

THE CLAVARIOID FUNGI OF NOVA SCOTIA¹

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Detailed description of 37 species of clavarioid fungi occurring in Nova Scotia are presented. Species from the 8 genera *Clavaria* Fr., *Clavariadelphus* Donk, *Clavicornia* Doty, *Clavulina* Schroet., *Clavulinopsis* van Ov., *Lentaria* Corner, *Ramaria* (Fr.) Bonorden and *Ramariopsis* Donk emend. Corner are represented. A circumscription of each genus and key to its species are provided. Microscopic and macroscopic details are illustrated for all described taxa. Macrochemical tests carried out on all specimens assisted in determining taxa.

Ramaria longissimispora is described as a new species. Var. *concolor* is a new variety of *R. formosa*. Eleven species are reported as new records for the province.

On présente une description détaillée de 37 espèces de champignons du type "clavaire" présents en Nouvelle-Ecosse. Ces espèces comprennent des représentants des 8 genres suivants: *Clavaria* Fr., *Clavariadelphus* Donk, *Clavicornia* Doty, *Clavulina* Schroet., *Clavulinopsis* van Ov., *Lentaria* Corner, *Ramaria* (Fr.) Bonorden et *Ramariopsis* Donk emend. Corner. On délimite chaque genre et on fournit une clé d'identification de ses espèces. On inclut des illustrations des détails microscopiques et macroscopiques de tous les taxons décrits. Des tests macrochimiques effectués sur tous les spécimens ont aidé à l'identification des taxons.

On décrit une nouvelle espèce, *Ramaria longissimispora*, de même que var. *concolor*, une nouvelle variété de *R. formosa*. La présence dans la province de onze des espèces présentées est signalée pour la première fois.

TABLE OF CONTENTS

Introduction	3
Materials and Methods	4
Key to the Genera	6
Circumscription of the Genus <i>Clavaria</i>	6
Key to the Species of <i>Clavaria</i>	7
<i>Clavaria fumosa</i>	7
<i>Clavaria purpurea</i>	8
<i>Clavaria vermicularis</i>	11
<i>Clavaria zollingeri</i>	11
Circumscription of the Genus <i>Clavariadelphus</i>	12
<i>Clavariadelphus pistillar</i>	12
Circumscription of the Genus <i>Clavicornia</i>	15

<i>Clavicornona pyxidata</i>	16
Circumscription of the Genus <i>Clavulina</i>	16
Key to the Species of <i>Clavulina</i>	19
<i>Clavulina cinerea</i>	19
<i>Clavulina cristata</i>	20
Circumscription of the Genus <i>Clavulinopsis</i>	21
Key to the Species of <i>Clavulinopsis</i>	21
<i>Clavulinopsis amoena</i>	22
<i>Clavulinopsis aurantio-cinnabarina</i>	25
<i>Clavulinopsis cineroides</i>	26
<i>Clavulinopsis corniculata</i>	26
<i>Clavulinopsis fusiformis</i>	29
<i>Clavulinopsis laeticolor</i>	30
<i>Clavulinopsis luteo-alba</i>	31
Circumscription of the Genus <i>Lentaria</i>	31
<i>Lentaria mucida</i>	32
Circumscription of the Genus <i>Ramaria</i>	33
Key to the species of <i>Ramaria</i>	34
<i>Ramaria botrytis</i>	36
<i>Ramaria botrytoides</i>	39
<i>Ramaria concolor</i>	39
<i>Ramaria conjunctipes</i>	43
<i>Ramaria fennica</i>	43
<i>Ramaria flavigelatinosa</i>	44
<i>Ramaria flavobrunnescens</i> var. <i>flavobrunnescens</i>	45
<i>Ramaria flavobrunnescens</i> var. <i>aurea</i>	47
<i>Ramaria flavobrunnescens</i> var. <i>formosoides</i>	47
<i>Ramaria formosa</i>	48
<i>Ramaria formosa</i> var. <i>concolor</i>	48
<i>Ramaria gracilis</i>	51
<i>Ramaria longissimispora</i>	52
<i>Ramaria magnipes</i>	53
<i>Ramaria obtusissima</i>	55
<i>Ramaria rubripermanens</i>	56
<i>Ramaria sandaracina</i> var. <i>sandaracina</i>	56
<i>Ramaria secunda</i>	61
<i>Ramaria stricta</i>	62
<i>Ramaria subbotrytis</i>	62
<i>Ramaria suecica</i>	65
<i>Ramaria xanthosperma</i>	66
Circumscription of the Genus <i>Ramariopsis</i>	69
Key to the Species of <i>Ramariopsis</i>	69
<i>Ramariopsis crocea</i>	69
<i>Ramariopsis kunzei</i>	70
Acknowledgements	71
References	71

Explanation of Figures

Scale bars in photographs of specimens represent 1 cm; in camera lucida drawings 10 μ m; and in electron micrographs 1 μ m. Symbols used in camera lucida illustrations: B—basidia; C—clamp connection; S—spores; Cy—cystidia.

Introduction

The Clavariaceae, commonly known as coral fungi, are abundant in Nova Scotia in moist weather. In dry seasons only a few common species are found. An investigation carried out during the months of July through October 1977, a relatively humid season, established the presence of 40 species and varieties representing 8 genera.

The Clavariaceae are basidiomycetes bearing spores upon the surface of simple or branched coral-like structures. The erect fruiting bodies are covered with a hymenium except for the base of the stem and the upper surfaces of oblique branches. Pigmentation ranges from yellow and brilliant pink to the complete absence of color in snow white fruiting bodies, and the texture of the fruiting body varies from soft and fleshy to tough and brittle, with some species waxy, gelatinous or pliable. Spore deposits are white or colored, indicative of genera, and spores may be smooth or ornamented with spines, warts or ridges.

The comparatively mild climate (-3.2 to 18.3°C) and the considerable annual rainfall (1204.5-1340.9 mm) (Statistics Canada 1978) permits the development of a relatively rich mycoflora in Nova Scotia. A damp hollow in a mixed woods, with abundant dead wood and a deep humus layer provides an excellent habitat for the larger multibranched fruiting bodies typical of the genus *Ramaria*. The simple sporocarps characteristic of the genus *Clavulinopsis* are more often found on open grassland or mossy areas. Dead leaves and herbaceous stems and twigs provide a habitat for some of the smaller fruiting bodies. Some small, simple or sparingly branched fruiting bodies are phycophilous, growing in films of green or blue-green algae that coat the soil or surface of rotting logs. The fungal hyphae are in close association with the algal cells, sometimes connected by haustoria, though the algal cells do not enter into the construction of the fruiting body. As small groups of algal cells are sometimes killed, the relationship is considered parasitic (Corner 1950).

The genera of the Clavariaceae are cosmopolitan, each comprising temperate and tropical species. A few species such as *Clavaria zollingeri* and *Clavaria vermicularis* are widely tolerant of temperature and are reported as cosmopolitan (Corner 1950).

The clavarioid fungi are conspicuous intermediates in the phylogeny of the higher basidiomycetes (Petersen 1971). Depending on whether or not the primitive fruiting body is considered to be resupinate or a simple club, the Clavariaceae may be placed at either end of the phylogenetic scale. The clavate fruiting body was the basic character recognized by pre-Friesian authors who grouped members of Dacrymycetes, Geoglossaceae, Xylariaceae and Clavariaceae together. Fries (1821) divided the genus *Clavaria* into tribes on the basis of the morphology of the fruiting body and later on spore color (Fries 1838), a characteristic also utilized by Karsten (1879) in his description of *Clavariella*. Coker (1923) published the first extensive study of the North American Clavariaceae, following the older genera. Donk (1933) recognized a number of additional genera and Corner (1950; 1970) revised the taxonomy of the family on a world-wide basis in terms of the hyphal properties and other microscopic features of fruiting bodies, segregating over 30 genera.

Sommers (sic; 1880) published the first checklist of fungi for Nova Scotia, but did not report species of Clavariaceae; however, in subsequent lists, Somers (1881; 1882; 1886) as well as MacKay (1908; 1913) and Harrison (1927) included clavarioid species in their lists of the fleshy basidiomycetes occurring in the province. Later, a list of 48 representative species of the Clavariaceae in the

Maritime Provinces are published by Wehmeyer (1950). The North American authority on the Clavariaceae, R.H. Petersen, from the University of Tennessee, and his student P. Olexia, collected in the area in 1965 and identified herbarium material now located in the E.C. Smith Herbarium, Acadia University (ACAD).

The purpose of this paper is to provide keys and detailed technical descriptions and illustrations for the representative species of the Clavariaceae occurring in Nova Scotia. Being an initial survey in the area, it is not intended to be monographic in scope. Delimitation of taxa at the genus and family level is approached in a traditional manner following Corner (1950).

Materials and Methods

Collections of representative species of Clavariaceae were made in Hants, Kings, Queens, Richmond, Guysborough, and Annapolis counties. Specimens were wrapped in waxed paper and transported to the laboratory where spore prints and descriptions were prepared from the fresh material. A spore print was prepared by placing a portion of the sporocarp on black and on white paper in a chamber consisting of two 20 x 30-cm pyrex glass dishes, one inverted over the other. A 12-hour period in this chamber permitted even drying of the material and ensured maturation of the spores. Field notes on pertinent ecological features were recorded at the time of collection.

