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naller, averaging only 3–7 × 3–
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ı Rea studied the material from
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ıear Gardner Bay, Hood Island,
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CORDYCEPS STYLOPHORA AND CORDYCEPS RAVENELII [1]

E. B. MAINS

(WITH 2 FIGURES)

Cordyceps stylophora was collected by Ravenel in South Carolina and was described and illustrated by Berkeley in 1857 (1). Ravenel distributed it in his Fungi Car. V: 49. It has been rarely collected. It was next obtained by G. H. Hicks in April 1892 near the Michigan Agricultural College at East Lansing, Michigan. A part of this collection is in the Herbarium of the University of Michigan and bears a notation that it was determined by Ellis. Longyear (3) reported it in 1904. Roland Thaxter collected a specimen in August 1896 at Burbank, Tennessee (4). Petch (7) has reported a collection (Cornell *14808*) by H. H. Whetzel from Cayuga Lake Basin, New York, made in November 1902. L. E. Wehmeyer obtained two specimens at Brookside, Nova Scotia, on July 25, 1931. A. H. Smith made a number of collections at Warrenburg and Catlin Lake, New York, during August and September 1934 and from Oakland County, Michigan, in August and September, 1937 and October 1938.

Most of the collections were immature. In the original description of the species Berkeley states that he had not seen "ripe asci." Massee (6) described the asci and spores. The latter are given as filiform, slightly curved when free, multiseptate, 125–135 × 1 μ, the component cells 3.5 μ long. He cites only the type specimen, Ravenel *1325*. Petch (7), however, states that he examined the type specimen and it was "quite immature." The Cornell specimen was also found to be immature. Mains (5) has also noted that most of the collections from Tennessee, New York and Michigan were immature. The Hicks' specimen was the nearest to full maturity, the asci being well developed and the ascospores

[1] Paper from the Department of Botany and the Herbarium of the University of Michigan.

differentiated. It had not reached full maturity since only a few free spores were found in a mount and there is no evidence of spore discharge from the ostioles of the perithecia.

In 1938, an attempt was made to obtain thoroughly mature clavae when A. H. Smith discovered on July 10 a number of immature clavae on a rotten log near Milford, Michigan. These were inspected from time to time during the summer for exudation of spores. This did not occur and on October 24 they were collected. The clavae were in good condition. The perithecia contained asci but the spores were not fully developed. The persistence of clavae for more than three months without reaching full maturity was puzzling.

On May 29, 1939, the log at Milford was again visited and a single clava was found showing abundant exudation of spores from the ostioles of the perithecia (FIG. 1, *A*, and *B*). Of the various collections, those obtained in April and May were the most mature while those later in the season, July to October well all much less mature. This suggested the possibility that the clavae might overwinter and mature in the spring. Consequently in September 1939 the locality at Milford was again visited and eight clavae were found. Five of these had developed perithecia as shown by the presence of ostioles. These were marked by driving nails in the log beside each. In late April of 1940, the log was again visited and four clavae were found to have survived the winter, two with perithecia and two sterile. The fertile clavae were found to have well developed asci and differentiated ascospores which issued from some of the asci when mounted on a slide under a cover glass. They were not completely mature since spores were not exuding from the ostioles of the perithecia. The clavae of this species therefore can overwinter and mature in the spring. These observations strongly suggest that they start their development about July, the perithecia developing during the summer and the asci in late summer and autumn. They then overwinter and the ascospores reach maturity by the middle or the last of May.

It is now possible to give a more detailed description of the species as follows:

Clavae, single or occasionally two, ochraceous-tawny to dark cinnamon-brown, 1.5–4.5 cm. long, the fertile portion a cylindrical

