

***Cortinarius* subgenus *Phlegmacium* subsection *Varii* in Europe**

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Abstract

The taxonomy and phylogeny of the new subsect. *Varii* (*Cortinarius*, subgen. *Phlegmacium*) are presented. The subsection is well circumscribed by molecular data and to some degree also on morphological features. We identify seven species in the subsection, six of them occurring in Europe. The study is mainly based on data from our own collections except for *C. variiformis* s. str. and *C. variosimilis*, whose descriptions follow the protologues, too. In the study we generated eighteen new sequences, which serve as the base for a phylogram covering the subsection. Species of subsect. *Varii* are characterised by their strict mycorrhizal associations, at least in Europe, with a wide variety of mycorrhizal hosts apparently mainly or exclusively growing on basic soils. Although more material is needed for some species, we publish here a provisional key of the subsection.

Résumé

Les auteurs présentent la taxinomie et la phylogénie de la nouvelle sous-section *Varii* (*Cortinarius*, Subgen. *Phlegmacium*). Cette sous-section est bien définie par des données moléculaires et dans une moindre mesure aussi par des caractères morphologiques. Nous distinguons sept espèces de *Varii*, dont six sont présentes en Europe. La présente étude se base dans une large mesure sur des données issues de nos propres récoltes, sauf pour *C. variiformis* s. str. et *C. variosimilis*, dont les descriptions données ici reposent aussi sur les protologues. Pour cette étude, nous avons établi dix-huit nouvelles séquences qui servent de base pour un phylogramme de la nouvelle section. Les espèces de la sous-section *Varii* se distinguent, au moins en Europe, par leur étroite relation mycorrhizienne avec un grand nombre d'hôtes et poussent manifestement principalement ou exclusivement sur sol calcaire. Quand bien même il serait nécessaire de disposer d'un plus grand nombre de récoltes de quelques espèces, nous publions ici une clé provisoire de la sous-section.

Zusammenfassung

Die Taxonomie und Phylogenie der neuen Subsektion *Varii* (*Cortinarius*, Subgen. *Phlegmacium*) werden vorgestellt. Diese Subsektion ist durch molekulare Daten und eingeschränkt auch durch morphologische Merkmale gut definiert. Wir unterscheiden sieben Arten bei den *Varii*, wovon sechs in Europa vorkommen. Diese Arbeit basiert weitgehend auf Daten unserer eigenen Aufsammlungen, außer bei *C. variiformis* s. str. und *C. variosimilis*, deren hier wiederge-

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gebene Beschreibungen auch auf den Protologen beruhen. Für diese Arbeit haben wir achtzehn neue Sequenzen erstellt, die als Basis für ein Phylogramm der Subsektion dienen. Die Arten der Subsektion *Varii* zeichnen sich zumindest in Europa durch ihre enge Mykorrhizabindung bei einer Vielzahl von Mykorrhiza-Wirten aus und wachsen offenbar hauptsächlich oder ausschließlich auf Kalkböden. Obwohl von einigen Arten eigentlich noch mehr Kollektionen benötigt würden, veröffentlichen wir hier einen vorläufigen Schlüssel der Subsektion.

Riassunto

Vengono qui presentate la tassonomia e la filogenesi della nuova sottosezione *Varii* (*Cortinarius*, subgen. *Phlegmacium*). Questa sottosezione è ben definita dai dati molecolari e anche, in maniera più limitata, dalle caratteristiche morfologiche. Possiamo distinguere in questa sottosezione ben sette specie, sei delle quali si trovano in Europa. Questo lavoro si basa in gran parte su dati provenienti dalle nostre collezioni, ad eccezione di *C. variiformis* s. str. e *C. variosimilis*, le cui descrizioni qui presentate si basano anche sui protologi. Per questo lavoro abbiamo generato diciotto nuove sequenze che sono servite come base per il filogramma della sottosezione. Le specie della sottosezione *Varii*, per lo meno in Europa, si caratterizzano per il loro stretto legame micorrizico con un gran numero di ospiti micorrizici e sembra che crescano principalmente o esclusivamente su terreni calcarei. Nonostante siano necessarie per alcune specie una maggiore quantità di raccolte, pubblichiamo una chiave provvisoria della sottosezione.

Resumen

Se muestra la taxonomía y filogenia de la nueva subsecc. *Varii* (*Cortinarius*, subgén. *Phlegmacium*). La subsección se encuentra bien circunscrita por los datos moleculares y también, hasta cierto grado, por los caracteres morfológicos. Identificamos siete especies en esta subsección, seis de las cuales se dan en Europa. El estudio se basa principalmente en datos de nuestras propias colecciones, excepto para *C. variiformis* s. str. y *C. variosimilis*, cuyas descripciones siguen los protólogos. En el estudio generamos dieciocho nuevas secuencias, que sirven de base para el filograma que abarca la subsección. Las especies o la subsecc. *Varii* se caracterizan por las estrictas asociaciones micorrícicas, al menos en Europa, con una amplia variedad de huéspedes micorrícicos, aparentemente principal o exclusivamente desarrollándose sobre suelos básicos. Aunque se necesite más material en algunas especies, publicamos aquí una clave provisional de la subsección.

Key words • Mots-clés • Schlüsselwörter • Parole chiave • Paraules clau: Basidiomycota, coniferous and deciduous forests, *Cortinarius decolorans*, *C. luteocingulatus*, *C. reverendissimus*, *C. variiformis*, *C. variosimilis*, *C. varius*, ITS, phylogeny, taxonomy.

Introduction

The *Varii* clade in *Cortinarius* was introduced by SOOP et al. (2019). It is formed by seven phlegmacioid fungi characterised by a mostly yellow-ochraceous pileus, more or less violet-bluish lamellae and a white to yellow veil. The clade is well supported by molecular markers, and shown to occur within a larger lineage of many European, North American and Southern *Phlegmacium* clades in the global phylogeny of the genus (SOOP et al., 2019). Its nearest sisters appear to be the clades */Caligati /Obsoleti*, *Arguti* as well as smaller lineages that include *C. tiliae* and *C. pini*, altogether making up the major part of the morphologically defined section *Phlegmacium* in the sense of BRANDRUD (1996). As pointed out by BRANDRUD (1996) all of sect. *Phlegmacium* species are very strict in their mycorrhizal associations; *C. varius* occurring exclusively (or almost exclusively) with *Picea* spp., *C. tiliae* only with *Tilia*, *C. argutus* only with *Populus*, etc.

The aim of this study is to discuss the subsection *Varii* and review its taxonomy and phylogeny in the light of recent research.

Materials and Methods

Molecular data

For the amplification and sequencing of the nrDNA ITS region, the Phire Plant Direct PCR Kit was used with protocols following PAPP & DIMA (2018). The sequencing was carried out by the LGC Genomics at Berlin with the primer pairs ITS1F/ITS4. The sequences were edited with Codon Code Aligner 8.0.1. The newly generated sequences were deposited in GenBank (Tab. 1).

