Recent records of telamonioid species of *Cortinarius* (Agaricales: Cortinariaceae) in New Brunswick, Canada

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Abstract

Eight species of *Cortinarius* (webcaps) subgenus *Telamonia* and two other telamonioid *Cortinarius* species are reported from New Brunswick, Canada. Internal transcribed spacer sequences of these were used to build a phylogenetic tree confirming species identifications and relationships to relevant material, especially types and other Canadian collections. Descriptions and photographs of fresh material and microscopic features are provided. Habitat details, particularly potential mycorrhizal partners and dominant bryophytes, were recorded for each collection and compared with published records. Seven species, *Cortinarius caninoides*, *Cortinarius cicindela*, *Cortinarius fulvescens*, *Cortinarius harvardensis*, *Cortinarius plumulosus*, *Cortinarius pseudobiformis*, and *Cortinarius valgus* are new distribution records for New Brunswick, and *C. plumulosus* is apparently a first record for North America. Because these species have rarely been reported, they have yet to be given common names.

Key words: Fungi; Agaricales; mushroom; *Cortinarius*; *Telamonia*; New Brunswick; Bay of Fundy; Canada; new distribution record

Introduction

The mushroom-forming genus *Cortinarius* (Basi-diomycota: Agaricomycetes: Agaricales: Cortinariaceae) is considered to be one of the largest of all fungal genera, as it is estimated to include several thousand species (Bhunjun et al. 2022). In the past, many authors have expressed doubts about the taxonomic uniformity of *Cortinarius* and have treated parts of this group as separate genera. Some of these segregates, such as *Dermocybe* and *Phlegmacium*, attained a limited level of acceptance by mycologists, but never came into wide usage.

Recent studies using genomic analyses have led to a reconsideration of how we view *Cortinarius*. The family Cortinariaceae, long thought to contain several genera, was shown by Matheny et al. (2015) to contain only *Cortinarius*, with other genera, such as *Crepidotus*, *Gymnopilus*, *Inocybe*, distributed in several other families. However, using multi-locus genomic data, Liimatainen et al. (2022) presented a phylogenetic analysis dividing *Cortinarius* into 10 genera: *Cortinarius*, *Phlegmacium*, *Thaxterogaster*, *Calonarius*, *Aureonarius*, *Cystinarius*, *Volvanarius*, *Hygronarius*, *Mystinarius*, and *Austrocortinarius*, all included in the Cortinariaceae. Species of seven of these genera (*Cortinarius*, *Phlegmacium*, *Thaxterogaster*, *Calonarius*, *Aureonarius*, *Cystinarius*, and *Hygronarius*) have been shown to occur in Quebec (Landry et al. 2021) and probably occur throughout North America.

In spite of its relatively small size, the province of New Brunswick is ecologically diverse and contains a variety of habitats favourable to Cortinariaceae. It is within the Atlantic Maritime Ecozone and contains seven ecoregions (McAlpine and Smith 2010). Of the seven genera of Cortinariaceae reported from Quebec, only members of *Calonarius* and *Hygronarius* have yet to be reported in New Brunswick.

As part of an ongoing effort to catalogue the fungi of New Brunswick, species of Cortinariaceae are currently being collected and studied. One of the taxonomically most difficult groups within the genus *Cortinarius* is the subgenus *Telamonia* and the superficially similar taxa referred to as “telamonioid”. Traditionally these have been characterized as having basidiomata with dry pilei and stipes and generally

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lacking brightly coloured lamellae. Here we report on eight species of *Cortinarius* subgenus *Telamonia* and two additional telamonioid species. We have included descriptions, illustrations, and habitat information for these species, based on genetically verified voucher specimens.

**Methods**

All collections were made in New Brunswick. They were photographed in the field and later scanned on a flatbed scanner. Notes were taken on the fresh material and spore prints were made by placing pieces of basidiomata over glass microscope slides. Colours were recorded from a cellphone using a handbook with the HSV/HSB (Hue, Saturation, Value or Hue, Saturation, Brightness) colour system, an alternative representation of the RGB (Red, Green, Blue) model commonly used in computer graphics (Malloch 2021). The basidiomata were then dried in a food drier for 24 h at 60°C. All collections were deposited in the herbarium of the New Brunswick Museum (NBM).

**Microscopic studies**

Microscopic features of sections of the pileipellis and lamellae were examined in Windex window cleaner (S.C. Johnson & Son, Racine, Wisconsin, USA) and in 3% KOH. Basidia and other hymenial structures were examined in 3% KOH after presoaking and clearing in aqueous Congo Red.

Basidiospores from spore prints were suspended in a drop of Melzer’s solution on a microscope slide and examined with a 100× objective using bright field illumination. When spore prints were not available (e.g., *Cortinarius evernius* (Fr.) Fr., Silky Webcap), basidiospores deposited on the universal veil were examined.

