STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate I and 3 Text-figs.)

IV. SOME CEYLON CORDYCEPS.

By T. Petch, B.A., B.Sc.

In the Fungi of Ceylon, Berkeley and Broome enumerated five species of Cordyceps, two of which were new, viz. C. Barnesii and C. dipterigena. As was pointed out by Massee, one of the five records was based on a misidentification; the specimen attributed to C. sobolifera being C. Barnesii. Massee added two other species to the Ceylon list, but in both cases the identification appears to be incorrect. During recent years, further species have been collected, bringing the total known Cordyceps of Ceylon to ten. In addition, several species of Isaria are known, of which the perfect stage has not yet been observed.

The localities in Ceylon from which species of Cordyceps have been recorded are, at least as far as relates to the species found on the ground or in rotting wood, chiefly in the higher districts. It is possible that an observer stationed in the low-country might be more fortunate in obtaining these fungi there than I have been, but even at Peradeniya (1600 ft.) they have been very rare during the last eighteen years. I have only one record from Peradeniya, viz. a single specimen of C. Barnesii. This distribution coincides with that of the subterranean fungi, Hydnangium, Rhizopogon, and Hymenogaster; and one is inclined to associate it with the absence of those keen mycophagists, the termites, from the higher regions of the hill country.

Cordyceps dipterigena, C. unilateralis, C. Blatta, and "Isaria crinita," are invariably found attached to living leaves or stems. The first two of these have been collected in the low-country, and I. crinita at a medium elevation. When the first three of these occur on living leaves they are always attached to the under surface, and a similar condition prevails in the case of spiders attacked by Torrubiella flava, Gibellula elegans, etc., the
insect being fastened to the leaf by strands or pads of hyphae round its feet, or by a weft of hyphae from its body. It would appear to follow that the hyphae of the fungus grow out from the insect and fasten it to the leaf before it dies; otherwise the insect would fall off when it died. Consequently, it would appear that the occurrence of the insects in the position described is evidence against the theory that these fungi grow on their several hosts only after the death of the latter.

*Cordyceps* *dipterigena*, *C. unilateralis*, *C. myrmecophila*, and *Isaria crinita*, contrary to the more general rule in *Cordyceps*, develop from the perfect insect. *C. Blattaee* might be included with these, as, although the cockroach bears fertile clavae in the nymphal stage, it is nevertheless an active stage.

*C. unilateralis* has been found in Ceylon on one occasion only, and not by a mycologist; yet three specimens were obtained, one on each of three leaves. As, however, ants are gregarious, it might be expected that several would be infected at the same time. *C. dipterigena* has been collected on several occasions, and it is usually possible, when one has been found, to obtain several others, up to twenty, by a careful examination of neighbouring bushes. The latter fact suggests that the insects are infected when they are in close association, i.e. in the larval stage, and that the clavae do not develop until the insect is mature.

**CORDYCEPS.**

A. Perithecia immersed in the Stroma.

*Cordyceps Barnesii* Thwaites. This species (Plate I, fig. 1) was described by Berkeley and Broome in *Fungi of Ceylon*, No. 977, the name being suggested by Thwaites in honour of Mr R. Barnes, who first called his attention to it. The fungus occurs on cockchafer grubs, and it was apparently common in the days of coffee in Ceylon, when “grub” was one of the coffee-planters’ enemies. There is an abundance of Ceylon material in Herb. Kew and specimens in Herb. British Museum and Herb. Peradeniya, all collected by Thwaites, while Beccari collected it in the Botanic Gardens, Peradeniya, when he passed through Ceylon on his way to Borneo. At the present day, however, it appears to be rare, and I have obtained only one recent specimen.

Berkeley and Broome’s description is “Stipite cylindrico velutino: clavula cylindrica, apice sterili; conidiiophoris ramosis stilboideis candidis, capitulis globosis (no. H20, cum icone). On larvae of *Malolontha*. Conidia 0000 [inch] long.”

The fungus (clava) attains a height of 6 cms., but it is not conspicuous. The stalk is fuscos or blackish brown, rather paler towards the base, the ascigerous part sordid reddish
brown, and the sterile tip pale yellow or whitish. The fungus consequently has a somewhat dingy appearance.

The stalk is cylindric, up to 2 mm. diameter and 4·5 cm. high, glabrous. The "minutely velvety" of the original description, and the strigose appearance depicted by Massee, relate only to that part of the stalk which is embedded in the soil and is consequently somewhat tomentose or clothed with fibrils. The head, or perithecial region, is sharply differentiated from the stalk, being abruptly thicker, 3-5 mm. diameter; it is 8-15 mm. long, with the upper and lower edges rounded and usually oblique, or incised on one side, not symmetrical. Above the perithecial region there is usually a sterile conical apex, up to 5 mm. long.