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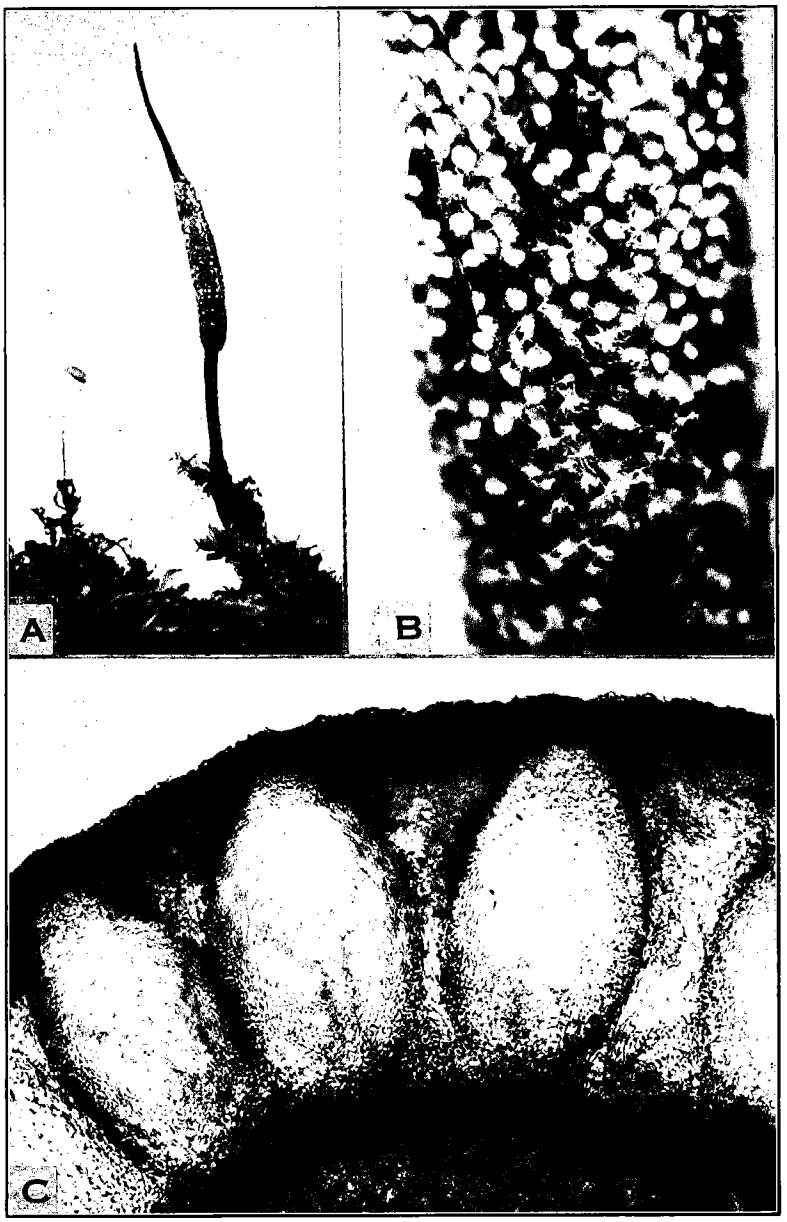

Fig. 1. *Cordyceps stylophora.*

swelling in the middle third of the clava, about 2 mm. thick, narrowed below into a sterile stipe about 0.8 mm. thick, attenuated above into a long acuminate sterile apex, the fertile portion smooth when fresh, longitudinally furowed when dry, punctate with the dark ostioles of the perithecia, the stipes surrounded at their bases by a brown mycelium; perithecia entirely embedded in the stroma, narrowly flask-shaped or ovoid, 240–420 × 144–240 μ; asci clavate-cylindric, somewhat attenuated below, slightly narrowed above, 170–220 × 8–10 μ; ascospores fusoid-cylindric, slightly narrowing at the ends, 102–164 × 2–3 μ, overlapping in the ascus, multiseptate, the cells 12–20 μ long, not regularly breaking into segments.

From coleopterous larvae in rotting logs, South Carolina, Tennessee, Michigan, New York and Nova Scotia.

Sections through the fertile portion of a clava (FIG. 1, *C*) show a somewhat similar differentiation as that described for *Cordyceps agariciformia* (*C. capitata*) by Jenkins. The differentiation is more pronounced and can be easily demonstrated from unstained, free-hand sections. There is a central cylinder composed of nearly colorless, longitudinal, parallel hyphae. Surrounding this is a thin intermediate layer of brownish, compactly interwoven hyphae. Beyond this is the perithecial layer. The perithecia are seated on and appear to arise from the intermediate layer. In the perithecial layer the perithecia are surrounded by hyphae which are nearly colorless and very loosely interwoven next to the intermediate layer becoming progressively more interwoven and colored outward, finally forming a rind of very compactly interwoven dark colored hyphae through which the ostioles of the perithecia open.

CORDYCEPS RAVENELII Berk. & Curt.