The slides were scanned along parallel transect lines and basidiospores lying in profile were photographed. The photographs were viewed using an open-source image editor (Gnu Image Manipulation Program, v. 2.10, https://www.gimp.org). Basidiospores lying in profile were rotated so that the apiculus was at the left and oriented to approximately 225°. Rotated basidiospores were then cut from the photograph and placed side by side on a new and separate image. The aligned basidiospores were measured using ImageJ (National Institutes of Health, Bethesda, Maryland, USA) and the results transformed using a spreadsheet. Measurements are expressed as the full size range and aspect ratio (Q) of the sample followed by the mean and SD of length, width, and Q. Sample size is shown in square brackets.

**Molecular studies**

DNA was extracted from dried herbarium specimens following standard procedures for mushroom-forming fungi. The fungal barcode, nrITS region (nrITS1-5.8S-nrITS2), was targetted for amplification, using the primer pair ITS1F–ITS4 (White et al. 1990; Gardes and Bruns 1993). DNA extraction, polymerase chain reaction (PCR), and sequencing were carried out at ALVALAB (Oviedo, Spain).

Raw chromatogram data were edited and assembled using ChromasPro (Technelysium DNA Sequencing Software, South Brisbane, Australia). A total of 11 new sequences were generated in our study. We assembled a molecular dataset that includes all type specimens of the species studied here and representatives of those species from Eurasia and North America (if available). The final dataset consisted of 38 nrITS sequences, including two species of *Cortinarius* subgenus *Dermocybe* (*Cortinarius neosanguineus* Ammirati, Limat. & Niskanen and *Cortinarius sierraensis* (Ammirati) Ammirati, Niskanen & Limat.) that were used as outgroup taxa.

Sequences were aligned using MAFFT version 7 (Katoh et al. 2019) with the strategy FFT-NS-i. The alignment was inspected and manually corrected in AliView (Larsson 2014). We ran a maximum likelihood analysis using RAxML 8.2.10 under a GTRGAMMAI model as recommended (Stamatakis 2014), with 100 rapid bootstrap replicates. The analysis was run using resources at the CIPRES Science Gateway (Miller et al. 2010). A phylogenetic tree was visualized in FigTree v. 1.4.4 (University of Edinburgh, Edinburgh, United Kingdom), then exported as an SVG file and edited in Adobe Illustrator (Adobe, San Jose, California, USA) for final presentation.

**Results**

The best tree from the maximum likelihood analysis of the sequences we studied is presented in Figure 1. The internal transcribed spacer (ITS) sequences of the New Brunswick collections grouped in all cases with their respective type collections and/or reference sequences from North America and Eurasia. The species-level clades recovered in the analyses get full bootstrap support (100%), with the exception of *Cortinarius tortuosus* (Fr.) Fr. (99%) and *Cortinarius gentilis* (Fr.) Fr. (Conifer Webcap; 98%). This is consistent with previous phylogenies of these two species (Landry et al. 2021; Liimatainen et al. 2022).

**Annotated Checklist**

*Cortinarius* subgenus *Telamonia*, section *Bicolores*

*Cortinarius plumulosus* Rob. Henry (Figures 2a, 3a)

Pileus conic-turbinate at first, not seen when fully expanded, with a large rounded umbo, glabrous, light orange brown (HSV30:20–30:90) but probably hygrophanous and faded, slightly paler at the margin, dry, 43 mm in diameter. Stipe equal, dry, pale violet
(HSV250:30–40:90), with universal veil present as a white annular band and irregular streaks below the annular zone, 75 × 13 mm. Lamellae dark brown (HSV20:70–80:30), subclose, adnexed, white at the margin. Cortina not seen, probably white. Flesh faded in the pileus but possibly concolorous with the surface tissues, pale violet (HSV250:30–40:90) in the stipe, lacking a distinctive odour and taste.

Figure 1. Best tree from maximum likelihood analysis of the nrITS sequences of Cortinarius. Bootstrap values ≥70% are shown on or below the branches. The symbol / indicates that the branch length has been reduced to facilitate graphic representation. All sequences of New Brunswick specimens were newly generated for this study and are shown in bold. The scale bar represents number of nucleotide substitutions per site.
Basidiospores bright orange brown (HSV25:70:80–90) in spore print, elliptical to obovate in profile, infrequently ovate, coarsely roughened, weakly dextrinoid, 8.2–9.7 × 4.8–5.8 µm, Q = 1.53–1.93 (mean [60]: 9.1 ± 0.4 × 5.2 ± 0.2 µm, Q = 1.75 ± 0.09). Cheilocystidia forming a partly sterile margin, barely distinguishable from immature basidia, narrowly clavate to almost cylindrical, with a basal clamp connection. Basidia clavate, four-spored, with a basal clamp connection. Lamellar trama parallel, brown, with clamp connections at the septa, only rarely encrusted. Pileipellis duplex, a cutis of hyaline hyphae over a hypoderm of brown hyphae that are rather short and almost brick-like. Clamp connections present on most septa.