A 35-mm single lens reflex camera was used to photograph the fresh specimens. Photographs of minute specimens were taken with a Zeiss Tessovar photographic apparatus. Specimens were dried in a standard drying oven at 38 to 40°C. After steaming and pressing, the collections were redried, filed in 12.5 x 20-cm herbarium envelopes, and deposited in the E.C. Smith Herbarium at Acadia University. Specimens designated as M- (e.g. M-526) are from the private collection of C.D. Marr, State University College, Oneonta, New York.

Macroscopic Features

A. *Color.* As sporocarp color is considered to be an important character in delimiting taxa, base, branch and contextual colors of the specimens were routinely recorded. Physical damage to the sporocarp of some species resulted in a color change or bruise. Localized color changes or stains, generally in the region of the stipe, were observed in some species. These colors plus those of dried specimens were also noted. Color references were taken from Reinhold Color Atlas (Kornerup & Wanscher 1962). As the ISCC-NBS centroid color charts (Kelly & Judd 1955) are now considered to be the standard color reference for agaricology, the nearest color equivalents from these charts are included in parentheses.

B. *Taste and Odor.* Taste and odor are useful characters that may aid the individual taxonomist, but they must be broadly interpreted owing to their inconsistency and individual variance.

C. *Form and Consistency.* Habit, branching, presence of extensive rhizomorphs, single or multiple stipe, and presence of a basal tomentum were considered as important characters of form. Consistency is a measure of the total combination of numerous hyphal characteristics and was recorded from both dry and fresh material.

Macrochemical Tests

Transverse sections about 2 mm thick, taken from approximately the second or third internode behind the terminal branch, were placed in a standard porcelain

spot dish depression. One or 2 drops of the chemical solution were applied to each branch section. Color reactions were recorded as positive or negative approximately 30 minutes after application. All tests were carried out on fresh material.

A. *Ferric sulfate*—10% solution. Any shade between blue and green is considered positive.

B. *Pyrogallol (Pyrogallic Acid)*—10% aqueous solution. Positive color reactions vary from orange-yellow to carrot red or orange-brown.

C. *α -Naphthol*—5% solution, made by dissolving 10 g of α -naphthol crystals in 70 ml of 95% ethanol (ETOH) and adding water to make a final volume of 200 ml. Violet and purple are positive color reactions.

D. *Guaiac tincture*—below saturation. Some shade of blue, usually dark blue, is a positive reaction.

E. *Guaiacol*—saturated aqueous solution. Pink, red, and rust brown are positive color reactions.

F. *Phenol*—2% aqueous solution. Red or violet is a positive color reaction.

G. *Aniline*—1:1 (v/v) aniline oil and water, the aqueous phase being the testing reagent. Red or violet or occasionally green is a positive color reaction.

H. *Melzer's reagent*—The reagent was prepared by dissolving 1.5 g potassium iodide (KI) in a solution of 0.5 g iodine (I_2) in 20 ml of 1:1 w/v chloral hydrate in water. A dull violet color is an amyloid reaction, a red color is dextrinoid and no color change is non-amyloid.

Microscopic Features

Microscopic observations were made from dried specimens. A small segment (2-3 cm) of the stipe or branches was rehydrated by placing in 95% ETOH for 1 minute, then in distilled water until the tissue was pliable. Freehand sections made with a razor blade, and crush mounts in 3% KOH, Melzer's reagent, or a mixture of 1% aqueous solution of Congo Red and phloxine, were examined for hyphal arrangement, presence or absence of clamps, thickness of the hymenium and subhymenium, presence of gloeoplerous hyphae, and measurements of spores, basidia, cystidia, hyphae and hyphal wall thicknesses. Camera lucida drawings of the spores, basidia, clamps, and cystidia were prepared. Spores from spore prints were coated with gold vapor and examined and photographed with a JEOL scanning electron microscope (JXA - 35) at a beam voltage of 15 kV.

A. *Spores*. Spore morphology, dimensions, and ornamentation were of primary importance in delimiting taxa. Spore measurements included ornamentation but not the apiculus.

B. *Clamps*. The presence or absence of clamps was considered to be a significant taxonomic character. Although variation in clamp morphology is not used as a species characteristic, it was routinely noted and may eventually have taxonomic value.

C. *Context*. The bulk of the context is composed of generative hyphae, which are thin-or thick-walled, septate, and may be clamped or clampless. All other types of hyphae arise from these generative hyphae. Skeletal hyphae, most easily located in the rhizomorphs, have thick walls, lack clamps or crosswalls, and are seldom branched. Gloeoplerous hyphae are recognized by their oily contents, few branches, and greater contortions than the surrounding hyphae.

Key to the Genera

1. Without gloeocystidia 2
1. With gloeocystidia; fruiting bodies simple or with pyxidate branching, mostly lignicolous; hyphae clamped, inflating or not; spores white, small, aguttate *Clavicornia* p. 15
2. Spores white 3
2. Spores colored (yellowish, ochraceous, brownish), smooth or variously roughened, ellipsoid, often elongate; fruiting bodies branched, often highly colored *Ramaria* p. 33
3. Mostly terrestrial 4
3. Lignicolous or epiphytic; fruiting bodies white, pallid, tan, ochraceous or brownish, tough, branched, sometimes simple; spores white or pale yellow, smooth, narrowly ellipsoid; hyphae becoming thick-walled *Lentaria* p. 31
4. Fruiting bodies simple, large, erect, massive, yellow brown, rufoescent, amber or tinged pink or violet, fleshy-spongy, firm or rigid; spores aguttate; hyphae usually clamped and inflating; lignicolous or terrestrial
. *Clavariadelphus* p. 12
4. Fruiting bodies branched or simple, fleshy or brittle; hyphae inflating; spores mostly 1-guttate or multiguttate; mostly terrestrial 5
5. Fruit-bodies simple or with radial, flattened or cristate branching; basidia subcylindrical, 2-spored *Clavulina* p. 16
5. Fruiting bodies simple or branched, never flattened or cristate; basidia clavate, mostly 4-spored 6
6. Fruit-bodies simple or branched; spores smooth 7
6. Fruiting bodies branched; hyphae clamped; spores mostly 1-guttate, minutely echinulate or asperulate *Ramariopsis* p. 69
7. Flesh brittle; hyphae without clamps; spores aguttate or multiguttate; fruiting bodies branched or simple *Clavaria* p. 6
7. Fleshy or somewhat brittle; hyphae clamped; spores mostly 1-guttate; fruiting bodies branched or simple, often yellow, orange, pink or red.
. *Clavulinopsis* p. 21

Circumscription of the Genus *Clavaria*

Clavaria Fr. s. str., Syst. Mycol. 1: 466, 1821.

Holocoryne Bon., Handb. Myk., 166, 1851; emend. Donk (1933).

Type Species: *C. vermicularis* Fr., Syst. Mycol. 1: 484, 1821.

Originally, the genus *Clavaria* was the receptacle for all clavarioid basidiomycetes. Holmskjöld (1790), in proposing the genus *Ramaria*, confined *Clavaria* to simple, club-shaped species. Persoon (1822) recognized only the genus *Clavaria*, dividing the species into 4 groups: a) branched or coral-like; b) elongated clubs, thickened, obsoletely branched; c) simple, the club not divided; d) Typhulae: firm, furnished with distinct and elongated stems.

Fries (1821), in arranging the species of *Clavaria*, introduced the following subheadings: a) *Ramaria*—branched species, subdivided into white-spored and ochre-spored, placing *C. flava* and *C. botrytis* in the white-spored group in error; b) *Syncoryne*—simple but bases fasciculate, subconnate, cespitose; c) *Holocoryne*—simple, clavate, bases discrete.

Bonorden (1851) removed the Friesian subgenera *Ramaria* and *Holocoryne*, leaving *Syncoryne*. This subgenus included *C. fusiformis*, *C. fumosa* and *C. vermicularis*. Donk (1933) chose *C. vermicularis* as lectotype, which was accepted by

Konrad and Maublanc (1937). Corner (1950; 1970) reduced the species of *Clavaria* from 500 to 24 certain, 16 possible and 22 incertae sedis.

Holocoryne Bon. was the Friesian subgenus raised to generic rank without explanation or indication of a type. Donk (1933) typified *Holocoryne* with *C. acuta* and its synonym *C. fulcata*, reducing the genus to a synonym of *Clavaria*.

Corner (1950; 1970) has retained and emended the two Friesian subgenera *Syncoryne* and *Holocoryne* with *C. vermicularis* and *C. acuta* respectively as their lectotypes. The basis of the separation is the wide, loop-like clamps at the bases of the basidia in *Holocoryne*. *Syncoryne* does not have clamps on the basidia or on any hyphae of the fruit-body.

The description of the genus *Clavaria* as conceived by Corner (1950; 1970) is as follows: Fruit-bodies generally simple, often cespitose, brittle; white, pink, reddish, purple, violet, grey or brown, rarely yellow; hymenium extending over the growing apices. Spores white or pink, generally smooth, subglobose to cylindrical-ellipsoid, thin-walled, generally aguttate or finely granular-guttate, rarely 1-guttate. Basidia mostly 4-spored. Hyphae thin-walled, inflating, without clamps.