Table 1. Collections for phylogenetic analyses and morphological studies

(abr.: AB = A. Bidaud; CFP = Cortinarius *Flora Photographica*; CR = C. Rossi; DB = B. Dima; GK = GS = G. Saar; IB = University of Innsbruck; JK = J. Kleine; JV = J. Vila; KS = K. Soop; MD = M. Dondl; PML = P. Moëgne-Loccoz; SSSt = G. Schmidt-Stohn; TEB = T. E. Brandrud; TF = T. Frøslev; TG = G. Turrini; TSJ = T. S. Jeppesen; TU = University of Turku; TUB = University of Tübingen).

Species	Location, host trees	Date	Collector	Voucher, herbarium	GenBank-accession no.
<i>C. decolorans</i>	Germany, Bavaria, Baumgartenschneid, <i>Picea</i> , <i>Fagus</i> , <i>Acer</i>	23.09.2013	M. Dondl	MD25-2013	MT739793
<i>C. decolorans</i>	Germany, Bavaria, Munich, <i>Picea</i> , <i>Salix</i> , <i>Fraxinus</i> , <i>Acer</i> , <i>Alnus</i> , <i>Fagus</i>	25.08.2014	M. Dondl	MD57-2014	MT739794
<i>C. decolorans</i>	Germany, Bavaria, Fischerbachau, <i>Abies</i> , <i>Picea</i> , <i>Fagus</i> , <i>Acer</i>	23.09.2017	M. Dondl	MD36-2017	MT739795
<i>C. decolorans</i>	Sweden, Uppland, Billudden, <i>Picea</i>	23.09.2012	K. Soop	KS-CO2085	MT739796
<i>C. decolorans</i>	Austria, Tyrol, Imst, <i>Picea abies</i>	02.10.2001	S. Garnica	TUB011413	AY174790
<i>C. decolorans</i>	Germany, Bavaria, Oberjoch, <i>Picea abies</i>	...10.2000	S. Garnica	TUB011392	AY174792
<i>C. decolorans</i>	Sweden, Gotland, Tjaukle, <i>Picea abies</i>	30.09.1995	K. Soop	KS-CO745 Neotypus	KJ421062
<i>C. luteocingulatus</i>	Italy, Urbino, La Cesane/ Fossombrone, <i>Quercus pubescens</i> , <i>Ostrya carpinifolia</i>	28.10.2015	G. Schmidt-Stohn	SSSt15-114	MT739797
<i>C. luteocingulatus</i>	Germany, Mecklenburg-Vorp., Plauer Lehmkuhle, <i>Quercus</i>	10.10.2019	G. Schmidt-Stohn	SSSt19-108	MT739798
<i>C. luteocingulatus</i>	Spain, Cadiz, Grazalema, <i>Abies pinsapo</i> , <i>Quercus faginea</i>	28.11.2019	C. Rossi	CR8512-19	MT739799
<i>C. luteocingulatus</i>	Sweden, Österplana, <i>Quercus</i> sp.	21.09.2004	T. Frøslev	TF 2004-055	MT739800
<i>C. luteocingulatus</i>	Spain, El Brull, <i>Quercus ilex</i> , <i>Q. pubescens</i>	07.11.2007	T. S. Jeppesen	TSJ 2007-068	MT739801
<i>C. luteocingulatus</i>	Czech Republic, <i>Quercus pubescens</i>	29.09.2014	T. S. Jeppesen	TSJ 2014-048	MT739802
<i>C. luteocingulatus</i>	France, Ain, Arelod, <i>Carpinus</i> , <i>Quercus</i>	23.10.1991	A. Bidaud	AB91-10-260 G288852/1 Holotypus	KF732343

Species	Location, host trees	Date	Collector	Voucher, herbarium	GenBank-accession no.
<i>C. luteocingulatus</i>	France, Seine-et-Marne, Noisiel, broadleaved forest	20.10.1996	G. Flantzer	GK 4391 G293699	KF732405
<i>C. luteocingulatus</i>	France, Provence, St. Rémy, <i>Quercus ilex</i>	03.12.1997	G. & L. Rioussset	GK4663 (G2951311)	KF732455
<i>C. luteocingulatus</i>	Spain, Burgos, Barrasa de Mena, <i>Quercus faginea</i>	20.11.1999	J. A. Cadiñanos	GDA 44814 TUB019702	KJ421179
<i>C. reverendissimus</i>	Germany, Baden-Württemberg, Bollschweil, <i>Abies alba</i>	22.10.2015	M. Nahm	GS7-15	MT739803
<i>C. reverendissimus</i>	Germany, Baden-Württemberg, Bollschweil, <i>Abies alba</i>	19.10.2017	G. Saar	GS17-35	MT739804
<i>C. reverendissimus</i>	Russia, W-Caucasus, Arkhyz, <i>Abies nordmanniana</i>	10.10.2016	T. E. Brandrud, T. Svetasheva	TEB629-16	MT739805
<i>C. reverendissimus</i>	Russia, W-Caucasus, Arkhyz, <i>Abies nordmanniana</i>	10.10.2016	T. E. Brandrud, T. Svetasheva	TEB630-16	MT739806
<i>C. reverendissimus</i>	France, Haute-Loire, Miaune, <i>Fagus, Abies</i>	16.10.1997	P. Chapon	GK4667 (G293709) Holotypus	KF732408
<i>C. variiformis</i>	Italy, Lecce, Cardigliano, <i>Cistus</i>	6.1.2007	C. Rossi	CR117-07	MT739807
<i>C. variiformis</i>	Italy, Catania, Maiara, <i>Cistus</i>	4.12.2015	G. Turrini	TG2015-227	MT739808
<i>C. variiformis</i>	Spain, La Palma, La Travesa, <i>Cistus monspeliensis, Pinus canariensis</i>	26.12.2005	J. Kleine	JK26-12-2005	MT739809
<i>C. variiformis</i> (<i>C. psalliotooides</i>)	France, Provence, St. Mitres-Remparts, <i>Quercus ilex</i>	22.11.1970	G. Chevassut & R. Henry	Henry 3154 Holotypus	KF732390
<i>C. variiformis</i>	Spain, Girona, Cadaqués, <i>Cistus monspeliensis</i>	28.11.2000	J. Vila & X. Llimona	JV1001128-19	KJ421162
<i>C. variiformis</i>	Spain, Girona, Roses, <i>Cistus monspeliensis</i>	28.11.2000	J. Vila & X. Llimona	JV1001128-24	KJ421163
<i>C. variiformis</i>	Spain, Barcelona, Premià de Dalt, <i>Cistus monspeliensis</i>	15.10.2002	J. Vila & X. Llimona	JV1021015-3	KJ421164
<i>C. variiformis</i>	Russia, W-Caucasus, Arkhyz, <i>Abies nordmanniana</i>	11.10.2016	T. E. Brandrud	TEB642-16	MK358113
<i>C. variiformis</i>	USA, Washington, Easy Pass, <i>Picea engelmannii, Abies lasiocarpa</i>	12.09.1989	M. M. Moser	IB89/493 Holotypus	KF732468
<i>C. varius</i>	Germany, Thüringen, Leite bei Harras, <i>Picea</i>	05.10.2017	P. Steindl	SS17-194	MT739810
<i>C. varius</i>	Norway, Telemark, Bamble, Røskleiva NR	09.09.2016	T. E. Brandrud, B. Dima	TEB405-16/ DB6172	MT739811

