

NOTES ON ENTOMOGENOUS FUNGI

By T. PETCH

(With 8 Text-figures)

22. *CORDYCEPS BICEPHALA* Berk.

THIS species was collected by Spruce at Panuré, Rio Negro, and was described by Berkeley in "Decades of Fungi," no. 617, *Hooker's Journ. Bot.* (1856), p. 278.

Berkeley described the head as elliptic. Cooke, *Vegetable Wasps and Plant Worms* (1892), p. 218, wrote "The heads are described as elliptic, but in the dried specimen they are as nearly as possible globose," and he gave a figure showing the stalk bifurcate above, each branch bearing a globose head. As previously pointed out by Lloyd (*Mycol. Notes*, no. 62 (1920), Fig. 1634), the heads are not globose. On the type specimen, they are ovoid, rounded or subacute above.

There does not appear to be any doubt that *Cordyceps australis* Speg. is the same species. Among numerous specimens collected by Mr Paul W. Richards in British Guiana, some have a lateral branch, a short distance below the head, which may remain sterile or may bear the conidial stage. Berkeley's specimen is exceptional in having two heads.

Mr Richards informs me that this species usually occurs on ants buried in moss on tree trunks, the insect being very much decayed. Berkeley's specimen was apparently gathered without the host insect. When fresh, the head and the upper part of the stalk are red, the remainder of the stalk being black. In formalin, the red parts become white, and in dried specimens they are white or pale ochraceous. The British Guiana specimens usually occurred on the ant, *Megaponera foetens*.

The conidial stage may arise, as stated above, as a branch of the perithecial clava, or as an independent linear clava from the host insect. This has been described by Spegazzini as *Isaria melanopus*. From Spegazzini's description and recent specimens, it is a *Hymenostilbe*, which must stand as *Hymenostilbe melanopoda* (Speg.), comb.nov. Spegazzini described the basidia (phialides) as cylindrical, with an obtuse apex, $10-15 \times 3 \mu$, and the conidia as obovate, $5-10 \times 3-4 \mu$. On the British Guiana specimens, which had been preserved in formalin, the basidia were ovate, minutely verrucose at the apex, $7-9 \times 4 \mu$, with a short central truncate sterigma, and the conidia hyaline, fusoid, with a truncate base, $7-9 \times 1 \mu$.

In Herb. Kew. there is a specimen of *Cordyceps bicephala* from Uganda, R. A. Dummer, 4033, April, 1918.

From their descriptions, *Cordyceps proliferans* P. Henn., on *Dinoponera grandis*, Brazil, *C. Huberiana* P. Henn., on *Megaponera* sp., Para, and *C. necator* Pat. & Har., from French Guinea, do not appear to differ from *C. bicephala*.

23. *CORDYCEPS ALBELLA* Masee

This species was described by Masee in *Ann. Bot.* ix (1895), 39, from a specimen in Herb. Kew., collected by Wright in Cuba, which Berkeley had left unrecorded. Masee stated that it was on a grasshopper which was covered with white mycelium, and consisted of numerous white or yellowish slender clavae, 5 mm. to 1 cm. high, 1–2 mm. diameter, cylindric or claviform, arising from the lower surface of the thorax and abdomen.

In the specimen in its present condition, the clavae arise from a mass of frass, which is separate from the insect. The remains of the insect are in a separate packet, and do not show any white mycelium. It seems doubtful whether the fungus really grew on the insect.

The clavae are about 5 mm. high, terete, smooth, about 200 μ diameter below, attenuated upwards to 150 μ diameter, and then expanding into a long clavate head, about 360 μ diameter. They are composed of parallel agglutinated hyphae which separate into conidiophores above, with a few outlying conidiophores on the upper part of the stalk. The conidiophores are penicillioid, hyaline, with a stalk 2 μ diameter, either branched above, the branches terminating in cylindric or clavate phialides, 7–10 \times 2–2.5 μ , or unbranched, bearing three similar phialides at the apex, each phialide bearing a chain of conidia. The conidia are hyaline, thick-walled, smooth, globose, 2–3 μ diameter, or broadly oval, 2.5–3.5 \times 2–2.5 μ , catenulate, united by a distinct isthmus about 1 μ long. The conidiophores are closely packed together in the head, so that the head is compact, not loose.

