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A Revision of the Genus *Cordyceps*.

BY

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—*—
With Plates I and II.
—*—

THE genus *Cordyceps* is of special interest, alike to the mycologist and entomologist, on account of the species being parasitic on insects. The peculiar combination of plant and animal has attracted attention from early times, and has given origin to some remarkable ideas as to the assumed medicinal value of such unusual productions. The historical and romantic side of the subject has been dealt with quite recently by Dr. Cooke¹. Saccardo² has collected diagnoses of fifty-nine species, including three which are excluded in the present work: of these, seventeen are arranged under *species imperfecte cognitae*, and even in the case of many not included in the imperfectly described batch, the specific characters are too brief to ensure certainty of determination. In the majority of instances, this imperfection is not due to the absence of type or authentic specimens, but to the fact that a considerable number were described

¹ Vegetable wasps and plant worms; S. P. C. K., London (1892).

² Sylloge Fungorum, Vol. ii, p. 566, and Vol. ix, suppl.

[Annals of Botany, Vol. IX. No. XXXIII. March, 1895.]

many years ago, before microscopic detail was considered to be an important factor in the discrimination of species, and up to now, these imperfect diagnoses have not been revised. The determination of a very fine species, recently received from Australia, suggested the necessity of a revision of the genus, and the following is an attempt in this direction, so far as practicable from an examination of the rich collection in the Kew herbarium.

MORPHOLOGY.

A characteristic feature of the genus *Cordyceps* consists in the fact that the ascigerous condition always springs from a sclerotium, formed within the body of the insect on which the fungus is parasitic. In those instances where a conidial form is known, as in *C. militaris*, the sclerotium is present before the ascigerous phase appears, but is not so compact in texture, and has not so completely destroyed the internal organs of the host at this period as when the ascigerous condition is developed. The conidial and ascigerous conditions are not met with at the same period, and it is probable that a considerable interval elapses between the appearance of the two phases; a condition of things that would account for the ascigerous stage not immediately following the formation of conidia in artificial cultures.

When fully developed, the sclerotium has completely destroyed and replaced the internal structure of the larva on which it is parasitic, the skin alone remaining intact; structurally it consists of very compactly interwoven hyaline branched septate hyphae, replete with glycogen and minute oleaginous highly refractive globules; when dry it is very compact and hard, and of a whitish colour.

The ascigerous condition usually emerges from the sclerotium at a point between two segments of the skin of the host, and most frequently in the cervical region; it consists of an erect stem-like sterile portion, composed of a fascicle of irregularly parallel septate hyphae, white internally, the

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external or cortical hyphae being usually tinged with colour, and in many species giving off numerous short lateral branches, which form the minutely velvety or downy exterior of the stem. The fertile portion, described in systematic works as the 'head' or 'club,' is usually terminal on the stem-like sterile stroma, and varies in form in different species from globose to clavate or cylindrical; in some few species the fertile portion is situated below the apex of the stem, or several fertile branches spring laterally from the upper portion of the stem. In structure the ascigerous portion, like the stem, may be composed of more or less parallel septate hyphae; not unfrequently the hyphae coalesce laterally and the compound cells are of various lengths, but much of the hyphal origin is still evident; in a few species the coalescence of the hyphae is complete on all sides, and the septa more numerous, so that the component cells present a polygonal outline irrespective of the direction in which the section is taken, and consequently resemble a true parenchymatous tissue.

The perithecia always originate deep in the stroma, and stand side by side, their mouths reaching the surface of the stroma. In form the perithecia are ovate or flask-shaped, and may remain completely immersed, or at maturity be quite superficial, the whole of the perithecium being exposed, and attached to the stroma by the extreme base; transitional stages connect the two extremes. As a rule, when the perithecia are more or less free from the stroma, the surface of the head is rough, whereas when they are completely immersed, it is smooth; but a section is always necessary in cases where the surface of the head is smooth, as in some species where the perithecia are entirely superficial, only very slightly narrowed at the mouth, and closely crowded, they form an almost even surface, as if immersed.

