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BOTANICAL GAZETTE

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LIFE HISTORY OF HYPOCREA ALUTACEA.¹

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(WITH PLATES XIV-XVI)

Hypocrea alutacea (Pers.) Tul. is an interesting plant, not only on account of its history, but because of its peculiar form and color characters, taken in connection with its structure. In shape it is like a club or spatula, one to three inches high, resembling in form other members of the old genus *Sphaeria* now placed in the genera *Xylaria* and *Cordyceps*. It differs from the *Xylarias* in not being black, as well as in differences of texture and structure. It resembles more nearly a simple *Clavaria*, in which genus it was first placed as *Clavaria simplex* Schmiechel.² It resembles also a *Cordyceps*, in which genus it has also been placed, and it is even said to grow sometimes on insects. Some forms are also strikingly like species of *Spathularia* among the *Discomycetes*. To the collector, therefore, unacquainted with the plant, when he first finds it, it calls forth various emotions, running all the way from admiration of its simple lines of beauty to a possible belief that it is a "brand" new fungus, then to a temporary location in the wrong genus. But an examination of the spores shows at once its relation to the genus *Hypocrea*. The larger number of species of *Hypocrea* either form low cushions, or extended incrustations on decaying organic matter, or they are parasitic on the surface of the larger fungi, resembling in this respect some of the species of *Hypomyces*.

¹ Contributions from the Botanical Department of Cornell University no. 103.

² *Icones et Analyt.* 18-26. *pl.* 4, *fig.* 2, *pl.* 5, *figs.* 1-3. 1762, according to TULASNE, *Selecta Fung. Carp.* 3:35. 1865.

The earlier students looked upon this fungus as an autonomous plant with an erect clavate stroma; among them are the following. PERSOON³ first described it as *Sphaeria alutacea*. SOWERBY⁴ discovered it in 1783, and described it in 1799 as *Sphaeria clavata*. SCHUMACHER⁵ followed Persoon. ALBERTINI and SCHWEINITZ⁶ in 1805 record it as growing on decaying Alnus. NEES VON ESENBECK⁷ in 1816 placed it in his subdivision of clavate Sphaeriae (*Keulensphärien-Sphaeriae Clavaeformes*) which he says are like a simple Clavaria, or Geoglossum in which the ascus layer has changed into perithecia. The first species which he places in this group is the leather-yellow Sphaeria, *S. alutacea* Pers. He states that it grows on the ground in fir woods. FRIES⁸ in his treatment of the genus Sphaeria places it in the tribe Cordyceps, series Hypocrea, as *Sphaeria alutacea*.

Those also who have placed it in the genus Cordyceps regarded it as an autonomous plant. LINK⁹ first placed it in Cordyceps as *C. alutacea* and was followed by FRIES.¹⁰ It was distributed under two different numbers in *Rab. Fung. Europ. Ex.* 132 (1860) from pine woods, England, as *C. alutacea* (Pers.) collected by C. E. BROOME, and no. 246 (1860) from mossy woods, near Leipzig, as *C. alutacea* β *albicans* (Pers.), a lighter form, from alutaceus to white, according to the note in connection with the specimen. BERKELEY¹¹ under *Cordyceps alutacea* Fr. says "clavate, tan colored or nearly white, head confluent with the stem. In fir woods amongst leaves and furze," and his figures show a variation in size between stout and slender forms. QUÉLET¹² in connection with *Cordyceps alutacea* (evidently using the name employed by FRIES in *Summa Veg. etc.*)

³ Obs. Mycol. 2:66. pl. 1, fig. 2, a, b, c. 1797. Comm. de fung. clavif. 12. 1797.

⁴ English Fungi 2: pl. 159. 1799.

⁵ Enum. Pl. Sellandiae 2:175. no. 1343. 1803.

⁶ Consp. Fung. Lusat. Sup. 1. 1805.

⁷ System der Pilze 289. pl. 40, fig. 304. 1816.

⁸ Syst. Myc. 2:325. 1823.

⁹ Handb. z. Erkenn. der Gewächse 3:347, no. 5. 1833.

¹⁰ Summa Veg. Scand. 381. 1849.

¹¹ Outlines Brit. Fungol. 382. pl. 26, fig. 6. 1860.

¹² Champignon du Jura et des Vosges 487. 1869.

says that the spores are cylindrical and two-celled, the upper globose, the lower oblong, and in a footnote says that from the texture and fructification the species would belong rather to *Hypocrea*. It grew among needles of *Pinus sylvestris*. WINTER¹³ records *C. alutacea* QUÉLET from the Jura mountains and says the spores are needle-like, with many segments, and 40–50 μ long! Evidently this is not QUÉLET'S species. CURREY¹⁴ says it is a *Cordyceps* with the fructification of *Hypocrea*.

The TULASNES¹⁵ in their classical studies forty years ago pointed out the resemblance in the habit of this plant to that of certain species of *Hypomyces*, as *H. lateritius* Fr., and *H. lactifluorum* Schw., which are parasitic on species of *Lactarius*, the *H. lactifluorum* deforming white species of *Lactarius* and giving them a bright red color. With this interpretation of the dual nature of the fungus they were led to believe that *Hypocrea alutacea* was in a similar way parasitic on a certain species of the simple clavarias, viz., *Clavaria ligula* Schaeff. Their interpretation of the dual nature of the fungus has since been generally conceded to be correct. SACCARDO,¹⁶ WINTER,¹⁷ and other systematists have followed them in considering it as parasitic on either *Clavaria ligula* or *Spathularia*, on which latter host BROOME reported it according to SACCARDO.¹⁸ It has been reported by DAY¹⁹ in North America also on an undetermined species of *Spathularia*, where he says, "Apparently parasitic on *Spathularia*" and reference is made to PECK, Rept. N. Y. State Mus. 26 84. 1874, where the plant is merely listed as growing on fallen leaves. WINTER (*l. c.*)

¹³ Rabenhorst's Krypt. Fl. etc. Pilze 12:149. 1885.