When fresh, the perithecia are completely immersed and the head is smooth, but in dried specimens the ostiola project slightly and the head is rough. The perithecia are conoid, 0·35 mm. deep, 0·15 mm. diameter, with a yellowish-brown wall. The asci are cylindric, capitate, very shortly pedicellate, eight-spored, 160-220 × 8-10 μ. The spores are linear, as long as the ascus, in a parallel bundle, and divide into part-spores which are very variable in length. In some asci the part-spores are 30-40 × 2 μ; in others, they are only 9-12 × 2 μ. This variation occurs both in Thwaites's specimens and in that recently collected. It appears to be not an uncommon phenomenon in the case of linear ascospores which divide into part-spores when mature.

The conidial stage of this species differs completely from that usually associated with Cordyceps. It was briefly described by Berkeley and Broome, and was figured by Massee, but that such a conidial stage can belong to a Cordyceps has been generally overlooked. The immature clavae bear scattered, white, stilboid conidiophores. These may be simple, up to 1 mm. high, or repeatedly branched at a wide angle, up to 4 mm. high, the branches terminating in ovoid, compact heads, 0·1-0·2 mm. diameter. The stalk of the stilboid conidiophore is composed of parallel hyphae; and these separate at the apex, or at the apices of the branches, to produce a normal Stilbum head of conidia. The conidia are hyaline, globose, 0·75 μ diameter, or oval, 1·5-2 × 0·75-1 μ, adherent in a solid mass. When the head is bearing perithecia, these stilboid conidiophores may still be present on the conical tip. A similar conidial stage occurs in Cordyceps falcatula (Plate I, fig. 12).

In Fungi of Ceylon, No. 978, Berkeley and Broome recorded for Ceylon, C. sobolifera Berk., "on larvae of some lamellicorn insect at the roots of coffee-trees. Bolagodde." As previously noted by Massee, the specimens are C. Barnesii.

Cordyceps gracilis (Grev.) Dur. and Mont. A single specimen (Plate I, fig. 2), which appears to be referable to this species,
Cordyceps coccinea Penz. and Sacco. This species, which was originally described from Java, has been found at Hakgala, Ceylon, on a coleopterous larva in decaying wood. Several clavae arise from the one larva.

The clava (Plate I, fig. 3) is up to 13 mm. high, with an orange-red head, and a stalk of the same colour, becoming paler below. The stalk is terete, glabrous, 0.3-0.4 mm. diameter, becoming horny-looking and dark red-brown when dry. The head is ovoid-cylindric, 3-4 mm. high, 1.25-1.75 mm. diameter, rough with rounded protuberances, up to 0.15 mm. high, in which the ostiola are situated. In section, by transmitted light, the peri-
ospheral layer is yellow-brown. The perithecia are immersed, crowded, elongated flask-shaped, 0.35 mm. high, 0.1 mm. diameter. The asci and spores are of the typical *Cordyceps* character, the part-spores being cylindric, 2-4 × 1 μ.

This differs from *C. militaris* in its immersed perithecia. The perithecia in the Ceylon specimens are more crowded than in Penzig and Saccardo's figure.

**Cordyceps dipterigena** B. and Br. This species was described by Berkeley and Broome in *Fungi of Ceylon*, No. 980, as "Pallida, stipite cylindrico; capite globoso; ostiolis inconspicuis. Sept. 1864. About 1½ inch high." The latter figure is probably a misprint for half an inch. Cooke, *Vegetable Wasps and Plant Worms*, p. 226 (1892), refers to this species, but he does not appear to have seen a specimen, as he quotes the height as an inch and a half without comment.

Massee (in *Ann. Bot.* ix, p. 20) gave a fuller description as follows: "Gregarious; stems simple, 4-1 cm. high, 1 mm. thick, cylindrical, smooth and even, pallid, head globose, smooth, pallid, about 3 mm. across; asci cylindrical, narrowed below into a long, slender pedicel, apex capitate, 8-spored; spores arranged in a parallel fascicle in the ascus, hyaline, filiform, multisep tate, slightly constricted at the septa, and apparently always breaking up into the component cells, which are linear-elliptic, ends narrowed, truncate, hyaline, 10 × 1.5 μ, before leaving the ascus. On dipterous insect. Ceylon (Thwaites). Type specimen in Herb. Kew., examined." Massee figured two clavae arising from an adult fly, but as far as can be determined, they are shown as growing from the under surface of the insect, which is the reverse of the usual position.

This species has been found on several occasions in the jungle at Hakgala (5600 ft.), always on flies of the genus *Mydaea*. The dead insects are situated on the under side of living leaves, or on small twigs, to which they are attached by a fimbriate, rather coarse, rufous brown border of mycelium. It has also been found at Ratnapura, in the low-country, on a fly of the same genus; and one of Thwaites's specimens is also from the low-country (Pasdun Korle).

