brown, 1-septate (but a considerable number of semi-mature spores still non-

septate), broadly ellipsoid, the two cells of ± equal shape and size, hardly constricted at the septum, with rounded ends, with persisting perispore (but occasionally squeezed off from liberated spores in squash preparations), no sculpture visible in LM, (11–)12.5–14(–15.5) × (6–)6.5–7.5 µm (13.5–15 × (6–)6.5–7.5 µm sec. HAWKSWORTH 1985, 11–14 × 6–8 µm sec. BOOM & ETAYO 2014).

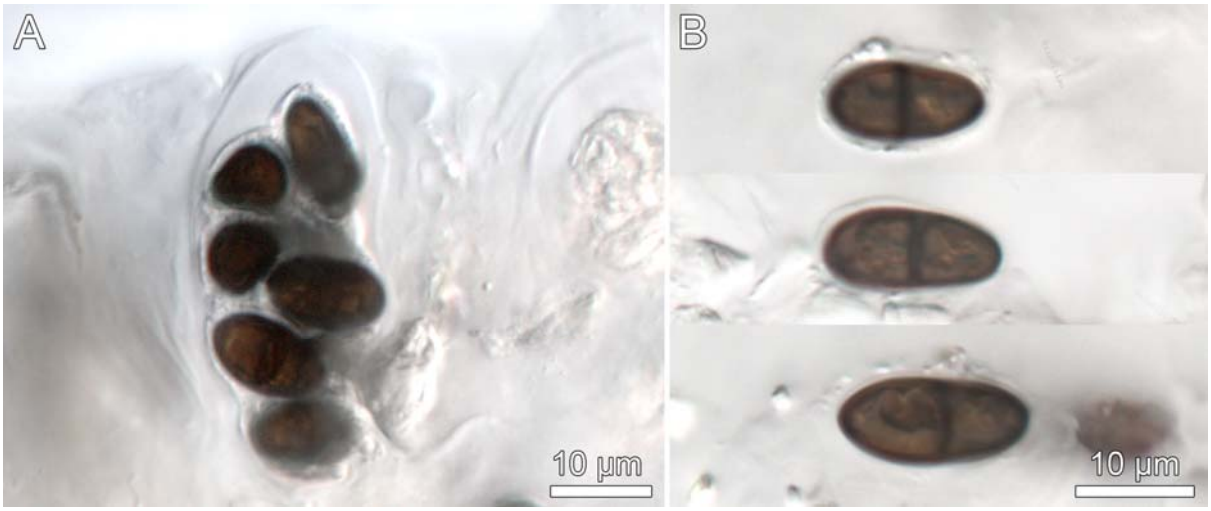

Figure 1: *Endococcus umbilicariae* (Hafellner no. 48136; medium: tap water). – **A**) Ascus. – **B**) Ascospores. – Photos: Walter Obermayer.

Notes: 1. LINDSAY (1869) described what he thought to constitute paraphyses as “very delicate and indistinct” and interestingly noted a similarity with *Verrucaria*. Furthermore, he had correctly observed the positive iodine reaction of the ascomatal centrum.

2. Based on a set of characters observed in a collection from western Spain, already BOOM & ETAYO (2014) had concluded that the species belongs to *Endococcus* but refrained from making the formal combination. Furthermore, the authors had observed a retarded pigmentation and septum formation of the ascospores and they describe the ascospores as halonate.

3. When combining *Microthelia umbilicariae* to *Polycoccum*, HAWKSWORTH (1985) saw affinities to *Polycoccum peltigerae* (Fuckel) Vězda, a view I cannot share. These two species are only distantly related ascomycetes and in a phylogenetic reconstruction still to be performed I expect them to come out in clades differing on class level (Eurotiomycetes vs. Dothideomycetes).

4. The latter species is not a *Polycoccum* either but fits smoothly to *Didymocyrtis* Vain. Therefore, the following combination is introduced:

Didymocyrtis peltigerae (Fuckel) Hafellner **combinatio nova**

MycoBank number: MB 833720

≡ *Didymosphaeria peltigerae* Fuckel, Symbolae mycologicae: 140 (1869) = Jahrbücher des Nassauischen Vereins für Naturkunde 23-24: 140 (1869-1870).

≡ *Polycoccum peltigerae* (Fuckel) Vězda, Ceská Mykologie 23(2): 109 (1969).