Species	Location, host trees	Date	Collector	Voucher, herbarium	GenBank-accession no.
<i>C. varius</i>	Sweden, Ångermanland, Stigsjö, <i>Picea</i>	10.09.2014	K. Soop	KS-CO2161	MT739812
<i>C. varius</i>	Austria, Karinthia, St. Margarethen, <i>Picea</i>	02.10.2003	G. Saar	TUB019761	KJ421000
<i>C. varius</i>	Estonia	01.10.2013	A. Kollom	TU105472	UDB020275
<i>C. varius</i>	Estonia	27.09.2012	A. Kollom	TU105351	UDB018643
<i>C. varius</i> (<i>C. saginoides</i>)	France, Ain, Meyriat, <i>Fagus</i> , <i>Picea</i>	22.10.1989	A. Bidaud & P. Reumaux	PML1264 (G294427/1) Holotypus	KF732418
<i>C. varius</i> (<i>C. rufior</i>)	France, Haute Ardennes, <i>Picea</i>	08.11.1988	G. Flantzer	GK1118 (G293726/1) Holotypus	KF732412
<i>C. varius</i> (<i>C. pseudopimus</i>)	France, Ain, Innimont, <i>Abies</i> , <i>Fagus</i>	08.10.1990	D. Mazuir	GK4516 (G293246/1) HOLOTYPUS	KF732400
<i>C. varius</i>	Germany, Baden- Württemberg, Locherhof, <i>Abies</i> , <i>Picea</i>	24.09.2007	G. Saar	TUB019715	KJ421143
<i>C. varius</i>	Sweden, Ångermanland, Torrom, <i>Picea</i>	23.09.1988	T. E. Brand- rud et al.	CFP801 Neotypus	KF732469

Phylogenetic reconstruction

Sequences were aligned with MAFFT online version 7 (KATO & STANDLEY, 2013) after downloading the closest BLAST hits from GenBank and UNITE. A number of samples from morphologically similar sections were also added to the dataset. Sect. *Phlegmacioides* was chosen as outgroup. Maximum Likelihood analysis was carried out in raxmlGUI (SILVESTRO & MIHALAK, 2012) using GTRGAMMA substitution model. For testing branch support we applied 1000 bootstrap replicates. The best scored ML-tree was edited in Adobe Illustrator 7 and is shown in Fig. 1.

Macro- and micromorphological descriptions

The collections were photographed in the field or in the laboratory and detailed descriptions were made using fresh material. In most cases only dried material was available for the microscopic analysis.

Since it was not always possible to obtain a sufficient quantity of spores deposited on the stipe or cortina, a spore preparation from the gills was made for each collection in order to achieve a better comparability. Spores from gill preparations proved on average to be 0.2 to 0.5 μm longer than deposited, completely ripe spores. This is due to the fact that the spores, during maturation, reduce their water content and thus shrink. Gill preparations contain a certain portion of unripe spores, which increases the average spore length. For the above reason, spore size statistics are exclusively based on measurements from gill preparations (Tab. 2).

Measurements and photographs were made in L4 solution according to Cléménçon (CLÉMÉNÇON, 1972, ERB et al., 1983). Spore sizes indicated in the text refer to a 95 % confidence interval in order to exclude aberrant spores. In the descriptions, the number of analysed collections, carpophores, and single spores are indicated (in this order) in square brackets. MV refers to the average

Species	Voucher	Country	n spores	L×W (all) + MV; µm	L×W 95 %-conf. + MV; µm	Q L/W (all) + MV	Q L/W 95 %-conf. + MV
<i>C. reverendissimus</i>	GS 17-35	Germany	85	8.2–9.5–10.4 × 5.2–5.8–6.3	8.5–9.5–10.5 × 5.4–5.8–6.2	1.40–1.62–1.83	1.44–1.62–1.80
<i>C. reverendissimus</i>	GS 7-15	Germany	44	8.3–9.7–11.2 × 5.6–6.1–6.4	8.3–9.7–11.1 × 5.7–6.1–6.5	1.30–1.61–1.85	1.37–1.61–1.85
<i>C. reverendissimus</i>	TEB 629-16	Russia	58	8.9–10.2–11.1 × 5.4–5.9–6.5	9.2–10.2–11.2 × 5.5–5.9–6.3	1.49–1.73–1.97	1.49–1.73–1.97
combined collections			187	8.2–9.8–11.2 × 5.2–5.9–6.5	8.4–9.8–11.2 × 5.5–5.9–6.3	1.30–1.65–1.97	1.41–1.65–1.89
<i>C. decolorans</i>	MD 57-2014	Germany	32	9.8–10.5–11.4 × 5.9–6.2–6.6	9.7–10.5–11.3 × 5.8–6.2–6.6	1.57–1.70–1.80	1.58–1.70–1.82
<i>C. decolorans</i>	MD 25-2013	Germany	53	9.0–11.0–12.2 × 5.7–6.5–7.1	9.6–11.0–12.4 × 5.9–6.5–7.1	1.40–1.68–1.94	1.58–1.68–1.88
combined collections			85	9.0–10.8–12.2 × 5.7–6.4–7.1	9.6–10.8–12.0 × 5.8–6.4–7.0	1.40–1.69–1.94	1.51–1.69–1.87
<i>C. luteocingulatus</i>	SS15-114	Italy	54	8.8–9.7–10.5 × 5.5–5.9–6.6	8.9–9.7–10.3 × 5.5–5.9–6.3	1.48–1.63–1.83	1.49–1.63–1.77
<i>C. luteocingulatus</i>	SS19-108	Germany	67	8.8–10.2–12.6 × 5.7–6.2–7.0	9.0–10.2–11.4 × 5.8–5.9–6.6	1.40–1.64–1.98	1.44–1.64–1.84
combined collections			121	8.8–10.0–12.6 × 5.5–6.1–7.0	8.8–10.0–11.2 × 5.5–6.1–6.7	1.40–1.64–1.98	1.46–1.64–1.82
<i>C. varius</i>	KS-CO2161	Sweden	69	8.9–9.7–10.9 × 5.6–6.0–6.4	8.9–9.7–10.5 × 5.6–6.0–6.4	1.45–1.60–1.77	1.46–1.60–1.74
<i>C. varius</i>	SS17-194	Germany	51	8.3–9.6–10.2 × 5.4–5.8–6.3	8.8–9.6–10.4 × 5.4–5.8–6.2	1.42–1.66–1.82	1.50–1.66–1.82
combined collections			120	8.3–9.6–10.9 × 5.4–5.9–6.4	8.8–9.6–10.4 × 5.5–5.9–6.3	1.42–1.63–1.82	1.47–1.63–1.79
<i>C. variiformis</i>	JK 26.12.2005	Spain	41	8.8–9.7–11.1 × 5.7–6.3–6.8	8.9–9.7–10.5 × 5.9–6.3–6.7	1.40–1.55–1.67	1.43–1.55–1.67
<i>C. variiformis</i>	TG 2015-227	Italy	70	8.9–9.7–10.6 × 5.4–6.0–6.6	8.9–9.7–10.5 × 5.6–6.0–6.4	1.41–1.62–1.79	1.48–1.62–1.76
combined collections			111	8.9–9.7–10.5 × 5.4–6.1–6.8	8.9–9.7–10.5 × 5.5–6.1–6.7	1.40–1.59–1.79	1.43–1.59–1.77
<i>C. variosimilis</i>	TEB 642-16	Russia	74	8.5–9.7–10.7 × 4.9–5.8–6.5	8.9–9.7–10.5 × 5.2–5.8–6.4	1.40–1.67–1.88	1.47–1.67–1.87
all			698				