Key to the Species of *Clavaria*

1. Fruiting bodies simple 2
1. Fruiting bodies branched, dull violet; spores 5.0-6.5 x 2.5-4.5 μm , broadly ellipsoid, flattened on one side *C. zollingeri* p. 11
2. Fruiting bodies greyish orange 3
2. Fruiting bodies white, yellowish or brownish towards tips, fasciculate; spores 4-6 x 3 μm , ovate to pip-shaped, apiculate *C. vermicularis* p. 11
3. Abundant cystidia projecting beyond the hymenial layer; spores 5.0-8.0 x 3.0-4.5 μm , ellipsoid, slightly apiculate; tips of fruiting bodies grey-brown *C. purpurea* p. 8
3. Cystidia absent; spores 4.5-8.0 x 2.5-4.0 μm , ovate to pip-shaped; tips of fruiting bodies dark brown *C. fumosa* p. 7

Clavaria fumosa Fr.

Syst. Mycol. 1: 483, 1821.

fumosa (L)—smoky

Figs 1, 2, 3

Fructifications: Simple, densely cespitose, often fused at the base, cylindrical then subclavate, becoming fusiform, often twisted and furrowed, hollow, 2-12 cm tall; apices acute or blunt, becoming dark brown—6F8 (deep brown—56) and shrunk with age, greyish orange—5B3 (light orange—52), drying sand—4B3 (pale orange yellow—73). Context friable. Stem indistinct; base white, mycelioid. Taste mild. Odor rancid. Spore deposit white. Terrestrial, common in mixed woods, among grass in fields, or on shaded lawns.

Macrochemical Tests: Positive color changes in pyrogallol, guaiacol, 2% phenol.

Microscopic Structures: Spores hyaline, smooth, ovate to pip-shaped, apiculate, aguttate or with granular contents, 4.5-8.0 x 2.5-4.0 μm , mostly 5-6 x 3.5 μm . Basidia 30-45 μm ; sterigmata 2 or 4, 4-5 μm long. Hymenium 35-45 μm thick, subhymenium 10-20 μm . Contextual hyphae 3-5 μm , inflating to 20 μm , interwoven; subhymenial hyphae 3-4 μm ; gloeoplerous hyphae 4-8 μm . Clamps absent.

Collections Examined: ACAD 12871, 4/8/77, Nicholasville, Kings Co.; ACAD 12872, 12/8/77, Comeau lawn, Kentville, Kings Co.; ACAD 12873, 15/8/77, Scots Bay, Kings Co.; ACAD 12874, 25/8/77, Nicholasville, Kings Co.

Discussion: *Clavaria fumosa* has been described as a large color variety of *C. vermicularis* (Corner 1950). Although the 2 are similar in habit and texture, *C. fumosa* can be distinguished by its larger average size, smoky grey color and the dark brown withered tips. No odor was previously reported, but a rancid odor was obvious in all collections studied.

***Clavaria purpurea* Fr.**

Syst. Mycol. 1: 480, 1821.

Clavaria nebulosa Pk., Bull. Torrey Bot. Club 25: 326, 1898.

Clavaria fumosa Kauffm., Pap. Mich. Acad. Sci. Arts Lett. 1: 124, 1923.

Clavaria fumosoides Kauffm., Pap. Mich. Acad. Sci. Arts Lett. 8: 145, 1928.

Clavaria occidentalis Zeller, Mycologia 21: 97, 1929.

Clavaria purpurea var. *australis* Coker, J. Elisha Mitchell Sci. Soc. 63: 63, 1947.

purpurea (L)—purple

Figs 4, 5

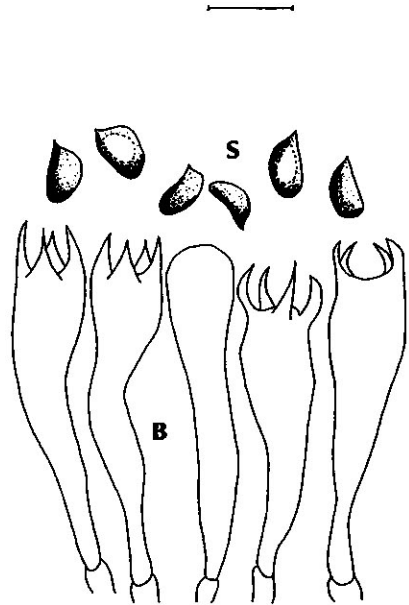
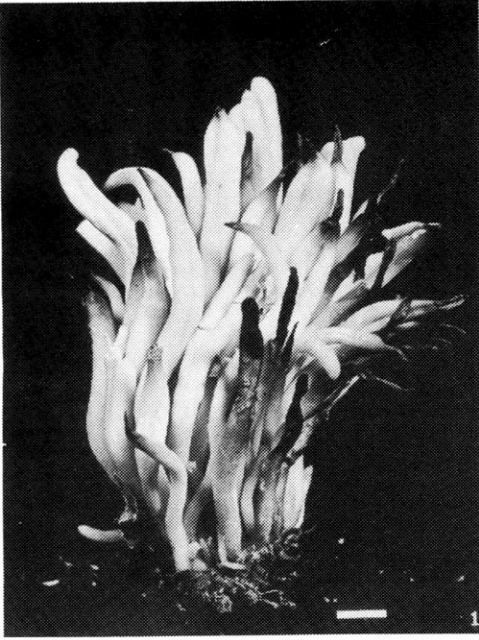
Fructifications: Simple, gregarious, solitary or cespitose, cylindrical and slender becoming fusiform, 3-12 x 0.3-0.5 cm, orange grey—5B2 (light greyish yellowish—79), greyish yellow—3C3 (light greyish olive—109) upon drying, smooth, dull, glaucous in places, tips soon withering and becoming grey brown—6E3 (greyish brown—61). Context white, brittle, becoming hollow. Stem indistinct, arising from a white woolly basal tomentum. Taste and odor absent. Spore deposit white. Terrestrial, under conifers (*Picea glauca*, *Abies balsamea*).

Macrochemical Tests: No significant color reactions in FeSO₄, pyrogallol, α -naphthol, guaiac tincture, guaiacol, or aniline. A faint pink reaction was observed with 2% phenol.

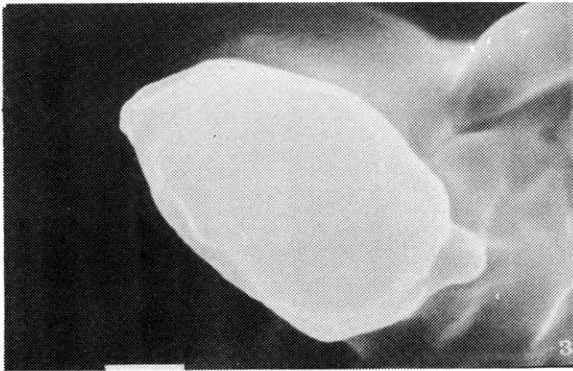
Microscopic Structures: Spores hyaline, smooth, ellipsoid, slightly apiculate, often inequilateral or curved, 5-8 x 3-4.5 μ m. Basidia 30-35 x 5-6 μ m, with 4 sterigmata 3-5 μ m long. Cystidia 65-90 x 8-11 μ m, cylindric, thin-walled, projecting beyond the hymenium, colorless, abundant. Hymenium 40-50 μ m thick. Contextual hyphae 4-15 μ m wide, closely packed, parallel; subhymenial hyphae 3-6 μ m wide. Clamp connections absent.

Collections Examined: ACAD 12875, 15/8/77, Scots Bay, Kings Co.; ACAD 5076, 13/09/62, Boularderie, Victoria Co.; ACAD 5016, 1/10/55 Glenmont, Kings Co.

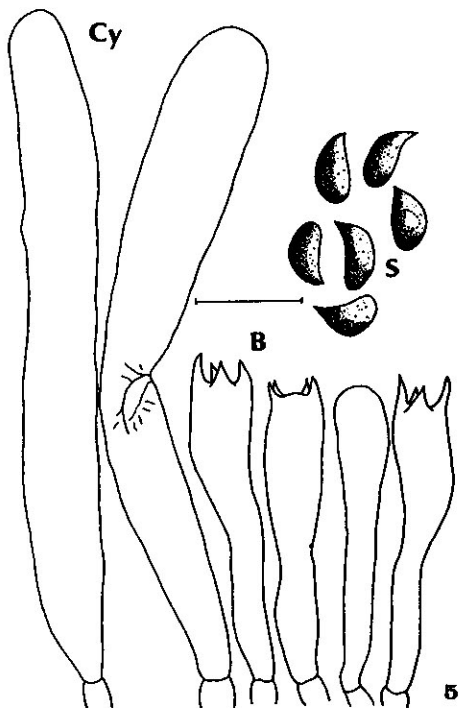
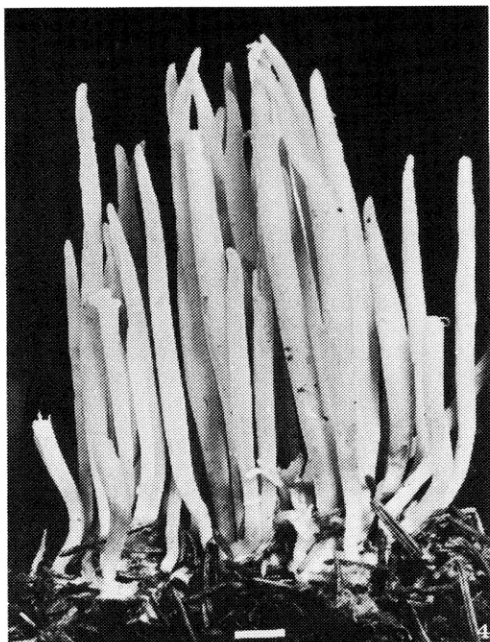
Discussion: *Clavaria purpurea* is a rare species (Corner 1950). Collection 12875 was found under spruce, beside *C. fumosa* from which it is indistinguishable in the field. The abundant cystidia projecting beyond the hymenium readily separate the 2 species microscopically. Coker (1923) reported a few clamp connections but none was observed in the material studied.