This is a coremioid *Penicillium*, which must be known as *Penicillium* (*Coremium*) *albellum* (Masee), comb.nov.

A specimen from Ceylon, included in the cover of *Cordyceps albella* in Herb. Kew., is quite different from the Cuban specimen. It is either *Hirsutella* or *Hymenostilbe*, but is not in a condition for further determination. It appears to be on the remains of a firefly.

24. *CORDYCEPS PALUSTRIS* B. & Br.

Cordyceps palustris was collected by Ravenel in South Carolina, and was described by Berkeley in *Journ. Linn. Soc.* i (1857), 159. There are specimens in Herb. Kew., "Ravenel 718, moist putrid logs, Northampton swamp," with a description of the colour, etc., from Ravenel,

and others, part of the same collection, in Herb. British Museum *ex* Herb. Ravenel. In both specimens the perithecia are globose, and the part-spores at first cuboid, becoming globose, 1.5μ diameter. Berkeley described the perithecia as globose, and the part-spores as forming moniliform chains of globose grains.

Massee (*Ann. Bot.* ix (1895), 11) described and figured the perithecia as "cylindric, narrowed at the base when mature, and in reality quite superficial," and stated that he had not seen the spores broken up into part-spores.

Möller (*Phycomyceten und Ascomyceten*, p. 230) described a *Cordyceps* with globose part-spores as *C. hormospora*. It occurred in Brazil on beetle larvae in rotten logs. Möller stated that *C. hormospora* was very closely allied to *C. palustris*, the description of the latter in Cooke, *Vegetable Wasps*, etc., agreeing almost completely with the Brazilian species, but on the other hand the form and arrangement of the perithecia in *C. hormospora* were certainly widely different from the description given by Massee for *C. palustris*.

In actual fact, the perithecia of *C. palustris* are globose with a short neck, completely immersed, as described by Möller for *C. hormospora*, and they are arranged close together in a single layer immediately beneath the cortex. Massee must have examined some other species, perhaps *C. Ravenelii*. *C. hormospora* agrees completely with *C. palustris*, and the former name is consequently a synonym of the latter.

25. *CORDYCEPS DIPTERIGENA* B. & Br.

Cordyceps dipterigena, which grows on flies, was described by Berkeley and Broome in 1873. As previously stated by von Höhnel and myself independently, there is practically no doubt that *Torrubia coccigena*, described by the Tulasnes as occurring on a coccus, is the same species, the remains of the host having been misidentified.

Möller described it from Brazil as *Cordyceps muscicola*. I have hitherto been reluctant to accept this reference, as Möller's figure shows a different habit, six perithecial clavæ arising from the insect, in place of the two perithecial and one conidial of the common Ceylon form. I have, however, recently examined a number of specimens from British Guiana and Panama, and find variation in the number and character of the clavæ. One specimen from British Guiana (Richards, no number) has six perithecial clavæ from the thorax, as in Möller's figure, with heads 2 mm. diameter, while another (Richards, 572) has two immature clavæ from the thorax and a conidial clava from the tip of the abdomen, exactly as in the common Ceylon form. A specimen from Panama (Williams, 45) has two conidial clavæ from the thorax, and two on the abdomen in the median line, while another Panama specimen (Williams, 46) has

two immature perithecial clavae from the tip of the abdomen. The conidial stage is the same as in the Ceylon specimens.

Most of the available Ceylon specimens were collected at a high elevation, and probably the smaller number of clavae is due to climatic causes. The heads of the perithecial clavae, however, vary from 1.2 mm. to 2.5 mm. diameter in the same gathering, and consequently the size of the head is not a character distinguishing the Ceylon from the American form.