The asci always contain eight spores, are very long and slender, have a slight swelling at the apex, and are hence described as capitate. The function of the capitate apex is to effect dehiscence when the spores are mature; at this

stage the contents of the head become swollen and the wall of the ascus is ruptured at the apex (Pl. I, Fig. 4).

The spores are almost as long as the ascus, and are arranged in a parallel fascicle which is slightly twisted on its axis, hyaline, very slender, multiseptate, rarely with few septa, or continuous; and after escaping from the ascus the multiseptate ones usually break up readily into their component cells.

Paraphyses are entirely absent.

The forms of *Isaria*, included at present in the Hyphomycetes, are supposed to be the conidial stage of species of *Cordyceps*, and in some instances there would appear to be little or no doubt on this point, although it has not been definitely proved by cultures in a single instance. Tulasne¹ has shown, from the evidence afforded by contiguity of development, that *Isaria farinosa*, Fr., is the conidial condition of *Cordyceps militaris*, Link. Atkinson² has recently studied the development of *Isaria farinosa*, Fr., in artificial cultures, and although some very interesting results were obtained, the ascigerous condition was not produced. The author concludes as follows: 'Several cultures on artificial media in culture-tubes have been made, but in no case has anything resulted which shows the perfect or ascigerous stage of the fungus. Upon nutrient agar, nutrient gelatine, and bean-stems, nothing but the cottony or fluffy growth, covered by the farinaceous fructification, appears. On potato this growth first appears, to be succeeded by the characteristic fructification of the *Isaria*-stage. The fact that the *Isaria*-stage will develop readily on various media such as described above, is evidence that it can develop readily as a saprophyte, and is thus more likely to be preserved in greater abundance and in wider distribution than if it were able to propagate itself only on insects.'

¹ Note sur les *Isaria* et *Sphaeria* entomogènes; Ann. Sci. Nat. Bot., sér. iv, Vol. viii, p. 35 (1857); also, *Torrubia militaris*, Sel. Fung. Carpol., Vol. iii, Pl. I, Figs. 19-31 (1865).

² Artificial cultures of an entomogenous fungus; Bot. Gaz., Vol. xix, p. 129, Pl. XIV-XVI (1894).

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The fact that *Isaria farinosa* can develop its characteristic fructification as a saprophyte on other than on insect substratum, demolishes the argument that those so-called species of *Isaria* not occurring on insects cannot be the conidial of species of *Cordyceps*.

Numerous species of *Cordyceps* have no correlated conidial form, and on the other hand, still more numerous forms of *Isaria* exist, which at present are not suspected of being connected with any known species of *Cordyceps*. Among the latter may be mentioned more especially *Isaria densa*, Fries, which has been brought into such prominence by the admirable researches of Giard¹. This fungus is parasitic on the larva of the cockchafer, known in different parts of France as *vers blancs*, *turcs*, *mans*, &c., and is well known as one of the most serious of insect scourges with which French agriculturists have to deal. Giard has clearly demonstrated, after years of patient research in the laboratory and in the field, that the conidia of *Isaria densa* can be utilized under certain conditions as an inoculation-medium, resulting in the wholesale destruction of the larvae.

The form-species of *Isaria* which can with the greatest amount of probability be considered as conidial conditions of species of *Cordyceps*, assume different forms of development, as shown by Atkinson and Giard, frequently appearing first as an effused, more or less velvety or cottony layer—the *Botrytis*-form,—and afterwards, influenced by unknown conditions, passing on to the more complex, erect or stipitate form known as *Isaria*; during this phase of development the sclerotium is formed within the body of the host, and finally the ascigerous form appears. Numerous species belonging to the form-genus *Isaria* are only known at present as saprophytes, growing on dead and usually more or less decomposed wood, bark, leaves, flowers, &c.; others are met with on decaying fungi or on dung; on the other hand, some species,

¹ *L'Isaria densa* (Link) Fries, Champignon parasite du Hanneçon commun (*Melolontha vulgaris* L.); Bull. Scient. de la France et de la Belg., Tom. XXIV, pp. 1-112, 4 pl. (1893).

as *Isaria fuciformis*, Berk., occur as true parasites under certain conditions, although usually developing as saprophytes, thus leading up to such truly facultative parasites as *Isaria farinosa*, the conidial state of *Cordyceps militaris*, and *Isaria densa*, which Giard has some reason for suspecting to be the conidial condition of *Cordyceps entomorrhiza*.