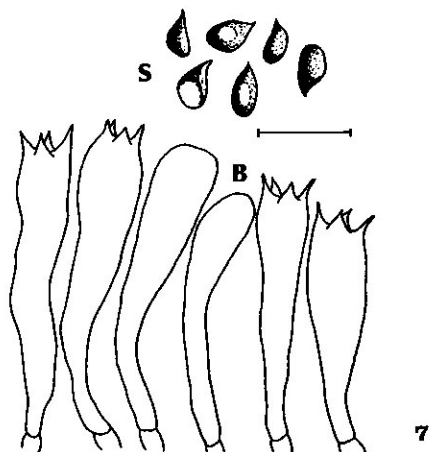
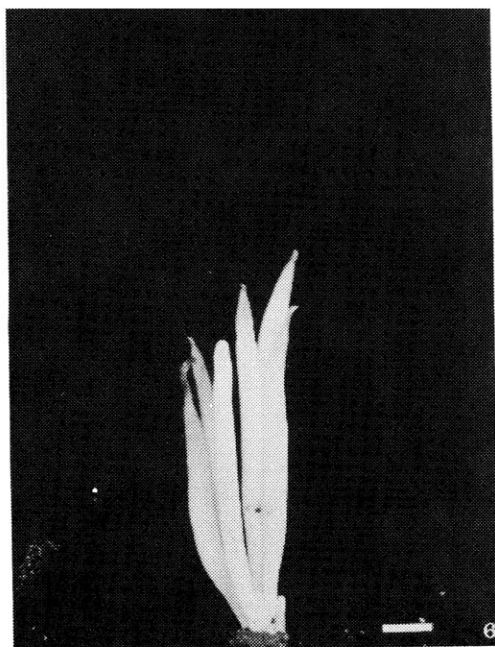
2



Figs 1, 2, 3. *Clavaria fumosa*.



Figs 4, 5. *Clavaria purpurea*.



Figs 6, 7. *Clavaria vermicularis*.

Clavaria vermicularis Fr.

Syst. Mycol. 1: 484, 1821.

Clavaria fragilis Fr., Syst. Mycol. 1: 484, 1821.*Clavaria cylindrica* S.F. Gray, Nat. Arr. Br. Pl. 1: 656, 1821.*Clavaria solida* S.F. Gray, Nat. Arr. Br. Pl. 1: 626, 1821.*Clavaria alba* Pers., Mycol. Eur. 1: 175, 1822.*Clavaria vermiculata* Pers., Mycol. Eur. 1: 184, 1822.*Clavaria vermiculata* Mich. ap. van Ov., Bull. Jard. Bot. Buitenzorg, Ser. 3, 5: 268, 1923.

vermicularis (L)—worm-shaped

Figs 6, 7

Fructifications: Simple, white throughout but usually yellowish to brownish towards the tips, drying greyish orange—6B6 (moderate orange—53), cespitose with a few scattered solitary individuals, fasciculate, 2 or 3 to more than 20 clubs per bundle, 2-7 cm tall, hygrophanous, cylindrical becoming flattened, tapered, often curving at the tips, apices acute. Context smooth, solid then becoming hollow, fragile. Taste mild. Odor absent. Spore deposit white. Terrestrial, among grass or humus in fields or mixed woods.

Macrochemical Tests: No significant color reactions with any reagent.

Microscopic Structures: Spores hyaline, smooth, ovate to pip-shaped, apiculate, 4-6 x 3 μm . Basidia 25 x 4-6 μm , with 4 sterigmata 3-5 μm long. Hymenium 30-35 μm thick, subhymenium 10-20 μm . Contextual hyphae 4-9 μm wide, closely packed, parallel. Subhymenial hyphae 2-3 μm wide. Clamp connections absent.

Collections Examined: ACAD 12876, 1/8/77, Harrington woods, Kings Co.; ACAD 12877, 15/8/77, Gospel Wood Road, Kings Co.

Discussion: *C. vermicularis* is a common and cosmopolitan species (Corner 1950), and is the type species of the genus. The pure white color, the fasciculate growth habit, and the fragile, watery flesh are the distinguishing field characteristics. The species has often been misnamed *C. vermiculata* but this name is pre-Friesian and invalid (Corner 1950).

Clavaria zollingeri Lev.

Ann. Sci. Nat. Ser. 3,5: 155, 1846.

Clavaria amethystina Zoll. Geneesk. Arch. Neerl. Ind. 1: 381, 1844.*Clavaria Nymaniana* P. Henn., Monsunia 1: 9, 1900.*Clavaria bicolor* Mass., Kew Bull., 54, 1901.*Clavaria lavendula* Pk., Bull. N.Y. State Mus. 139: 47, 1910.*Clavaria rosalana* Petch., Annu. Rep. Bot. Gard. Peradeniya 7: 290, 1922.*Clavaria violacea* Petch., Annu. Rep. Bot. Gard. Peradeniya 9: 332, 1925.

zollingeri—after Zollinger, Dutch mycologist who named the synonym *C. amethystina*.

Figs 8, 9

Fructifications: Cespitose, solitary or gregarious, 2.0-6.5 cm tall, cylindrical, sparingly branched, rugose; apices rounded or blunt; hygrophanous, dull violet—17D3 (greyish purple—228), cinnamon brown—6E6 (moderate brown—58) upon drying. Stem 0.5-2.5 cm, grey (14D1), base mycelioid, velvet-

like, context white, friable. Odor absent. Taste of tallow. Spore deposit white. Terrestrial, in mixed woods or under trees in open places.

Macrochemical Tests: No significant color reaction in FeSO_4 . Positive reactions were observed with pyrogallol, guaiac tincture, 2% phenol. No distinct color change but a fading of color was observed with α -naphthol, guaiacol, aniline.

Microscopic Structures: Spores 5-6.5 x 2.5-4.5 μm , hyaline, smooth, ovoid or broadly ellipsoid, flattened on one side, aguttate, apiculus 0.5-1.0 μm . Basidia 29-50 x 4.5-6.0 μm , 2 or 4 sterigmata 3.5-5.0 μm long. Hymenium 40 μm , thickening to 80 μm ; subhymenium 20-30 μm . Contextual hyphae 4-7 μm broad, inflating to 15 μm , constricted at the septa, walls slightly thickened. Clamp connections absent.

Collections Examined: ACAD 12878, 18/81/77, cemetery, Lequille, Annapolis Co.

Discussion: *Clavaria zollingeri* is an uncommon and variable species. The sparse branching habit and the violet color easily distinguish this species in the field.

Circumscription of the Genus *Clavariadelphus*

Clavariadelphus Donk, Rev. Niederl. Homobas., Aphyll. 2: 72, 1933.

Type species: *C. pistillaris* (Fr.) Donk, Rev. Niederl. Homobas., Aphyll. 2: 73, 1933.

Donk (1933) proposed the genus *Clavariadelphus* for *Clavaria pistillaris*, *C. ligula* and *C. truncata*. Corner (1950) included *C. fistulosa*, *C. juncea* and *Craterellus unicolor*. Fries (1974) had placed *C. pistillaris*, *C. ligula*, *C. fistulosa* and *C. juncea* in *Clavaria* subgenus *Holocoryne*. Corner (1970) expanded the genus, distinguished by the unbranched habit, the ellipsoid, smooth, white or pale yellowish or brownish aguttate spores, and monomitic clamped hyphae, to include 9 additional species. He has pointed out the unique range in this group from the agaric to the typhuloid form.

Petersen (1972), finding *C. fistulosus* to be a discordant element in *Clavariadelphus*, proposed the genus *Macrotyphula* to accommodate and separate this species.

The following is Corner's description of the genus: Fruit-bodies typically solitary, filiform to clavate, ligulate or turbinate, in some species truncate and sterile at the expanded apex; light yellow or light ochraceous at first, becoming deep ochraceous, brown, rufescent or ferruginous; flesh rather firm; hymenium thickening. Spores white or pale yellowish, smooth, elongate-ellipsoid, contents finely granular-guttate. Hyphae monomitic with clamp connections, inflating, thin-walled, not secondarily septate.