Table 2. Spore measurements Geert Schmidt-Stohn

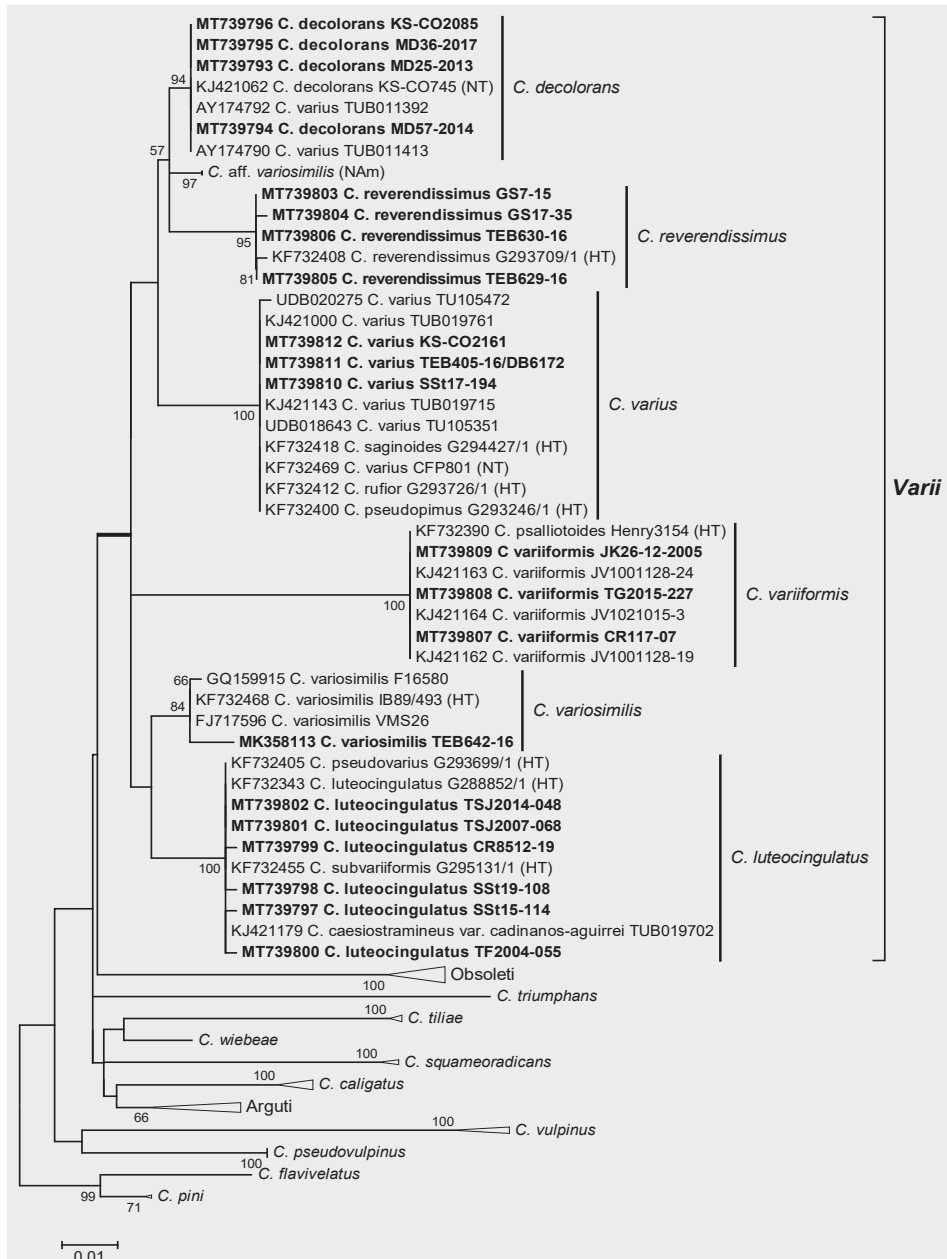
value, and Q_{MV} to the average length/width quotient ($Q = L/W$). The term «intercarpic variation» here means the variation of spore measurements between specimens from different collections of one species.

Focus stacking was used to produce the microphotographs (Fig. 2 and 3) by processing 20 to 30 single images at different focal distances (c. 0.2 µm per step) to obtain the final image (SCHMIDT-STOHN, 2011).

Results and Discussion

The alignment process resulted in a dataset of 113 sequences and 693 sites. A phylogram representing the genetic relationships within and outside *Varii* is shown in Fig. 1. The *Varii* clade is recovered in our analysis as a strongly supported monophyletic clade, congruent with that of SOOP et al. (2019), and composed of seven species-level terminal clades. We here describe the clade as *Cortinarius* subsection *Varii*.

So far, six species of *Varii* have been reported from Europe, of which only one is known also from North America (*C. variosimilis*). Another taxon included in the phylogeny (*C. aff. variosimilis*), has so far only been recorded from North America (Canada). This taxon, being unpublished, is not further treated in our study. All species are well delimited based on ITS data.



Bálint Dima

Fig. 1 — Maximum likelihood phylogenetic tree depicting the relationship between *Cortinarius* subsect. *Varii* and its nearest *Phlegmacium* clades. ML bootstrap support values are shown above 50%

Morphological characteristics and their variation

Cortinarius subsect. *Varii* is rather uniform as to its morphological characters. Some species (such as *C. varius*) have rather sparse remnants of universal veil, whereas the remnants are more pronounced on others (such as *C. variiformis*) with white veil remnants on the pileus (margin) and whitish to yellowish girdles and scales upon the clavate stipe. The spores are medium large in all species (about 10 μm long) and mostly subamygdaloid. Sporograms from our detailed examination of the spores of *Varii* species (see Methods above) are shown in Fig. 2 and Fig. 3.



Photo: Geert Schmidt-Stohn

Fig. 2 — Sporograms of selected collections examined in the study

The members of subsect. *Varii* morphologically resemble many of the closely related clades mentioned in the Introduction, but especially those of clade */Obsoleti* and *C. tiliae*. These could sometimes be difficult to distinguish without molecular data. The members of *Varii*, can, however, usually be recognised on the smoother, structure-less pileus surface, more prominent and persistent violet-bluish hues in lamellae and their positive, yellowish alkaline reaction.