The genus *Hypocrea*—as understood in the broader sense—may be looked upon as the type of a number of genera, characterized as such more by the amount of facultative parasitism acquired by their respective conidial forms, than by any strictly morphological characters. The majority of species included in the genus *Hypocrea* are undoubtedly true saprophytes throughout the cycle of their development; at the same time, some exotic species, whose life-history is unknown, occur on a vegetable matrix which from appearances suggests parasitism, and in the case of certain species occurring on coriaceous leaves, there appears to be very little room for doubt on this point. *Epichloë*, an allied genus, is mainly characterized by having both the conidial and ascigerous condition developed in the form of a sessile, effused stroma on the culms of living graminaceous plants. In the genus *Claviceps*, parasitic on the fruits of graminaceous plants, we have a higher stage of development; a conidial condition first appears, followed by the formation of a compact, external sclerotium, which after a period of rest, produces the highly differentiated, stipitate ascigerous form of fruit. It remains to be explained why the members of the two genera last mentioned confine their attacks to plants belonging to the order Gramineae. *Cordyceps* differs mainly from the last-named genus in being parasitic on insects, and in the sclerotium being formed within the body of the host; the additional character of the spores breaking up into their component cells, as given by Saccardo¹, being of no value, inasmuch as the spores of some species of *Cordyceps* are continuous, as in *Claviceps*. The ascigerous condition of the

¹ Sylloge Fungorum, Vol. ii, p. 566.

species of *Cordylia* is morphologically identical with that of *Cordyceps*; the generic distinction turns on the absence of a true, compact sclerotium, and in being parasitic on subterranean species of fungi. Finally, the genus *Corallomyces* is in absolute morphological agreement with the ascigerous portion of those species of *Cordyceps* having large superficial perithecia, but differs in the absence of a sclerotium, and in being a true saprophyte.

The numerous forms of *Isaria* having no associated ascigerous stage have not been dealt with.

HOSTS.

As defined in the present work, all the species of *Cordyceps* grow on insects, and have been recorded as occurring on representatives of the following Orders: Hemiptera, Diptera, Lepidoptera, Hymenoptera, and Coleoptera. The larval condition of the insect is the most frequent host, especially such as bury themselves in the ground or amongst moss or vegetable *débris*, but different species occur on every stage of insect development; fewest being known to occur on the adult or imago condition, which however is by no means exempt from attack. Our knowledge respecting the various hosts is very incomplete, owing to their being in many instances beyond certain recognition when the fungus shows itself; and again, until recently it was considered sufficient to state that the fungus was parasitic on a chrysalis, caterpillar, moth, &c.

Gray¹ appears to have been among the first to attempt a determination of the various insects attacked by parasitic fungi, and to his researches we are indebted for the determination of certain hosts given under their respective parasites. The hosts are also enumerated, so far as determinable, in the excellent 'Host-Index' by Farlow and Seymour².

¹ Notices of insects which are known to form the bases of fungoid parasites. A Memoir, privately printed. London (1858).

² A Provisional Host-Index of the Fungi of the United States (1890-91).

The species of *Cordyceps* are spoken of as parasites, because it is known that in several instances the fungus attacks the insect while still alive; and in all probability this condition of things is the rule, although the fruiting stage may not be developed until after the death of the host.

DISTRIBUTION.

The genus is cosmopolitan, being best represented in temperate regions. Taking into consideration only the fifty-one fully described species, their distribution is as follows:—

Old world . . . 27 species.

New world . . . 29 species.

There are 22 species peculiar to the Old World, and 23 species peculiar to the New World, distributed as follows:—

Old World.

Europe, 8 species.