Thwaites collected in Ceylon a specimen which bears nine immature perithecial clavae. The locality was not recorded, the specimen being accompanied by a note in Thwaites' handwriting, "collected 24 June 1861. Fungus on large dipterous insect for Rev^d M. J. Berkeley, with G. H. K. T.'s kind regards." It was most probably collected in the low-country. The specimen was not referred to in the *Fungi of Ceylon*. Lloyd named it *Cordyceps Thwaitesii*, but, as pointed out by Thaxter, it is immature *C. dipterigena*.

C. Ouwensii v. Höhnelt, from Java, is a fairly frequent variation of *C. dipterigena*, and has been collected in Ceylon in company with the normal form.

C. Muscae P. Henn., from New Pomerania, is, from the type specimen, an immature clava of *C. dipterigena*.

C. opposita Syd., on a fly from New Guinea, is, from the type specimen, *C. dipterigena*. It has the two opposite perithecial clavae from the thorax, and the conidial clava from the abdomen, of the normal form. Sydow described and figured perithecia on the conidial clava. It is probable that these are the perithecia of the parasite, *Byssostilbe tomentosa*, as figured by me in *Trans. Brit. Myc. Soc.* viii (1923), 211.

The synonymy of *Cordyceps dipterigena* is as follows:

Cordyceps dipterigena B. & Br. in *Journ. Linn. Soc.* xiv (1873), 111; *Torrubia coccigena* Tul., *Sel. Fung. Carp.* iii (1865), 19; *Cordyceps coccigena* (Tul.) Sacc., *Syll. Fung.* ii (1883), 576; *Cordyceps Muscae* P. Henn. in *Engl. Jahrb.* xxv (1898), 507; *Cordyceps muscicola* Möller, *Phycomyceten und Ascomyceten*, 221 (1901); *Cordyceps Ouwensii* v. H., *Fragm. z. Myk.* 214 (1909); *Cordyceps Thwaitesii* Lloyd, *Mycol. Notes*, 65 (1920), 1060; *Cordyceps opposita* Syd. in *Engl. Jahrb.* lvii (1922), 325.

Of the species of *Cordyceps* described as parasitic on flies, two appear to be valid, viz. *C. dipterigena* B. & Br. from the tropics, and *C. Forquignoni* Quélet from Europe. The name, *C. coccigena* (Tul.) Sacc., is a misnomer, and obviously to be discarded.

The conidial stage of *C. dipterigena* is a *Hymenostilbe*, which may be known as *Hymenostilbe dipterigena*. It usually arises from the tip of the abdomen, but may replace a perithecial clava from the thorax or arise from the broken stalk of a perithecial clava.

Hymenostilbe dipterigena Petch, n.sp. Clava terete, usually simple,

sometimes forked, up to 2 cm. long, 0.25 mm. diameter, pale brown becoming blackish brown, ashy above, surface matt, then pruinose; basidia cylindric or cylindrico-clavate, $9-20 \times 2-5 \mu$, apex rounded, strongly verrucose or glandular in the upper half; conidia hyaline, smooth, clavate, cylindric or oval, $4-9 \times 1.5-4 \mu$.

In the Ceylon form, the basidia are $14-18 \times 2-3 \mu$ and the conidia clavate or cylindric, $6-9 \times 1.5-2 \mu$. In young specimens from Panama (Williams, 45 and 46) and Tobago (Williams, 47), the basidia are shorter and broader, $9-11 \times 4-5 \mu$, the glandular processes are larger, up to 1.5μ , and the conidia are clavate, $4-7 \times 2 \mu$, or oval, $6-8 \times 3-4 \mu$; but in a specimen from British Guiana (Richards, 572) the basidia are $18-20 \times 3 \mu$, and the conidia $6-9 \times 2.5-3 \mu$.

26. *CORDYCEPS SPHINGUM* (Schw.) B. & C.