Type: [Germany, Hesse], „im Oestricher Wald, auf dem noch lebenden Thallus von *Peltigera canina*, sehr selten, im Frühling" (?G) n. v. (data from protologue, position of words changed). The Fuckel herbarium ought to be stored in Geneva, but the type could not be traced in the CJBG database.

5. DARMOSTYUK (2018) reported on a specimen identified as *Polycoccum umbilicariae* from the Carpathians in the Ukraine. As the host of the sample on which this record is based, is *Umbilicaria cylindrica*, and judging from the photographs of the ascospores (DARMOSTYUK 2018: 177, Fig. 1F–G), this finding is likely to belong to *Endococcus freyi* described as new further below.

Hosts of *Endococcus umbilicariae*: *Lasallia pustulata* (thallus) (1, T), *Lasallia hispanica* (thallus) (2). – Note: *Lasallia* has been reduced to subgeneric rank within *Umbilicaria* (compare DAVYDOV et al. 2017), but this is not generally accepted (see discussion further below).

Ecology and distribution of the observed hosts: A circumscription of the ecological requirements of *Lasallia pustulata* is given by various authors (e.g. WIRTH et al. 2013). It grows on siliceous rocks, predominantly on rough inclined slightly eutrophicated (e.g., by dust from sources in the surroundings) mostly sunny rock faces at lower elevation (in the Alps most frequently in the montane, only rarely in the upper montane belt where thalli are consistently smaller, but not above the treeline). Usually it occurs in rather late stages of succession. Surprisingly, the only record in the Polish Tatra Mts. is from the subnival belt (but there are a number of records from lower elevations in other parts of the Carpathian mountain chain (KRZEWICKA 2004). The required site conditions for *Lasallia hispanica* have been specified by SANCHO & CRESPO (1989). It preferably grows on sunny, often wind exposed xeric eutrophicated flat to slightly inclined surfaces of siliceous rocks and boulders and is said to co-occur not rarely with *L. pustulata*.

Various aspects of population ecology including modes of dispersal, gap dynamics, etc., in connection with the various modes of reproduction possible in *Lasallia pustulata* have been studied and discussed in detail by HESTMARK (1992, 1997).

Lasallia pustulata is widely distributed in Europe reaching also northern Africa and Macaronesia (with additional enclaves in orobiomes in Eastern Africa as well as North America). Further closely related species (*L. brigantium*, *L. hispanica*) occur in southwestern Europe (with *L. hispanica* extending to northern Africa) from mid elevations upwards and (*L. rossica*) in the east of the continent at higher altitudes (see e.g. SANCHO & CRESPO 1989).

Known distribution and previous records of *Endococcus umbilicariae*: For a long time, this relatively conspicuous species was only reported from Norway, based on the type that had been separated from lichen material collected for commercial purposes (LINDSAY 1869). In more recent years it has also been found in France (ROUX et al. 2014) and Spain (BOOM & ETAYO 2014), but the still very few localities from where *E. umbilicariae* is

known indicate that it is a rare species. Collections cited below constitute additions to the mycofloras of Finland as well as to offshore Africa (Canary Islands, Madeira). A preference for host populations growing under not too continental environmental conditions is evident.

A record from Ukraine (DARMOSTYUK 2018, sub *Polycoccum umbilicariae* on *Umbilicaria cylindrica*) refers most likely to a closely related species, here treated under *Endococcus freyi* (see below).

Exsiccata examined: Hafellner, Lichenicolous Biota no. 303 (BCN, BR, CANB, E, GZU, LE, M, NY, PRM, UPS). – Hafellner, Lichenicolous Biota no. 312 (BR, CANB, GZU, NY, UPS).

Further specimens seen: **Europe**: **Finland**: Alandia, Jomala, Södersunda, Degerberget, grid 27°, E: 6690:104, water seepage on W exposed cliff, 22. VIII. 1976, leg. Roland Skytén (GZU). – **Spain**: prov. de Madrid, Sierra de Guadarrama, Puerto de la Morcuera, 40°49'N / 3°45'W, elev. 1700 m alt., growing on north-facing granite rocks, (2), 4. VI. 2001, leg. L. G. Sancho & S. Pannewitz (separated from G. B. Feige & H. T. Lumbsch, Umbilicariaceae exs. no. 81) (GZU). – **Africa**: **Canary Islands:** Gran Canaria, a short distance N below the summit of Pico de las Nieves, 27°58'00''N / 15°34'20''W, *c*. 1870 m alt., conspicuous wall-like basaltic outcrop in pine forest, on steep rock faces exposed to the N, 26. II. 1994, leg. J. Hafellner no. 48136 - Lichenicolous Biota no. 303 (BCN, BR, CANB, E, GZU, LE, M, NY, PRM, UPS). – **Madeira**: Pico Escalvado c. 1 km S of Pico do Arieiro, 32°43'00''N / 16° 55'45''W, *c*. 1670 m alt., volcanic cliffs, on steep rock faces exposed to the N difficult to access, 20. II. 1990, leg. J. Hafellner no. 27351 & A. Hafellner - Lichenicolous Biota no. 312 (BR, CANB, GZU, NY, UPS).