¹⁴ Synopsis of the fructification of the compound Sphaeriae in the Hookerian Herbarium. Trans. Linn. Soc. London 22:264. 1858.

¹⁵ Selecta Fung. Carp. 3:35. 1865.

¹⁶ Sylloge Fungorum 2:530. 1883.

¹⁷ Rabenhorst's Krypt. Flora, tc., Pilze, 12:142. 1887.

¹⁸ According to SACCARDO *l. c.* See also ELLIS, N. A. P. 89. 1892, where its occurrence on *Spathularia flavida* is ascribed to BROOME.

¹⁹ DAY, DAVID F., A catalogue of the native and naturalized plants of the city of Buffalo and its vicinity. Bull. Buff. Soc. Nat. Sci. 4:161. 1882. The reference in FARLOW'S Host Index (see FARLOW & SEYMOUR, A provisional host index of the fungi of the United States 175. 1891) to *H. alutacea* as parasitic on *Spathularia*, Dr. FARLOW writes me, was made from DAY'S catalogue, and he adds that he has never found it on *Spathularia*.

points out that the stroma of the parasite is completely merged with that of the host, and that only the upper clavate part of the host bears perithecia, while the stem is free or bears the conidial form.

Some very discriminating observers, however, have dissented from TULASNE's interpretation of the dual nature of the fungus, though no proof has been brought forward to demonstrate either its parasitic nature or its autonomy. CORNU²⁰ as early as 1878 collected several specimens on decaying leaves of *Abies picea* in a forest in the environs de Pontarlier. He searched diligently for specimens of *Clavaria pistillaris* of which he says *Clavaria ligula* is like a reduced form. He found none in the neighborhood of the *Hypocrea alutacea*, nor could he find any evidence that it grew either as a parasite or saprophyte on insects or on any subterranean fungus. Although he cannot say with certainty, he does not think the plant can be regarded as a parasite or that it develops at the expense of *Clavaria ligula*. He regards it rather as analogous in habit and nutrition to species of *Xylaria* which grow, some on wood, others on leaves and humus, and he cites an exotic species *X. compuncta* Jungh., as resembling in some respects the *Hypocrea alutacea*, the plant being alutaceous to pallid, but dark punctate from the perithecia.

In 1894 SCHROETER,²¹ a keen and discriminating student of the fungi, also took issue with the prevalent theory that *Hypocrea alutacea* was a parasite on *Clavaria ligula*. He says that this is not the case with the forms which grow in Schlesien. He says the fungus grows on wood as ALBERTINI and SCHWEINITZ have pointed out, and as he himself has observed at Breslau, while *Clavaria ligula* grows on needles of conifers. LINDAU²² also in his treatment of the Hypocreales follows SCHROETER's judgment rather than that of TULASNE and WINTER. FARLOW²³ records collecting *Hypocrea alutacea* at Shelburne, N. H., under *Pinus strobus* where was also growing *Clavaria ligula*, but he was unable to trace any direct connection between the two.

There is thus a reasonable doubt probably as to which horn of

²⁰ Note sur l'*Hypocrea alutacea* Pers. Bull. Soc. Bot. de France 26: 33-35. 1879.

²¹ Krypt. Fl. Schles., Pilze, Zweite Hälfte 3: 272. 1894.

²² Engler und Prantl Pfl. Fam. 1: 365. 1897.

²³ Lloyd's Myc. Notes 9 (195): 110. 1902.

this dilemma we shall choose. At least none of these students has left us any evidence which can be considered proof of one or the other of the theories as to the nature of *Hypocrea alutacea*.

My first acquaintance with the plant was in August 1901, when Mr. A. M. FERGUSON, one of the students in my laboratory, collected several specimens growing on very rotten wood in one of the forested gorges at Ithaca, N. Y. In looking up the literature at the time I was impressed with the diversity of opinion on the subject, as well as the lack of any attempt at experimental proof one way or the other in support of the theories advanced. It occurred to me that perhaps here was an opportunity to settle by simple experiment this dispute of a century. At least the trial could be made. Accordingly the plants were placed over night in a new and clean pasteboard box, covered. On the following day I found that the bottom of the box was nearly covered with numerous ascospores which had been shot out of the perithecia during the night. There was also a thick and loose covering of the spores over the fruiting portion of the fungus as the plants lay in the box.

For culture media I employed sterilized slices of a species of *Lactarius* which had been prepared a few days before for culturing *Nyctalis asterophora*. These slices were in test tubes and about half covered with water. With a sterilized platinum needle, transfers of ascospores were made from the fresh pile on the plants to the agaric substratum in the tubes. Twelve tube cultures were started. With this number it was quite probable that from the fresh pile of spores several plantings could be made which would be pure. If the spores should grow, and the mycelium mature perithecia, there would likely be some indication as to whether *Hypocrea alutacea* is single or dual in its nature. If single, then we would expect the development of a clavate stroma in the pure culture. If dual, the stroma would be spread over the surface of the dead slice of the agaric. At the same time dilution cultures were made in agaric agar-agar in Petri dishes. None of the spores germinated in them, however.

In a week's time I left Ithaca for the mountains of western North Carolina. At the time of leaving there was very little evidence of any growth in the tube cultures, although *Nyctalis asterophora* spores, sowed at the same time, produced a mature crop of plants in a week.

It is interesting now to note the form of the individual plants from which cultures were attempted. One of them resembled in shape *Spathularia flavida*, as if it might have been somewhat arrested in development (*pl. XIV, fig. 1, b*), while others resembled *Clavaria ligula*, and one was more or less deformed, curved strongly, and with a broad groove on the concave side. These forms would seem to satisfy the wish of the most ardent advocate of the parasite theory who does not attempt to put the theory to the crucial test. In structure, however, there was no indication of a difference of the structural elements such as one might expect to find were the plant parasitic on *Clavaria ligula* or *Spathularia*, and an advocate of this theory would be compelled to join WINTER in saying that the parasite and host were completely merged. It should also be said that no normal specimens of *Clavaria ligula* or of *Spathularia* were at the time growing in the immediate vicinity of the *Hypocrea*.