Isaria Sphingum was described by Schweinitz in 1822. Link (1825) listed it as *I. sphingophila*. The Tulasnes (1865) described and figured the perfect stage, from American specimens, as *Torrubia Sphingum*, while Berkeley and Curtis enumerated it in 1869 as *Cordyceps Sphingum*.

As recorded by the Tulasnes, Lebert had previously (1858) described the perfect stage as *Akrophyton tuberculatum*. There is no doubt, from Lebert's figures, that he had the perithecial stage of *Isaria Sphingum*. Maire, in 1917, published the combination, *Cordyceps tuberculata* (Lebert) Maire, following the Brussels rule that the first trivial name applied to the ascigerous stage must be used. Lebert found his specimen in the Museum at Geneva. Its origin was not recorded, but the host insect was said to be *Sphinx pinastri*.

Cordyceps tuberculata is a fairly common and striking species, and has, in consequence, been frequently illustrated. It generally occurs on the perfect moth, but has also been found on caterpillars. It occurs on Micro-lepidoptera, as well as on the larger moths.

The perfect moth is found, sitting in a natural position on a tree trunk, or under a leaf, with the clavae radiating from it in all directions. The white or pale yellow mycelium covers the head, thorax, and abdomen, but if the moth sits with outspread wings it does not cover the wings. The mycelium, however, penetrates the wings along the larger veins. On moths which sit with folded wings the mycelium may cover the whole insect, sometimes entirely, sometimes leaving the tips of the wings visible; and the same effect is produced on insects which have fallen to the ground and possibly lost their wings.

Clavae are produced from the head, thorax, and abdomen, and along the veins of the wings in the case of moths which die with wings outstretched. If the insect has become a uniform mummy, clavae are produced anywhere.

The perithecial forms may be divided into three groups, which are connected with one another by all possible gradations, viz.:

A. Specimens with attenuated narrow conical clavæ up to 2 inches long, which bear perithecia in groups on the clavæ; this is the usual form on moths with extended wings.

B. Specimens with short stumpy columnar clavæ, which bear a group of perithecia, usually at and on the apex.

C. Specimens without clavæ, bearing perithecia directly on the mycelium which covers the insect.

The clavæ have a central core of parallel hyphæ, with a looser outer tomentose layer. When old, the outer layer is lost and the clavæ appear horny. The perithecia are orange-yellow when fresh, but become red-brown when dry. Möller sent a specimen to Hennings, who described the perithecia on the clava as superficial, but Möller contradicted that and stated that they were immersed, sometimes to one-third their height. That is purely a matter of condition. If the clava has lost its outer tomentose coat, the perithecia are superficial.

In view of the existence of these different forms, it is not surprising that the fungus has received several names. The form usually figured is A. Berkeley and Curtis's type of *Cordyceps Sphingum* B. & C. is A. Forms B and C were figured in *Trans. Brit. Myc. Soc.* ix (1923), Pl. II, figs. 13, 14, as *Torrubiella ochracea* Pat.

Möller, in Brazil, sent form A to Hennings, who described it as *Cordyceps Moelleri*, while Möller himself described form C as *C. cristata*. *C. isarioides* Masee was based on a specimen in Herb. Kew., labelled with that name by Curtis; it consists of two clavæ of form B, with fragments of the wing of a moth attached.

Isaria Sphingum was re-described by Vosseler in 1902 as *I. Surinamensis*, from a specimen from Surinam. He stated that he had submitted the specimen to Masee, who assigned it to *I. Sphingum*, but he did not accept that identification because its clavæ were longer, up to 12 cm. Vosseler's figure, however, agrees completely with *I. Sphingum*. Vosseler found what he considered to be conidiophores on the clavæ, but if so they were immature.

Vincens, in 1915, published an account of *Cordyceps Sphingum* (*Bull. Soc. Path. Végétale de France*, II, fasc. 1) and described the conidial stage in part. On a specimen which bore perithecia, he found conidiophores on minute clavæ, not more than 2 mm. high, after searching for them in vain on the longer clavæ. The conidial clavæ had a conoid or cylindric base, contracted suddenly above into a slender appendage which bore a palisade layer of phialides. The phialides were figured as flask-shaped, bearing at their apex a chain of globose conidia, 2 μ diameter. Vincens' specimens were from South America.

