

SPECIES OF *CORDYCEPS* PARASITIC ON *ELAPHOMYCES*

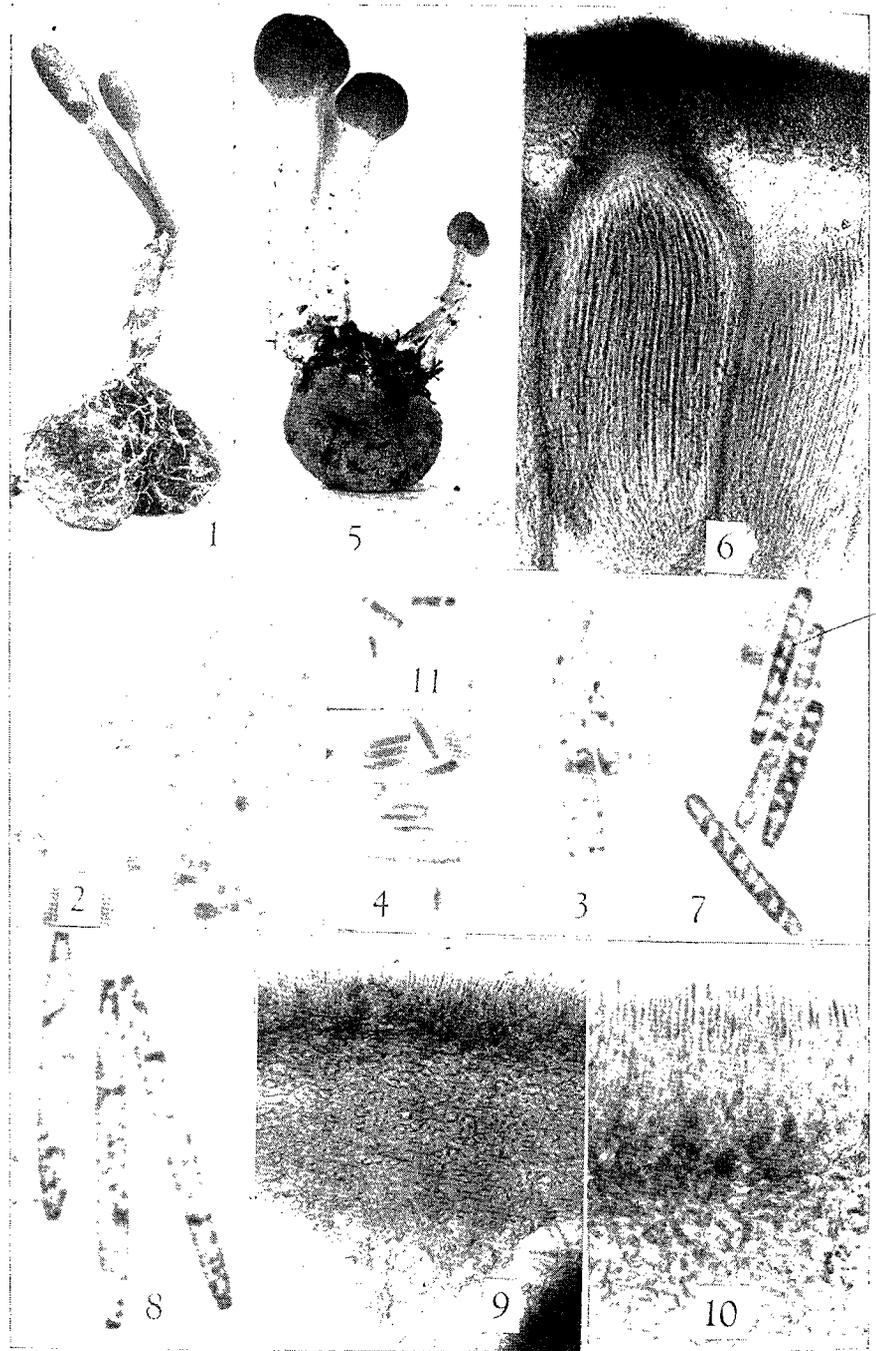
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The species of *Cordyceps* which are parasitic on *Elaphomyces*, a genus of subterranean ascomycetous fungi, are very closely related. By their parasitism they are markedly separated from other species which infect insects and spiders. However in their general morphology they are similar to the other species of the genus. Two species, *C. ophioglossoides* and *C. capitata*, have been recognized on *Elaphomyces* in Europe. In addition *C. canadensis* and *C. nigriceps* have been described from North America. Both however are usually treated as synonyms of *C. capitata*. *C. intermedia*, *C. japonica* and *C. jezoensis* have been described from Japan.