Of course, during the next five weeks, while collecting fungi in the mountains of North Carolina, I was on the lookout for *Hypocrea alutacea* and its relation to either of these supposed hosts. I found one day a large colony of *Spathularia clavata* growing under a white pine tree. The *Spathularia* extended over an area of 75 to 100 square feet. Among the *Spathularia* plants I found four or five specimens of *Hypocrea alutacea*. These were growing not on wood, but apparently from decaying organic matter among the pine needles, and, as far as one could judge, their habitat was the same as that of the *Spathularia*. Singularly, the form of these specimens was quite regular. The form was not, however, similar to that of the *Spathularia*, but more like that of *Clavaria ligula*. But no specimens of the latter plant were found growing in the immediate vicinity. No other specimens were found during that season.

On returning to Ithaca in the latter part of September, I hastened to examine my tube cultures of the *Hypocrea*. There were two perfect specimens, one in each of two tubes. Both of them possessed the *Clavaria*-like form and stood up clearly from the substratum. Here, then, were two specimens of *Hypocrea alutacea* in pure culture from the ascospores, and the form in general like that of the plants found in their natural environment. Moreover, they were certainly growing as saprophytes and not as parasites. This, I believe, demon-

strates that *Hypocrea alutacea* is an autonomous plant,²⁴ and it is the first proof we have that it is not of a dual nature, parasitic on *Clavaria ligula* or *Spathularia*.

It might still be contended that the plants which I found growing among the pine needles along with the *Spathularia* in North Carolina, were of a different species from those growing on rotting wood at Ithaca, N. Y. Especially might this view be taken since FRIES²⁵ describes *Hypocrea alutacea* as growing among needles of the fir, and describes a form *turgida*, growing on rotting wood. SCHROETER (*l. c.*) when he states that according to his observations *Hypocrea alutacea* grows only on wood, cites FRIES'S disposition of the two forms and says that possibly the form on wood is a different species which should be called *Hypocrea turgida*. It seems to me, however, more rational to attribute the slight variation in form to a recognizable range of variation in the species, either inherent in the species, or attributable to the change of substratum. According to FRIES the more robust form grows on wood. The form on wood at Ithaca was more robust than the form among the pine needles in North Carolina. But I have collected a form on wood in North Carolina of the same size as, or even smaller than, those among the pine needles. However, the forms which I grew in pure culture on sterilized *Lactarius* were more slender and were more like those found among the pine needles, although their direct parentage was from the robust form from wood.

The wood forms are found on half-decayed wood, and also on very rotten wood. From this condition of the substratum it is an easy transition to wood mold or leaf mold, in the adaptation of the plant to a limited range in the variation of the condition of the same general substratum. Since the plant can grow as a saprophyte on dead mushrooms, as shown by the pure cultures, it might be possible that sometimes in the forest it grows as a saprophyte on decaying *Spathularia* or *Clavaria ligula* buried among the leaves. It is very probable, however, that there is a range in the habitat of the species from wood

²⁴ These facts, as well as photographs of *Hypocrea alutacea* from the wood substratum and in pure cultures were presented before the Botanical Society of America at the Washington meeting, December 30, 1902 to January 1, 1903.

²⁵ Syst. Myc. 2:325. 1823.

or leaf mold to very rotten wood and to wood in a one-fourth to a one-half decayed condition. This range would be represented by a habitat life curve, which rises from the leaf or wood mold in the ground to the upper limit on the decaying wood, influenced, to some extent at least, by other conditions of environment. Or if the wood habitat is the normal one, then the curve would descend according to conditions to the wood mold and leaf mold in the ground. This range in habitat is manifested by a large number of the higher fungi. The curve rises or descends from the normal habitat according to the peculiarities of each species and according to the modifying influences of other environmental conditions.

The history of *Hypocrea alutacea* has become more interesting by the publication of *Hypocrea Lloydii* Bresadola in 1902, which was collected by C. G. LLOYD in West Virginia, in the summer of 1901. Following the brief description, BRESADOLA notes²⁶ that the species is very interesting, with the aspect of *Cordyceps* but fructification of *Hypocrea*. The photograph published at the time, with the description, suggested to me that the plant might be identical with *Hypocrea alutacea*, and I inquired of Mr. LLOYD if he did not think this to be the case. My letter was communicated to Dr. BRESADOLA, and his reply was published in a note by Mr. LLOYD²⁷ in September 1902. These notes from BRESADOLA are very interesting. In the first place he was not familiar with *Hypocrea alutacea*, since he had never seen the plant; but accepting, as was natural under the circumstances, TULASNE'S interpretation of its parasitic nature, the plant communicated to him by Mr. LLOYD was believed to be a new species in the section *Podocrea* of SACCARDO,²⁸ a section formed to include species of *Hypocrea* with a vertical stroma. BRESADOLA also compared the structure of the stroma of *H. Lloydii* with the structure of both *Clavaria ligula* and *Spathularia flavida*, and finds it very different from either. He concludes by saying that if *Hypocrea Lloydii* is really identical with *Hypocrea alutacea*, a species unknown to him, then he does not believe in the parasitic nature of the latter. At this time LLOYD (*l. c.*) accepted BRESADOLA'S note as

²⁶ BRESADOLA, G., *Hypocrea* (*Podocrea*) *Lloydii* n. sp., Lloyd's Myc. Notes 9 (176):87. 1902.

²⁷ *Idem* 10 (183):99. 1902.

²⁸ Syll. Fung. 2:530. 1883.

indicating that *H. Lloydii* and *H. alutacea* were identical. Later, however, he states²⁹ that PATOILLARD believes *H. Lloydii* "is a good species and very different from *H. alutacea*." LLOYD saw specimens of *H. alutacea* at the Herbarium of the Museum of Paris and said that he does not think it possible the two plants are the same.