Typically, the dead fly bears two perithecial clavae (Plate I, fig. 4), symmetrically situated, one on either side of the thorax, and a conidial clava from the tip of the abdomen. The conidial clava, however, is often absent. I have gathered a specimen with three immature perithecial clavae arising from the thorax, but have not met with one having any greater number. As a rule the clavae are simple, but the specimen from Ratnapura bears two immature perithecial clavae, one of which has two short lateral branches.
logical Society.

The perithecial clavae are up to 6 mm. high, and consist of a well-defined stalk, about 0-3 mm. diameter, and a flattened-globose head, up to 2-5 mm. diameter. The stalk may be so short that the head appears to be sessile, and, in general, the long-stalked examples have the smaller heads. Immature examples are pallid or greyish white, but when mature the stalk is dark brown to black, longitudinally fibrillose, usually expanding upwards, while the head is yellow-brown to red-brown, glabrous, with darker, subtranslucent, scattered ostiolar which may or may not project. The head is sharply differentiated from the stalk, and may have a flat base, or is sometimes umbilicate below.

The conidial clava is usually longer, up to 2 cm. long, and 0-25 mm. diameter, almost equal. At first it is brown with a white bloom, but becomes dark brown to black, grey at the apex, usually irregularly bent in the upper part. Conidia are present in the early stage, before the clava has become dark brown; they are clavate, or almost cylindric, 6-9 x 1-5-2 μ, and are borne on cylindric, verrucose basidia, 16 x 2 μ, which form a continuous external palisade layer.

In the larger specimens the head is generally flattened-globose, even, with the margin uniformly rounded above and below; but examples occur which are verrucose with strongly projecting ostiolae, and others in which the vertical edge is grooved or fluted. The specimens with smaller heads show more variation. In several examples the head is barrel-shaped, i.e. taller than usual relatively to the breadth, with a convex, vertical side and a flat top; or it may be of the same general shape, but contracted upwards so that the top is smaller than the base (Plate I, fig. 5). In these latter forms, the ostiola are confined to the flat top, and the fungus is then C. Ouwensii van Höhnel, which is certainly identical with C. dipterigena. In one extreme variation the head consists of a digitate group of six, almost distinct, perithecia (Plate I, fig. 6).

The perithecia are immersed, vertical, crowded, elongated oval or obtusely flask-shaped, up to 0-8 mm. high, 0-25 mm. diameter, occupying almost the whole of the head, except for a small white region at the base. The wall of the perithecium is thin and hyaline. The ascus are cylindric, capitate, 250-500 μ long, 5 μ diameter, and contain eight filiform spores, almost as long as the ascus, in a parallel bundle. The part-spores are narrow-oval, ends obtuse, 4-6 x 1-1-5 μ. Massee's measurement of the part-spores appears to be too large, while his figure of the perithecium has no resemblance to reality.

In Herb. Kew, sub Cordyceps dipterigena, there is a specimen from Ceylon—a fly which bears nine immature perithecial
clavae. This was marked by Massee, "not dipterigena," and it is apparently the Ceylon specimen referred by him to C. albella (B. and C.). It was named C. Thwaitesii by Lloyd, but, as Thaxter has pointed out, it is C. dipterigena, though it differs from all other Ceylon specimens in having such a large number of perithecial clavae. Like the recent Ceylon specimens, it is on a species of Mydaea.

Massee (loc. cit. p. 23) also recorded for Ceylon, C. armeniaca, on a coleopterous insect. The Ceylon specimen in Herb. Kew appears to be C. dipterigena on the remains of a fly.

In Trans. Brit. Myc. Soc. vii, p. 28 (1921), I suggested that C. coccigena (Tul.) Sacc. really grew on a fly and was identical with C. dipterigena. I have since found that the similarity of the two species was noted by von Höhnel.

Specimens of C. dipterigena are frequently parasitised, either by another Hypocreaceous fungus, Byssostilbe tomentosa Petch, or by a Hyphomycete, Sporotrichum album Petch.

C. muscicola Möller would appear to be identical with C. dipterigena. Möller's figure shows six clavae arising from one fly.

Cordyceps myrmecophila Ces. This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 979, from Thwaites 1218, cum icone. They gave a description of the species, as follows: "C. myrmecophila Ces. (sub Hypocrea); Rab. (no. 1033). Ochroleuca: stipite filiformi tenacello; clavula ovoidea ad basin sterili, superne costata acutiuscula, e peritheciiorum summo ostiolo, gibberulosa. On dead ants."