Photo: Geert Schmidt-Stohn

Fig. 3 — Sporograms of selected collections examined in the study

As many as five of the six European taxa seem to be restricted to Europe. The two frondose species in subsect. *Varii* are xerothermic, *C. variiformis* occurring more or less exclusively in Mediterranean *Cistus* vegetation (possibly also with *Quercus ilex*) and *C. luteocingulatus* with *Quercus* spp. Of the four coniferous forest species, two seems to be associated strictly with *Picea abies*; *C. varius* is frequent and widely distributed in boreal-subalpine *Picea* forests of Europe, whereas the sister *C. decolorans* is uncommon and so far known mainly from Sweden. *Cortinarius reverendissimus* appears to be strictly associated with *Abies* spp. This is occurring in the C European *Abies alba* area, as well as within the Caucasian *Abies nordmanniana* range. The fourth coniferous forest species, *C. variiformis* is so far only found once in Europe, under *Abies nord-*

manniana in Caucasus, but is more frequent in western North America, where it apparently has a wider host range, associated with *Abies*, *Pseudotsuga* and possibly also with *Picea*. The frequent *C. varius* is in some areas gathered for consumption. The Mediterranean maquis species *C. variiformis* is in some regions also frequent, and is widely collected for consumption e.g. in Sardinia (F. Bellù, pers. comm.).

Phylogenetic and morphological relationships

Subsection *Varii* is well supported phylogenetically, based on multi-gene molecular studies (LIIMATAINEN et al., 2014, and SOOP et al., 2019). Also morphologically the group is fairly well defined, although with morphological overlap e.g. with the clade *Obsoleti* as discussed above. In multi-gene phylogenies it nests among a number of lineages with clavate stipes and abundant veil remnants (within the morphologically-defined section *Phlegmacium*; BRANDRUD, 1996). The subsection is further related to e.g. section *Phlegmacioides*, whose taxa are morphologically similar but normally possess a bluish-violet coloration on young fruitbodies, and a different cap cuticle structure. They share a yellowish alkaline reaction (however, stronger in *Phlegmacioides*).

The phylogenetic structure of the formerly morphologically defined section *Phlegmacium* sensu BRANDRUD (1996) is not fully resolved. It is apparent that there are a number of more or less well supported clades within this large group, such as the clades *Varii*, *Obsoleti*, *Arguti*, *Caligati*, and possibly a group of *C. saginus*, *C. populinus* and *C. norrlandicus*, including a few remaining species with uncertain affinity, such as *C. tiliae*, *C. triumphans* and *C. pini* (LIIMATAINEN et al., 2014, GARNICA et al., 2016, SOOP et al., 2019, and unpublished phylogenies). To fully resolve the taxonomic structure of sect. *Phlegmacium*, including an emendation or splitting of the section, and unravelling the position of the type species of *Phlegmacium*, *C. saginus*, a more world-wide taxon sampling and analyses with more genes are needed. In the meantime, it is possible to circumscribe some well supported subgroups, and give them taxonomic status at the subsectional rank. We therefore here introduce *Varii* as a subsection of the genus *Cortinarius*.

Prior to molecular-phylogenetic studies, only two or three species in subsect. *Varii* were more or less accepted and in use in Europe. BRANDRUD (1996) in a monographic treatment of sect. *Phlegmacium* included two species (*C. varius* and *C. variiformis*), but already at that time mycologists working in the Mediterranean region were aware that *C. variiformis* s. lat. could by reason of morphology and ecology be split into the two taxa *C. luteocingulatus* and *C. variiformis* s. str. (see above). So we can say, prior to molecular methods, that three species in *Varii* were reasonably easy to distinguish on morphological criteria: *C. varius*, *C. variiformis* and *C. luteocingulatus*. Later, molecular methods have shown, that the coniferous forest species *C. varius* in Europe can be split into four different, well supported species including *C. decolorans*, *C. reverendissimus* and *C. variosimilis*, with their own eco-geographical patterns, paired with some morphological differentiation. However, there seems to be an overlap in morphological variation in this complex, and some taxa could be regarded as semi-cryptic species. At the moment, these species (except *C. varius* s. str.) are not very well known in Europe, and their characteristics and variation should be studied further.

Taxonomy

Cortinarius subsectio *Varii* Soop, Brandrud, Saar & Dima, subsect. nov.

MycoBank: MB833846

Typus: *Cortinarius varius* (Schaeff.) Fr. 1838

Currently identified subsection members in Europe:

C. decolorans

C. luteocingulatus

C. reverendissimus

C. variiformis

C. variosimilis

C. varius

Principal characters of the subsection

Basidiomata medium-sized to large, resembling species of both clades */Caligati* and */Obsoleti*, as well as *C. tiliae*, *C. triumphans* and others formerly included in sect. *Phlegmacium*. **Pileus** 30–150 mm diam., viscid, yellow to orange brown or ochraceous-brown, structure-less, rarely finely radially fibrillose. **Lamellae** young with more or less violet-blue, sometimes persistent tinges, especially towards the edge. **Stipe** clavate, white, with white to yellowish veil remnants. Context white to cream. **Alkaline** reaction insignificant on the cap, but yellow in the context in some species. **Spores** subamygdaloid, $8.3\text{--}12.4 \times 5.2\text{--}7.1 \mu\text{m}$, moderately to strongly verrucose. Known from Europe and North America. The species are strictly host-specific, in Europe associated with *Picea*, *Abies* or *Quercus*, in rich to calcareous forests, or in *Cistus* shrublands.

Comments

One should note the often yellowish reaction with KOH or other alkalines, which can be used as a differential character against */Obsoleti*, as well as the persistent violet-blue hues in the lamellae (edge).

Cortinarius decolorans (Pers.) Fr. 1838

Fig. 4–7

MycoBank: MB224473

Neotypus in Soop et al. (2019): Sweden, Gotland, Tjaukle Änge, with *Picea*, K. Soop CO745, Herb. S F304386, GenBank KJ421062 (ITS + LSU).

Illustrations:

SOOP 2018

M. DONDL <http://www.interhias.de/schwammerlseiten/galerie/galeriestart.html>: 2013-25, 2014-57, 2017-36

Description (based on own findings)

Pileus 45–75 mm, young margin straight involute, viscid in humid weather, not hygrophanous, colour ± uniform light ochre yellow to orange brown, the margin paler and finely fibrillose from veil, sometimes with white veil remnants. **Lamellae** adnate to notched, ± crowded, sometimes narrow, young greyish white, sometimes with a violaceous-blue tinge. **Stipe** 25–55 × 12–18 mm, cylindrical to clavate (–32 mm), white, enveloped by white to yellowish veil, staining brownish on handling. **Context** cream whitish. **Odour** insignificant to aromatic, sweetish.

Macrochemical reactions: KOH (40%) staining (weakly) yellow to weakly red-brown in the context.