In a collection of entomogenous fungi made by Mr C. B. Williams in Trinidad, British Guiana, etc., there are seven specimens of *Cordyceps tuberculata*. One of these is immature, the clavae just beginning to form. Another bears perithecial clavae only. A third bears perithecial clavae and conidial clavae, while the remaining four bear conidial clavae only. These conidial clavae, or synnemata, occur, scattered or crowded, on the mycelium on the head, thorax and abdomen, and in lines along the veins of the wings. They are about 0.5 mm. high and resemble small *Stilbums*. From a small conical base of interwoven hyphae, there arises a stem, about 50μ diameter, which expands above into a globose or ovoid head, about 0.1 mm. diameter, white in colour. The stalk is not composed of parallel agglutinated hyphae as in *Stilbum*, but consists of hyphae which run vertically, but more or less irregularly, upwards. Externally it is either naked, or clothed with spreading hyphal ends. The hyphae branch above to form the head, in which they bear phialides terminally and laterally. These phialides are clavate, 9μ high, 3μ diameter above, the apex rounded. Each phialide bears a single chain of conidia, which are narrow-oval or cylindric, ends rounded or truncate, hyaline, continuous, $4-6 \times 1-1.2\mu$, becoming rather more oval, 1.5μ broad. The conidia persist in chains for some time. In some cases, a long conidium appears to be produced, which subsequently divides into conidia of the normal length. When the synnema is mounted, the head appears densely fringed with radiating lines of conidia. Scattered phialides also occur on the hyphae of the stalk: in that situation they are conoid, or flask-shaped with a neck about 2μ long, from $7 \times 4\mu$ to $9 \times 3\mu$, bearing the same chains of conidia as in the head.

The conidial stage in Williams' specimens is exactly *Isaria pistillariaeformis* Pat., described by Patouillard from specimens on a Micro-lepidopteron from Ecuador. It is apparently a common form in the West Indies, and is represented in a collection made by Miss Wakefield in that region. But, owing to the loose nature of the stalk, the heads are readily detached, and hence they are likely to be lost, unless the specimens are very carefully handled.

In a Ceylon specimen on *Psilogramma menophon* Cram., the well-known long clavae bear a palisade layer of phialides. These phialides are cylindric or clavate, rounded or acute above, $5-10\mu$ high, with a short sterigma up to 2μ long. The conidia are oval or broadly oval, $3-4 \times 1.5\mu$. Towards the base of the clava, there are conidiophores up to 40μ long, simple, or with one lateral branch, bearing

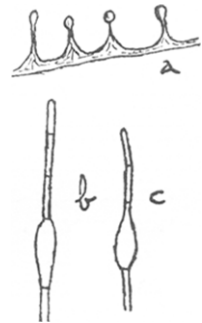


Fig. 1. *Isaria pistillariaeformis*. a, a row of synnemata, $\times 6$; b, phialide and conidia from the head, $\times 1000$; c, phialide and conidia from the stalk, $\times 1000$.

clavate conidia, $4-6 \times 1.5-2 \mu$, in chains. In addition to the long clavae, this specimen bears short slender clavae, up to 2 mm. high, of uniform diameter, or suddenly attenuated to half the diameter at about half their height. These bear a palisade layer of phialides in the upper part, as described by Vincens, the phialides and conidia being the same as on the longer clavae of the specimen.

Another Ceylon specimen, on *Macroglossa affictitia*, also has a palisade layer of phialides on clavae, 2 cm. long. The phialides are same as in the foregoing specimen, but the sterigmata are up to 4μ long, and the conidia are oval, $2.5-3 \times 2 \mu$, or globose, $1.5-2 \mu$, with a mucous coat. A small clava, 0.6 mm. high, on this specimen, has the same phialides and conidia.