The stromata of these species are elongated, either clavate or capitata. They are attached to the ascocarps of the subterranean hosts either directly as in *C. capitata* or by rhizomorphs as in *C. ophioglossoides*. The stipe consists of compact somewhat interwoven longitudinal hyphae which continue upward spreading outward to form a central core of more or less densely interwoven hyphae in the upper ascogenous portion of the stroma. Covering this upper core is the perithecial layer. This consists of an inner tissue of loosely interwoven outwardly developing hyphae and an outer dense cortex. In some species the cortex is simple, consisting of densely irregularly interwoven hyphae, pseudoparenchymatous in section. In other species it is duplex, made up of an inner layer of densely interwoven hyphae and an outer layer having short parallel hyphae at right angles to the surface, palisade-like in section. These differences are used in this study as diagnostic distinctions in the separation of species. The perithecia are completely embedded. They have well differentiated walls of a compact pseudoparenchymatous structure and short ostioles lined with periphyses. The asci are long, cylindric narrowing below. The walls are very thin, with hemispherical thickenings at the apices which are provided with narrow pores. The ascospores are hyaline, filiform, acuminate at the ends and multiseptate. They break into one-celled fragments. It is difficult to distinguish and study the ascospores and measurements are given of the part-spores. Since the terminal segments obscure differences they are excluded from the measurements which are given.

This treatment of the species for North America includes *C. ophioglossoides* and *C. capitata*. *C. nigriceps* is considered the same as *C. capitata*. *C. canadensis* is recognized as a valid species. Although *C. japonica* has not been seen from North America it probably occurs and consequently has been included. Three species are described as new.

In addition to the specimens in the Herbarium of the University of



Michigan (MICH), collections from the Farlow Herbarium (FH), the Herbarium of the New York Botanical Garden (NY), the Herbarium of the New York State Museum (NYS), the Herbarium of the University of California (UC) and the National Fungus Collections of the U.S. Bureau of Plant Industry (BPI) have been studied.<sup>1</sup>

## KEY TO SPECIES

- A. Stromata clavate, the ascogenous portion not abruptly enlarged from the stipe ..... B
- A. Stromata capitate, the ascogenous portion spherical, ovoid or cylindrical abruptly enlarged from the stipe ..... D
- B. Cortex of the ascogenous portion having an ectal layer of short parallel hyphae palisade-like in section; segments of ascospores  $6-8 \times 1-1.5 \mu$  ..... 3. *C. tenuispora*
- B. Cortex of ascogenous portion without a differentiated ectal layer ..... C
- C. Ascospore-segments  $2-4 \times 2 \mu$  ..... 1. *C. ophioglossoides*
- C. Ascospore-segments  $10-18 \times 3-4 \mu$  ..... 2. *C. japonica*
- D. Cortex of the ascogenous portion having an ectal layer of short parallel hyphae palisade-like in section ..... E
- D. Cortex of the ascogenous portion without a differentiated ectal layer ..... F
- E. Ascospore-segments  $(18)24-48(54) \times 4-5 \mu$  ..... 5. *C. canadensis*
- E. Ascospore-segments  $3-6 \times 2 \mu$  ..... 6. *C. valliformis*
- F. Ascospore-segments  $8-25(32) \times 2.5-3 \mu$  ..... 4. *C. capitata*
- F. Ascospore-segments  $2-5 \times 1.5-2 \mu$  ..... 7. *C. fracta*