This is also a rare species. It was described by Berkeley (1) in 1857 from a collection made by Ravenel in South Carolina. Ravenel issued it in his Fungi Car. IV : 28. It has been reported from South Carolina, North Carolina, Tennessee, Kentucky, Iowa, Pennsylvania and New Hampshire. In 1940 it was discovered in a number of localities in Michigan by A. H. Smith and the writer on grubs of the June beetle. The first collection was obtained on June 4, and the clavae proved to be immature. However, they were planted in the writer's garden where they continued to develop. It was noted that the developing perithecia appeared to

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break through a cortical layer. The perithecia of this species have been described as free, superficial or partially immersed. Sections through the fertile portion of a clava (FIG. 2, *A–C*) show that a considerable portion of it is a central cylinder consisting of light colored, narrow, longitudinal hyphae. Surrounding this is an intermediate layer, 30–36 μ thick, of densely interwoven hyphae. Arising from this and growing outward at right angles are numerous dark, brown parallel hyphae which form a very dense layer about 60 μ thick. The perithecia arise at intervals from the intermediate layer and apparently as they develop push through the outer layer. Where the perithecia are closely associated, the outer layer is torn loose from the intermediate and sloughs off (FIG. 2, *B*). Since the perithecia finally reach a length up to 480 μ, they appear to be superficial even where the outer layer remains (FIG. 2, *C*).

The following description is drawn from fresh specimens of the Michigan collections:

Clavae 5–9.5 cm. long, dark chocolate-brown, club-shaped, the fertile portion occupying the upper portion of the clava, 2.5–4 cm. long, 4–7 mm. thick, the apices obtuse to acute, sometimes free from perithecia, the stipes 2–3 mm. thick; perithecia at first nearly hemispherical, finally cylindric, rounded above or somewhat narrowed, 348–480 × 240–360 μ, blackish brown, at first embedded, finally becoming almost or entirely free; asci somewhat clavate, 240–312 × 8–10 μ; ascospores slightly narrowing at the ends, 192–255 × 2–3 μ, hyaline, multiseptate, the cells 20–30 μ long, only slightly segmenting.

From larvae of "June beetle," in woods, Milford, Michigan, E. B. Mains and A. H. Smith, June 4, 1940 (*5062*), June 5, 1941 (*5325*); Dexter, Michigan, June 14, 1940, A. H. Smith (*15100*); Waterloo, Michigan, June 26, 1940, A. H. Smith (*15131*); Pinckney, Michigan, June 17, 1940, E. B. Mains (*5090*); Ann Arbor, Michigan, July 3, 1940, A. H. Smith (*15174*).

Species of *Cordyceps* are commonly grouped according to whether their perithecia are embedded or superficial. Some species, as for example *Cordyceps militaris,* have been placed in both groupings. However, in *C. militaris,* the perithecia are embedded in a peripheral layer of loose hyphae without an outer compact rind.