A third Ceylon specimen, on a micro-lepidopteron, has minute clavae, with phialides as above, sterigmata up to 3μ high, and conidia cylindric, $7 \times 1 \mu$, or oval, $5 \times 1.5 \mu$, furnished with a mucous coat.

In *Trans. Brit. Myc. Soc.* x (1924), 43, I described *Hirsutella clavispora*, on a caterpillar attached to a living leaf. The caterpillar, which bore five long cylindric clavae, was covered with mycelium which extended from it to the leaf. A re-examination of this specimen, in comparison with more recent specimens of *Cordyceps tuberculata*, has convinced me that *Hirsutella clavispora* is a conidial form of that species. The conidia are cylindric or clavate, $4-8 \times 1-1.5 \mu$, with a mucous coat. The sterigmata are only about 4μ long, the previous longer measurement being probably based on a chain of conidia. These conidia agree with those of *Isaria pistillariaeformis*, but the latter have no mucous coat.

A further Ceylon collection, on caterpillars probably of *Ophiusa* sp. is immature *Cordyceps tuberculata*. Each caterpillar bears up to fifty clavae, about 1 cm. long, brown and subtranslucent towards the tip. They have passed the conidial stage, but a few phialides can be found. The clavae bear groups of perithecia in the upper half, which agree with those of *C. tuberculata*, but are immature. There is no covering of mycelium on the caterpillar.

Robin (*Végétaux Parasites*, Plate IX, fig. 6) gave a figure of a fungus on a caterpillar from the East Indies which is probably the conidial stage of *C. tuberculata*.

The conidial stage of *C. tuberculata* may take the form of a palisade layer of phialides on long clavae (*Isaria Sphingum*, *Hirsutella clavispora*), or a similar layer on a thin apical appendage of a minute clava about 2 mm. high, or a cluster of similar phialides forming the head of a minute *Stilbum* (*Isaria pistillariaeformis*). These forms may occur together on the same specimen, but the third has not yet been observed on specimens from the East Indies.

The variation in the conidia is considerable. In the *Isaria pistillariae-*

formis form the conidia are cylindric to oval. In *Hirsutella clavispora* or *Isaria Sphingum* forms, they are cylindric to clavate, or oval, or oval to globose, though the last are infrequent, and I have not seen chains of globose spores as figured by Vincens. It does not, however, appear possible to separate these forms as species.

The long clavae, which bear a palisade layer of phialides, should be classed as *Hymenostilbe* rather than *Hirsutella*.

The synonymy of this species is as follows:

Cordyceps tuberculata (Lebert) Maire in *Bull. Soc. d'Hist. Nat. de l'Afrique du Nord*, VIII (1917), 165; *Akrophyton tuberculatum* Lebert in *Zeitschr. f. wiss. Zool.* IX (1858), 448; *Torrubia Sphingum* (Schwein.) Tul., *Sel. Fung. Carp.* III (1865), 12; *Cordyceps Sphingum* (Schwein.) B. & C., *Fungi Cubenses*, no. 746 (1869); *Cordyceps Sphingum* (Tul.) Sacc., *Syll. Fung.* II (1883), 572; *Ophionectria Cockerellii* Ellis in *Journ. Inst. Jamaica*, I (1892), 142; *Cordyceps Cockerellii* Ellis, *op. cit.*, p. 180; *Cordyceps isarioides* Curtis MS. ex Masee in *Ann. Bot.* IX (1895), 36; *Cordyceps Moelleri* P. Henn. in *Hedwigia* (1897), 221; *Cordyceps cristata* Möll., *Phycomyceten und Ascomyceten* (1901), 212; *Cordyceps rostrata* P. Henn. in *Hedwigia*, XLI (1902), 165; *Cordyceps tarapotensis* P. Henn. in *Hedwigia*, XLIII (1904), 246; *Torrubiella ochracea* Pat. in *Bull. Soc. Myc. France*, XXII (1906), 58.