Through the courtesy of Dr. BRESADOLA I have had the opportunity of seeing the type specimen of *Hypocrea Lloydii*, and I consider it identical with *Hypocrea alutacea*. In *plate XVI* are photomicrographs of a section from the dried specimen through a portion of the clavula showing the perithecia, and in *plate XV* are similar photomicrographs of the plant collected at Ithaca, the material having been fixed while it was fresh. The only differences which can be observed are those which are due to the difference in the age of the plants at the time they were collected. The specimen of *H. Lloydii* was quite mature, as shown by the more advanced stage of disappearance of asci or freedom of spores from the asci. The perithecia are therefore somewhat older and larger, and are thus crowded against each other, and flattened on the sides where they are closely packed.

The form of the plants themselves at first sight appears different, *H. Lloydii*, *plate XIV*, *fig. 3*, being long and slender, while those of *H. alutacea*, *plate XIV*, *fig. 1*, are stouter. But the individuals of *H. alutacea* which were all growing close together differ more among themselves than the *H. Lloydii* does from the individual of *H. alutacea* at the left. It is unfortunate that this specimen is curved, and therefore that not all of the stem is shown in the photograph. However, the long stem of the single individual of *H. Lloydii* (the species is based on the single specimen collected), as one can see from an examination of the photograph, is due to the fact that the lower half of it was in the leaf mold, the stroma having its origin about 4^{cm} below the surface of the leaf mold. It is a matter of common observation in the case of many stipitate fungi to find the stem considerably elongated under such conditions. I have seen notable examples in the case of *Collybia radicata*, *Clavaria ardenia*, and others, the length of the stem depending on the depth of the substratum below the surface. The plant is quite variable also in regard to its stoutness. This is perhaps also due to some extent to con-

²⁹ Mycological Notes 15 (264):156. 1903.

ditions of environment, though at present it is difficult to say just what conditions produce a robust form and what ones produce a more slender form. SCHROETER (*l. c.*) found the robust form on decaying wood, and suggested that perhaps it might be a different species which should bear the name given by FRIES (*l. c.*) to the robust form, *β turgida*. Along with this variation in the robustness of the plant, there is a variation in the direction of a deformity where the clavula may be flattened, triangular, curved, etc., which has led some observers to question the identity of some of the forms described and figured by different writers. That the form on wood is not always robust is well shown in a small and slender specimen which I collected several years ago on a log in the mountains of North Carolina. The log was not much decayed, and possibly the conditions of nutrition were not so favorable as in the case of much decayed wood, which was the condition of the substratum on which the robust Ithaca specimens grew (*plate XIV, fig. 1*). The variation in these individuals growing close together is sufficient to show what the range in form may be in specimens from different localities.

There is also a variation in color. The plant is usually said to be "tan" color, or "leather" color (to which the specific name *alutacea*, refers), or "pallid," and sometimes "white." White forms gave rise to the variety *β Sphaeria albicans* Pers.³⁰ BERKELEY³¹ describes the plants as tan-colored or nearly white. The color very likely depends very largely on the age of the plants when collected. The Ithaca plants here described were entirely white when collected. But the fact that the asci are so well preserved and most of the spores are still in the asci shows that the plants were just ripening. The plants in pure culture which had their parentage directly from the white ones, had white stems, but the clavulae were tan-colored at the time they were photographed, probably because they were quite well ripened. From the general character of the plant we should expect that the young clavula would be white in all cases, and that the color is an attribute of ripening or age, and it is then reasonable to expect, even in specimens with well-formed spores, that as the plants are collected there would be a sufficient variation in age to account for the color variation observed.

³⁰ Syn. Method. Fung. 2. 1801.

³¹ Outlines British Fungology 382. 1860.

That the American plants are identical with European ones is evident from an examination of the specimens in Raben. Fung. Europ. Ex. nos. 132 and 246 mentioned above, and I had the opportunity also, while in Paris in October 1903, of personally examining, through the courtesy of M. HARIOT, the specimens of *Hypocrea alutacea* in the herbarium of the Museum of Paris, among which were some specimens from TULASNE'S herbarium.

The spores in this species, while presenting slight variations, are quite peculiar. As is well known, the spores in the genus *Hypocrea* are eight in an ascus uniseriate, and each one is two-celled, but at maturity the constriction at the septum is very strong, and the segments of the spore are separated so that the ascus appears to have sixteen nearly globose or oval spores in a single row. The separation of the two segments of the spore is one of the characters distinguishing *Hypocrea* from *Hypomyces*, while short, two-celled spores distinguish *Hypocrea alutacea* from species of *Cordyceps*, which have long filiform spores separating at maturity into numerous segments. CORNU (*l. c.*) also points out that species of *Cordyceps* grow on living or recently dead insects or plants, while *Hypocrea alutacea* grows on decaying wood and leaves, though this distinction may not hold good, since as a saprophyte *Hypocrea alutacea* might grow on dead insects under certain conditions, and it has even been reported on insects. The two segments of the spores of *Hypocrea alutacea* are somewhat different in form. They are usually described as 'superior cell globose, inferior cell oval, or suboval, or oblong.' BRESADOLA³² does not call attention to the difference in shape of the two segments in *Hypocrea Lloydii*, but says "articuli subcuboideis subglobosi." But the two segments are different in form, as I have found by examination, and the spores in the photomicrograph, *plate XVI, fig. 9*, from *H. Lloydii* show very clearly this difference in form, a globose and oblong segment alternating throughout the chain formed by the juxtaposition of the spores in the length of the ascus. The upper segment (the one nearest the free end of the ascus) is globose or subglobose or subcuboid, while the lower segment is elongated slightly in the direction of the axis of the spore and is usually not quite so broad as the upper segment. The lower segment is very

³² Lloyd's Myc. Notes 9 (176):87. 1902.

short oblong, or suboval. The shape of the segments is exactly the same in the Ithaca specimens of *Hypocrea alutacea* as can be seen in *plate XV, fig. 6*, a photomicrograph. The spores measure from $4.5-5.5 \mu$ long \times $2.5-3 \mu$ wide. The upper segment is $2.5-3 \mu$ in diameter, and the lower one is $2.5-3.5 \mu$ long \times $2-2.5 \mu$ in diameter. After fixing and imbedding in balsam the measurements are somewhat smaller than here given.