Specimens examined—CANADA, New Brunswick: Charlotte Co., Little Lepreau, 45.135°N, 66.492°W, 5 October 2020, D. Malloch 05-10-20/03 (NBM-F-009374), GenBank no. OP353626 (ITS); 24 September 2021, D. Malloch 24-09-21/01 (NBM-F-009378; not sequenced or included in the description above although similar macro- and micro-morphologically).

Closely related to Cortinarius evernius (Liima-tainen et al. 2020) but with narrower basidiospores. Both of the New Brunswick collections had rather robust basidiomata with turbinate pilei and relatively thick stipes, in contrast to the more slender

basidiomata of *C. evernius*. *Cortinarius cagei* Melot is similar but differs in its association with hardwood trees, such as species of beech (*Fagus* L.), linden (*Tilia* L.), and hazel (*Corylus* L.; Brandrud et al. 1998). In common with most other members of the section *Bicolores*, all of these species have hygrophanous pilei, brown lamellae, and firm tapered stipes with blue flesh. Landry et al. (2021) reported a collection as *C. cf. cagei* that is very similar to ours and might be conspecific. Aside from that possibility, *C. plumulosus* seems to be unreported in North America. Collections of this species have not been reported frequently in the literature. The type specimen was collected in the Vosges Mountains of France in a forest of European Silver Fir (*Abies alba* Miller). Our collection was in a dense patch of moss (*Rhytidiadelphus* (Limpr.) Warnst. sp.) in an area of a lawn shaded by two large Balsam Fir (*Abies balsamea* (L.) Miller) trees.

*Cortinarius evernius* (Fr.) Fr. (Silky Webcap; Figures 2b, 3b)

*Pileus* conic-turbinate at first, expanding to more broadly so at maturity, with a low but prominent broad umbo, dry, fibrillose at first with the universal veil, shiny, medium grey brown (HSV35:30:50–60), hygrophanous, 18–23 mm in diameter. *Stipe* equal to very narrowly clavate, often tapered at the base, very finely streaked or banded with universal veil material, pale yellow (HSV55:05:100) in the upper ⅔, white to very pale violet (HSV250:03:100) below, dry, 55–93 × 5–8 mm. *Lamellae* chocolate brown (HSV35:80:40–50), white toward the edge but not really marginate, subclose, adnexed. *Veil* difficult to interpret. The universal veil on the pileus margin appears to be pale yellow and contrasts with the violet cortina. However, the bands on the stipe are yellow while the veil near the stipe base appears to be violet. *Flesh* in the pileus is a dilute brown below the pileipellis but is otherwise nearly white; in the stipe it is mostly white but has definite but very pale shades of violet near the middle, with a nondescript mushroom odour, slightly sweet but otherwise without a distinctive taste.

*Basidiospores* not forming a spore print, ovate to elliptical in profile, rarely obovate, with walls moderately roughened, 9.0–10.8 × 5.0–5.8 µm, $Q = 1.63–1.95$ (mean [38]: $9.9 \pm 0.5 \times 5.5 \pm 0.2$ µm, $Q = 1.81 \pm 0.09$). *Basidia* four-spored, clamped at the basal septum. *Cheilocystidia* forming a sterile margin, clavate, clamped at the basal septum. *Lamellar trama* parallel, light brown, obscurely encrusted with fine granules. *Pileipellis* duplex, with a compact hyaline cutis.
Picea
Sphagnum
C. cicindela (Fr.) Fr. is superficially
Pleurozium (NBM-F-009368), GenBank no.
Tsuga from roots of Western Hemlock (Abies
Sphagnum. Encrusted externally. Trama of short broad strongly encrusted hyphae. Encrusted hyphae and a thick dark brown hypoderm duplex, with a thin and compact cutis of pale narrow 8.5 ± 0.7 × 5.3 ± 0.4 µm, Q = 1.61 ± 0.08).
7.4–10.8 × 4.2–6.4 µm, Q = 1.47–1.88 (mean [42]: the apex), darkening slightly in Melzer's Solution, ovate and obovate, coarsely roughened (especially at marginate. The apex may have some violaceous colours, the flesh of the stipe, as in C. evernius, is never strongly violaceous.