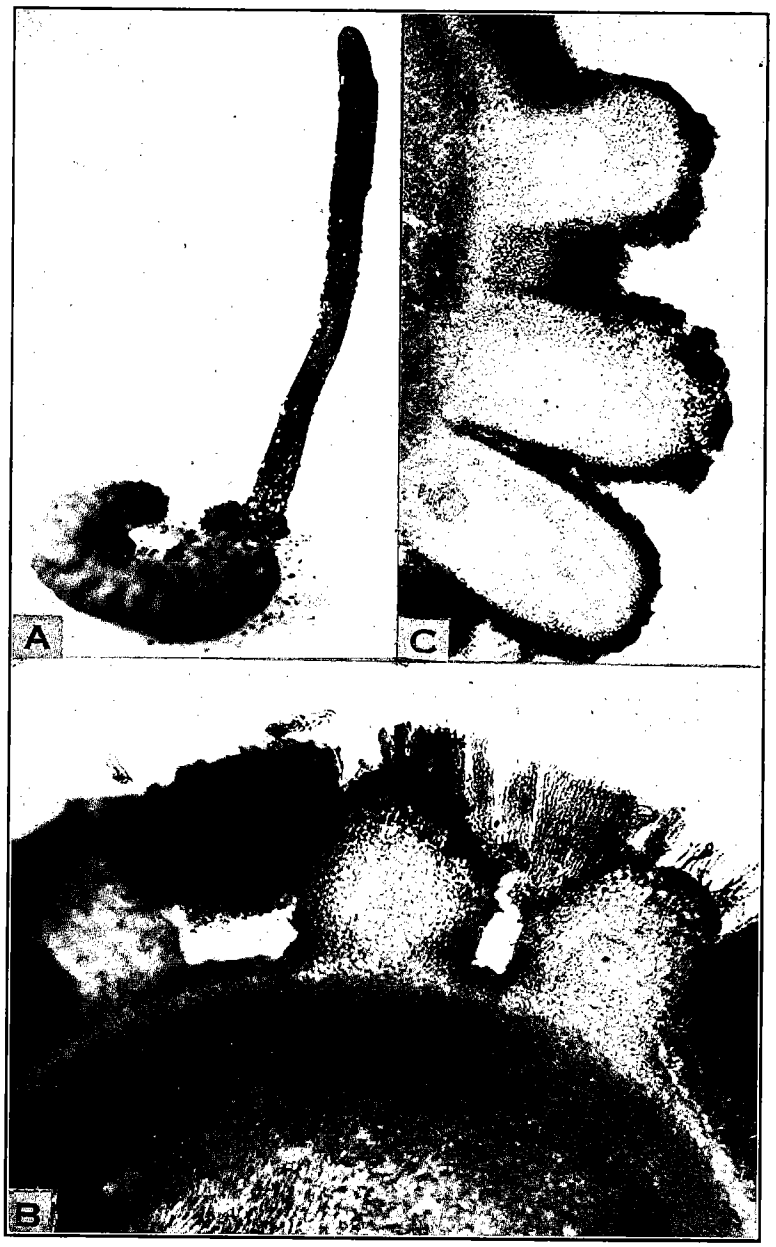
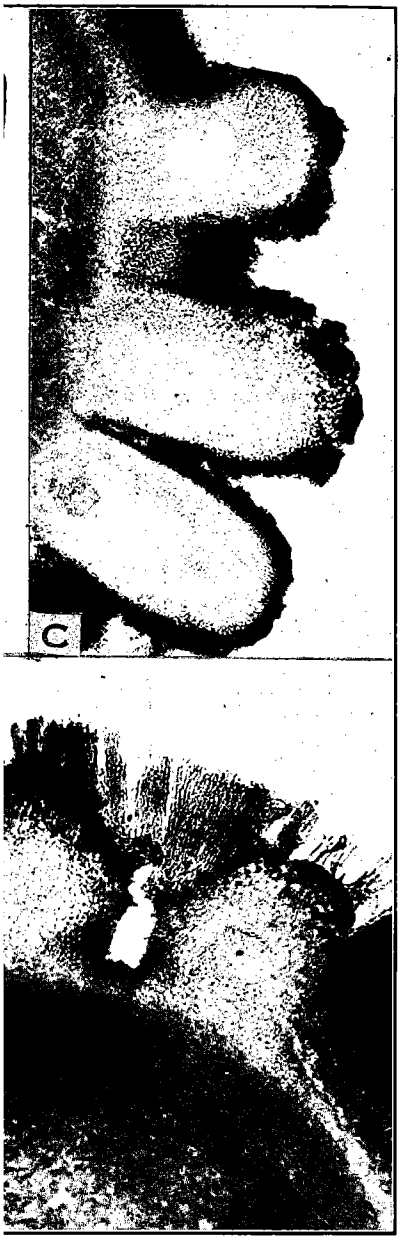


FIG. 2. *Cordyceps Ravenelii.*



yceps Ravenelii.

Upon drying or in age, the tissue between the perithecia shrinks leaving most of each perithecium exposed and projecting. The dense outer rind of *C. stylophora* prevents this. *Cordyceps michiganensis, C. paludosa* and *C. superficialis* unquestionably have superficial free perithecia in all the collections examined. These species are very rarely collected and the available material is rather limited. From such observations as it has been possible to make it seems probable that the development of these species is similar to that of *Cordyceps Ravenelii;* the peripheral layers being very thin and the perithecia emerging very early in their development.

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EXPLANATION OF FIGURES

FIG. 1. *Cordyceps stylophora. A,* clava showing swollen fertile portion and acuminate sterile apex (1.5 ×); *B,* portion of clava, showing exudation of spores (60 ×); *C,* portion of cross section of immature clava showing central cylinder covered by intermediate layer and cortical layer containing perithecia (150 ×).

FIG. 2. *Cordyceps Ravenelii. A,* clava arising from June beetle larva (natural size); *B,* cross section of fertile portion of clava showing portion of central cylinder covered by intermediate layer from which perithecia and cortical layer arises; developing perithecia have torn portions of the cortical layer loose (105 ×); *C,* portion of cross section of clava showing half developed perithecia projecting above the cortical layer (105 ×).