Photo: Matthias Dondl

Fig. 4 — *Cortinarius decolorans* MD25-2013



Photo: Matthias Dondl

Fig. 5 — *Cortinarius decolorans* MD25-2013

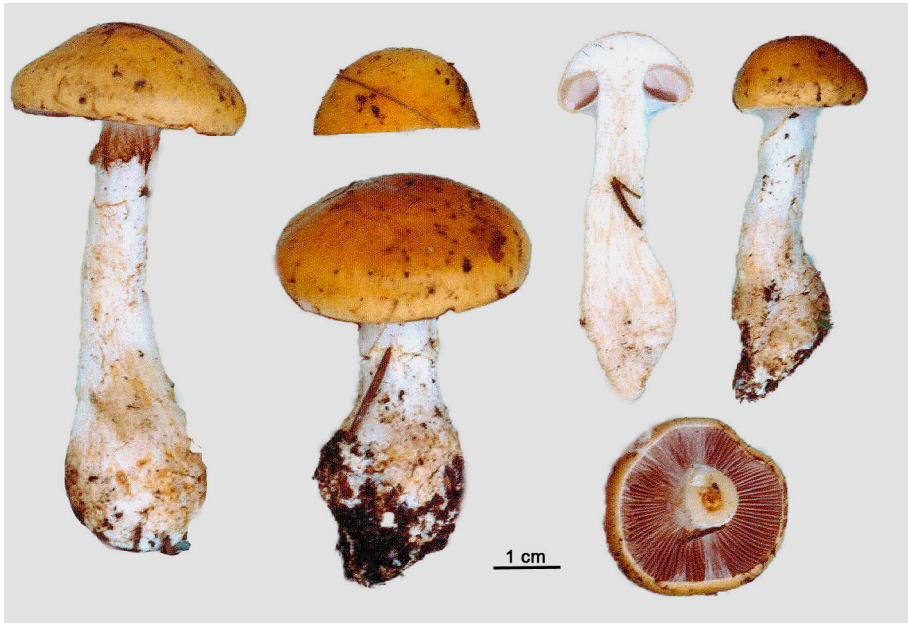


Photo: Karl Soop

Fig. 6 — *Cortinarius decolorans* KS-CO745



Photo: Matthias Dondl

Fig. 7 — *Cortinarius decolorans* MD57-2014

Spores [2, 2, 85], $9.6\text{--}12.0 \times 5.8\text{--}7.0 \mu\text{m}$, $MV = 10.8 \times 6.4 \mu\text{m}$, intercarpic variation of MV : $10.5\text{--}11.0 \times 6.2\text{--}6.5 \mu\text{m}$, $Q = 1.51\text{--}1.87$, $Q_{MV} = 1.69$, intercarpic variation of Q_{MV} : $1.68\text{--}1.70$, amygdaloid, medium verrucose, some apically constricted. **Basidia** 4-spored. **Hymenophore** substerile. **Pileipellis** duplex with ixotrichoderm of $5\text{--}8 \mu\text{m}$ wide, finely to strong golden encrusted hyphae, **Hypoderm** with $10\text{--}30 \mu\text{m}$ wide yellow and brown cells.

Habitat and distribution: On rich to calcareous soil in hilly or montane *Picea* forests, Central- and Northern Europe, rare.

Collections studied: see tab. 1.

Comments

Cortinarius decolorans resembles *C. varius*, but the lamellae mostly lack violet-blue hues except on the margin. When *C. varius* has pale lamellae, the two species can sometimes be confused. Moreover *C. decolorans* seems to have slightly longer spores. More material is needed to fully understand the morphological variation and the possible overlap of characters with *C. varius*. *Cortinarius decolorans* is so far known only from a few localities in Austria, Germany and Sweden (material verified by sequencing). Traditionally, *C. decolorans* has been treated under a wider concept of *C. varius* (cfr. e.g. BRANDRUD, 1996). Like *C. varius* it seems to be strictly associated with *Picea* spp., but this must be further documented.

Cortinarius luteocingulatus Bidaud & Fillion 1992

Fig. 8, 9

Bull. trimest. Fed. Mycol. Dauphiné-Savoie 31 (No. 124): 9 (1992)

MycoBank: MB355426

Holotypus: AB 91-10-260 (PC).

Synonyms:

C. pseudovarius Moëgne-Loec. & Reumaux 2000

C. subvariiformis Bidaud 2000

C. caesiostramineus var. *cadiñanos-aguirrae* Moëgne-Loec. & A. Ortega 2002

C. variiformis Malençon p.p.

Illustrations: BIDAUD et al. (1992), BRANDRUD et al. (1998) as *C. variiformis* (pl. D11, D12); BIDAUD et al. (2002) as *C. pseudovarius* and *C. subvariiformis*; ORTEGA et al. (2002) as *C. caesiostramineus* var. *cadiñanos-aguirrae*; LUDWIG (2017).

Pileus 30–75 mm, rounded then convex-expanded, viscid, not hygrophanous, dark golden yellow to orange brown, red-brown, glabrous to rarely finely innate-fibrillose towards margin, sometimes with white veil remnants at the margin. **Lamellae** saturated, nicely violet-blue, medium crowded, emarginate, **cortina** white. **Stipe** 35–70 × 8–20 mm, cylindrical to clavate (–30 mm), sometimes with a pointed base, white. **Veil** ochre, leaving one or two small incomplete rings. **Context** white, discolouring to yellow in the stipe cortex and brownish in the stipe base. **Odour** insignificant, reminiscent of yeast or dough, or sometimes more pleasant, fruity.

Macrochemical reactions: KOH brownish to pale reddish on the cap and in the context; lugol black; guaiac slowly deep green.

Spores [2, 2, 121], 8.8–11.2 × 5.5–6.7 μm, MV = 10.0 × 6.1 μm, intercarpic variation of MV: 9.7–10.2 × 5.9 μm, Q = 1.46–1.82, Q_{MV} = 1.64, intercarpic variation of Q_{MV}: 1.63–1.64, ellipsoid to subamygdaloid, medium to strongly verrucose. **Basidia** 4-spored, 35–42 × 9–11 μm. **Pileipellis** duplex, golden-brown incrustated hyphae, 4–8 μm wide. **Hypoderm** elements robust with a yellow-brown, parietal pigmentation, up to 30 μm wide.

Habitat and distribution: In calcareous nemoral and Mediterranean *Quercus* forests, both in evergreen *Quercus ilex* forests as well as with deciduous *Quercus* spp. At its northern border in S. Scandinavia, it often occurs in semi-open, grazed woodland meadows; from southern Scandinavia to northern Africa, occasional.

Collections studied: see tab. 1



Photo: Claudio Rossi

Fig. 8 — *Cortinarius luteocingulatus* CR 8512-19



Photo: Geert Schmidt-Stohn

Fig. 9 — *Cortinarius luteocingulatus* SSt19-108

Comments

C. luteocingulatus resembles *C. varius*, but is distinguished by the brownish veil girdles, the almost negative alkaline reaction, and the occurrence in *Quercus* dominated broad-leaf forests. The strong and remarkable Lugol reaction may turn out to be a significant character (at species or section level), and must be further tested on future collections. The species was treated under the broad concept of *C. variiformis* by BRANDRUD (1996) and BRANDRUD et al. (1990-2018).

Atlas des Cortinaires 10: 373 (2000)

MycoBank: MB459538

Holotypus: Gallia, Forêt de Miaune (Haute-Loire), leg. P. Chapon, 16.10.1997, G293709 (AdC n° 4667) in herb. G

Illustration: BIDAUD et al. (2000).