Cortinarius evernius is commonly reported to be associated with conifers. There are other collections of this species in the herbarium of the New Brunswick Museum, but these have not been confirmed genetically. Brandrud et al. (1990) stated that it is usually thought to associate with conifers in northern or mountain habitats, often with Sphagnum L., but that it has also been collected in subalpine birch forests. In Quebec, it has been found on wet soils in coniferous forests, often with Sphagnum (Landry et Labbé 2022). Our collection was gregarious to clustered in a carpet of Red-stemmed Feathermoss (Pleurozium schreberi (Brid.) Mitt.) and other mosses in a well-drained site, associated with Balsam Fir. No Sphagnum was present.

Cortinarius subgenus Telamonia, section Brunnei
Cortinarius cicindela Kytöv., Niskanen & Liimat. (Figures 2c, 3c)
Pileus not seen when young, broadly conical and then irregularly buckled in age, with a prominent umbo, finely striate at the margin, dry, glabrous, dark brown (HSV10:80:30–40), dark brown to black in exsiccates, hygrophanous, 21–33 mm in diameter. Stipe equal, light silvery grey (HSV20:00–10:100), soon darkening to brown (HSV20:70:40–50), dry, glabrous, 60–80 × 3–5 mm. Lamellae very pale orange brown (HSV15:50:60), adnexed, subclose, not marginate. Flesh concolorous with the surface tissues, lacking a distinctive odour and taste.
Basidiospores reddish brown in spore print, mostly elliptical in profile, varying obscurely between ovate and obovate, coarsely roughened (especially at the apex), darkening slightly in Melzer’s Solution, 7.4–10.8 × 4.2–6.4 µm, Q = 1.47–1.88 (mean [42]: 8.5 ± 0.7 × 5.3 ± 0.4 µm, Q = 1.61 ± 0.08). Pileipellis duplex, with a thin and compact cutis of pale narrow encrusted hyphae and a thick dark brown hypoderm of short broad strongly encrusted hyphae. Lamellae trama parallel, with hyphae clamped and strongly encrusted externally.
Specimen examined—CANADA, New Brunswick, Northumberland Co., Kennedy Lakes Protected Natural Area, 46.792164°N, 66.478584°W, 4 July 2019, D. Malloch 04-07-19/08 (NBM-F-009368), GenBank no. OP352899 (ITS).

A typical member of section Brunnei, characterized by dark brown hygrophanous pilei, dark brown lamellae, and basidiomata that become blackened when dried. All are associated with coniferous trees. Niskanen et al. (2009) studied section Brunnei extensively and provided a key to the species. Identification in the group is difficult, requiring precise determination of basidiospore size and shape. Cortinarius cicindela, one of the smaller members of the section, is very similar to Cortinarius carabus Kytöv., Niskanen & Liimat. and can be distinguished from it mainly by its slightly longer and less markedly obovate basidiospores and by its habitat, C. carabus growing mainly in sandy forests of pine (Pinus L.) and C. cicindela growing in more mesic forests of spruce (Picea A. Dietrich) and fir (Abies Miller). However, Niskanen et al. (2009) reported one sequence matching that of C. carabus from roots of Western Hemlock (Tsuga heterophylla (Rafinesque) Sargente) in British Columbia, which suggests the species is not restricted to Pinus spp. Both species were reported from Quebec by Landry et al. (2021).

In their original description of C. cicindela, Niskanen et al. (2009) reported that, in northern Europe, it can occur in Sphagnum bogs and other wet places with spruce and pine species, but also in mesic or dry forests with these trees. It was reported by Landry et Labbé (2022) from Radisson, northern Quebec, in mesic to humid soil among Sphagnum. Our collection was gregarious on Sphagnum in a wet forest dominated by Red Spruce (Picea rubens Sargente), Balsam Fir, and Paper Birch (Betula papyrifera Marshall).

Cortinarius gentilis (Fr.) Fr. (Conifer Webcap; Figures 2d, 3d)
Pileus conic-convex at first, expanding to broadly convex, with a low umbo, moist, glabrous except for some marginal pubescence, light brown to brown (HSV05–20:70:50–70), with marginal pubescence pale yellow to light yellow (HSV40:20–30:100), 13–37 mm in diameter. Stipe equal, yellowish white to pale yellow (HSV40:05–10:100), reddish brown (HSV380:70:30–40) where bruised, glabrous to fibrillose with yellow veil material, 40–70 × 3–7 mm. Lamellae light brown (HSV15:50:60) at first, more yellow when viewed on edge, darkening at maturity, adnexed to sinuate. Universal veil yellowish white (HSV40:05:100). Flesh concolorous with the surface tissues, concolorous with the bruising colour in the interior of the stipe, with a raphanoid odour, fairly tasteless.