Asia, 5 „

Africa, 1 „ (Only 2 species recorded).

Australasia, 6 „ (Only 1 additional species recorded.)

East Indies, 2 „

New World.

North America, 9 species. (All from the United States.)

West Indies, 4 „

South America, 8 „

Six species are common to the Old and New World, viz. *C. clavulata*, *C. myrmecophila*, *C. entomorrhiza*, *C. militaris*, *C. sphingum*, *C. armeniaca*: all British except the last named.

C. entomorrhiza has the widest distribution of any known species, being recorded from Europe, Asia, Africa, United States, Australia, and New Zealand.

The Australasian species are remarkable for their gigantic size, as indeed are also the larvae on which they are parasitic. *C. entomorrhiza* is the only species found in this region that is not peculiar to it.

CLASSIFICATION.

From what has already been said relating to the structure and affinities of the genus under consideration, it is evident that two distinct factors—morphological and biological—are available as affording the basis of a systematic arrangement. If grouped from a morphological stand-point, the genera *Cordylia*, *Claviceps*, and *Corallomyces*, at least, would be absorbed in the older genus *Cordyceps*; this would necessitate the formation of subgenera, which are objectionable from every point of view; hence the biological character is here preferred, as limiting *Cordyceps* to those species parasitic on insects, the ascigerous condition arising from a sclerotium formed within the body of the host.

CORDYCEPS, Fries (emended).

Entomogenous. Conidial state forming an effused downy web, or an erect, clavate, simple or variously branched stroma, consisting of loosely compacted hyphae, which bear the hyaline, continuous, minute conidia at the tips of short branchlets. Ascigerous stage springing from a compact sclerotium formed within the body of the host; stroma differentiated into an erect stem-like, simple or branched, sterile portion, which bears at its apex the fleshy, globose or elongated ascigerous portion; rarely the sterile axis is continued above the ascigerous part, or several elongated fertile branches spring laterally from the erect, sterile stroma. Perithecia ovate or flask-shaped, either entirely immersed in the fleshy stroma, partly immersed, or quite superficial; asci very long, narrowly cylindric-clavate, slightly constricted just below the capitate apex, narrowed downwards into a long, slender base, 8-spored, not becoming blue with iodine; spores almost as long as the ascus, filiform, the apical third often slightly thickest, multiseptate, rarely continuous, hyaline, arranged in a parallel fascicle; more or less flexuous when free, and often breaking up into their component cells; paraphyses absent.

Cordyceps, Fries, Syst. Myc. ii, p. 323 (1823). Used as the name of a tribe of the Pyrenomycetes, including species at present included in the genera *Cordyceps* and *Xylaria*.—Sacc., Syll. vol. ii, p. 566 (excluding the species parasitic on fungi, which constitute the genus *Cordylia*, suggested by Tulasne—Sel. Fung. Carp. iii, p. 20).

Torrubia, Lév. The first mention of this name appears to be in Ann. Sci. Nat. ser. 3, p. 43, vol. xx (1853), where Tulasne refers to it in a footnote as follows: '*Torrubia*, Lév. (msc. in Herb. Mus. Paris).' The genus is first defined by Tulasne—Sel. Fung. Carp. iii, p. 4 (1865).

* *Perithecia* entirely or partly immersed.

† *Spores* septate.

1. *Cordyceps Barnesii*, Thwaites, Fungi of Ceylon, no. 977, in Linn. Soc. Journ., Bot., vol. xiv, p. 110 (1875); Sacc., Syll. ii, no. 5052. (Plate II, Figs. 19-26.)

Stem cylindrical or slightly thickened at the base, minutely velvety, brown, 3-5 cm. long, 2 mm. thick, often flexuous or angularly crooked, simple or rarely forked; head 1-2 cm. long, 3-4 mm. thick, simple, apex acute, smooth, dotted with the mouths of the densely crowded perithecia when seen under a pocket-lens, 2-3 mm. at the acute apex usually but not always sterile; asci cylindrical, apex capitate, base narrowed into a short pedicel, 8-spored; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, straight or slightly curved when free, 3-septate, $120 \times 2 \mu$, readily breaking up into the four component cells which are slightly rounded at the ends, 30μ long.