1. *Cordyceps ophioglossoides* (Fr.) Link Handbuch 3: 347. 1833. (figs. 1 & 2). *Sphaeria ophioglossoides* Fr. Syst. Myc. 2: 324. 1832. *Torrubia ophioglossoides* Tul. Sel. Fung. Carp. 3: 20. 1865. *Torrubia parasitica* Schroeter, in Cohn Krypt. Flora Schles. 3 pt. 2: 277. 1908. *Cordyceps parasitica* P. Henn. Nerthus 6: 4. 1904 according to Seaver N. Am. Flora 3 pt. 1: 53. 1910. Stromata clavate, simple or rarely branched above, 2-8 cm long, usually attached to the host by rhizomorphs; ascogenous portion one-fourth to one-half the length, not sharply enlarged from the stipe, 3-8 mm thick, reddish brown to olivaceous brown, punctate with the ostioles of the perithecia, with a cortex consisting of one layer of closely interwoven hyphae pseudoparenchymatous in section; stipes 2-8 mm thick, olivaceous to dark brown; perithecia ovoid,  $600-800 \times 250-500 \mu$ , entirely embedded in the stroma; asci cylindric, narrowing below,  $400-450 \times 5-8 \mu$ , with a

<sup>1</sup> The writer is indebted to the Curators I. Mackenzie Lamb, Donald P. Rogers, Stanley Jay Smith, Lee Bonar and John A. Stevenson for the loan of specimens for this study.

FIGS. 1-2, *Cordyceps ophioglossoides*. FIG. 1, stromata and rhizomorphs from ascocarp of *Elaphomyces* E.B.M. 4198 (MICH) approx.  $\times 1$ . FIG. 2, part-spores, Mougeot & Nestler no. 565  $\times 1000$ . FIG. 3, *Cordyceps japonica* part-spores, type (BPI)  $\times 1000$ . FIG. 4, *Cordyceps tenuispora*, part-spores, type (NY)  $\times 1000$ . FIGS. 5-7, *Cordyceps capitata*. FIG. 5, stromata from ascocarp of *Elaphomyces* A.H.S. 17593 (MICH) approx.  $\times 1$  (photo by A. H. Smith). FIG. 6, section showing perithecia and cortex, Mougeot & Nestler no. 763, approx.  $\times 100$ . FIG. 7, part-spores, Mougeot & Nestler no. 763,  $\times 1000$ . FIGS. 8-10, *Cordyceps canadensis*. FIG. 8, part-spores A.H.S. 38566 (MICH)  $\times 1000$ . FIG. 9, section of cortex, type (NY) approx.  $\times 250$ . FIG. 10, section of ectal layer of cortex, type (NY), approx.  $\times 375$ . FIG. 11, *Cordyceps fracta*, part-spores, type (MICH)  $\times 1000$ .

hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, multiseptate, breaking into 1-celled segments  $2-4(5) \times 1.5-2 \mu$ .

On *Elaphomyces cervinus*, *E. granulatus*, *E. muricatus*, *E. variegatus* and *Elaphomyces* sp.

Specimens studied: 165 from Connecticut (BPI, FH), District of Columbia (BPI), Iowa (BPI), Maine (FH, MICH, NY), Maryland (BPI, MICH), Massachusetts (FH, NY, BPI), Michigan (MICH), New Hampshire (FH, MICH, NY, BPI, UC), New York (FH, MICH, NY, BPI, NYS), New Jersey (NY), North Carolina (FH, BPI, MICH), Ohio (MICH), Oregon (MICH), Pennsylvania (NY, MICH), Rhode Island (FH, NY), Tennessee (FH, MICH, BPI), Vermont (FH, NY, BPI), Virginia (MICH, NY, BPI), Washington (MICH), West Virginia (MICH, NY), Ontario (MICH, NY, BPI), Quebec (MICH, NY, BPI).

In addition 40 specimens from Austria, Belgium, Czechoslovakia, England, Finland, France, Germany, Hungary, Italy, Russia, Switzerland, and Japan were studied. Of the exsiccati cited by Fries in the Systema. Mougeot-Nestler no. 565 has been studied and is proposed as the lectotype.

This is the most common species. It is distinguished by the small segments of the ascospores (fig. 2) which are  $2-4 \times 1.5-2 \mu$ , and the clavate stromata in which the ascogenous portion is not sharply enlarged from the stipes (fig. 1). The stromata are usually attached to the hosts by rhizomorphs (fig. 1). The cortex of the ascogenous portion of the stromata is made up of very closely interwoven brown hyphae and does not have a differentiated ectal layer.