The genus is north-temperate, consisting of 9 species.

***Clavariadelphus pistillaris* (Fr.) Donk**

Rev. Niederl. Homobas., Aphyll. 2: 73, 1933.

var. *americanus* Corner

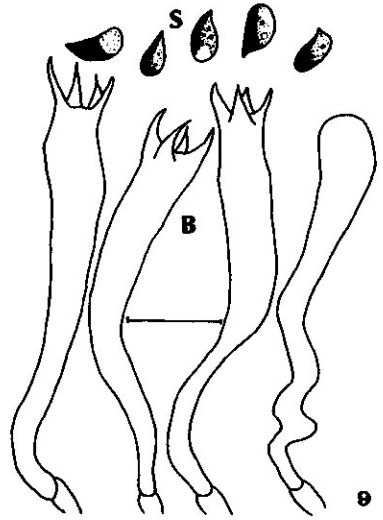
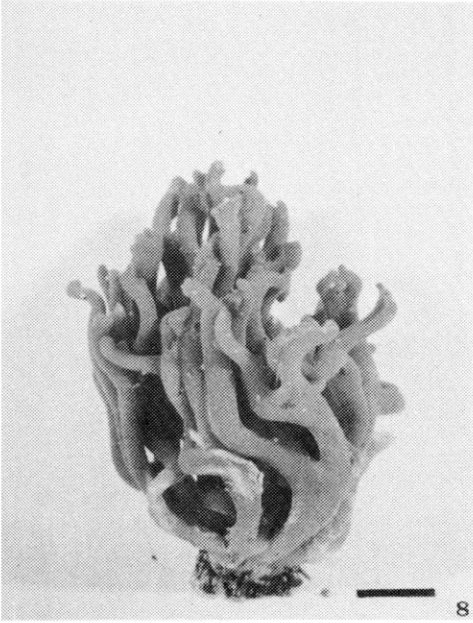
Ann. Bot. Mem. 1: 280, 1950.

Clavaria pistillaris sensu Harper, J. Mycol. 5: 261, 1913.

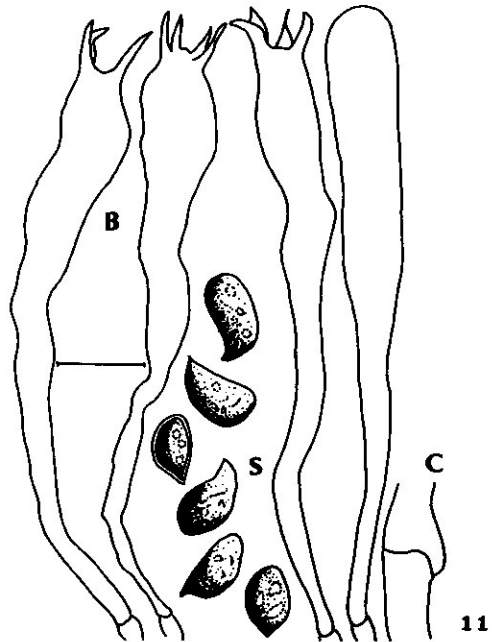
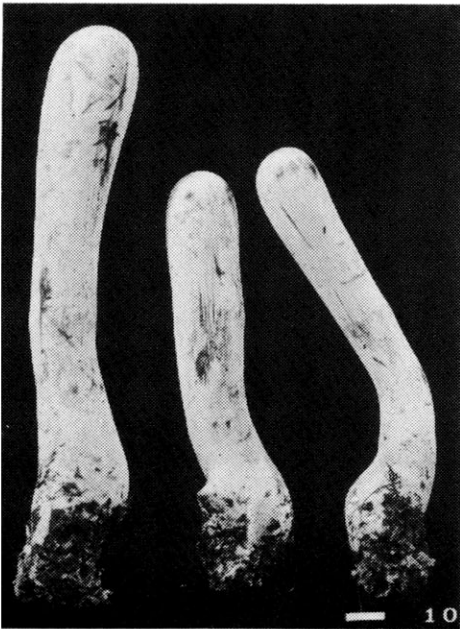
pistillaris (L)—like a pestle

Figs 10, 11

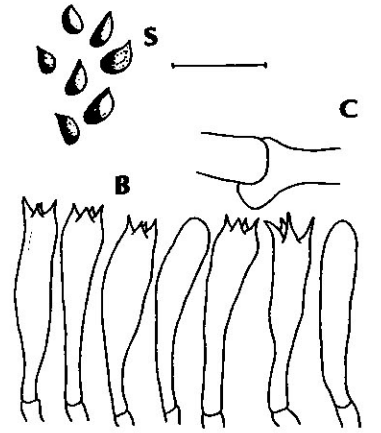
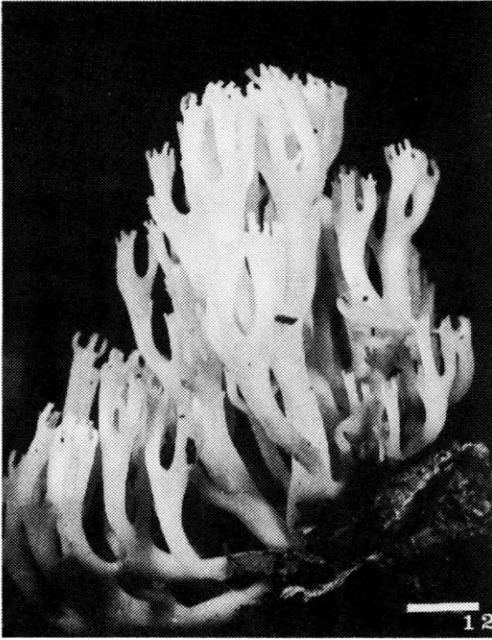
Fructifications: Simple, gregarious, occasional short-branching, strongly clavate, becoming turbinate or subtruncate, 6.0-15.0 x 0.3-3.0 cm, yellowish white—3A2



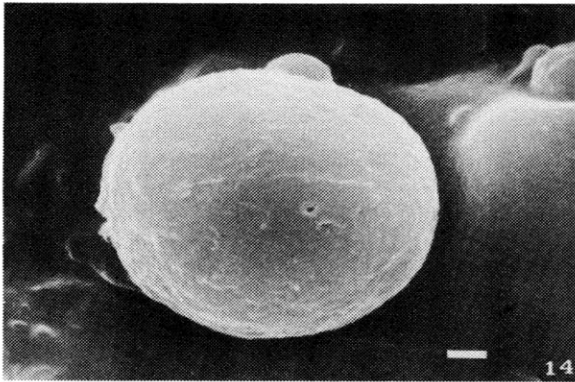
Figs 8, 9. *Clavaria zollingeri*.



Figs 10, 11. *Clavariadelphus pistillaris*.



13



Figs 12, 13, 14. *Clavaricorona pyxidata*.

(yellowish white—92) to grey brown—8D6 (moderate reddish brown—43) when young with a flesh or rose-pink tinge, drying Madeira—8E5 (greyish reddish brown—46), smooth, becoming longitudinally rugose and hollow. Context firm, solid becoming spongy with age, turning purple-brown on cutting or bruising. Spore deposit white. Odor absent. Taste bitter. Terrestrial, in mixed or deciduous woods.

Macrochemical Tests: Significant positive color reactions in FeSO_4 , pyrogallol, α -naphthol, guaiac tincture, guaiacol, 2% phenol, aniline.

Microscopic Structures: Spores smooth, hyaline, aguttate, variable in size, pip-shaped to oblong-ellipsoid, 6-14 x 3.5-5.0 μm . Basidia 65-100 x 5-7.5 μm , with 4 sterigmata 3-5 μm long. Hymenium thickening up to 150 μm , subhymenium 25-40 μm . Contextual hyphae 4-10 μm broad, long-celled; subhymenial hyphae 2-5 μm . Clamp connections abundant.

Collections Examined: ACAD 12879, 18/8/77, Lequille, Kings Co.; ACAD 12880, 25/8/77, Nicholasville, Kings Co.; ACAD 12881, 25/8/77, Nicholasville, Kings Co.; ACAD 12882, 31/8/77, West Gaspereau, Kings Co.

Discussion: Wells and Kempton (1968) erected *C. cokeri*, with type Coker R27 (Connecticut), as a species closely allied to *C. pistillaris* but separated from it on the basis of its pinkish coloration, smaller spores and non-vinescent flesh. It has been suggested (Wells & Kempton 1978) that the description of *C. cokeri* includes *C. pistillaris* var. *americanus*. This suggestion has been refuted by Corner (1970), and thus the name *C. pistillaris* var. *americanus* has been assigned to the ACAD collections 12879, 12880, 12881, 12882. Var. *americanus* differs from the European species in the flesh or rose-pink tinge to the hymenium and in its smaller spores. There is a wide variation in spore size. Corner (1970) has pointed out that the species is so easily recognized that insufficient attention has been given to variations in spore size.

Local collections were frequently infected with an unidentified fungal parasite.

Circumscription of the Genus *Clavicornora*

Clavicornora Doty, Lloydia 10: 38-44, figs 1-6, 1947.

Type species: *C. taxophila* (Thom) Doty, Lloydia 10: 38, 1947.