Conidial stage. Several of the specimens have the head covered with conidial-bearing branches instead of perithecia; these branches are erumpent, like the perithecia, and towards the base of the head are slender, very irregularly branched, about .5 mm. thick, white, each branchlet bearing at its apex a globose or piriform head, about 1-1.5 mm. across, which is densely covered with minute, hyaline conidia, $2 \times 1 \mu$ diameter. The branches become shorter and less branched higher up the

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head, while at the apex they are short and unbranched, bearing a single head at the apex, but this is probably only due to their being younger, the development of the branches being acropetal. The branches consist of very slender hyphae running parallel to the long axis of growth, and expanding like a brush to form the apical head, each hypha bearing a chain of conidia at its tip, the terminal ones becoming free. So far as I can ascertain from the material at hand, the perithecia follow the conidial development on the same head, but on this point I am not certain.

Ceylon (Thwaites, no. 1120 with sketch).

Thwaites' note accompanying the specimens runs as follows. 'Peradeniya, Dec. 1868. Parasitic upon the larvae of a lamellicorn insect (one of the Melolonthidae), which feeds upon the young roots of coffee and other plants. No. 1120. Please call this *Cordiceps Barnesii*, B. and Br., after my friend E. H. Barnes, Esq., who first directed my attention to it.'

The specimen from Ceylon, 'on larvae of some lamellicorn insect at the roots of coffee-trees, Bolagodde,' (Thwaites), and referred by Berkeley to *Cordyceps sobolifera*, Fungi of Ceylon, no. 978, proves to be *Cordyceps Barnesii*; hence there is no proof of the extension of *C. sobolifera* from its Western home to Ceylon.

2. *Cordyceps palustris*, Berk., Journ. Linn. Soc., vol. i, p. 159, tab. 1 (1857); Sacc. Syll. ii, no. 5018; Ellis & Everh., N. Amer. Pyrenom. p. 61. (Plate II, Figs. 1-6.)

Stem 1-3 cm. high, 3-4 mm. thick, simple or divided into 2-4 short branchlets, even, glabrous, brown; ascigerous portion 1-2 cm. long, wider than the stem, obtusely cylindrical-ovate, dull brownish-purple or flesh-colour, minutely rough with the slightly projecting mouths of the perithecia; asci elongated, narrowly cylindrical capitate, tapering below into a long, slender pedicel, 8-spored; spores arranged in a parallel fascicle, slightly curved, filiform, ends narrowed, hyaline, multiguttulate, then multiseptate, septa thick, 100-120 × 1 μ, component cells 1.5 μ long.

On moist, putrid logs, growing singly from the larva of some coleopterous insect. On *Hexapoda*, sp. indet. (Host-Index, p. 182).

Northampton Swamp, S. Carolina, May. (Ravenel, no. 718).

Type specimen, in Herb. Kew., examined.

The perithecia are cylindrical, narrowed at the base when mature, and in reality quite superficial, but owing to being densely crowded and the mouths somewhat obtuse, they appear, when examined with a pocket-lens, to be almost completely immersed in the substance of the stroma. The spores are at first filled with highly refractive oil-globules, and afterwards become multiseptate. I have not seen the spores break up into their component cells, and Berkeley did not intend to convey this idea, as interpreted by Saccardo and Ellis, but meant that the contents became broken up by septa into small parts. Iodine does not colour the asci blue.

3. *Cordyceps insignis*, Cke. and Rav., Grev. vol. 12, p. 38 (1883); Cooke, Veg. Wasps and Plant Worms, p. 170, pl. 1, fig. 3; Sacc., Syll. Suppl. v. ix, no. 4002; Ellis and Everh., N. Amer. Pyren. p. 63.