Basidiospores orange brown (HSV35:50–60:90) in spore print, elliptical to obovate in profile, infre-
quent ovate, roughened with small spine-like warts, unchanging in Melzer’s solution, darkening in KOH, 7.8–9.7 × 5.6–6.6 µm, Q = 1.34–1.60 (mean [49]: 8.7 ± 0.4 × 6.0 ± 0.2 µm, Q = 1.45 ± 0.07). Basidia clavate, four-spored, with a basal clamp connection. Hy
genial cystidia lacking. Pileipellis duplex, composed of a compact cutis of pale encrusted hyphae, with a brown hypoderm of short and broad encrusted hyphae. Lamellar trama parallel, of narrow brown finely encrusted hyphae.

Specimens examined—CANADA, New Brunswick, Charlotte Co., Little Lepreau, 45.135°N, 66.491°W, 24 September 2003, D. Malloch 24-09-03/04 (NBM-F-00454), GenBank no. OP352903 (ITS); Little Lepreau, 45.135°N, 66.475°W, 24 September 2003, D. Malloch 24-09-03/02 (NBM-F-000452; not sequenced but morphologically similar).

Cortinarius gentilis was traditionally placed in Cortinarius subgenus Leprocysthe among other bright orange-brown species (e.g., Hansen and Knudsen 1992); however, ITS sequences show it to be a member of subgenus Telamonia, sect. Brunnei (Høiland and Holst-Jensen 2000). Although its association with coniferous trees and the overall stature of its basidiomata are consistent with the Brunnei, the colour of the basidiomata and the bright yellow veil remnants on the stipe are less so. There are several collections of C. gentilis in NBM, including others from New Brunswick and one (NBM-F-0311) from Newfound-land and Labrador. Two records, possibly representing separate species, have been reported for Quebec by Landry et al. (2021). Their collection YL3407, as photographed, is very similar in appearance to those made in New Brunswick.

This well-known species was stated by Niskanen et al. (2009) to occur in dry to mesic coniferous forests with pine and spruce in northern Europe. Landry et Labbé (2022) give the habitat as soil under conifers and plantations of Jack Pine (Pinus banksiana Lambert). Landry et Labbé (2022) reported what appear to be the same collections on soil under conifers and plantations of Jack Pine with poplars (Populus sp.).

Cortinarius caninoides and C. circinans were originally described validly in the same publication. Landry et al. (2021) pointed out that the types of these two names had ITS sequences similar enough that they could be considered conspecific, and, following Art. 11.5 of The International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018), they chose to recognize C. caninoides as their preferred name for this species, citing C. circinans as a synonym.

Robert Henry’s original description (Kühner and Romagnesi 1953) lists the habitat as soil under pine and birch (Betula L.). Landry et al. (2021) reported three sequenced collections from Quebec and gave the habitat as being under conifers, possibly with Jack Pine (Pinus banksiana Lambert). Landry et Labbé (2022) reported what appear to be the same collections on soil under conifers and plantations of Jack Pine with poplars (Populus sp.). Our material was gregarious to clustered among Red-stemmed Feathermoss, associated with Heart-leaved Birch (Betula cordifolia Regel) and Balsam Fir.
Cortinarius pseudobiformis Bidaud & Carteret  
(Figures 2f, 3f)

Pileus convex when young and remaining so at maturity, with a low broad umbo, dry, silky-shiny, glabrous or with a very sparse covering of white universal veil material, dark reddish brown (HSV00:20:50), hygrophanous, with fading beginning in a ring surrounding the umbo, 38–40 mm in diameter, unchanging in KOH. Stipe tapering up gradually from an only very slightly enlarged base, thickly covered with the white silky universal veil, mostly white but with a very dilute violaceous colour at the apex, dry, 70 × 13 mm. Lamellae orange brown (HSV25:40:50–60), close, adnate to adnexed, finely eroded at the margin, not marginate. Universal veil and cortina white. Flesh concolorous with the surface tissues in the areas of the pileus surrounding the broad umbo but only in the uppermost 1 mm on the umbo, violaceous (HSV280:30–40:60–70) in the upper 20 mm of the stipe but with this colour soon fading to greyish when exposed to air, light brown (HSV25:40:60–70) in the stipe cortex, dull whitish in the umbo and lower part of the stipe, with a pronounced but nondescript mushroom odour and taste, unchanging in KOH.

Basidiospores weak reddish brown in spore print, elliptical to obovate in profile, rarely ovate, with a tapering apex, usually with a suprahilar flattening, coarsely roughened, strongly dextrinoid, 8.3–10.7 × 5.1–6.1 µm, Q = 1.42–1.82 (mean [53]: 9.5 ± 0.5 × 5.8 ± 0.2 µm, Q = 1.63 ± 0.09). Basidia clavate, four-spored, with a basal clamp connection, occasionally filled with a yellow-brown substance. Cheilocystidia not well defined, appearing as narrow clavate cells arising from the terminal ends of the lamellar trama. Pileipellis duplex, a cutis of narrow hyaline hyphae above a subpellis of short brown encrusted cells. Clamp connections present on most septa.