Conidial stage: *Hymenostilbe Sphingum* (Schwein.) Petch, *comb. nov.*; *Isaria Sphingum* Schwein., *Syn. fung. Car. Sup.*, no. 1298 (1822); *Isaria sphingophila* Link, *Sp. Plant.* VI, 2 (1825), 114; *Isaria pistillariaeformis* Pat. in *Bull. Soc. Myc. France*, IX (1893), 163; *Isaria surinamensis* Vosseler in *Jahresb. d. Vereins f. vaterl. Naturk. in Württemberg*, LXIII (1902), 380; *Hirsutella clavispora* Petch in *Trans. British Myc. Soc.* X (1924), 43.

Cooke, *Vegetable Wasps and Plant Worms* (1892) did not give Britain as a locality for *Isaria Sphingum*. Masee, *Fungus Flora*, III (1893), 447, recorded it "on the pupa of a dipterous insect in Scotland." That record is from Berkeley and Broome, *Notices of British Fungi*, no. 1710 (1878), and it is erroneous.

27. *CORDYCEPS MAWLEYI* Westwood

The name, *Cordyceps Mawleyi* Westwood, was published by L. O. Westwood in *Gardeners' Chronicle*, IX, Ser. 3 (1891), 553, for a fungus found in numbers in a border of herbaceous perennials in a garden at Berkhamsted. They were said to occur on an underground caterpillar of either a Noctuid or a *Hepialus*, about one inch below the surface. No details of colour or size were given, and apparently all were immature, as no spores were mentioned. The fungus was said to produce a profusion of filaments from the segments behind the head of the caterpillar. The figure apparently shows an immature clava and strands of mycelium arising near the head. The figure

would pass well for an immature *Cordyceps gracilis* (Grev.) Dur. and Mont., and the host and habitat agree with that identification. In the absence of any distinguishing characters, the best that can be done for *C. Mawleyi* is to place it as a synonym of *C. gracilis*.

28. *CORDYCEPS LLOYDII* Fawcett

This species was described and figured by Fawcett as having a single capitate clava, arising from between the head and the thorax of an ant. From specimens collected recently by Mr Paul W. Richards in British Guiana, it appears that it may produce two perithecial clavae, both dorsal, one between the head and the thorax, and the other between the thorax and the abdomen, each seated on a narrow white band of mycelium which encircles the body of the ant at the joint. The insect is attached to the leaf by pale brown mycelium. The free part-spores are elongated oval, ends truncate, $7-10 \times 1-1.2 \mu$. The host in these examples is *Camponotus* sp.

Two of Mr Richards' specimens bear conidial clavae, arising in the same positions as the perithecial clavae. These are either simple and linear, or are stout below and branch into thin clavae above. It seems probable that the latter arise from decapitated immature perithecial clavae.

Of two specimens from British Guiana, collected by Mr A. W. Bartlett, one bears perithecial clavae and the other conidial clavae. The latter has a clava from between the thorax and the abdomen, which begins as an erect stout stalk about 0.15 mm. diameter, abruptly contracted above to 0.1 mm. diameter, and continued as a long thin flexuose appendage; and another, long, thin, flexuose, 0.1 mm. diameter, arising from the pad of mycelium beneath the thorax, which fastens the insect to the leaf.

This conidial stage is a *Hymenostilbe*, which may be known as *Hymenostilbe Formicarum*.

Hymenostilbe Formicarum Petch, n.sp. Clava terete, simple, up to 14 mm. long, 0.2 mm. diameter expanding to 0.3 mm. above, or with a stout stalk, up to 5 mm. high, forking into two long, thin, linear clavae above, pale brown, ashy above, fibrillose below, pruinose above; basidia cylindric, $24 \times 4 \mu$, verrucose above, with one, or two, broad truncate sterigmata; conidia narrow-clavate or subcylindric, one end acute, the other truncate or rounded, $6-11 \times 1-1.2 \mu$. The conidial stage of *Cordyceps Lloydii* Fawcett. British Guiana, Richards, no. 774, 238 (part); A. W. Bartlett.