The spores lie very close together, end to end in the ascus, so that the sixteen segments often appear connected into a necklace-like string. They appear sometimes to adhere to some extent even after escaping from the ascus, but the individual spores can be determined usually by the difference in shape of the two segments.

There is one other question in connection with this plant which it is now necessary to consider. In what genus shall the species be placed? Typical species of *Hypocrea* have a crustaceous, or cushion-shaped or hemispherical stroma, while the stroma of *Hypocrea alutacea* is vertical and elongated. Such a marked difference in the form of the plant is usually regarded as representing a different generic type, just as the erect stromata of the species of *Xylaria* represent a different generic type from the crustaceous, cushion-like or hemispherical stromata of *Hypoxylon*. SACCARDO³³ used the name *Podocrea* as a subgenus for the species of *Hypocrea* with a vertical stroma, and included three species: *Cordyceps larvata* Mont.,³⁴ *C. brevipes* Mont.,³⁵ and *Hypocrea Petersii* B. & C.³⁶ *Hypocrea alutacea* he did not place in this section, since he followed the TULASNES in believing it parasitic on *Clavaria ligula*. LINDAU³⁷ in 1897 raises *Podocrea* to generic rank, and places *Hypocrea alutacea* as the first species, although KARSTEN³⁸ had founded the genus *Podostroma* five years earlier, for a species which he found on a larva of a decaying insect among mosses in Finland. *Podostroma* Karsten, therefore, should have precedence over *Podocrea* (Sacc.) Lindau, and it is unfortunate that LINDAU did not use the name *Podostroma alutacea*.

KARSTEN (*l. c.*) described one species, *P. leucopus*. The char-

³³ Syll. Fung. 2:530. 1883.

³⁵ *Idem* 676, p. 201. 1856.

³⁴ Syll. Crypt. no. 674, p. 200. 1856.

³⁶ Grev. 4:13. 1875.

³⁷ Engler und Prantl Pflanzenf. 11:364. 1897.

³⁸ Hedwigia 31:294. 1892.

acters of this genus and species are so remarkably like those of *Hypocrea alutacea* that it may be well here to give a translation both of the generic and specific diagnosis.

PODOSTROMA n. gen.—Character of the Hypocreaceae. Stroma stipitate, clavate, erect, entomogenous, fleshy, bright colored. Perithecia immersed in the stroma. Asci cylindrical, 16-spored. Spores sphaeroidal, hyaline. Paraphyses none.

Pod. leucopus n. sp.—Stromata solitary. Clavula bearing the perithecia obovoid to oblong, alutaceous-pallid, about 6^{mm} long and 4^{mm} stout. Stipe equal, terete, flexuous, about 5^{cm} long and 2^{mm} stout, white. Perithecia in the periphery, spheroidal, immersed, opening by a pore. Asci cylindrical, sessile, about 75×4 μ . Spores 16, monostichous, spheroidal, hyaline, 2–3 μ in diameter. On larva of certain putrid insects among mosses in coniferous woods, Syrjäås, October.

The specimens of no. 246 Rabenh. Fungi Europ. Ex. in the herbarium of the Botanical Department here represent very well in form and size the *Podostroma leucopus* described by KARSTEN. The plants are slender when dry, 3^{cm} high, the stem less than 1^{mm} in diameter and was likely not more than 2^{mm} when fresh. The clavula is obovoid, about 3.5^{mm} long a trifle over 2^{mm} in diameter, and was very likely stouter when fresh. The plants of no. 132 Rabenh. Fungi Europ. are much stouter, the stem more than 2^{mm} in diameter when dry, short, and the clavula elongate and tapering gradually into the stem. The spores in no. 246 are mostly cuboidal in the specimen examined, and the asci show that they are young. Many of the asci give the appearance of having sixteen equal sub-cuboidal spores. But occasionally, where they are a little older, every alternate one is slightly elongated and narrowed, so that it is suboval or short suboblong. Still younger asci show the plasma content divided into eight parts, and then occasionally one of these young spores is divided into two cells. This indicates clearly that here are eight spores. The second division is so prominent and the constriction so deep it gives soon the appearance of sixteen spores. It would appear that in the later growth of the spores the inferior segment elongates slightly at the expense of its diameter. The specimens collected at Ithaca show the same character from the individuals when asci are just maturing the spores. The plasma is first divided into eight portions, showing that there are eight spores.

In older ones each of these is divided into two equal parts, and the inferior one is usually elongated slightly. But many asci which were dried at this stage show sixteen segments in a crowded chain, all of about the same form, and subglobose to subcuboidal. In a very few cases the spore is pyriform, divided into two cells by a cross wall cutting off the lower smaller cell without any perceptible constriction at the septum. It will be seen that the age of the asci and spores at the time of collection of the plant will vary, and consequently there will be a variation in the form of the spore segments. All may be subcuboidal and of the same size and form, or when older the inferior segment may be slightly elongated and narrowed, and the superior one will be globose to subcuboidal. They are so crowded also in the ascus that there is a tendency for them to cling into a chain or necklace, and this may be aided not only by a small amount of periplasm, but also by remains of the disintegrating ascus which are difficult to perceive.