Pileus 30–120 (–150) mm, rounded then convex with long time involute margin, fleshy, viscid, not hygrophanous, ochre brown to leather coloured and red-brown, glabrous to rarely finely innate-fibrillose, sometimes with white veil remnants, with tendency to brownish discolouring. **Lamellae** violet rose, violet tinge often rather persistent towards edge, then light brown with light and serrate edge, medium crowded, emarginated. **Stipe** 40–100 × 12–25 mm, cylindrical to clavate-fusoid (–40 mm), white. **Veil** white, abundant, leaving a sheath which discolours brownish. **Context** hard, cream-white. **Odour** insignificant or pleasant, sweetish.

Macrochemical reactions: KOH (30%) brick red on cap and yellowish in context.

Spores [3, 3, 187], 8.4–11.2 × 5.5–6.3 μm, MV = 9.8 × 5.9 μm, intercarpic variation of MV: 9.5–10.2 × 5.8–6.1 μm, Q = 1.41–1.89, Q_{MV} = 1.65, intercarpic variation of Q_{MV}: 1.61–1.73, subamygdaloid, finely verrucose. **Basidia** 4-spored. **Marginal elements** trivial. **Pileipellis** duplex, 2–4 μm wide, hyaline and ± yellow hyphae. **Hypoderm** elements 8–22 μm wide with a yellowish, vacuolar and parietal pigmentation. **Veil hyphae** 2.5–5 μm wide.

Habitat and distribution: In calcareous *Abies* or mixed *Abies-Picea* or *Abies-Fagus* forests, possibly strictly associated to *Abies*, rare. So far verified with sequencing from the *Abies alba* regions of Central Europe (Germany, France), and the *Abies nordmanniana* range of W. Caucasus (Russia). Apparently not occurring outside of the *Abies* range in northern and western Europe. Only known from Europe.

Collections studied: see tab. 1.



Photo: Günter Saar

Fig. 10 — *Cortinarius reverendissimus* GS17-35



Aquarel: Pierre Moëgne-Loccoz

Fig. 11 — *Cortinarius reverendissimus* GK 4667

Comments

This is a species with very stout basidiomata. It may occur together with *C. varius* but seems to be rarer, and seems restricted to *Abies*-dominated forests. *Cortinarius reverendissimus* may be confused with *C. rhizophorus*, which also may occur under *Abies* on calcareous soil.

Cortinarius variiformis Malençon

Fig. 12–14

Flore Champignons Supérieurs de Maroc I: 526 (1970)

MycoBank: MB312192

Holotypus: H 6029355 between Rabat and Casablanca Sidi-Bettache, G. Malençon 5311 («1272») (MPU).

Synonym: *C. psalliotoides* Rob. Henry (1978)

Illustrations: BALLARÀ et al. (2007), LUDWIG (2017)

Short description (based on J. BALLARÀ et al., *Fungi non delineati* XLI-XLII p. 100-102 (2007) and own collections)

Pileus 60–130 mm, expanded or somewhat funnel shaped, margin long involute, cap yellow ochre, fleshy, viscid, not hygrophanous, sometimes with white veil remnants. **Lamellae** adnate to sinuate, crowded to medium spaced, mauve violet to grey-blue with violet edges. **Cortina** abundant. **Stipe** 60–80 × 12–30 mm, cylindrical to fusoid, short and (deeply) rooting, white, **Veil** forming double rings with a yellow margin, abundant. **Context** hard, white. **Odour** sweetish to unpleasant.

Macrochemical reactions: KOH yellow in the upper stipe context.

Spores [2, 2, 111], 8.9–10.5 × 5.5–6.7 μm, MV = 9.7 × 6.1 μm, intercarpic variation of MV: 9.7 × 6.0–6.3 μm, Q = 1.43–1.77, Q_{MV} = 1.59, intercarpic variation of Q_{MV}: 1.55–1.62, subamygdaloid, medium verrucose. **Basidia** 4-spored. **Lamella** edge with abundant sterile cells of various shape. **Epicutis** of gelatinous hyphae, 3–5 μm wide, finely to strongly yellow incrustated. **Hypocutis** elements subcellular, yellowish encrusted, 12–20 μm wide.



Photo: Claudio Rossi

Fig. 12 — *Cortinarius variiformis* CR 117-07



Photo: Gianni Turrini

Fig. 13 — *Cortinarius variiformis* TG 2015-227



Photo: Jesko Kleine

Fig. 14 — *Cortinarius variiformis* JK 26.12.2005

Habitat and distribution: In Mediterranean shrub stands with *Cistus* (especially under *Cistus monspeliensis*), apparently mainly on siliceous soil. Known from Spain, Italy, Canary Islands, Morocco (holotype), probably also from France (CHEVASSUT & HENRY, 1978, sub nom. *C. psalliotoides*), occasional.

Collections studied: see tab. 1.

Comments

Cortinarius variiformis has formerly often been treated in a wide sense, including *C. luteocingulatus*, for example by BRANDRUD (1996) and BRANDRUD et al. (1990–2018, Pl. D11, D12). But *C. luteocingulatus* is usually more slender, has no or weak alkaline reaction in its context, and occurs under *Quercus* spp. in temperate and Mediterranean areas, whereas *C. variiformis* is a typically xerophilic species, hitherto only reported under *Cistus*. HENRY (1978) indicates that he gathered the conspecific *C. psalliotoides* under “Chênes verts” and notes remarkably shorter spores than we found ($7.2\text{--}9.4 \times 4.3\text{--}5.8 \mu\text{m}$). Maybe he overlooked that *Cistus* or *Quercus* is a rare mycorrhiza-partner, too. *C. variiformis* sometimes grows semi-hypogaeically. It is locally collected for consumption (F. Bellù, pers. comm.). The type of *C. variiformis* is deposited in herb. Montpellier but unfortunately has not been available for sequencing.

Cortinarius variosimilis M. M. Moser & Ammirati

Mycotaxon 72: 306 (1999)

MycoBank: MB459647

Holotypus: Moser IB 89/493 (Holotyp), USA, Washington, Trail to Easy Pass, 12. Sept. 1989, under *Abies lasiocarpa* and *Picea engelmannii*.

The following description is based on the protologue (MOSER & AMMIRATI, 1999)

Pileus 30–85 mm, hemispheric, then convex with incurved margin, glutinous, centre bright yellow brown, towards margin paler and often covered with strong veil remnants, not innate-fibrillose. **Lamellae** pale violet to argillaceous with slight violet tinge, later grey brown, edges strongly eroded to serrulate, crowded, emarginated. **Stipe** 40–110 × 7–20 mm, clavate (–32 mm), white to pale pinkish buff. **Veil** white, abundant woolly, sometimes with an almost membranaceous ring, discolouring buffy ochraceous. **Context** whitish, pale pinkish buff to slightly yellowish in the base. **Odour** insignificant.

Macrochemical reactions: KOH (30%) pale yellow in context.

Spores [1, 1, 74], 8.9–10.5 × 5.2–6.4 μm, MV = 9.7 × 5.8 μm, Q = 1.47–1.87, Q_{MV} = 1.67, amygdaloid, verrucose. **Basidia** 4-spored 30–39 × 8.5–10.4 μm. **Marginal elements** trivial. **Pileipellis** hyphae 3.5–4.5 μm wide, hyaline and with yellowish incrustation. **Hypoderm** elements 12–21 μm wide with a ochraceous to yellow brown parietal pigmentation.