The genus, first published by Doty in 1947, is a natural group distinguished by the peculiar branching habit, the small white spores, clamped hyphae, and the presence of gloeocystidia.

Donk (1964) placed *Clavicornora* in Hericiaceae. Originally these fungi were classified according to the form of the fruit-body. As the fruit-body was found to be transitional, Corner (1970), using microscopic characters as the basis of his classification scheme, proposed the family Clavicornoraceae.

Corner (1950) describes the genus as follows: Fruit-body pyxidately branched, usually with a distinct stem, or simple and narrowly obconic with sterile cyathiform apex; branches verticillate, narrowly obconic with sterile cyathiform tops, proliferating whorls of 2-8, mostly 3-4, similar branchlets from the margin of the top, successive whorls more or less alternating; the lignicolous species attached by a fibrillose-strigose or subtomentose subiculum of secondary mycelium: white, light yellowish ochraceous, fuscous brown or tinged lilac, growing tips white: hymenium waxy-mucilaginous, flesh toughly gelatinous, dry and pliable or fibrous-subcoriaceous. Spores small, white, smooth, or punctate

rough, ellipsoid or subglobose, thin-walled, aguttate. Basidia small, 4-spored. Cystidia present or not; gloeocystidia large, traversing the subhymenium and hymenium.

Clavicornona pyxidata (Fr.) Doty

Lloydia 10: 38-44, 1947.

Clavaria pyxidata Fr., Syst. Mycol. 1:470, 1821.

Clavaria coronata Schw., Trans. Am. Philos. Soc. ii, 4: 182, 1832.

Clavaria petersii Berk., Grevillea 2: 7, 1873.

Clavaria laetissima B., J. Linn. Soc. Bot. 18: 386, 1881.

Clavicornona coronata (Schw.) Doty, Lloydia 10: 2, 1947.

pyxidata (L)—box-shaped

Figs 12, 13, 14

Fructifications: 3-12 cm tall, gregarious, ivory—4B3 (yellowish grey—93) to ochre yellow—5C7 (dark orange yellow—72), drying greyish brown—8D2 (light brownish grey—63), pyxidately branched, 4-6 branches in a whorl, axils rounded, apices finely toothed, cup-shaped. Context white, pliable, rather tough. Stem 1.5-2.5 mm thick, covered with a dense whitish or brownish pink pubescence, arising from an amorphous base which may form a resupinate mat 1 to several centimeters wide. Spore deposit white. Taste mildly peppery, developing tardily. Odor sweet. Lignicolous, on decaying logs in mixed woods.

Macrochemical Tests: No significant color reactions in FeSO_4 , pyrogallol, α -naphthol, guaiac tincture, guaiacol, 2% phenol, aniline.

Microscopic Structures: Spores smooth, hyaline, ovoid, pip-shaped, aguttate, 2.0-4.5 x 2.5-3.0 μm . Basidia 12-20 x 3-4 μm , with 4 sterigmata 2-3 μm long. Cystidia 20-35 x 3-6 μm , fusoid, subcylindrical, smooth, acute, thin-walled, colorless, projecting 15-20 μm beyond hymenium. Hymenium 20-30 μm , not thickening; subhymenium 10-12 μm , of small rounded cells. Contextual hyphae 6-12 μm broad, parallel, inflating, usually thin-walled but sometimes the wall thickening to 0.5-1.0 μm , subhymenial hyphae 3-4 μm . Gloeoplerous hyphae 5-10 μm in diameter, longitudinal in the subhymenium, with cylindrical rounded tips projecting into the surface of the hymenium as gloeocystidia, contents dense. Clamp connections present.

Collections Examined: ACAD 12883, 4/8/77, Nicholasville, Kings Co.; ACAD 12884, 4/8/77, Nicholasville, Kings Co., ACAD 11875, 28/6/77, Harrington woods, Kings Co.

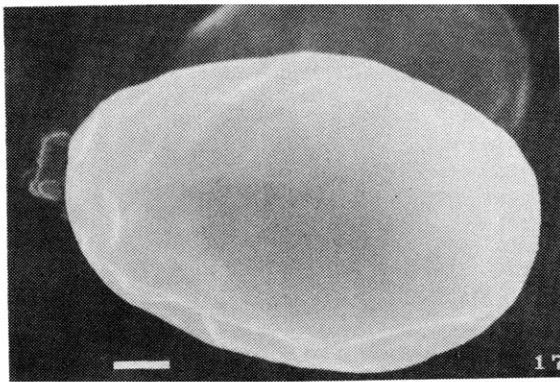
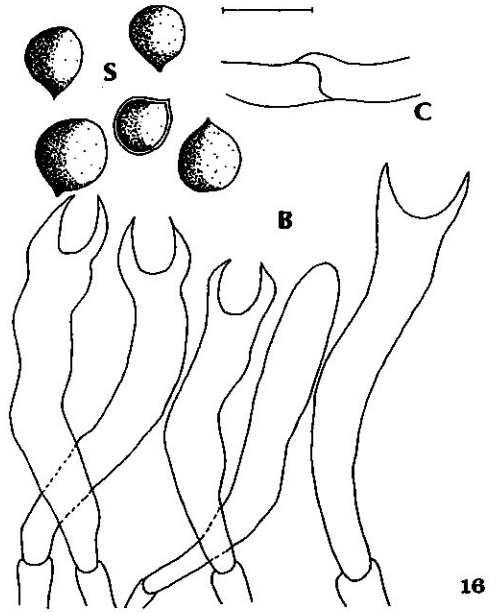
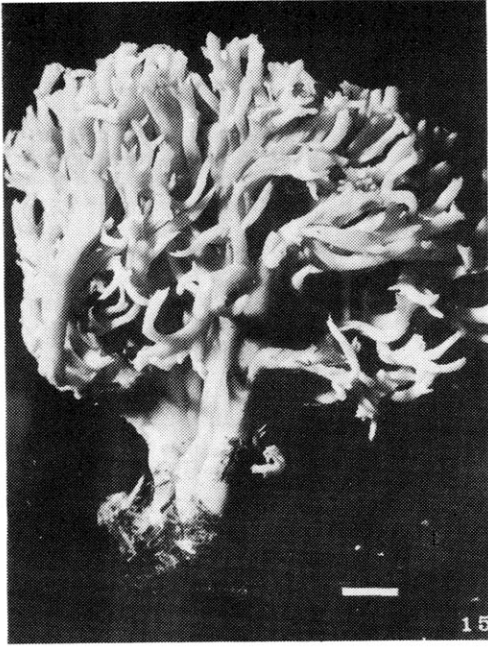
Discussion: Coker (1923) regards *C. pyxidata* as one of the most widely distributed of all species of plants. It is easily recognized in the field by the cup-shaped expansions at the ends of the branches. The cystidia and gloeocystidia distinguish it from other members of this genus.

Circumscription of the Genus *Clavulina*

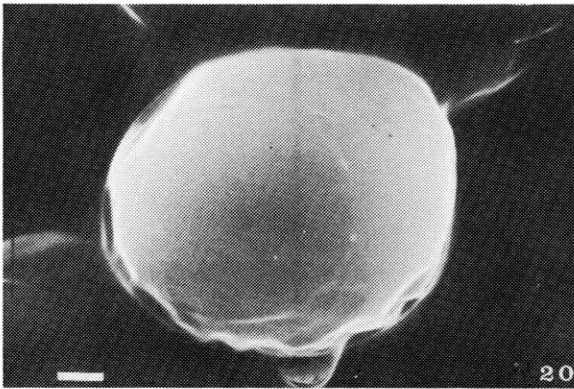
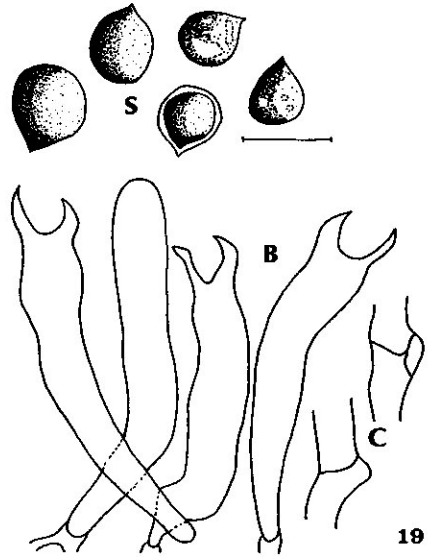
Clavulina Schroet., Cohn, Krypt. Fl. Schles., Pilze, 442, 1888.

Type species: *C. cristata* (Fr.) Schroet., Cohn, Krypt. Fl. Schles., Pilze, 442, 1888.

Schroeter (1888) proposed this genus for *Clavaria cinerea*, *C. cristata*, and *C. rugosa* on the presence of 2-sterigmate basidia bearing globose or subglobose spores, and on the basidia becoming septate and partially evacuated after spore discharge. Karsten (1889) added *C. odorata* from Finland. A fifth species, *C.*



Figs 15, 16, 17. *Clavulina cinerea*.