Endococcus freyi Hafellner **species nova**

MycoBank number: MB 833721

Diagnosis: Species *Endococco umbilicariae* similis sed ab eo differt ascomatibus minoribus et ascosporis majoribus atque apicibus ascosporarum subacutis. Forma ascosporarum ut in *E*. *stigma* sed ascosporae in magnitudine [(15–)17–20 × (6–)7–8.5 µm vs. 11–14 × 5.5–7 µm in *E*. *stigma*] differentes. Habitat in thallis *Umbilicariarum* in regionibus frigidis holarcticis.

Type: **Austria**: Kärnten (Carinthia), [Eastern Alps, Hohe Tauern], Kreuzeckgruppe, [NW über Dellach im Drautal], oberhalb der Hugo-Gerbers-Hütte, [46°49'05''N / 13°01'45''E], ca. 2400 m alt., GF 9144/3, auf Amphibolitfels, 2. XI. 1986, leg. W. Petutschnig [holotype in GZU].

Host of type: *Umbilicaria cylindrica* (thallus)

Icon.: This publication Fig. 2 (photographs of part of ascomatal cavity with mature asci, ascal tips, ascospores)

Etymology: Named after the Swiss teacher Eduard Frey (1888–1974), mountaineer and one of the outstanding lichenologists working in the Alps, at that time also the leading expert in *Umbilicaria* taxonomy.

Description: Infection not causing severe damage to the host thallus but slight bleaching in areas where the ascomata of the lichenicolous fungus develop might occur. Vegetative hyphae inconspicuous. **Ascomata** black, semi-immersed, smooth, with rounded to broadly conical ostiolar region, (170–)200–250 µm. Ascomatal wall brown throughout, 30–40 µm thick, in

longitudinal section with several layers of polygonal hyphal cells, more tangentially flattened towards the centrum, Hamathecial filaments developed as **periphysoids**, forming a circumostiolar crown, 18–25 µm long, some with ramifications, consisting of only few cells, cells 5–10 µm long, lumina 1–2 µm wide, with gelatinized walls and outer delimitation therefore indistinct; interascal filaments not discernable in mature ascomata. **Asci** broadly clavate, 8-spored (some with reduced spore numbers together with aborted spores), 50–70 × 16–22 µm, fissitunicate, verrucarialean, i.e. gelatinous cap secreted namely in the apical region of exoascus and gradually pervading the entire hymenium hemiamyloid, I(Lugol)$_{dilut.}$ + bluish, I(Lugol)$_{conc.}$ + pale orange-brown, K/I + persistently blue. **Ascospores** brown, 1-septate (some non-septate spores intermixed and semi-mature spores occasionally also still non-septate), ellipsoid, the two cells of ± equal shape and size, not or hardly constricted at the septum, with somewhat pointed ends (shape similar to spores of *Endococcus stigma*), with persisting perispore (but occasionally squeezed off from liberated spores in squash preparations), no sculpture visible in LM, (15–)17–20 × (6–)7–8.5 µm (the paratype from the Canadian Arctic with many spores near the lower limits).

Hosts: *Umbilicaria cylindrica* (thallus) (1, T), *Umbilicaria crustulosa* coll. (thallus) (2)