2. *Cordyceps japonica* Lloyd. Myc. Writings 6: 913. 1920. (fig. 3). *Cordyceps unemurai* Imai Trans. Sapporo Nat. Hist. Soc. 11: 32. 1929. Stromata clavate, 2.5-7 cm long, developing directly from the host; ascogenous portion one-third to one-half of the length, 4-10 mm thick, rough from projecting ostioles, black when dry, with a cortex consisting of one layer of closely interwoven brown hyphae pseudoparenchymatous in section; stipes 2-7 mm thick, dark olivaceous brown or black; perithecia ovoid;  $500-700 \times 250-350 \mu$ , entirely embedded; asci cylindric,  $250-400 \times 7-10 \mu$  with a hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, multiseptate, breaking into 1-celled cylindric segments  $10-18(20) \times 2.5-4 \mu$ .

On *Elaphomyces japonica*, Mikawa, Japan, J. Umemura, June 1916, type (BPI); *Elaphomyces* sp. Feldkirch, Austria, T. Murr. Oct. 1915 (FH).

Although this species has not been found in North America it probably occurs. It was originally reported by Lloyd (1916) as *Cordyceps capitata* var. *canadensis*. He later (1920) recognized it as a distinct species and named it *C. japonica*. The type from the Lloyd Herbarium of the National Fungus Collection, U.S. Department of Agriculture has been studied. As illustrated by Lloyd (1916 fig. 860, 1920 fig. 1621) the stromata are clavate with less differentiation between the stipe and ascogenous portion than in *C. ophioglossoides*. A specimen from Austria identified as *C. ophioglossoides* in the Farlow Herbarium is very similar in stromata, cortex and part-

spores. *C. japonica* is similar to *C. ophioglossoides* in clavate stromata and cortex. However, it differs in having the stromata directly attached to the host without rhizomorphs, and in having larger part-spores (fig. 3). Imai (1929) has described a clavate species, *C. jezoensis*, from Japan which has part-spores much larger  $16-50 \times 3.5-4.5 \mu$ .

3. *Cordyceps tenuispora* sp. nov. (fig. 4). Stromatibus clavatis, 7 cm longis, supra 10-15 mm crassis, castaneis; cortice duplice interne pseudoparenchymato externe valliformi; stipitibus 3-5 mm crassis, flavobrunneis; peritheciis anguste ovoideis,  $750-1000 \times 250-300 \mu$ , immersis; ascis cylindricis,  $430-600 \times 4-6 \mu$ ; ascosporis hyalinis, filiformibus, multiseptatis, in unicellularia fragmenta secendentibus  $6-8 \times 1-1.5 \mu$ .

Specimen typicum: Thornton, Pennsylvania, May 27, 1919, C. F. Murphy (NY).

Stromata up to 7 cm long, clavate; ascogenous portion obovoid,  $10-15 \times 8-10$  mm, not abruptly enlarged from the stipe, dark chestnut-brown when dried, with a cortex having an inner layer of closely interwoven brown hyphae pseudoparenchymatous in section and an ectal layer of parallel hyaline hyphae palisade-like in section; stipes 3-5 mm thick, yellowish brown; perithecia narrowly ovoid,  $750-1000 \times 250-300 \mu$ , narrowing to an acute base below, narrowing to a slender neck above, completely embedded; asci cylindrical  $430-600 \times 4-6 \mu$ , with a hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, breaking into 1-celled cylindrical segments  $6-8 \times 1-1.5 \mu$ .

Host not found, probably on *Elaphomyces* sp. Thornton, Delaware Co., Pennsylvania, May 27, 1919, C. F. Murphy type (NY); Cumberland, Maryland, W. T. Lakin, Lloyd Coll. 37226 (BPI).

This species has clavate stromata. It differs from both *C. ophioglossoides* and *C. japonica* in having a cortex with a palisade-like ectal layer. The ascospores are very slender (fig. 4) and the segments are somewhat longer than those of *C. ophioglossoides* and much shorter than those of *C. japonica*. Although the hosts were not collected there is not much doubt that they are species of *Elaphomyces*.