Cortinarius pseudobiformis has a dark brown hygrophanous pileus, a nearly cylindrical stipe covered by a thick white universal veil, orange-brown lamellae, and violaceous flesh in the upper part of the stipe. Unlike other species in this report, it has markedly dextrinoid basidiospores. Landry et al. (2021) reported and illustrated this species from Quebec. The basidiomata in their photograph resemble our material except for the slightly bulbous base of the stipe. Although Landry et al. (2021) described the lamellae of their collection as brownish violet at first, we did not observe any violaceous colours in ours, perhaps because they were more mature.

This species is not commonly reported and habitat data are limited. Landry et Labbé (2022) report it on acid soil under fir trees among mosses near a bog. Landry et al. (2021) state it is found under Balsam Fir, poplar (“trembles”), and birch. Their illustrations show the habit to be well drained and with Red-stemmed Feathermoss and Dicranum Hedw. Our collection was solitary in a well-drained area at the base of a mature Balsam Fir among numerous seedlings of that species, associated with Balsam Fir and a few individuals of Heart-leaved Birch. Its appearance in mid-June is much earlier than the Quebec collections.

Cortinarius subgenus Telamonia, section Tortuosi

Cortinarius tortuusus (Fr.) Fr. (Figures 4a, 5a)

Pileus conic-turbinate at first, broadly convex at maturity, with a rounded to subacute umbo, dry, glabrous, chocolate brown (HSV25:80:30–40), strongly hygrophanous, 26–38 mm in diameter. Stipe equal or slightly swollen at the base, with a slightly flocculose annular zone in some but with this lacking in others, white with an appressed universal veil layer over a very pale straw-coloured ground colour, dry, 45–65 × 4–5 mm. Lamellae medium brown (HSV20:70:50–60), subclose, adnexed, not marginate. Cortina white, sparse, not visible on mature basidiomata. Flesh concolorous with the surface tissues in the pileus, pale yellow orange (HSV40:20:98) in the stipe, lacking a distinctive odour and taste.

Basidiospores orange brown in spore print, elliptical to ovoate in profile, infrequently obovate, with a tapering apex, usually with a suprahilar flattening, coarsely roughened, strongly dextrinoid, 8.0–11.5 × 5.0–6.1 µm, Q = 1.54–1.92 (mean [70]: 9.3 ± 0.5 × 5.4 ± 0.2 µm, Q = 1.71 ± 0.08). Basidia four-spored, clavate. Hymenial cystidia lacking. Pileipellis duplex, a cutis of narrow brown encrusted hyphae overlying a thicker layer of broad hyphae. Clamp connections produced at nearly all septa.


Some earlier authors, e.g., Brandrud et al. (1998), included C. tortuosus in the section Bicolores along with the superficially similar C. eveniuns, but more recent molecular results (Liimatainen et al. 2022) suggest placement in a separate section. Although the stipe of C. tortuosus may be lightly violaceous at its apex (Brandrud et al. 1990), it is never as markedly violaceous throughout its length, inside and out, as that of fresh basidiomata of C. eveniuns.

The neotype was growing among Sphagnum in a spruce forest (probably Norway Spruce [Picea abies (L.) H. Karsten]) in Sweden. Liimatainen et al. (2017)
stated that *C. tortuosus* has a very narrow ecological niche, growing in wet and acidic soils with conifers. Soop (2021) reported that, in Sweden, it is fairly common in moist spruce forests, often in *Sphagnum*. Landry et Labbé (2022) report it in Quebec on poorly drained soil in coniferous forests, usually in *Sphagnum*. Our collection was not in *Sphagnum* but was clustered among Red-stemmed Feathermoss, associated with Heart-leaved Birch and Balsam Fir. There are other collections of this species in the herbarium of the NBM, but these have not been confirmed genetically.
Cortinarius subgenus Telamonia, section Valgi

Cortinarius valgus Fr. (Figures 4b, 5b)

Pileus conic-convex at first, expanding to more broadly so at maturity, with a low rounded umbo, dry, glabrous except for the minutely white-fibrillose margin, dark orange brown (HSV25:50:50) when young and fully hydrated, strongly hygrophanous and soon fading and revealing some orange shades on the umbo, 21–43 mm in diameter. Stipe equal down to the distinctly bulbous base, slightly white fibrillose with veil material but otherwise glabrous, with a weakly defined annular zone when young, mostly pale straw coloured with some darker regions below, very obscurely violaceous at the apex, dry, 40–60 × 4–8 mm. Lamellae light brown (HSV30:40–40:70), subclose, adnexed, not marginate. Cortina not seen. The universal veil as seen on the stipe and pileus margin is sparse but appears to be white. Flesh pale greyish white, lacking a distinctive odour and taste.