If KARSTEN'S plant had not been reported as growing on an insect, one would have no hesitancy in placing it in *Hypocrea alutacea*, for all the characters of form, color, and structure agree. The only difference is that of the substratum. The fact that it is reported as growing on a decaying insect, taken in connection with its agreement in form, structure, and color with *Hypocrea alutacea*, is rather strong evidence that this is only a further extension of the range of decaying organic matter on which the fungus grows. It should also be noted that *Podostroma leucopus* was found in coniferous woods, and *Hypocrea alutacea* is usually found under pines or spruces, though it occurs on decaying wood of the broad-leaved trees, as is seen from its occurrence on *Alnus* cited above, and ELLIS³⁹ reports it at Newfield, N. J., on "bark of a decaying (maple?) limb, lying on the ground."⁴⁰

There remains to be considered the standing of the subgenus *Fracidia* proposed by FRIES⁴¹ in 1849 for certain exotic species of

³⁹ Jour. Myc. 2:50. 1886.

⁴⁰The Tulasnes find a conidial form (Select. Fung. Carp. 3:38. pl. 4, fig. 4. 1865) *Verticillium globuligerum* Sacc. (see Syll. Fung. 2:530. 1888) growing on the lower part of the stem, which they regard as the conidial stage of *Hypocrea alutacea*. I have not seen it.

⁴¹ Summa Veg. Scand. 381, 382. 1849.

Xylaria. In a footnote on page 381 of his *Summa Veg. Scand.* he definitely cites *Xylaria flabelliformis* (Schw.) B., *X. pumila* Linn., *X. comosa* and *X. collabens* Mont., as pertaining to the subgenus Fracidia. In 1864 he transfers *Sphaeria alutacea* Pers., which he had formerly placed in *Cordyceps* (*l. c.*), to the subgenus Fracidia, where he writes it as follows: "*Sphaeria s. Fracidia alutacea*,⁴² but differing in color from the species of Xylaria first placed in this subgenus, as *Cordyceps militaris* differs from *C. ophioglossoides*." This short paper by FRIES is a critical review of CURREY'S *Synopsis of the fructification of the compound Sphaeriae of the Hookerian Herbarium*.⁴³ CURREY (*l. c.*, 260) employs the genus Sphaeria, which is divided into sections and divisions. FRIES in his annotations on certain species (*l. c.*) merely follows CURREY in writing Sphaeria as the genus, the *s.* probably standing for subgenus. It is therefore difficult to see how "*Sph. s. Fracidia alutacea*" can be taken as raising Fracidia from subgeneric to generic rank, and if the name is to be employed for a genus it should be used for those species of Xylaria first ascribed to it by FRIES and cited above. The TULASNES⁴⁴ list *Fracidia alutacea* in their synonymy of *Hypocrea alutacea*, but this could not be taken as raising Fracidia to generic rank. *Podostroma* Karsten⁴⁵ (1892) is therefore the generic name to be employed for our plant, instead of *Podocrea* Lindau⁴⁶ (1897), although it was employed as a subgenus by SACCARDO (*l. c.*) in 1883; but SACCARDO did not include the *Hypocrea alutacea* in his subgenus. The International Botanical Congress at Vienna, June 1905, recommends that when the species of a subgenus are raised to generic rank, the name of the subgenus in which they were placed be employed, but this is a recommendation

⁴² Adnotata ad Cel. Fr. Currey dissertationem; Synopsis of the fructification of the Sphaeriae of the Hookerian Herbarium in Act. Soc. Linn. Lond., Vol. XXII, pp. 257-86 et 313-35. Bot. Zeit. 22: 189, 190. 1864.

⁴³ Trans. Linn. Soc. London 22: 257-286. pls. 45-49. 1859; and "Synopsis of the fructification of the simple Sphaeriae," etc. *Idem* 313-335. pls. 57-59.

⁴⁴ Selecta Carp. Fung. 35. 1865. The reference is "in Schlechtendalii Ephem. Bot. Berol., t. XXII (1864), p. 189, n. 22," which is TULASNE'S way of referring to Bot. Zeit. of which SCHLECHTENDAL was an editor. I wish to acknowledge here the aid of Dr. FARLOW of Harvard University and Dr. BRITTON of the New York Botanical Garden in straightening out this reference.

⁴⁵ Hedwigia 31: 294. 1892.

⁴⁶ Engler und Prantl Pflanzenf. 11: 364. 1897.

and therefore not mandatory. Fracidia, as shown above, was never raised to generic rank, and if it were to be it should be used for the species of Xylaria which FRIES first referred to it. KARSTEN might have used SACCARDO's subgenus Podocrea in 1892, but since he founded the new genus Podostroma five years before LINDAU raised Podocrea to generic rank, Podostroma should stand. Furthermore it is very doubtful if any of the three species first placed by SACCARDO in his subgenus Podocrea are generically the same as *Hypocrea alutacea*, although SACCARDO⁴⁷ suggests that *Podostroma* Karsten appears to be very like his section Podocrea.

In the light of this study, then, the name to be applied to *Hypocrea alutacea* (Pers.) Tul. with its principal synonymy would be as follows:

Podostroma alutaceum (Pers.) Atkinson.

Clavaria simplex p. p. Schmiedel. Icon. et Analyt. 18-26. *pl.* 4, *fig.* 2, *pl.* 5, *figs.* 1-3. 1762, according to Tulasne.

Sphaeria alutacea Pers. Observ. Myc. 2:66. no. 99. *pl.* 1, *fig.* 2, *a, b, c.* 1797. Comm. de fung. Clavif. 12. 1797.

Sphaeria clavata Sowerby. Eng. Fung. 2: *pl.* 159. 1799.

Sphaeria alutacea Alb. & Schw. Consp. Fung. Lusat. Sup. 1. 1805.

Sphaeria alutacea β *Sphaeria albicans* Pers. Syn. Method. Fung. 2. 1801.

Sphaeria alutacea Fr. and β *turgida* Fr. Syst. Myc. 2:325. 1823.

Cordyceps alutacea Link. Handb. z. Erkenn. der Gewächse 3:347. no. 5. 1833.

Cordyceps alutacea Fr. Summa Veg. Scand. 381. 1849.

Cordyceps alutacea Berk. Outlines Brit. Fung. 382. *pl.* 23, *fig.* 6. 1860.

Cordyceps alutacea Quélet. Champ. Jura et d. Vosges 487. 1869.