There is no Thwaites's specimen in Herb. Peradeniya, and none has been collected recently. The figure (Plate I, fig. 7) shows a specimen, 3 cm. high, with a flexuose stalk, 0.2 mm. diameter, and an ovoid, somewhat pointed, head, 3.5 mm. high, 1.5 mm. diameter. The whole fungus is pale yellow. The coloured drawing shows the head smooth, but a separate pencil drawing, unfortunately not enlarged, shows longitudinal ribs and projecting ostiola.

The description given by Berkeley and Broome does not coincide with that in Saccardo, Syll. ii, p. 586, but is the same as that quoted by them in Ann. Mag. Nat. Hist. Ser. 2, vii, p. 186 (1851), when recording the occurrence of C. myrmecophila on an Ichneumon, at Leigh Wood, Somerset. It was not drawn up from the Ceylon specimen, as might be imagined from its inclusion in the Fungi of Ceylon without quotation marks.

In shape, the Ceylon drawing is similar to the figure of C. australis Speg., given by Möller, and that of C. depokensis Koord.

Cordyceps unilateralis (Tul.) Sacc. var. javanica von Höhnl. Three examples of this species were collected together at Anur-
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adhapura, in the low-country, on ants attached to living leaves. A single clava arises in each case from the head of the insect. The insect is sparsely covered with brown mycelium which fastens it to the leaf chiefly at the feet (Plate I, fig. 9).

The clava is up to 12 mm. high, thin and flexuose, 0'4 mm. diameter below, tapering upwards, black or black-brown and minutely tomentose or bristly below, ashy in the upper half. The perithecial discs or plates are laterally attached, and situated on the lower half of the clava. One specimen has a single perithecial plate, another has two, while the third has four, three on one side and one on the other, situated 2.5-4 mm. from the base. The discs are black, glabrous, circular, 0'9 mm. diameter, 0'4 mm. thick, with a sharp upper edge, contracted below and sloping inwards to the point of attachment; in some cases they are slightly curved round the clava. The upper surface is slightly convex, tuberculate with close-set tubercles, 0'05-0'1 mm. diameter. Internally the discs are white. The perithecia are conical or flask-shaped, 0'2 mm. deep, 0'1 mm. diameter, with a yellow-brown wall. Unfortunately the available examples are immature.

The outer layer of the disc is parenchymatous, and by trans-
mitted light the "cell walls" appear as a coarse irregular network, with meshes 8-20 μ broad, divided by thinner lines into smaller meshes.

The upper part of the clava bears conidia. These are hyaline, oval, 3-5 × 1 μ, borne on basidia having a total height of 24 μ and consisting of an oval base, 8 × 4 μ, bearing a slender, almost equal, sterigma, 1 μ diameter and up to 16 μ long. The conidial stage of this *Cordyceps* is consequently *Hirsutella.*

The Ceylon specimens agree with von Höhnel's figure and description, except that his specimen had much more pronounced tubercles or perithecial elevations. *Isaria myrmicidae,* in Lloyd, *Mycol. Notes,* No. 62, p. 915 (1920), would appear to be the conidial stage of this species.

*Cordyceps Blattae* Petch, n. sp. This species has been col-

lected at Hakgala on two occasions, on a cockroach (*Blatta germanica*) attached to the underside of living leaves. A slight covering of brown mycelium overruns the insect and fastens it to the leaf.

The clava (Plate I, fig. 8) is cylindric, 1 cm. high, with a very short sterile base, 0'5 mm. diameter, from which it expands upwards regularly to a diameter of 1 mm. at the rounded apex. It is grey or lavender, the tissue being dark red-brown, covered with a grey or lavender pruina. The substance of the club is rather soft and viscid, and shrinks as it dries, so that the originally even, unicolorous clava becomes covered with minute,
red-brown, longitudinal protuberances arranged in vertical lines. In section, by transmitted light, the outer layer of the clava is purple-red.

The perithecia are immersed, conoid, 0·2 mm. high, 0·15 mm. diameter, with ostiola scarcely projecting. The asci are 100–130 × 8–12 μ, cylindrico-clavate, or narrow clavate, with or without a tapering pedicel, four- or eight-spored, the apex of the ascus being slightly thickened, but not capitate. Paraphyses are absent.

The ascospores (Plate I, fig. 14) are in a parallel bundle, spirally twisted, but the individual spores do not extend from the base to the apex of the ascus. As a rule, two reach the apex of the ascus and one extends downwards towards the base. They are elongated fusoid, 50–80 × 3–4 μ, usually acute, hyaline, multiseptate, with strong septa 5–8 μ apart.

It will be evident that the ascus and ascospores are quite different from the typical form in Cordyceps. The ascus is clavate with a slightly thickened apex, instead of cylindric with a capitate apex, and the spores, instead of the usual parallel bundle of linear spores, terminating at the same level, end at different levels and are elongated-fusoid. From the shape of the spores, it would seem improbable that they divide into part-spores. The spores and asci are those of an Ophiionectria, not those of a Cordyceps, and the fungus may be regarded as an Ophiionectria having perithecia embedded in a vertically-elongated stroma.