Stem 3-4 cm. long, $\frac{3}{4}$ cm. thick, equal, pallid, sulcate (obviously due to shrinkage during drying), very minutely velvety at the base; head broadly ovate, livid purple (when dry), 1.5 and 1 cm., very slightly scabrid from the mouths of the narrowly ovate, completely immersed perithecia; asci narrowly cylindrical, slightly constricted below the capitate apex, narrowed below into a slender, stem-like base, 8-spored; spores arranged in a parallel fascicle slightly twisted on its axis, hyaline, filiform, multiseptate, wavy when free, $170-180 \times 1.5 \mu$, component cells 6-7 μ long, separating readily at maturity.

On larvae buried in the ground. S. Carolina (Ravenel, no. 3251). On *Hexapoda*, sp. indet. (Host-Index, p. 182).

Ravenel's label accompanying the specimen is as follows:
'I found but a single specimen of this and have divided the

stipe and capitulum, retaining half. I send the whole of the large larva. The colour is pretty well preserved. I have seen several insect *Cordyceps* here, but this differs from anything I have seen. On dead larva buried in ground. Seaboard of S. C., April 1881. H. W. Ravenel.'

Type specimen in Herb. Kew.

Cooke, in describing the present species, says the asci are $600\ \mu$ long, and the spores $450\ \mu$ long, component cells $12\ \mu$ long. These measurements are wrong, being much too large, and probably due to a mistake as to the objective used during examination. The asci in reality measure $200-225 \times 7-8\ \mu$.

4. *Cordyceps Puiggarii*, Speg., Fung. Fueg. no. 304, in Bol. Acad. Nacional Cord. 1888; Sacc., Syll. Suppl., vol. ix, no. 4010.

5. *Cordyceps alutacea*, Quélet, Champ. Jura et Vosges, in Mém. Soc. d'Emulat. de Montbéliard, 1875, p. 57; Sacc., Syll. ii, no. 5023.

Growing among the leaves of *Pinus sylvestris*.

Distrib.—France.

In a footnote Quélet says that in texture and fructification this species closely approaches the genus *Hypocrea*.

6. *Cordyceps sobolifera*, Berk. and Broome, Fungi of Ceylon, no. 978; Sacc., Syll. no. 5021.

Clavaria sobolifera, Hill, Watson and Hill in Phil. Trans., vol. 53, p. 271, tab. 23 (1763).

Sphaeria sobolifera, Berk., Lond. Journ. Bot. vol. ii, p. 207 (1843).

Torrubia sobolifera, Tulasne, Sel. Fung. Carp. iii, p. 10, t. 1, figs. 32, 33.

On the larva of a beetle, probable one of the Melolonthidae.

Distrib.—Dominica; Martinique; Guadaloupe; S. America, with a note on label, as follows: 'On a larva which destroys the cotton crop in S. America.'

7. *Cordyceps sphaecocephala* (Kl.).

Cordyceps sphaecophila, Berk. and Curt., Fung. Cub. no.

751, in Linn. Soc. Journ., Bot., vol. x, p. 376 (1869); Sacc., Syll. ii, no. 5015.

Torrubia sphecocephala, Tul., Carpol. iii, p. 16, t. 1, figs. 5-9 (1865).

Sphaeria sphecocephala, Klotzsch, in Herb. Hook., Kew; this name is adopted by Berkeley—On some Entomogenous Sphaeriae; Lond. Journ. Bot., vol. ii, p. 205 (1843)—with the following explanation: 'The name given to it by Klotzsch with the authority of Künze attached to it, is clearly a wrong transcription of Künze's name in Myc. Hefte, for a somewhat analogous form of *Sp. militaris*; viz. *S. sphaerocephala*. It is, however, so good that I have retained it.'

The word *sphēcophila* was introduced by Berkeley in his mention of the species in Fung. Cuben., no. 751, presumably by mistake, and this name has been taken up by Saccardo—Syll. ii, no. 5015.

Exsicc.—Fung. Cubens. Wrightiani, no. 751.

Parasitic on wasps.—species of *Vespa* and *Polybia*.

Distrib.—Jamaica (Dr. Bancroft); Cuba (Wright); St. Vincent, collector not noted; Brazil (Glaziou, no. 18778 a).