4. *Cordyceps capitata* (Fr.) Link. Handbuch 3: 347. 1833 (figs. 5-7). *Sphaeria capitata* Fr. Syst. Myc. 2: 324. 1832. *Cordyceps nigriceps* Peck Bul. Torrey Bot. Club 27: 21. 1900. Stromata capitate, 2-11 cm long; ascogenous portion abruptly enlarged into ovoid, spherical or subcylindrical heads,  $5-20 \times 5-15$  mm, natal-brown, olive-brown to olive-black, punctate to rough from the ostioles of the perithecia, with a cortex of closely interwoven brown hyphae pseudoparenchymatous in section; stipes 2-8 mm thick, ochre-yellow, olive-buff, olive-grey to olive-black, furfuraceous; perithecia ovoid,  $650-950 \times 250-420 \mu$ , entirely embedded; asci cylindrical,  $350-540 \times 10-12 \mu$ , gradually narrowing below, with a hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, multiseptate, breaking into 1-celled, cylindrical or somewhat fusoid segments  $8-25(32) \times 2.5-3 \mu$ .

On *Elaphomyces cervinus*, *E. granulatus* and *Elaphomyces* sp.

Specimens studied: 46 from Alabama (MICH, BPI), Florida (FH, MICH, BPI, NY), Maine (NYS), Massachusetts (FH, BPI, NY, NYS),

North Carolina (BPI), Oregon (MICH), South Carolina (BPI, NY), Virginia (MICH), Washington (MICH), Manitoba (BPI), Quebec (BPI). Exsiccati: Ravenel Fungi Car. Fasc. 5: 48.

Specimens from Belgium, France and Hungary have been studied, including exsiccati, Flora Hungarica Exsiccata Cent. 1 Fungi 8; Mougeot and Nestler Stirpes Crypt. Vog.-Rhen. 763; Rehm Ascomycetes 1186b, Ronneguère Fungi Gall. Exs. 781; Westendorp et Wallays Herb. Crypt. Belg. 21.

One of the results of this study has been the discovery that two species have generally been included in *Cordyceps capitata*. Both have capitata stromata (fig. 5). One has the segments of the ascospores cylindric or slightly fusoid (fig. 7),  $8-25 \times 2.5-3 \mu$  and the cortex of the ascogenous portion of the stroma consisting of closely interwoven brown hyphae without a differentiated ectal layer (fig. 6). The other has the segments of the ascospore more or less fusoid (fig. 8), mostly  $24-48 \times 4-5 \mu$ , often with the end walls thickened and has a cortex of two layers (fig. 9). The inner layer consists of closely interwoven brown hyphae (fig. 9). The outer layer is made up of short parallel hyaline or slightly brown hyphae which are at right angles to the surface of the stroma forming a palisade layer (fig. 10). *C. capitata*, has been mostly described as having the larger spore segments but specimens of both are in herbaria under that name and both occur in Europe. It is not possible to determine to which the name *Sphaeria capitata* Fr. applies from the description given by Fries in the Systema. However he gives the following citation "Moug. Crypt. exs. C. VIII. ined." This evidently refers to Mougeot et Nestler, Stirpes Cryptogamae Vogeso-Rhenanae 763 which was issued in 1823 a year after the publication by Fries. Three specimens of this number at the New York Botanical Garden and the Farlow Herbarium have been available for study. They have cylindric part-spores  $(12)14-22(32) \times 2.5-3 \mu$  and a cortex of densely interwoven hyphae without a differentiated ectal layer (figs. 6 & 7). The Mougeot-Nestler no. 763 is accepted in this study as the lectotype of the species *C. capitata*.

Peck (l.c.) described a species *Cordyceps nigriceps* which he distinguished from *C. capitata* by "free margin of the club" and narrow spore segments. He describes the segments of the ascospores as cylindric  $20-40 \times 4 \mu$ . The specimen of *Cordyceps nigriceps* collected by C. L. Fox in Maine labeled type in the Herbarium of the New York State Museum has been studied. It consists of one broken stroma. The segments of the ascospores are cylindric,  $14-22 \times 3 \mu$  and the cortex does not have a differentiated ectal layer. The ascogenous portion projects slightly downward over the stipe. It appears to be *C. capitata* as recognized here.