There would appear to be some probability that Cordyceps unilateralis may have similar asci and spores. Von Höhnel's illustration shows spores with well-developed septa, and a spore-bundle terminated by the tip of a single spore, but unfortunately only the end of the spore-bundle is figured. The figure was not drawn by von Höhnel. From von Höhnel's description, however, it would seem that all the spores were almost as long as the ascus. Another species described by von Höhnel, C. rhizoida, has eight spores, each about half the length of the ascus, in an irregular bundle, and thus resembles C. Blatta in that respect, but the spores are different in shape and continuous.

B. Perithecia superficial.

Cordyceps falcata Berk. A species which appears to agree with C. falcata Berk. has been collected on several occasions at Hakgala on a coleopterous larva in rotting logs. The Ceylon specimens are smaller than those in the type from India.

The clavae (Plate I, figs. 10, 11) emerge through the holes made by the larvae. The perithecial clava is up to 2 cm. long, 1–1·5 mm. diameter at the base, cylindric or compressed, usually curved, tapering upwards to an acute apex, minutely tomentose,
white, becoming pinkish or reddish. The perithecia are superficial, usually developing in a continuous group, two or three millimetres above the surface of the wood, on the convex side of the clava or encircling it, but in the latter case they are more numerous on the convex side than on the other. In some instances scattered perithecia occur, apart from the main group. Massée's statement that the barren areas on the clava in the type are due to the fact that the perithecia have fallen off is incorrect, if the Ceylon and Indian species are identical. Barren clavae, i.e. clavae which have not yet developed any perithecia, are generally common. The clavae which are producing perithecia have a sterile tip, 2–10 mm. long.

The perithecia have a pinkish tinge when fresh, but become reddish brown when dry. They are ovate, up to 0.6 mm. high, 0.4 mm. diameter, with the apex somewhat narrowed and produced, and are slightly tomentose. They may be loosely adherent to one another laterally, but are not immersed in the stroma. The asci are cylindric, 40–440 μm × 8–10 μm, and divide into part-spores within the ascus. In one collection, the part-spores are 4–8 × 1.5 μm, in another 8–12 × 2.5 μm, cylindric with rounded ends. In the latter, the part-spores were extruded from the perithecium in a yellowish drop.

The conidial stage (Plate I, fig. 12) similarly emerges from the beetle-boring as a tuft of short, branching, much-divided conidiophores. As a rule, these are rigid and short, but in some instances they are lax and up to 2 mm. long. The conidiophore, in general, originates on the larva as a single stalk, and branches when it reaches the exterior of the wood, but in the longer lax forms, branching only occurs at some distance above the surface. These latter forms are generally found on the lower surface of the log, and the difference is no doubt due to greater humidity in that situation. The conidiophore divides at a wide angle, and each branch terminates in a minute, white or yellowish, globose or ovoid, empty head. The conidia are hyaline, oval or subglobose, 1.5–3 μm × 0.75–2 μm. The type of conidiophore is thus stiltoid, and in this respect C. falcata agrees with C. Barnesii. If the perithecial clava is kept in a damp chamber, it develops the stiltoid conidial form from the sterile apex. Stilbum ramorum Peck, found on similar larvae, would appear to be a parallel species.

According to my notes, there are specimens of this species, collected by Thwaites, included under C. militaris, in Thwaites 341 in Herb. Kew.

Cordyceps translucens Petch, n. sp. This species was found at Hakgala, among dead leaves, on a larva of a coleopteron. Several clavae arise from the one larva.
When fresh the clava (Plate I, fig. 15) is hyaline and translucent, with the central portion of the stalk and the contents of the perithecia appearing white and opaque. When dry it becomes amber-coloured or yellow-brown, and horny. The total height is up to 1 cm. The stalk is stout, erect, or curving upwards, 1 mm. diameter. The head is well differentiated from the stalk, globose or ovoid, up to 2.5 mm. high, 2 mm. diameter, bristling with strongly-projecting perithecia. The perithecia are superficial, broadly conoid or flask-shaped, 0.5 mm. high, 0.3 mm. diameter, with a cylindrical ostiolum, 0.05 mm. high and broad. A few isolated perithecia may occur on the stalk. The perithecia are united laterally by a slight weft of mycelium, the upper half being free and glabrous. The asci are cylindric, capitulate, 4 μ diameter, with eight spores of the normal type, and the paraphyses are cylindric, 6 x 1 μ.

Cordyceps pruinosa Petch, n. sp. This species was collected by Thwaites at Nuwara Eliya (No. 341 in part) and was assigned by Berkeley and Broome to C. militaris. There are specimens of that gathering in Herb. Kew and Herb. Peradeniya. I have a recent specimen, on a cocoon, but the clavae are immature. The type was said to be on pupae.