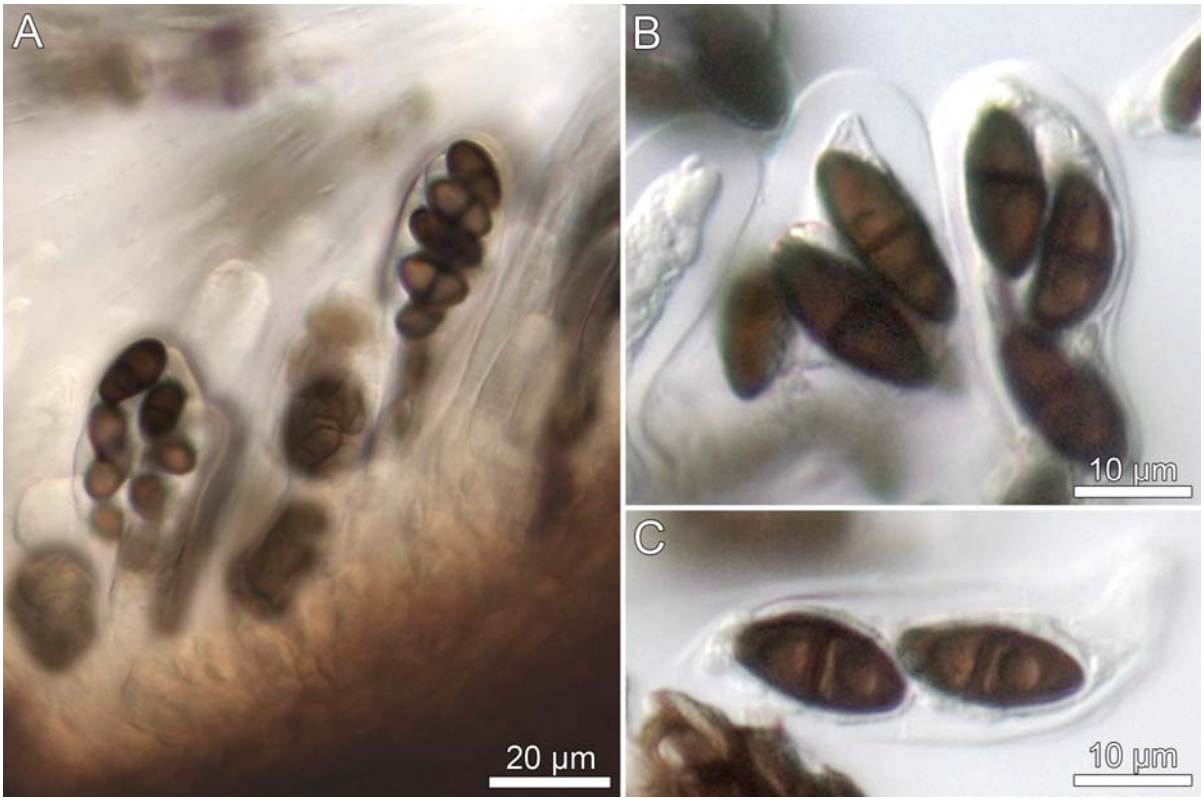

Figure 2: *Endococcus freyi* (holotype; medium: tap water). – **A**) Part of ascomatal cavity with mature asci. – **B**) Ascus tips of mature asci. – **C**) Ascospores. – Photos: Walter Obermayer.

Notes: 1. The semiimmersed ascomata of *Endococcus freyi* are rather conspicuous under a dissecting microscope. Nevertheless, they are difficult to distinguish from the ascomata of the apparently much more common *Stigmidium gyrophorarum* (these usually somewhat smaller, less protruding

and often on distinctly bleached areas) and from the pycnidia of the host lichen which are also regularly present. The latter are hardly protruding, often provided with a thalline collar and are concentrated in the healthy marginal zone. So *Endococcus freyi* might be easily overlooked unless its presence becomes evident in a section or a squash preparation.

2. The other *Endococcus* on Umbilicariaceae, *E. umbilicariae*, has smaller ascospores of a different shape. The morphoanatomically most similar species, also occurring on siliceous rocks in arctic to temperate-alpine environments in the Holarctic region are: *Endococcus propinquus* (ascospores with similar wall thickness but of different shape and of smaller size), *Endococcus brachysporus* (ascospores of different shape and of smaller size, compare SÉRUSIAUX et al. 1999), and *E. stigma* (ascospores with similar wall thickness and equally with subacute ends but of smaller size).

3. The two *Umbilicaria* species on which *Endococcus freyi* has so far been recorded belong to different clades (subgenera?) as circumscribed in the phylogenetic reconstruction of Umbilicariaceae performed by DAVYDOV et al. (2017). Whereas the type host, *Umbilicaria cylindrica*, is a member of clade "*Umbilicaria*", the second host, *U. crustulosa* coll., is a member of clade "*Gyrophora*".