5. *Cordyceps canadensis* Ell. & Everh. Bull. Torrey Bot. Club 25: 501. 1898. (figs. 8-10). *Torrubia capitata* sensu Tul. Sel. Fung. Carp. 3: 22. 1864. *Cordyceps agariciformia* Seaver in part, N. Am. Flora 3 pt. 1: 53.

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1910. Stromata capitate, 5-8 cm long; ascogenous portion abruptly enlarged into spherical, ovoid or subcylindric heads, 6-17 × 5-17 mm brown, olive-brown to black, punctate or roughened from the ostioles, with a cortex of closely interwoven brown hyphae pseudoparenchymatous in section having a well differentiated ectal layer of short hyaline or brownish parallel hyphae palisade-like in section; stipes 3-8 mm thick, yellow, olive-yellow, olive-brown or black, furfuraceous; perithecia ovoid, 550-1000 × 270-450 μ, entirely embedded; asci cylindric 300-550 × 12-16 μ, gradually narrowing below, with a hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, multiseptate, breaking into 1-celled, subfusoid segments, (18)24-48 × 4-5 μ, often with the end walls thickened.

On *Elaphomyces granulatus*, *E. muricatus*, *E. variegatus* and *Elaphomyces* sp.

Specimens studied: 58 from Alabama (MICH), Connecticut (FH), Delaware (NY), District of Columbia (BPI), Florida (NY, FH, BPI), Kentucky (NY, BPI), Maine (NY, FH), Maryland (BPI), Massachusetts (NY, FH, NYS, BPI), Michigan (MICH), New Jersey (NY), New York (MICH, CU, NY), Pennsylvania (BPI, NYS), Tennessee (FH, MICH), Virginia (BPI), Ontario (NY, FH, BPI, MICH), Mexico, Hidalgo (MICH).

Four specimens from Germany have been studied including Rehm Ascomycetes 1186; Sydow Myc. March. 279; Rabenh.-Winter-Pazschke Fungi Europ. 3957.

This species has been generally included in *Cordyceps capitata*. The species was described by Ellis and Everhart (l.c.) from a collection made by Dearness no. 2641 at London, Canada. They state that the ascospores separate "into cylindric segments, 10-20 (mostly 15) × 2-2.5 μ". It is emphasized that "the slender cylindrical segments of the sporidia are only about half as long and wide as in *C. capitata* (Holmsk.) and very different from the globose-ellipsoid joints of the sporidia of *C. ophioglossoides* (Ehr.)."

Among the specimens in the Ellis Herbarium which is now in the Herbarium of the New York Botanical Garden is a packet bearing the label "*Cordyceps canadensis* Ell. & Dearness". This is pasted over writing on the flap of the packet which viewed by transmitted light reads as follows "Scarcely more than a form of *C. ophioglossoides*. 2641. *Cordyceps canadensis* Ell. & Dearness". Below on the packet is written "When fresh quite different from *C. ophioglossoides*, stipe shorter and stouter, head capitate, joints of sporidia oblong or fusoid 15 μ, asci 300-325 × 7-8 μ. Seems to agree with *capitata* except that joints are 15 instead of 25-40 μ. Joints 12-15 × 2-2½. 12-20." These measurements have been crossed out and written on the packet in another handwriting is "joints 30-45 μ long". This appears to be the specimen from which *Cordyceps canadensis* was described. It consists of a stipe and a portion of a spherical head. The cortex consists of two definite layers (fig. 9), an inner of closely interwoven hyphae and an ectal layer of short palisade hyphae (fig. 10). The segments

of the ascospore are fusoid (26)36–48 × 4  $\mu$  with the end walls thickened. With the emphasis which Ellis placed upon the small size of the spore segments in distinguishing the species *C. canadensis* this is puzzling. While Ellis' description agrees with that of *C. capitata* as treated here the specimen is not that species but is the other species which has been commonly described as *C. capitata*. It seems necessary therefore to use the name *C. canadensis* for it. This species has the largest part-spores of the species which have been found in North America (fig. 8). Imai (1929) has described a species *C. jazoensis* from Japan with part-spores 16–50 × 3.5–4.5  $\mu$ . This has clavate stromata similar to *C. ophioglossoides*.