Figs 18, 19, 20. *Clavulina cristata*.

leveillei from Java, was added by van Overeem (1923) and Donk (1933) added *C. amethystina*. Twenty-six new species were added to the genus by Corner, his conception of the genus being as follows: "Fruit-bodies simple or branched, generally with flattened branching and more or less cristate tips, in some species slightly dorsiventral with a sterile hymenium on the uppersides of the main branches: white or variously coloured, never bright yellow, orange, red, or black: flesh tough, waxy-fibrous, or rather brittle: mostly terrestrial, a few lignicolous, rarely on herbaceous remains (*C. cristata* var. *incarnata*).

Spores white (? brown in *C. decipiens*), generally ochraceous after prolonged drying (in the herbarium), subglobose, or broadly ellipsoid, blunt, smooth, with 1 large gutta nearly filling the spore, occasionally multiguttulate, 5-14 μ long.

Basidia subcylindric, projecting, usually becoming secondarily septate with one or more septa after spore-discharge, stichobasidial (? in all species); sterigmata 2, rarely 1, generally incurved and short, in some species nearly straight.

Cystidia present in a few species, generally absent.

Hymenium thickening: subhymenium persistently filamentous or becoming pseudo-parenchymatous.

Hyphae monomitic, with clamps in most species, generally with colourless slightly but distinctly thickened, walls (pale brown in *C. ornatipes* and *C. decipiens*), secondarily septate only in the species without clamps, mostly short-celled (20—120 μ long), more or less inflated but often irregularly: H-connexions frequent." (Corner, 1950).

Key to the Species of *Clavulina*

1. Fruit bodies pale grey to orange grey, tips blunt *C. cinerea* p. 19
1. Fruit bodies white to pale yellow, much branched, tips cristate, tinged brown, black or brick red *C. cristata* p. 20

Clavulina cinerea (Fr.) Schroet.

Cohn, Krypt. Fl. Schles. Pilze, 442, 1888.

Clavaria cinerea Fr. Syst. Mycol. 2: 468, 1821.

Ramaria cinerea S.F. Gray, Nat. Arr. Br. Pl. 1: 655, 1821.

Clavaria fuliginea Pers., Mycol. Eur. 1: 166, 1822.

Clavaria grisea (Fr.) Karst., Finl. Nat. o. Folk 37: 186, 1882.

Clavaria sphaerospora E. & E., J. Mycol. 4: 62, 1888.

Ramaria cinerea (Fr.) Quél., Flore Mycol. 465, 1888.

cinerea (L)—ash grey

Figs 15, 16, 17

Fructifications: Solitary, gregarious or cespitose, 2.5-10.0 cm, branches compact, flattened, divaricate, polychotomous below, dichotomous above, becoming longitudinally rugulose, axils acute, apices blunt, sometimes toothed, pale grey—6C1 (medium grey 265) to orange grey—6B2 (brownish pink 33). Stem up to 4 x 1 cm, mycelioid to finely scaly, arising from a well-developed white sterile mat. Context firm, white, slightly coriaceous. Spore deposit white. Odor and taste indistinct. Terrestrial, in fields and on humus in mixed or coniferous woods.

Macrochemical Tests: No significant color changes in aniline, α -naphthol, guaiac tincture, guaiacol, pyrogallol. An occasional positive reaction was observed with FeSO_4 and 2% phenol.

Microscopic Structures: Spores smooth, hyaline, subglobose, 6.5-8.5 x 6.0-8.0 μm . Basidia 35-45 x 5-7 μm , subcylindrical, with 2 sterigmata 6-7.5 μm long.

Hymenium 50 μm , thickening to 100 μm ; subhymenium 15-25 μm . Contextual hyphae 5-12 μm broad; subhymenial hyphae 2-4 μm . Clamps abundant.

Collections Examined: ACAD 12885, 24/8/77, West Gaspereau, Kings Co.; ACAD 12886, 29/8/77, Melanson, Kings Co.; ACAD 12887, 7/9/77, Harrington slope, Kings Co.; ACAD 12888, 4/11/77, Aldershot sand plains, Kings Co.

Discussion: This species is distinguished from *C. cristata*, which seems to be the more common form, by the absence of cristate tips and by the darker pigmentation of the hymenium. The grey color is caused by the fuscous cytoplasm of the effete basidia (Corner 1950).

Helminthosphaeria clavariarum was commonly found as a parasite. The stem is attacked first, with infection then spreading to the rest of the plant giving it an overall black color. Parasitization has often resulted in the misidentification of this species as *C. nigricans* (Corner 1970).

***Clavulina cristata* (Fr.) Schroef.**

Cohn, Krypt. Fl. Schles., Pilze, 442, 1888.

Clavaria cristata Fr. Syst. Mycol. 1: 473, 1821.

Clavaria fallax Pers., Mycol. Eur. 1: 167, 1822.

Clavaria trichopus Pers., Mycol. Eur. 1: 168, 1822.

Clavariella cristata (Fr.) Karst., Finl. Nat. o. Folk 37: 188, 1882.

Clavariella trichopus (Pers.) Karst., Finl. Nat. o. Folk 37: 188, 1882.

Clavaria cristata var. *minor* Pat., Tab. Anal., Fung. 261, 1884.

Ramaria cristata (Fr.) Quél., Flore Mycol. 464, 1888.

cristata (L)—crested

Figs 18, 19, 20

Fructifications: Solitary, gregarious or cespitose, 2.5-8.0 cm tall, white to yellowish white—2A2 (yellowish white 92), much branched, polychotomous, flattened, divaricate, axils acute, apices acute becoming cristate, tinged brown, black or brick red—7D7 (strong brown—55). Stem usually distinct, 0.5-3.0 in diam, up to 1.0 cm, velvety mycelioid. Context white, fibrous to moderately brittle. Spore deposit white. Taste bitter, odor absent. Terrestrial, in coniferous or deciduous woods.

Macrochemical Tests: No significant color changes in FeSO_4 , α -naphthol, guaiac tincture, guaiacol, aniline. Positive reactions with 2% phenol. Occasional positive reactions occurring with pyrogallol.

Microscopic Structures: Spores smooth, subglobose, pale green, 6-8.5 x 5.0-7.5 μm . Basidia 30-45 x 5-7 μm , subcylindrical, with 2 sterigmata 5-7 μm long. Hymenium 50 μm , thickening to 100 μm ; subhymenium 15-25 μm . Contextual hyphae 5-12 μm broad, subhymenial hyphae 2-4 μm , clamp connections abundant.

Collections Examined: ACAD 12889, 18/8/77, Lequille, Annapolis Co.; ACAD 12890, 22/8/77, Moores Falls, Kings Co.; ACAD 12891, 31/8/77, Moses Mountain, Hants Co.; ACAD 12892, 29/8/77, West Gaspereau, Kings Co.; ACAD 12893, 19/9/77, Grand River, Richmond Co.; ACAD 12894, 29/8/77, Melanson, Kings Co.; ACAD 12895, 20/10/77, AESK, Kentville, Kings Co.; ACAD 12896, 11/9/73, Kejimikujik Lake area, Annapolis Co.

Discussion: This species is the most abundant and the most variable of all the clavarias. The extreme variability has resulted in much confusion in attempts to

identify *C. cristata*, *C. cinerea* and *C. rugosa* at the species level. Coker (1923) regards *C. cinerea* and *C. rugosa* as forms of *C. cristata*. Microscopically, the 3 species are indistinguishable. The white color and cristate tips, characteristic of *C. cristata*, separate it from *C. cinerea*, which is grey with blunt tips. In *C. rugosa*, which was not included in this survey, the clubs are "stouter, simple, or lobed, irregular, rugose, and generally appear deformed" (Wehmeyer 1935). Generally, specimens can be placed in one of the three groups. However, intermediate forms of each character occur, sometimes making it difficult to assign individuals to a specific taxon. It will be necessary for further study to be done on this genus in order to define the species clearly.

Circumscription of the Genus *Clavulinopsis*

Clavulinopsis van Ov., Bull. Jard. Bot. Buitenzorg, Ser. 3,5: 278, 1923.

Cornicularia Bon., Handb. Mycol., 166, 1851.

Type species: *C. sulcata* van Ov., Bull. Jard. Bot. Buitenzorg, Ser. 3,5: 279, 1923.

The earliest generic name for this group, which includes most, if not all, the yellow or orange but white-spored *Clavarias*, is *Cornicularia* Bon. (1851) based on *Clavaria corniculata* Fr., but it is a later homonym. *Clavulinopsis corniculata* was included in *Ramaria* S.F. Gray (1821) and thus *Ramaria* should have precedence as a genus. This would have complicated the definition of *Ramaria* so it was not followed.

Van Overeem (1923) described a Javanese clavaria, which belonged to this group, as *Clavulinopsis sulcata* and as a monotypic genus. Though no generic character was indicated, the name *Clavulinopsis* must be accepted as validly published in a combined generic-specific diagnosis.

Donk (1933) recognized *Clavulinopsis* but regarded it as synonymous with *Clavulina*. Doty (1948) accepted *Clavulinopsis* with *C. sulcata* as the type species. Corner (1950) expanded the genus to include approximately 60 species. Three subgenera, *Acularia*, *Clavulinopsis* and *Paraclavaria*, are separated (Corner 1970) on the basis of spore shape and ornamentation with types *C. helvola* (Fr.) Corner, *C. miniata* (Berk.) Corner, (earliest valid name for *C. sulcata* van Ov.) and *C. corniculata* (Fr.) Corner, respectively.