8. *Cordyceps myrmecophila*, Cesati, in Klotzsch, Herb. Myc., no. 1033 (1846); Cesati, Comm. Critt. Ital. i, p. 61, t. iv, fig. ii (1861); Nyl., Obs. Pez. Fenn. p. 88, pl. ii, fig. 4 (1868).

Exsicc.—Klotzsch, Herb. Myc. Ed. nova, cura Rabenh. Ed. i, no. 1033; Ed. ii, no. 719; Rab.-Winter, Fung. Eur. no. 3649.

Growing on *Formica rufa*, also on undetermined species belonging to the Coleoptera and Hymenoptera.

Distrib.—Britain; Finland; Italy; Switzerland; U. States; Brazil; Ceylon; Borneo.

9. *Cordyceps curculionum*, Sacc., Mich. i. p. 320 (1879); Syll. ii, no. 5013.

Torrubia curculionum, Tulasne, Carpol. iii, p. 20 (1865).

Parasitic on *Heilipus celsus*, Schoen.

Near Lima, Peru.

10. *Cordyceps Wallaysii*, Westend., Ac. Soc. Bot. Belg., vol. vii, p. 81, fig. 21 (1859); Sacc., Syll. ii, no. 5014.

On the undetermined larva of some insect, attached to grass.

Distrib.—Belgium (Westendorp).

11. *Cordyceps cinerea*, Sacc., Mich. 1, p. 320 (1879), Sacc., Syll. ii, no. 5026.

Torrubia cinerea, Tul. Carpol. i, p. 61 (1861); iii, p. 16, pl. i, fig. 11 (1865).

Exsicc.—Rabenh., Fung. Eur. no. 1010.

On larvae and perfect insects of species of *Carabus*.

Distrib.—France; Germany.

12. *Cordyceps unilateralis*, Sacc., Syll. ii, no. 5027.

Torrubia unilateralis, Tulasne, Carpol. iii, p. 18, pl. 1, figs. 3-4 (1865).

Growing on an ant—*Atta cephalotus*, Fabr.

The specimen described by Tulasne came from Brazil, and a specimen in Kew Herbarium was collected by Professor Trail, F.R.S., in the same country, and growing on the same species of ant.

13. *Cordyceps australis*, Speg., Fung. Arg. Pug. iv, p. 80, no. 208; in Ann. Soc. Cient. Argentina (1880); Sacc. Syll. ii, no. 5028.

Growing on an ant—*Pachycondyla striata*.

Apiahy, Brazil (Dr. Puiggari).

14. *Cordyceps martialis*, Speg., Fung. Puigg., no. 305; in Bol. Acad. Sc. Córdoba (1889), Sacc., Syll. Suppl. vol. ix, no. 4011.

On the larva of some member of the Cerambicidae, near decaying stumps.

Distrib.—Apiahy, Brazil.

15. *Cordyceps goniophora*, Speg., Fung. Puigg., no. 307; in Bol. Acad. Cient. Cord. (1889), Sacc., Syll. Suppl. vol. ix, no. 4012.

On the decayed body of a species of *Mutilla*; among moss.
Distrib.—Aphiahy, Brazil.

16. *Cordyceps Ditmari*, Quélet, Soc. Bot. France, p. 330—xxxviii, pl. vi, fig. 14, séance du 22 Oct. 1877; Sacc., Syll. no. 5024.

On wasps and flies.

Distrib.—France; Germany; Ireland.

Quélet says that the fungus called *Isaria sphecophila*, Ditmar, in Sturm's *Deutschl. Flora*, iii, p. 115, tab. 57, is the conidial form of the present species, and hence called it *Cordyceps Ditmari*. I have received a *Cordyceps* agreeing exactly with Quélet's description, and accompanied by *Isaria sphecophila*, Ditm. from Ireland, collected by Dr. McWeeney. It was growing on the remains of a large bluebottle-like fly.

17. *Cordyceps larvicola*, Quélet, Bull. Soc. Bot. France, tom. xxv, p. 292, pl. iii, fig. 1 (1878).