Basidiospores orange brown in spore print, broadly elliptical to slightly ovate in profile, less frequently slightly obovate, coarsely roughened, slightly dextrinoid, 6.9–9.7 × 4.9–6.7 µm, Q = 1.30–1.65 (mean [40]: 7.9 ± 0.6 × 5.4 ± 0.4 µm, Q = 1.45 ± 0.06). Hymenial cystidia lacking. Basidia clavate, four-spored, with a basal clamp connection. Pileipellis a thin cutis of narrow brown encrusted hyphae, not clearly duplex and with hypoderm poorly defined. Clamp connections present throughout.


This collection is difficult to characterize. Landry et al. (2021) reported C. valgus from Quebec and stated that their collection’s ITS sequence was identical to that of the neotype, as is ours. They describe their basidiomata as having some slightly olivaceous colours, the pileus with an uneven margin, and the lamellae slightly violaceous when young.

We did not observe any violaceous colour in our collection. Cortinarius rheubarbarinus Rob. Henry, a later synonym with ITS sequence identical to that of C. valgus (Liimatainen et al. 2020), was illustrated by Brandrud et al. (1992, 1994). Although their collections resemble ours, they were described as growing in dry calcareous soil in association with beech, hornbeam (Carpinus L.), and oak (Quercus L.). It is possible that these collections have not been sequenced.

According to Soop (2021), C. valgus grows in both acidic and richer forests of spruce. Landry et Labbé (2022) report two collections from Quebec as growing on soil in young plantations of spruce and pine. The New Brunswick material was clustered in a relatively moist rocky site among Sphagnum sp. and Red-stemmed Feathermoss, associated with Heart-leaved Birch and Balsam Fir.

Cortinarius subgenus Camphorati, section Anomali

Cortinarius harvardensis L. Nagy, Dima & Ammirati (Figures 4c, 5c)

Pileus conical when young, expanding to more broadly so at maturity, with a low rounded umbo or without an umbo, dry to moist, glabrous, light orange brown (HSV30:40:30:70–100) and dull grey (HSV15:05:70) toward the margin when young, later maintaining the colour on the umbo but otherwise dull orange grey (HSV25:05:90; photos show violaceous colours in the cap not recorded in the description), possibly hygrophanous, 16–41 mm in diameter. Stipe equal down to the swollen base, without a distinct bulb, slightly white fibrillose with veil material but otherwise glabrous, with a moderately well-defined annular zone when young, mostly white, very obscurely violaceous at the apex, dry, 36–78 × 3–8 mm. Lamellae light brown (HSV30:30:60–80) to dull violaceous grey (HSV310:10–15:70), subclose to close, adnexed, not marginate. Cortina possibly white. Flesh dark bluish grey (HSV280:10:50) to dull reddish grey (HSV00:10:60) in the pileus, violaceous grey (HSV270:20–30:50) in the centre of the upper stipe, concolourous with the surface tissues in the cortex of the stipe, paler grey in the rest of the stipe context, concolourous with the surface tissue in the stipe cortex, lacking a distinctive odour and taste.

Basidiospores reddish brown in spore print, broadly elliptical to slightly obovate in profile, less frequently slightly obovate, finely echinulate-roughened, 6.9–9.9 × 5.3–6.6 µm, Q = 1.22–1.49 (mean [80, of two collections]: 7.5 ± 0.5 × 5.8 ± 0.2 µm, Q = 1.28 ± 0.05). Basidia clavate, four-spored, with a basal clamp connection. Hymenial cystidia lacking. Lamellar trama parallel, with a few adhering colourless crystals but not encrusted with pigment material. Pileipellis duplex, a cutis of hyphae one or two cells deep overlying a compact subpellis of short broad hyphae, with cuticular hyphae containing a yellowish cytoplasmic pigment. Clamp connections on nearly all hyphae.


Reported from Massachusetts (holotype), Nova Scotia, and Quebec by Dima et al. (2021). It is characterized by its orange-brown to bluish-grey pileus, its white stipe with flesh in upper part blue, and lamellae
that are blue at first. The subglobose basidiospores are also characteristic.