According to Thwaites, the clavae (Plate I, fig. 13) were bright crimson when fresh. The specimens in the Peradeniya Herbarium vary in height from 1.5 to 4.75 cm. The stalk is about 0.5 mm. diameter, and the head narrow-clavate or subcylindric, acute above, 7 mm. high, 1.5 mm. diameter. The stalks of the herbarium specimens still bear a red pruina, and the same red pruina occurs between the apices of the perithecia. The red colour changes to violet with caustic potash.

The perithecia are narrow-oval or ovoid-cylindric, 0.4 mm. high, 0.1 mm. diameter, with a conical apex, superficial, closely crowded together. The wall of the perithecium, by transmitted light, is pale yellow, with a vivid crimson apex. The asci are 4-6 μ diameter, of the normal type, eight-spored, and the paraphyses, cylindric, 6 x 1 μ.

In the recent example, the cocoon bears about ten immature clavae. These are crimson, narrow-clavate or almost linear, up to 1 cm. long and 0.1-0.4 mm. diameter, strongly longitudinally fibrillose. On one of these the perithecia are just developing.

This species would appear to differ from C. militaris in the fibrillose immature clava, and the red pruina when mature.

ISARIA.

The conidial stages of the various species of Cordyceps are not in all cases co-generic with Isaria farinosa (Dicks.) Fr., the conidial stage of Cordyceps militaris. As already stated, the
Cordyceps are not (Dicks.) Fr., the already stated, the conidial stages of C. Barnesii and C. falcata are compound Stilbiums, occurring in the former on the immature perithecial clava, and in the latter in the perithecial clava. Further, the conidial stage of C. unilateralis is a Hirsideilla, while that of C. dipterigena does not appear to fall into any genus yet described. It is consequently to be expected that an examination of the “Isaria” stages of the various species of Cordyceps would show that they belong to a wide range of genera of the Hyphomycetae. The examination should, of course, aim at determining the character of the ultimate branches of the conidial stroma and the mode of attachment of the conidia.

The following notes have been made on several species of Isaria which occur in Ceylon on insects, but of which the perithecial form has not yet been discovered.

Isaria Sinclairii (Berk.). This, the largest Isaria yet found in Ceylon, occurs fairly frequently at Hakgala on Cicada pupae, usually growing in clusters from the insect (Text-fig. 1). It is up to 6 cm. high, with a white stalk up to 2.5 mm. diameter below, branching above, the branches bearing ovoid, irregular, loose heads up to 1 cm. high and 5 mm. diameter. The conidia are oblong-oval, ends sometimes acute, hyaline, continuous, 8-10 × 2-3 μ, on basidia which are borne in clusters, either surrounding the conidiophore or terminal. The basidia are broadly flask-shaped, about 6 μ high, and 3 μ diameter below, the basal part being subglobose. It belongs to the section Verticillium of Vuillemin, and it does not appear to differ from Isaria arbuscula Hariot from Mexico, and I. Hariotti Arnaud from Madagascar, both of which have the same type of conidiophore, and conidia, 7-10 × 2-3 μ, and 5.5-7 × 2.5-3 μ, respectively.

Von Höhnel described I. amorpha on a cicada in Java, but that species is said to have spores only 3.4 × 1.1-1.5 μ. The Isaria form known as Cordyceps Miquelii (Tul.) Sacc., on Cicada pupae in Brazil, has cylindrical conidia (fide Cooke), but is
insufficiently described. *C. sobolifera* Tul., on *Cicada* pupae in the West Indies, appears to be different, as far as can be deter-
mined from the published descriptions. The Ceylon species appears to be identical with *C. Sinclairii*, on *Cicada* pupae in New Zealand, the conidia of which are said to be oblong, and 7 μ long; but it would seem probable that all the species of *Isaria* with large conidia which have been recorded on cicadas are the same.

**Isaria** sp. on Lepidoptera. This species occurs at Hakgala on pupae of *Agrotis*, etc. It is up to 4 cm. high, with a lemon-yellow stalk and a white, divided head. The stalk becomes dull brown when dry, but still shows the yellow colour when mounted; it is about 0.5 mm. diameter, longitudinally fibrillose, branching above, the branches being suberect and each terminating in an ovoid head of contiguous branchlets. The yellow branchlets give off hyphae, 2 μ diameter, on which flask-shaped basidia, 6 × 2.5 μ, are borne in clusters, either surrounding the hypha, or terminally. The *Isaria* heads are thus composed of spheres of basidia and conidia, about 40 μ diameter. The conidia are oblong-oval, or oval and inequilateral, or cylindric, sometimes curved, 3-4 × 1-2 μ. The type of conidiophore at first sight appears to be that of *Beauveria*, but the characteristic sterigma of the latter genus are absent, the spores being apical on the basidium and (as observed) solitary or in a short chain of three or four. In the larger specimens, the main stalk may be clothed with these spheres for half its length.