Known distribution and previous records: Known from the Eastern Alps in Austria and the Canadian Arctic. A recent record of a similar lichenicolous fungus from the Carpathian Range in the Ukraine (DARMOSTYUK 2018, sub "*Polycoccum umbilicariae*" on *Umbilicaria cylindrica*) might also belong here.

Exsiccata examined: –

Further specimens seen: **Europe**: **Austria:** Tirol, Osttirol, Nationalpark Hohe Tauern, Venediger-Gruppe, Osthänge kurz SE unter der Essener-Rostocker-Hütte, 47°03'15''N / 12°18'00''E, ca. 2100 m alt., GF 8939/2, Schieferabbrüche und alpine Rasen, auf teilweise Ca-hältigen Schieferabbrüchen, (2), 9. IX. 1989, leg. J. Hafellner no. 84290 & A. Hafellner (herb. Hafellner). – **Northern America**: **Canada:** North-Western Territory [now Nunavut]: Baffin Island region [now Qikiqtaaluk Region], Broughton Island [now Qikiqtarjuaq] E of Baffin Island, Cumberland Peninsula, Old Broughton settlement site [Qikiqtarjuaqruluk], c. 5 m alt., snow melt streams and boggy water accumulation areas, (1), 1.–22 VII. 1974, leg. Catherine LaFarge L-61641a, det. J. H. (GZU).

Discussion

Taxonomy of *Endococcus* and related genera

Some very divergent proposals for a placement of *Endococcus* have been made in the past. In the recent outline by DIEDERICH et al. (2018), *Endococcus* has been assigned to Eurotiomycetes–Chaetothyriomycetidae–Verrucariales–Verrucariaceae, whereas JAYASIRI et al. (2016) concluded from morphoanatomical similarities that *Endococcus* [*rugulosus*] should belong to Dothideomycetes–[Dothideomycetidae]–[Lichenotheliales]–Lichenotheliaceae(!) which sounds a little bizarre for a mycologist familiar with a wide range of lichenicolous fungi. Previously, TRIEBEL (1989) had also assigned *Endo-*

coccus to Dothideales but with unclear relationship, whereas *Muellerella* was placed in Verrucariales.

A relatively close relationship between the genera *Endococcus*, *Muellerella*, *Phaeospora*, and *Merismatium* p.p. (i.e. *Halospora*) was occasionally noticed in the past (e.g. ARNOLD 1874, 1877, 1881, 1895, KEISSLER 1930, HAWKSWORTH 1979), resulting in a considerable number of proposed transfers of species to one or the other genus in various directions. The delimitation of phaeo-didymosporous *Endococcus* [1855] from phaeo-phragmosporous *Phaeospora* [1879] and phaeo-dictyosporous *Halospora* [1952] is still rather formal. Equally, the delimitation of oligospored *Endococcus* [1855] from polyspored *Muellerella* [1862] – in this genus namely from the *M*. *pygmaea* group – needs a critical reevaluation as is the justification of a segregated genus *Bellemerella* [1997], said to be closely related to *Muellerella*. Probably only a phylogentic reconstruction based on sequence data of a larger set of taxa and including also all relevant type species will show if the phenotypic characters “ascospore number per ascus” and “ascospore septation” do have taxonomic value above species level in this group of ascomycetes. But this appears to be a difficult task, because of all these genera only a non-type *Endococcus* has so far been successfully sequenced, and even this one without repeat. It is questionable if the separation of all these genera is justified. In case that a phylogenetic reconstruction recommends the extreme conclusion to merge all these genera, *Endococcus* would take priority over all the other generic names mentioned above. Therefore, such conclusions would not have an effect on our results concerning the species treated here. But some dozens of species of lichenicolous fungi would require a complete re-arrangement.

In a hierarchial taxonomic arrangement of all genera with lichenicolous species (DIEDERICH et al. 2018), the genera here in focus are assigned to two orders within Chaeothyriomycetidae. Whereas *Muellerella* was assigned to Chaetothyriales inc. sed., the other genera here in discussion were included in Verrucariales-Verrucariaceae. This is at least partly based on a phylogenetic reconstruction including species of other genera here in focus, performed by MUGGIA et al. (2015) who were able to demonstrate that the *Muellerella lichenicola* group and connected *Lichenodiplis*-type anamorphs belong to a sister clade of *Epibryon* in Chaetothyriales. The so far unanswered question is, whether the *Muellerella lichenicola* group, the *Muellerella pygmaea* group, and the type species *Muellerella polyspora* are definitely so closely related which in our opinion is not at all sure. A so far hardly discussed possibility is that in a systematic arrangement of phaeosporous Chaetothyriomycetidae some phenotypic characters have not been correctly weighted so far. On the one side, ascospore number and septation might have been over-emphasized, whereas on the other side ascospore wall thickness – noted occasionally in species delimitations but possibly a more significant character linking entire species groups across current generic concepts – has been widely neglected. So far thin-walled and thick-walled species groups are scattered over all genera here in focus but, e.g., the very first key character for the recognition of *Halospora* species among true *Meris-*