Hypocrea alutacea Tul. Selecta Fung. Carp. 1:62. 1861, and 3:35. *pl.* 4, *figs.* 1-6. 1865.

Hypocrea alutacea Peck. Rept. N. Y. State Mus. 26:84. 1894.

Hypocrea alutacea Cornu. Bull. Soc. Bot. de France 26:33-35. 1879.

Hypocrea alutacea Sacc. Syll. Fung. 2:530. 1883.

Hypocrea alutacea Winter, Rabenhorst's Krypt. Flora Deutschland, etc., Pilze 1²:142. 1887.

? *Podostroma leucopus* Karsten. Hedwigia 31:294. 1892.

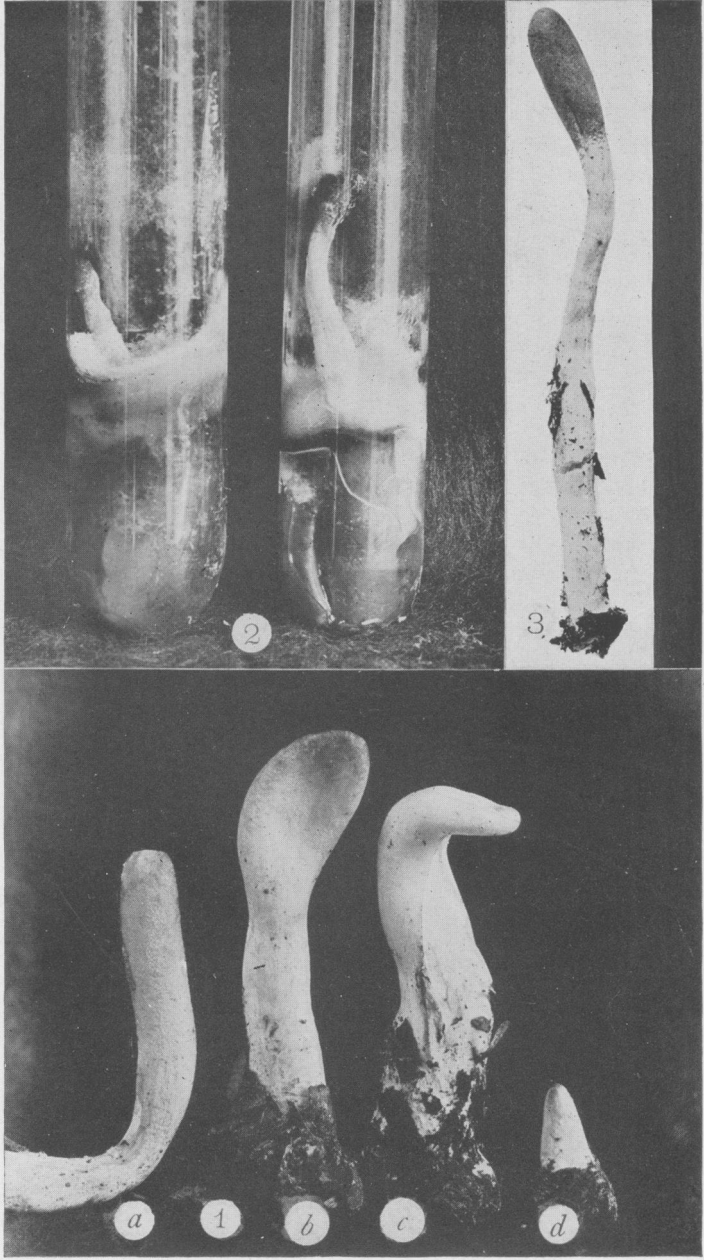
Hypocrea alutacea Schroeter. Krypt. Flora Schles., Pilze, Zweite Hälfte 3:272. 1894.

Podocrea alutacea Lindau. Engler und Prantl's Pflanzenf. 1¹:364. 1897.

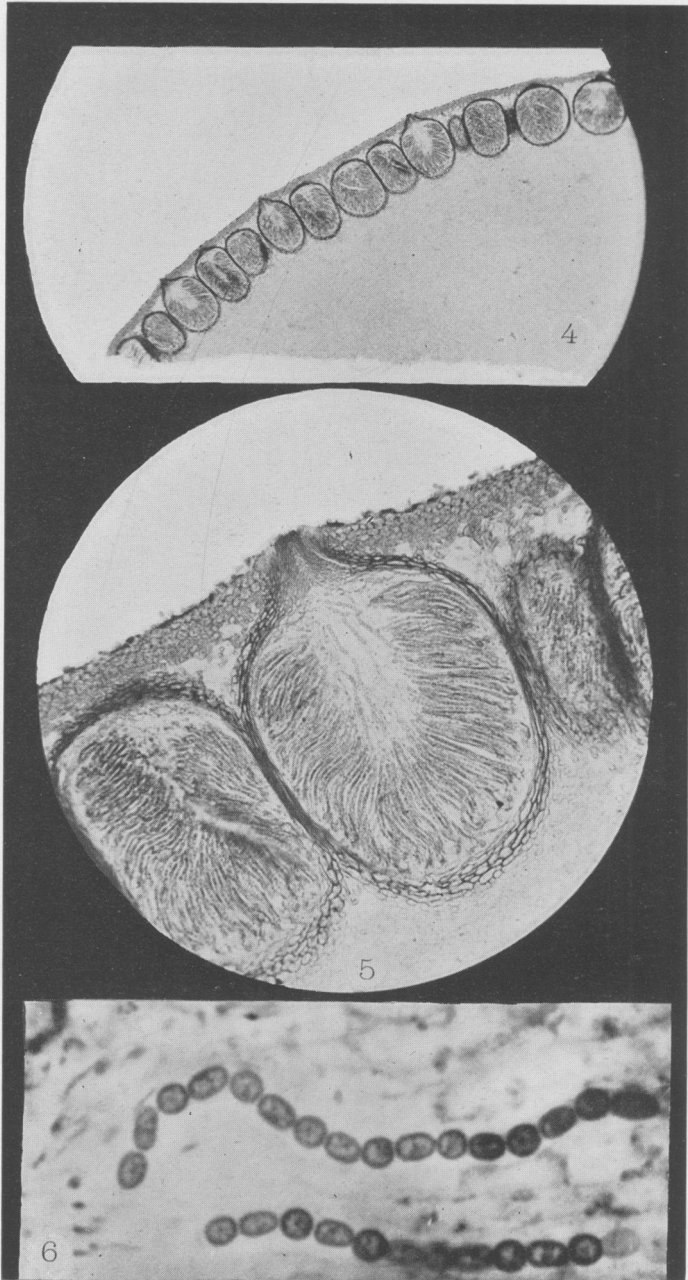
Hypocrea Lloydii Bresadola. Lloyd's Mycolog. Notes 9 (176):87. *fig.* 55. 1902.