This species would appear to resemble *Isaria tenuipes* Peck. Pettit stated that the latter species had basidia in whorls or opposite, after the type of *Verticillium*, but he gave the spores as oval to globose, 2.5-3.5 μ, in a spherical cluster or sometimes an irregular chain at the apex of the basidium. The Ceylon specimens would be assigned to *Spicaria*, from the fact that the conidia may be in chains; but it may be considered doubtful whether it will be practicable to maintain as distinct groups *Verticillium* forms and *Spicaria* forms of *Isaria* on that character.

**Isaria** sp. on Lepidoptera. This species has been taken on a caterpillar and on cocoons at Hakgala. It is white, up to 7 mm. high, with a slender stalk, 0.15 mm. diameter, branching profusely but with branches often widely separated from one another, each branch terminating in a loose head of plumose branchlets. The branchlets are covered with stalked conidiophores, up to 50 μ high, each bearing a sphere up to 40 μ diameter. These spheres are clusters of basidia, as in the foregoing species, from which this differs in having the majority of the spheres terminal on short, rigid conidiophores perpendicular to the branchlet. The conidia are oval or subcylindric, curved in one aspect,

41

In the arrangement of the conidiophores this species resembles *Verticillium Barbozae* Vincens, as figured in *Bull. Soc. Myc. France*, xxxi, plate IV. Vincens stated that he had not been able to find more than one spore at the apex of a basidium, and that nothing in the appearance of the spores favoured the supposition that they were formed in chains; hence the fungus was not a *Spicaria*. In the Ceylon species, however, the conidia may occur in short chains.

*Isaria* sp. on Lepidoptera. I have this form on a larva in rotting wood from Hakgala, and on a Tineid case from Peradeniya. In the latter the clubs arise round the mouth of the case. The clavae are scattered, simple, up to 5 mm. high. The stalk is slightly yellowish, about 0.2 mm. diameter at the base, tapering upwards to about half the height of the fungus, where it passes into the head and is continued to the apex as an unbranched columella. The head is narrow-clavate, or narrow-cylindric, 2.5 mm. high, 0.4 mm. diameter, white, and the conidia are narrow-oval, 4-6 x 1.5 μ. The columella gives off hyphae 2.5 μ diameter, which bear flask-shaped basidia, up to 10 x 2.5 μ, in whorls, the conidia being produced terminally in chains. This does not appear to agree with *Isaria Tinearum* Speg.

*Isaria* sp. on Orthoptera and Lepidoptera (Text-fig. 2). I have collections of this form on a grasshopper, on a cricket, on cocoons of *Thosea recta*, and on a caterpillar of *Homona coffearia*. Whether these all belong to the same species or not may be regarded as uncertain.

The insect is usually covered with a thin, white or cream-coloured film of mycelium, which tends to become glabrous. From this there arise numerous Isarias, each consisting of a cream-coloured or brownish white stalk, up to 2.5 mm. high, 0.5 mm. diameter, expanding upwards, simple or branched, and terminated by a globe, white or pale yellowish head, up to 2 mm. diameter. The heads appear compact, but are powdery on the upper surface, which consists

Fig. 2. *Isaria* on locustida, natural size.
of loosely intertwined hyphae, bearing conidia laterally. The conidia are oval, often inequilateral, $3-4 \times 1.5-2.5 \mu$.

HIRSUTELLA.

**Hirsutella Saussurei** (Cooke) Speare. This species (Text-fig. 3) occurs throughout the tropics on hornets, and is well-

Fig. 3. *Hirsutella Saussurei*, on *Vespa cincta*, natural size.

known in all but name. Lloyd refers to it as *Isaria crinita*, the first specimen of this type discovered, having been considered part of the insect, which was named *Vespa crinita*. Speare has shown that it belongs to the genus *Hirsutella*, and has given it the name cited above, on the assumption that it is identical with *Isaria Saussurei* Cooke, which was figured, but not named, by Saussure in 1853. According to Cooke, however, the hairs or filaments of *I. Saussurei* are orange, whereas those of the Ceylon fungus are dark brown or black.

Only one collection of this species has been made in Ceylon,
This species (Text-iornets, and is well-

Hirsutella clavispora Petch; Trichosterigma clavisporum
the insect in a matted glabrous sheet; and spreading out in a
fimbriate margin over the substratum. Clavae arising from
the mycelium, erect, terete, simple, up to 8 mm. high, 0.35 mm.
diameter below, tapering upwards, brownish white (dry), smooth.
Basidia with an ovate base, up to 8 μ high, 2-3 μ diameter,
rounded or attenuated above, bearing a rigid, simple, filiform
sterigma, 5-9 μ high. Conidia hyaline, continuous, clavate,
4-8 x 1-1.5 μ. On a caterpillar attached to a living leaf, Perad-
eniya, January 1912 (Plate I, fig. 16).