matium species was the very different ascospore wall thickness between these two genera (HAFELLNER 2011) which TRIEBEL (1989) had already realized and perfectly depicted. But in this case, she had not drawn the necessary taxonomical conclusions.

Taxonomy of *Umbilicariaceae*

For the Swiss lichenologist Eduard Frey the Umbilicariaceae were one of his favorite research topics. In two papers he dealt in some detail with the systematics of *Umbilicaria* (FREY 1929, 1936) and alluded to several problems and aspects (e.g. value of various phenotypic characters for *Umbilicaria* taxonomy, such as ascospore septation, surface of apothecial discs, thalline characters), but altogether he did not publish a comprehensive taxonomic synopsis at that time. Only in the treatment of Umbilicariaceae for the Rabenhorst Flora (FREY 1932–1933), he was forced to offer an overall view of his concept, at least for the species occurring in Central Europe. Later, in a kind of summary of the insights he had gained over the years, he presented an overview (FREY 1949) classifying all *Umbilicaria* species in a single genus in which he accepted three subgenera (*Lasallia*, *Gyrophoropsis*, *Gyrophora*) with *Gyrophora* subdivided in 4 sections (*Velleae*, *Polymorphae*, *Glabrae*, *Anthracinae*).

More or less at the same time SCHOLANDER (1934) has presented an alternative concept. He had regarded ascomatal subdivision during ontogeny resulting in different surface types of the apothecial disc as a distinguishing character important enough to accept four genera (*Umbilicaria*, *Omphalodiscus*, *Gyrophora*, *Actinogyra*). This idea was later on taken up and elaborated by LLANO (1950). However, already FREY (1936) has pointed out that intermediate types as well as changes from one type to the other in aging ascomata frequently occur, making this concept hardly practicable. And as it has been shown later, such a subdivision definitely does not result in monophyletic groups (see below).

A first attempt for a taxonomy of Umbilicariaceae using sequence data has been presented by IVANOVA et al. (1999). Their results showed *Umbilicaria spodochroa* in a basal position of the branch to be excluded in order to get two monophyletic clades (*Lasallia*, *Umbilicaria*). In a later study, DAVYDOV et al. (2010) have shown a monophyletic clade *Lasallia*, if *Umbilicaria caroliniana* (a species with thallus pustules not always present) is transferred to *Lasallia*. The most recent and comprehensive study has been presented by DAVYDOV et al. (2017) who identified 6 major clades in *Umbilicaria*. Based on their reconstruction of Umbilicariaceae phylogeny, acceptance of *Lasallia* would make the rest (*Umbilicaria*) paraphyletic. In order to escape this problem, *Lasallia* has been reduced to subgeneric rank within a broader defined genus *Umbilicaria* (compare DAVYDOV et al. 2017: 1287, Fig. 2). Furthermore, in this study *Umbilicaria spodochroa* did not come out in a basal position but in the *U*. *vellea* group in subgen. *Gyrophora* which is also reasonable from its morphoanatomy. In case that the phylogenetic reconstruction performed by DAVYDOV et al. (2017) will be confirmed by future repeats with

different species sets and/or genes, it would be worth to consider, as an alternative to their concept, a split of *Umbilicaria* in order to get monophyletic clades apart from a *Lasallia*-clade. But this is a question to be resolved by specialists in *Umbilicaria* taxonomy.

As *Lasallia* in its common circumscription is an easily recognizable genus, it is widely accepted in lichen floras (e.g., AWASTHI 2007, GALLOWAY 2007, HITCH & PURVIS 2009, JOHN & TÜRK 2017, KROG et al. 1994, MCCUNE & GEISER 2009, SANCHO 2004, WIRTH et al. 2013) and regional revisions of Umbilicariaceae (e.g., FREY 1977, KROG & SWINSCOW 1986, KRZEWICKA 2004, WEI & JIANG 1993). A key including the species in question and taking into consideration also secondary chemistry characters was published by POSNER et al. (1991).

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