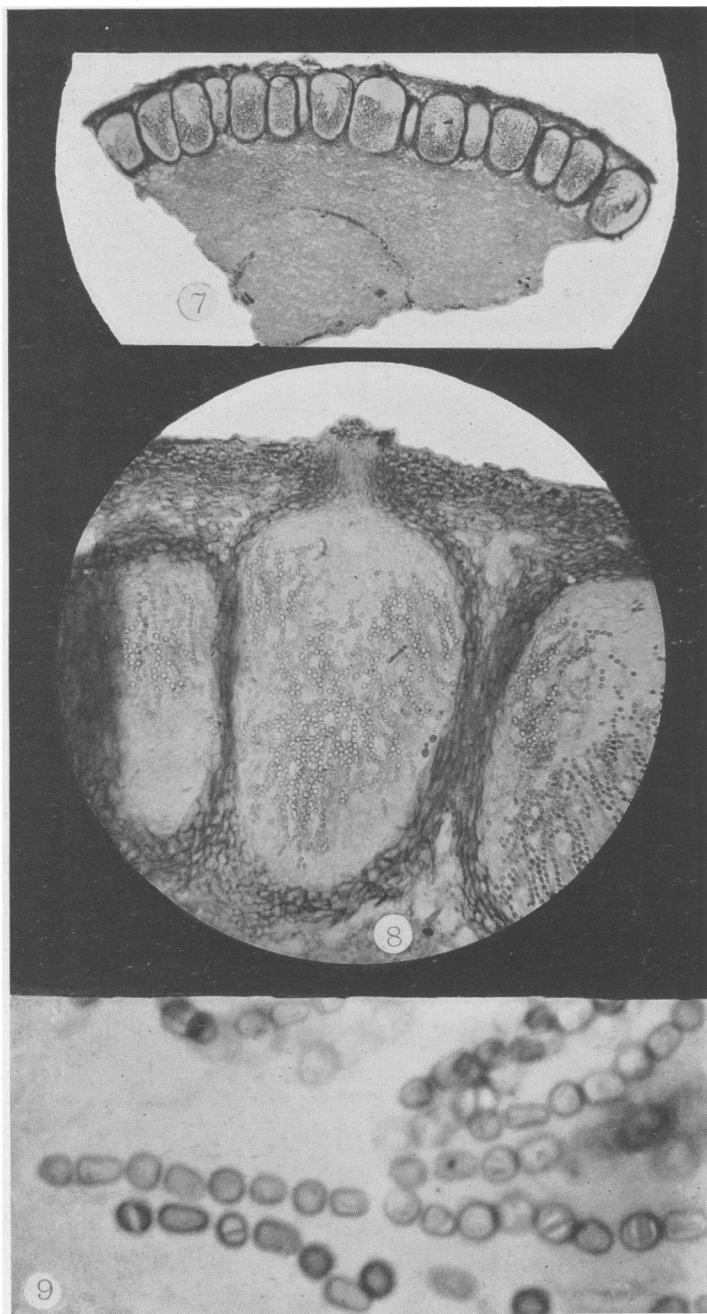
CORNELL UNIVERSITY, ITHACA, N. Y.

⁴⁷ Syll. Fung. 11:355. 1895.



ATKINSON on HYPOCREA





ATKINSON on HYPOCREA

EXPLANATION OF PLATES XIV-XVI.

The photographs and photomicrographs were made by the author, except *fig. 3* of *plate XIV* which was made from a print kindly loaned by Mr. C. G. LLOYD.

PLATE XIV.

FIG. 1. Plants collected at Ithaca on very rotten wood. *a*, *Clavaria* form; *b*, *Spathularia* form; *c*, abnormal form; *d*, young individual; real size.

FIG. 2. Pure culture in test tubes, parentage from *a* and *b* of *fig. 1*; real size.

FIG. 3. *Hypocrea Lloydii* Bresadola, from leaf mold; note that one-half of the stem was developed underneath the leaves and leaf mold, which makes the stem long; real size.

PLATE XV.

Photomicrographs from plants collected at Ithaca. In *figs. 4, 5* the plate-holder was 36^{cm} from the object, and in *fig. 6*, the plate-holder was 48^{cm} from the object.

FIG. 4 with Zeiss ocular 4, obj. 16^{mm}.

FIG. 5 with ocular 4, obj. 3^{mm}.

FIG. 6 with ocular 18, obj. 3^{mm}. Note the chain of 16 segments of the eight spores from a single ascus, beginning at apex of series at left, the segments alternate, globose or cuboidal, and oblong.

PLATE XVI.

Photomicrographs from type specimen of *Hypocrea Lloydii* Bresadola. In *figs. 7, 8* the plate-holder was 36^{cm} from the object, and in *fig. 9* the plate-holder was 48^{cm} from the object.

FIG. 7 with ocular 4, obj. 16^{mm}.

FIG. 8 with ocular 4, obj. 3^{mm}.

FIG. 9 with ocular 18, obj. 3^{mm}. Note form of the sixteen segments in the chain of 8 spores from one ascus, apex of series at left.