Cordyceps Helopis, Quélet, Bull. Soc. Bot. France, tom. xxvi, p. 235 (1879); Sacc., Syll. ii, no. 5025.

On the larva of *Helops caraboides*, Panz.

Distrib.—France.

The present fungus was first described by Quélet as *C. larvicola*, growing on some undetermined larva. The year following this the same fungus was collected by Boudier, and its host determined as *Helops caraboides*, Panz. Thereupon Quélet re-described the fungus, calling it *C. Helopis*, giving *C. larvicola* as a synonym. The oldest name is restored in the present work.

18. *Cordyceps stylophora*, Berk. and Broome, Journ. Linn. Soc., Bot., vol. i, p. 158, pl. i (1857); Sacc., Syll. ii, no. 5017; Ellis and Everh., N. Amer. Pyren. p. 61. (Plate II, Figs. 40–42.)

Exsicc.—Rav., Fung. Car. Exs., Fasc. v, no. 49.

Solitary; entirely tawny when dry; stem 1.5–2.5 cm. high, 1.5–2 mm. thick, straight or flexuous, velvety or sometimes almost strigose at the base, longitudinally wrinkled when dry; head cylindrical, 1–1.5 cm. long, 2.5–3 mm. thick, almost

ion of

f *Mutilla*; among moss.

. Bot. France, p. 330—
Oct. 1877; Sacc., Syll.

id.

Isaria sphaecophila, Dit-
p. 115, tab. 57, is the
s, and hence called it
l a *Cordyceps* agreeing
accompanied by *Isaria*
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ull. Soc. Bot. France,

. Bot. France, tom. xxvi,

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scribed by Quélet as
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vaboides, Panz. There-
, calling it *C. Helopis*,
he oldest name is re-

d Broome, Journ. Linn.
Sacc., Syll. ii, no. 5017;
(Plate II, Figs. 40-42.)

c. v, no. 49.

stem 1.5-2.5 cm. high,
, velvety or sometimes
dinally wrinkled when
2.5-3 mm. thick, almost

the Genus *Cordyceps*.

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smooth, marked with minute depressions corresponding to the mouths of the immersed, scattered perithecia; the apex of the head runs out into a slender, pointed, sterile, spine-like prolongation 1-1.5 cm. long; asci cylindrical, very slightly narrowed below the slightly capitate apex, 8-spored; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, slightly curved when free, multiseptate, $125-135 \times 1 \mu$, the component cells about 3.5μ long.

On *Hexapoda*, sp. indet. (Host-Index, p. 182). On larvae buried in rotten logs. South Carolina (Ravenel, no. 1325).

Type specimen in Herb. Kew., examined.

A remarkable species, characterized by the long, slender, sterile apiculus, continuing beyond the apex of the fertile head; or in other words, the fertile portion—head—occupies about the median third of the stem. This character appears to be constant, being present in each of the eight specimens sent by Ravenel to Berkeley, several being fertile and in a fine state of preservation. The specimens in Ravenel's Exsicc. are poor and scanty.

19. *Cordyceps gentilis*, Sacc., Syll. ii, no. 5020.

Torrubia gentilis, Cesati, Myc. Borneo, in Mem. Acad. Neapol. p. 14 (1879).

Growing on a wasp.

Distrib.—Sarawak, Borneo (Beccari).

20. *Cordyceps Hawkesii*, Gray. Notices insect bases of fungi, pl. v, figs. 10-12 (1858); Grev. vol. xix, p. 76; Sacc., Syll. Suppl. vol. ix, no. 4013.

'The caterpillar may be that of a species of *Pielus*, or of some closely allied genus.'

Distrib.—Tasmania (Hawkes).

21. *Cordyceps Forquignoni*, Quélet, xvi Suppl. Champ. Jura et Vosges, p. 6, t. 21, fig. 18; Sacc., Syll. Suppl. ix, no. 4007.

On *Musca rufa* or *Dasyphora pratorum*.

Distrib.—France.