The type was reported to be associated with pine and oak (Dima et al. 2021). Landry et Labbé (2022) list three Quebec specimens confirmed by sequences. No species of oak were recorded from any of the Quebec localities. All of the photos of Quebec material, except one made on a scanner, show well-drained habitats with Red-stemmed Feathermoss. Records from Nova Scotia include three collections made by Keith N. Egger, all found in association with Eastern Hemlock (Tsuga canadensis (L.) Carrière) and vermillion-brown (HSV35:30–40:80–90) at first, bright orange brown (HSV35:70:90) at maturity, subclose, adnexed, dull greyish white but becoming light reddish brown (HSV15:30:70) where handled, dry, minutely fibrillose, 25–38 × 3–6 (9) mm. Lamellae light yellow brown (HSV35:30–40:80–90) at first, bright orange brown (HSV35:70:90) at maturity, subclose, adnexed, not marginate. Cortina white. Flesh concolorous with the surface tissue in the pileus, bright orange brown (HSV35:70:60–80) in the stipe, lacking a distinctive odour and taste.

Basidiospores bright rusty orange brown (HSV 35:80:80) in spore print, narrowly ovate to elliptical in profile, less frequently obovate, coarsely roughened, unchanging in Melzer’s solution, 7.4–9.7 × 4.5–5.7 µm, Q = 1.48–2.00 (mean [56]: 8.5 ± 0.5 × 4.9 ± 0.2 µm, Q = 1.73 ± 0.10). Basidia clavate, four-spored, with a basal clamp connection. Hymenial cystidia lacking. Pileipellis duplex, a thin cutis of narrow finely encrusted hyphae over a subpellis of short-celled broad hyphae. Clamp connections present on most septa.


The overall appearance of this collection is similar to that of C. valgus. It differs in the more orange-brown colour of the lamellae and in the orange-brown colour of the flesh of the stipe. Landry et al. (2021) note that the bands of reddish-brown veil material on the surface of the stipe are a diagnostic feature of the Quebec material. This may also be true of our collection, although much of the brown colour appears to be due to bruising.

The habitat range of C. fulvescens appears to be fairly broad. The neotype from Finland was collected in submesic forest dominated by Norway Spruce mixed with some birch and European Aspen (Populus tremula L.; Hyde et al. 2016). Soop (2021) reported it in Swedish spruce forests, often near Sphagnum. According to Hyde et al. (2016), it grows in mesic to dry coniferous forests with spruce and/or pine and hemlock (Tsuga (Endler) Carrière). Landry et Labbé (2022) report sequenced material from Quebec collected in sandy soil among mosses in coniferous forests and plantations with fir, pine, and spruce. The New Brunswick collection was gregarious in gravel at the edge of a driveway, associated with Heart-leaved Birch and Balsam Fir. The uncharacteristically short stipe in this collection was probably because of the rather thin disturbed soil.

Discussion

Seven species, C. caninoides, C. cicindela, C. fulvescens, C. harvardensis, C. plumulosus, C. pseudo-biformis, and C. valgus, are new distribution records for New Brunswick. The collection of C. plumulosus may also be a new record for North America. Although previous collections of C. eturnius, C. gentilis, and C. tortuosus from New Brunswick have been accessioned in the herbarium of the NBM, their identification has not been confirmed genetically. Most datasets for species of Cortinarius generated using molecular techniques have been based on the ITS and LSU regions (Landry et al. 2021; Liimatainen et al. 2022). Our results are thus consistent with recent usage.

All of the collections presented here, except C. cicindela, were made close to the shore of the Bay of Fundy in southeastern Charlotte County, New Brunswick. This area is in the Fundy Coast Ecoregion (Zelazny 2007). Clayden et al. (2011) characterized this region as having a “perhumid” climate, one
in which precipitation much exceeds evaporation and plant transpiration, resulting in year-round wetness. Fog occurs frequently during the summer. Mean summer temperatures are about 14.5°C and mean annual precipitation is 1000–1400 mm (McAlpine and Smith 2010). The vegetation is mainly boreal to hemiboreal, characterized by low-diversity stands of Red Spruce, Black Spruce, Balsam Fir, and Heart-leaved Birch. Much of the understory is dominated by bryophytes, especially carpets of the mosses Red-stemmed Feathermoss, Broom Forkmoss (Dieranum scoparium Hedw.), Glittering Woodmoss (Hylocomium splendens (Hedw.) Schimp.), Knights Plume Moss (Ptilium cristat-castrensis (Hedw.) De Not.), and Sphagnum spp., and the liverwort Greater Whipwort (Bazzania trilobata (L.) Gray).

Cortinarius cicindela was collected in the Buttermilk Ecodistrict of the Valley Lowlands Ecoregion, an area characterized by a greater representation of shade-tolerant hardwoods mixed with fir and spruce (Zelazny 2007). The annual precipitation is 1000–1300 mm (McAlpine and Smith 2010), but summers are warmer and less foggy and winters colder than in the Fundy Coast Ecoregion, so more of this may come from snow.

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