Corner (1950) describes the genus as follows: Fruit-bodies simple or branched, variously colored, often white, yellow, orange or red; stem sterile, more or less distinct; fleshy-waxy to rather tough, terrestrial. Spores white, or tinged yellow from the oil drop, smooth or, in a few species, coarsely echinulate, globose, pip-shaped or ellipsoid, usually 1-guttate, sometimes multiguttate. Hyphae monomitic, clamped, mostly inflating. Basidia mostly 4-spored, occasionally 2- or 3 spored.

Key to the Species of *Clavulinopsis*

1. Fruiting bodies simple 3
1. Fruiting bodies loosely branched 2
2. Yellowish white, with brown tips; up to 10 cm tall, context tough, odor unpleasant (strong); spores globose to subglobose, 3.5-6.0 x 4.0-6.5 μm *C. cineroides* p. 26
2. Butter yellow, tips concolorous; 2-5 cm tall, moderately brittle, odor of green corn; spores subglobose, apiculate, 4.0-6.0 x 4.5-6.5 μm . *C. corniculata* p. 26
3. Fruiting bodies some shade of yellow 4

3. Fruiting bodies dark orange to carrot red, stem indistinct; cespitose with solitary individuals; spores subglobose, apiculate, $3.5-5.0 \times 4-6.5 \mu\text{m}$ *C. aurantio-cinnabarina* p. 25
4. Spores globose or subglobose 5
4. Spores ovoid or ellipsoid 6
5. Vivid yellow, tips becoming brown; simple, densely fasciculate, fusiform, hollow, flattening, sometimes spirally twisted; spores globose with central apiculus, $4.0-6.0 \times 4.5-6.5 \mu\text{m}$ *C. fusiformis* p. 29
5. Vivid yellow, tips concolorous; cylindrical and blunt or subclavate, often becoming deeply longitudinally rugulose, often twisted, occasionally spathulately flattened and then with 1-4 blunt points or short antlered branches; spores subglobose, apiculate, $4-6 \times 4-6 \mu\text{m}$ *C. amoena* p. 22
6. Dark yellow, drying concolorous; context firm, not brittle, basal tomentum white, crusty; spores $5-6.5 \times 4-5.0 \mu\text{m}$ *C. laeticolor* p. 30
6. Melon yellow, drying light yellow; context friable, arising from a fine woolly basal tomentum; spores $5-8 \times 3.5-4.5 \mu\text{m}$ *C. luteo-alba* p. 31

Clavulinopsis amoena (Zoll. & Mor.) Corner

Ann. Bot. Mem. 1: 352: 1950.

Clavaria amoena Zoll. & Mor., Nat. Geneesk. Arch. Neerl. Ind. 1: 380, 1844.

Clavaria subaurantiaca P. Henn. & Nym., Monsunia 1: 8, 1900.

Clavaria strigosa P. Henn. & Nym., Monsunia 1: 8, 1900.

Clavaria subargillacea Ito & Imai, Trans. Sapporo Nat. Hist. Soc. 15: 55, 1937.

Clavaria pallidrosea Fawcett, Proc. R. Soc. Victoria 51: 271, 1939.

Clavulinopsis aurantio-cinnabarina (Schw.) Corner f. *amoena* (Zoll. et Mor.) Petersen, Mycol. Mem. 2: 25, 1968.

amoena (L)—beautiful, pleasing

Figs 21, 22

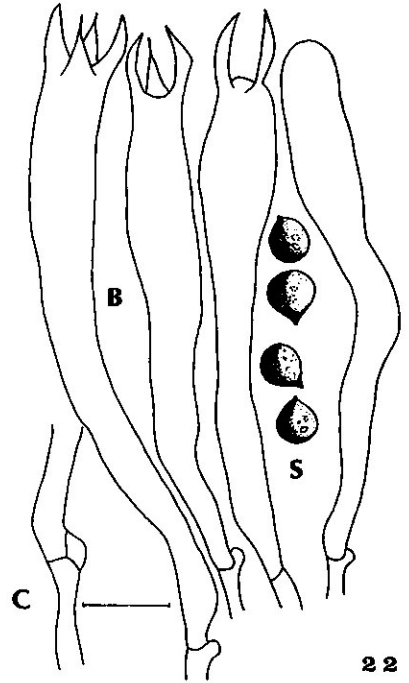
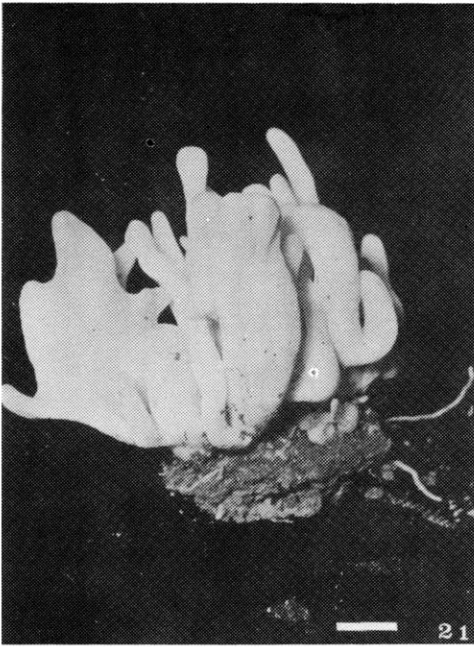
Fructifications: Simple, solitary or gregarious, cespitose, very variable in form, size and habit, 2-7 cm x 2-7 mm or flattened to 20 mm, cylindrical and blunt or subclavate often becoming deeply and extensively longitudinally rugulose, often twisted, occasionally spathulately flattened with 1-4 blunt points or short antlered branches, vivid yellow—3A8 (vivid yellow—82), maize—4A6 (brilliant orange yellow—67) upon drying; context waxy-firm becoming hollow, concolorous; stem indistinct. Spore deposit white. Odor absent. Taste mildly farinaceous. Terrestrial in deciduous woods.

Macrochemical Tests: No color reactions occurring in pyrogallol, α -naphthol, guaiac tincture, guaiacol, 2% phenol, aniline. Positive color change with FeSO_4 .

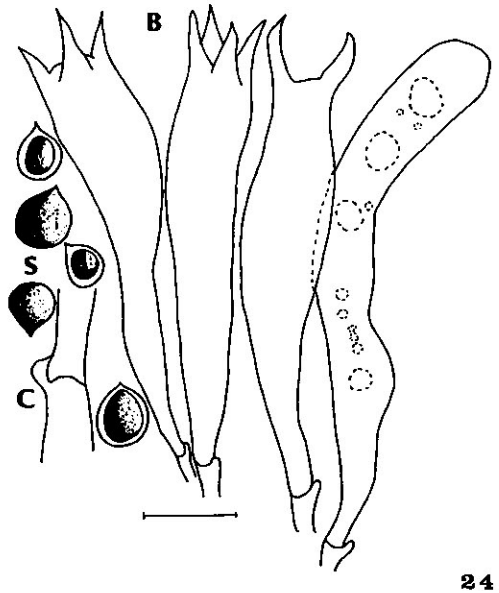
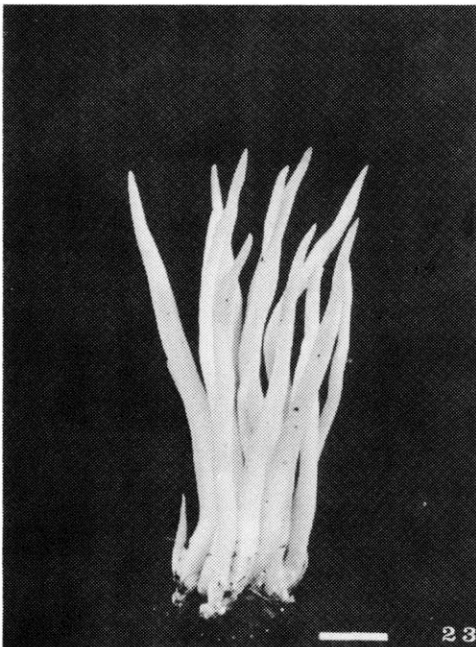
Microscopic Structures: Spores $4-6 \times 4-6 \mu\text{m}$, pale green, smooth, subglobose, thin-walled, apiculus $0.5-1.0 \mu\text{m}$ long. Basidia $45-60 \times 5-8 \mu\text{m}$; 2 or 4 sterigmata, $5-8 \mu\text{m}$ long. Hymenium $45-50 \mu\text{m}$, thickening to $70-150 \mu\text{m}$; subhymenium $10-20 \mu\text{m}$. Clamp connections present.

Collections Examined: ACAD 12897, 26/9/77, Sunken Lake, Kings Co.

Discussion: There is considerable variation within this species in height, thickness of hymenium and spore size. Corner (1950) attributes the variability in height to the variation in apical growth. The richness of the substratum determines the extent of hymenial growth, thus determining the thickness. According to Corner



Figs 21, 22. *Clavulinopsis amoena*.



Figs 23, 24. *Clavulinopsis aurantio-cinnabarina*.