6. ***Cordyceps valliformis* sp. nov.** Stromatibus capitatis, 5–7 cm longis; capitulis spheroides vel ovoideis, 3–15 × 3–12 mm, atrobrunneis; cortice duplice interne pseudoparenchymato externe valliformi; stipitibus 1–5 mm crassis, atrobrunneis; peritheciis ovoideis, 500–700 × 200–350  $\mu$ , immersis; ascis cylindricis, 230–460 × 6–8  $\mu$ ; ascosporis hyalinis, filiformibus, multiseptatis, in unicellularia fragmenta secendentibus 3–8 × 2  $\mu$ .

Specimen typicum: Highlands N. Carolina, Aug. 1933, V. K. Charles (BPI).

Stromata capitata, 5–7 cm long; heads spherical or ovoid, 3–15 × 3–12 mm, abruptly enlarged from the stipe, dark brown with a cortex having an inner layer of closely interwoven brown hyphae pseudoparenchymatous in section and an ectal layer of short hyaline parallel hyphae palisade-like in section; stipes 1–5 mm thick, dark brown, smooth or furfuraceous; perithecia ovoid, 500–700 × 200–350  $\mu$ , entirely embedded; asci cylindric, 230–460 × 6–8  $\mu$ , with a hemispherical thickening of the wall at the apex; ascospores hyaline, filiform, multiseptate, breaking into 1-celled cylindric segments 3–8 × 2  $\mu$ .

On *Elaphomyces cervinus* and *Elaphomyces* sp. Highlands N. Carolina Aug. 1933, V. K. Charles, type (BPI); Virginia Oct. 10, 1938, Dr. Jones FP 86265 (BPI); Mountain Lake, Giles Co. Virginia, Sept. 2–4, 1936, D. H. Linder (FH); Pottersville, Ulster Co. New York, Aug. 8, 1922, H. D. House (NYS); Petawana Forest, Ontario, Sept. 1, 1947, A. H. Smith 26425 (MICH).

This species differs from *C. canadensis* in having much smaller segments of the ascospores. From *C. capitata* it differs in having a differentiated ectal layer of the cortex and smaller segments of the ascospores. *C. intermedia* Imai (1934) in Japan is similar in size of segments of the ascospores. It is described as attached to the host by short rhizomorphs. Information is not available concerning the cortex. Collections which Kobayasi (1941) has reported from Japan as *C. capitata* may belong here. He describes and figures a differentiated palisade-like ectal layer for the cortex. He however gives the segments of the ascospores as more fusoid and 13–23 × 2–4.5  $\mu$ .

7. ***Cordyceps fracta* sp. nov.** Stromatibus capitatis, 1.5–2.5 cm longis; capitulis sphaeroideis, 2.5 mm crassis, purpureoatris; cortice pseudoparenchymato; stipitibus 0.5–1.0 mm crassis, flavoviridis vel olivaceis; peritheciis ovoideis, 500–600 × 250–350  $\mu$ , immersis; ascis cylindricis, 300–480 ×

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fragmenta secendentibus 2-5 × 1.5-2 μ.

Specimen typicum: Cades Cove, Great Smoky Mts. Nat. Park, Tenn.  
Aug. 18, 1938, A. H. Smith 10334 (MICH).

Stromata capitate, 1.5-2.5 cm long, arising directly from the host; heads  
2.5 mm in diameter, purplish black, with a cortex of closely interwoven  
brown hyphae pseudoparenchymatous in section without a differentiated  
ectal layer; stipes slender, 0.5-1.0 mm thick, yellowish green to olivaceous;  
perithecia ovoid, 500-600 × 250-350 μ, entirely embedded; asci cylindric,  
300-480 × 5-6 μ, with wall hemispherically thickened at the apices; asco-  
spores hyaline, filiform, multiseptate, breaking into 1-celled cylindric seg-  
ments 2-5 × 1.5-2 μ.

On *Elaphomyces appalachensis*. Known only from the type specimen.

The specimen upon which this species is based was previously reported  
as *C. intermedia* Imai (Mains 1939). According to the description given  
by Imai, *C. intermedia* has larger stromata attached to the host by rhizo-  
morphs and somewhat larger, specially wider, segments of the ascospores.  
*C. fracta* has part-spores (fig. 11) similar to *C. valliformis* which differs in  
having a differentiated ectal layer to the cortex.

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ANN ARBOR, MICHIGAN

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