Habitat and distribution: In Europe so far found under *Abies nordmanniana* in Russian Caucasus. Widespread in western North America in *Abies-Picea-Pseudotsuga* forests.

Collections studied: see Tab. 1.

Comments

According to the protologue of MOSER & AMMIRATI (1999), this is relatively frequent in Wyoming, and according to various, recent net sources, this is apparently widespread in western North America, and is considered “the North American *C. varius*”. According to the protologue *C. variosimilis* is distinguished from the European *C. varius* by its paler colours on pileus and lamellae, weaker reactions with alkaline solutions and smaller spores. The species was verified for the first time in Europe in Caucasus in 2016, where it occurred under *Abies nordmanniana* (collection with only a couple of mature specimens, morphologically not possible to distinguish from *C. varius*). The habitat indicated in MOSER & AMMIRATI (1999) is mixed forests with *Abies lasiocarpa* and *Picea engelmannii* in Wyoming, and *Pseudotsuga-Abies* forests in Oregon-Washington, and finally *Pseudotsuga-Lithocarpus* forests in California. So it seems likely that this at least is able to associate with *Abies* and *Pseudotsuga*, possibly also *Picea*, and thus being less strict in mycorrhizal associations than its European relatives, such as *C. varius* and *C. reverendissimus*.

Cortinarius varius (Schaeff.) Fr. 1838

Fig. 15, 16

Mycobank: MB529640

Typus: lectotype (MBT393126): Schaeffer (1770) pl. XLII fig. II (lectotypus hic designatus); epitype (MBT393125): Cortin. *Flora Photogr.* CFP801 (herb. S), Sweden, on calcareous soil in coniferous forest. (epitypus hic designatus; invalidly designated as neotype in BRANDRUD 1996)

Synonyms:

C. saginus subsp. *grandisporus* Chevassut & Rob. Henry 1982

C. pseudoopimus Rob. Henry 2000

C. rufior Reumaux 2000

C. saginoides Bidaud & Reumaux 2000

Illustrations: BRANDRUD et al. (1993), BIDAUD et al. (2000) as *C. saginoides*, as *C. rufior*; LUDWIG (2017), SOOP (2018).

Description (based on BRANDRUD 1996)

Pileus 40–100 mm, young margin involute, viscid in humid weather, not hygrophanous, colour ± uniform ochraceous yellow to lion brown or ochraceous brown. **Lamellae** adnate, +/- crowded,

greyish violet, more distinctly and sometimes deeply violet-blue towards edge, violet colour often rather persistent, especially in a ring at stipe apex. **Stipe** 40–100 × 10–20 mm, cylindrical to clavate (40 mm), stiff, white. **Veil** remnants sparse, sometimes forming a weak whitish (rarely ochraceous yellow tinged) girdle. **Context** white, tinged yellowish in stipe apex. **Odour** insignificant, or with a faint, yeast-like component («phlegmacium smell»). KOH (40%) staining yellow in the context



Photo: Günter Saar

Fig. 15 — *Cortinarius varius* GS03-10



Photo: Geert Schmidt-Stohn

Fig. 16 — *Cortinarius varius* SSt17-194

Spores [2, 2, 120], 8.8–10.4 × 5.5–6.3 μm, MV = 9.6 × 5.9 μm, intercarpic variation of MV: 9.6–9.7 μm × 5.8–6.0 μm, Q = 1.47–1.79, $Q_{MV} = 1.63$, intercarpic variation of Q_{MV} : 1.60–1.66,

amygdaloid, medium verrucose. **Basidia** 4-spored. **Lamellar edge** fertile, sometimes with some sterile cells. **Pileipellis** duplex, epicutis of 3–8 µm wide, finely to strongly golden encrusted hyphae. **Hypoderm** with 15–30 µm wide yellow-brown cells.

Habitat and distribution: On rich to calcareous soil in boreal to montane-subalpine *Picea* forests, apparently strictly associated with *Picea abies*, but an association also with *Abies alba* in mixed *Abies* forests of Central Europe cannot be ruled out; common in Middle and Northern Europe. Apparently strictly European, never confirmed from elsewhere e.g. from the *Picea sibirica* taiga of Siberia. Not recorded outside the natural *Picea abies* range in W Europe (never found in Great Britain, records of *C. varius* apparently refer to *C. luteocingulatus*). Records from montane conifer zones in S Europe are uncertain due to possible mixing with the *Abies* associate *C. reverendissimus*.

Collections studied: see Tab. 1.

Comments

Cortinarius varius is characterized by the vivid yellow brown pileus, contrasting with the violet blue lamellae, and the yellow alkaline reaction, which is otherwise a character shared with sect. *Phlegmacioides*. The species is very common in spruce forests on richer soils and is in some countries a popular edible mushroom. Other members of subsect. *Varii* are either less brightly coloured (*C. reverendissimus*, *C. luteocingulatus*), have less bluish tones in their lamellae (*C. decolorans*, *C. reverendissimus*) or lack the yellow alkaline reaction (*C. luteocingulatus*). Moreover, *C. luteocingulatus* and *C. variiformis* live in symbiosis with *Quercus* and *Cistus*. In mixed *Abies-Picea* forest, *C. varius* can be difficult to separate from *C. reverendissimus*, and although it seems that the latter normally is larger, with paler lamellae and more veil, it seems that these characters sometimes overlap. With the material seen so far, it also seems hardly possible to distinguish these taxa on spore size; in consequence these two species should be regarded as semicryptic.

The original plate of Schaeffer (1770) is here designed as lectotype, and the nrDNA ITS-sequenced material illustrated in *Cortinarius* Flora Photographica (BRANDRUD et al., 1990-2018) is designed as epitype (formerly erroneously designed as neotype by Brandrud 1996).

Key to the species of the subsection *Varii*

- | | | |
|----|---|---------------------------|
| 1 | Mediterranean, with <i>Cistus</i> | <i>C. variiformis</i> |
| 1* | In nemoral and boreal stands..... | 2 |
| 2 | With <i>Quercus</i> | <i>C. luteocingulatus</i> |
| 2* | With coniferous hosts..... | 3 |
| 3 | With intensely blue colours in the lamellae and a bright yellow alkaline reaction, under <i>Picea</i> | <i>C. varius</i> |
| 3* | With other characters..... | 4 |
| 4 | Large basidiomes, in <i>Abies</i> forests on calcareous soil..... | <i>C. reverendissimus</i> |
| 4* | Medium sized basidiomes, occurring under <i>Picea</i> , <i>Abies</i> or <i>Pseudotsuga</i> | 5 |
| 5 | Spores large (usually longer than 10 µm), under <i>Picea</i> | <i>C. decolorans</i> |
| 5* | Spores shorter, under <i>Abies</i> , <i>Pseudotsuga</i> and possible <i>Picea</i> (mainly North Amer.)..... | <i>C. variosimilis</i> |

Acknowledgements

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