This species does not appear to be related to Torrubiella
ochracea Pat., the Ceylon analogue of Cordyceps Sphingum, as
T. ochracea has verrucose conidia on the hyphae of the stroma.

Hirsutella arachnophila Petch; Trichosterigma arachno-
covering the body of the insect and forming a flattened pulvinate,
pale yellow, somewhat spongy, tomentose stroma with a fim-
briate margin. Clavae arising from the stroma, pallid yellow,
cylindric, up to 4 mm. high, 0.15 mm. diameter below, tapering
slightly upwards, smooth, simple. Basidia scattered or crowded,
globose, 3 μ diameter, or subglobose, up to 6 x 5 μ, each bearing
a single rigid, simple sterigma, about 2 μ long. Conidia narrow-
oveal, continuous, ends acute, 4-8 x 2 μ. On spiders attached to
living leaves, Hakgala, March 1922; Peradeniya, March 1909;
Peradeniya, March 1917. This species is the conidial stage of
Torrubiella flavula Petch. The specimen from Peradeniya, March
1909, differs in colour, being lilac grey. A similar colour differ-
ence occurs in Gibellula elegans P. Henn., which is also parasitic
on spiders.

Hirsutella citriformis Speare; Trichosterigma attenuatum
brownish, over-running the host insect. Clavae arising from the body or legs of the insect, usually from the joints, or along the margins of the wing covers. Clavae pale brown (dry), up to 6 mm. long, 0.2 mm. diameter below, tapering upwards to 0.08 mm. diameter, rigid, slightly inflated at the apex, terete, smooth, bristling with hyaline sterigmata when magnified. Basidia oval or flask-shaped, 8–10 x 3 μ, attenuated into a rigid, simple sterigma, up to 26 μ long, 1.5 μ diameter at the base, tapering upwards. Conidia hyaline, continuous, oval or lozenge-shaped, usually acute at each end, 6–7 x 3–5 μ. On a Pentatomid on bark, Hakgala, May 1912. The insect in the only available specimen bears more than forty clavae, but many of them have been broken (Plate I, fig. 17).

**Hirsutella floccosa** Speare. An example, apparently of this species, was gathered at Hakgala on a leaf hopper, March 1922. Speare states that this species differs from other species of the genus in that the synnemata are merely wart-like outgrowths arising from an external cotton-like subiculum. In the Ceylon example the wart-like outgrowths are lacking. The insect is sparsely covered with white mycelium which spreads from it over the leaf, and the basidia are situated, rather widely separated, on the hyphae. The hyphae are hyaline, 2–3 μ diameter, thin-walled, regular, and septate. The basidia are 5–14 μ high, 3 μ diameter, flask-shaped, tapering into the simple bristle-like sterigma, which is 3–10 μ long. The conidia are narrow-oval, 4 x 1.5 μ, but apparently immature.

**Gibellula.**

**Gibellula elegans** P. Henn. This species is common on spiders attached to living leaves. The whole fungus may be yellow, or the stroma yellow and the clavae pinkish or flesh-coloured, or the stroma yellow and the clavae lavender. In the latter case, the lavender colour ultimately fades, leaving the clavae pale ochraceous and the conidial heads ashy or whitish. There are no evident morphological differences between these colour forms. The conidiophores may occur on the stroma as well as on the clavae; on the latter, owing to their peculiar origin from loops of hyphae which are stouter than the hyphae of the clava, they have the appearance of being another fungus parasitic on the clavae. The Ceylon species is distinguished from *Sterigmatocystis* by its rod-shaped conidia, 3–5 x 1 μ, with rounded ends. As Vuillemin has shown, the apex of the conidiophore of *Gibellula* is not notably inflated, and the resemblance to *Sterigmatocystis* is merely superficial.

In *Gibellula phialobasia* Penz. and Sacc., the structure of the conidiophore is different, according to the figure and description,
avae arising from the joints, or along the brown (dry), up to aperting upwards to at the apex, terete, ta when magnified, attenuated into a \( \frac{3}{5} \) \( \mu \) diameter at the continuous, oval or l, 6-7 \( \times \) 3-5 \( \mu \). On a The insect in the only clavae, but many of le, apparently of this hopper, March 1922. other species of the wart-like outgrowths ulum. In the Ceylon cking. The insect is high spreads from it ated, rather widely are hyaline, 2-3 \( \mu \) ite. The basidia are ering into the simple ng. The conidia are mature.

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