I have recently received specimens of *C. Lloydii*, on *Polyrachis* sp., from Dr G. O. Ocfemia, Philippine Islands.

As previously recorded (*Trans. Brit. Myc. Soc.* xvi (1931), 75), *Cordyceps Sherringii* Massee is immature *C. Lloydii*.

Examination of the type specimen shows that *Cordyceps subdiscoidea* P. Henn. in *Hedwigia*, xli (1902), 168, is *C. Lloydii*.

29. *CORDYCEPS* on Hymenoptera

Lebert, in *Zeitschr. f. wiss. Zool.* ix (1858), 452, instituted the genus *Polistophthora*, with the species, *Polistophthora Antillarum*, for a fungus on a wasp from Jamaica. Lebert stated that it was the "Vegetable Fly," and from his figures and description there is no doubt that it was *Sphaeria sphecocephala* Kl. in Herb. Hooker, Berkeley (1843), which is *Cordyceps sphecophila* B. & C. (1869). Lebert's genus and trivial name are consequently superfluous.

Cordyceps gentilis (Ces.) Sacc. was described by Cesati from a specimen on a wasp from Sarawak. I have recently examined a specimen on a hornet from Siam. The stalk was over 5 cm. long, 0.5 mm. diameter, pale brown, matt, not horny, longitudinally striate, and of the same texture as that of *C. sphecophila*, the outer layer tending to split and curve away, like the outer layer of the stalk in some agarics. The head was up to 12 mm. long, 1.2 mm. diameter, cylindric, acute at the apex with a short thin tip, yellow, glabrous, irregularly longitudinally ridged and furrowed. The part-spores were narrow-oval or sub-fusoid, $8-11 \times 1.5-2.5 \mu$. The structure of the head and the arrangement of the perithecia were the same as in *C. sphecophila*.

C. gentilis differs from *C. sphecophila* in its longer, more acute head, which becomes irregular (? in drying). In the latter species, the head is ovoid or narrow-oval, and acute. *C. oxycephala* Penz. & Sacc., on a wasp from Java, which was described and figured with an oblongo-fusoid, acute head, and was said to differ from *C. sphecophila* in its more acute, rougher head, is evidently *C. gentilis*. There is very little difference between *C. sphecophila* and *C. gentilis*. In the type of *C. sphecophila*, the part-spores are narrow oval, $10-15 \times 1.5-2 \mu$.

C. lachnopoda Penz. and Sacc., also on a hymenopteron from Java, was described as having a yellow stalk, covered everywhere with hyaline spreading hairs. It would be of interest to know whether these hairs are the remains of conidiophores. Except for that feature, the description and figure do not reveal any marked difference from *C. sphecophila*.

C. thyrsoides Möller was described from a specimen on a bee from Brazil. From the description and figure, it is *C. sphecophila*.

The parallel European species, *C. Ditmari* Quélet, was described from a specimen on a wasp found in Jura. It was figured by Quélet with a double collar on the stalk, just below the head, but he stated in his description, "la cuticule forme parfois, en s'exfoliant, une double collerette fimbriée," so that he evidently recognised that this feature was accidental. The stalk of *C. Ditmari* is of the same texture

as that of *C. sphecophila*, and in both species the outer layer may split off and recurve.

In the European specimens of *C. Ditmari* issued in Rehm, *Ascomyceten*, no. 1287, on *Vespa* sp., the head is somewhat one-sided, with a free lower edge, differing in the latter respect from *C. sphecophila*, in which the head merges below into the stalk. The surface of the head is yellow, smooth and waxy looking, and the cortical layer consists of long clavate cells fused laterally. In *C. sphecophila* and *C. gentilis*, the appearance of the surface of the head is the same, but the cortical layer in these two consists of merely cuboid cells. In all three, the perithecia are subvertical, and readily separable from the friable context. The part-spores of this specimen of *C. Ditmari* were narrow-oval, ends obtuse, $8-9 \times 1.5-2 \mu$.

In the copy of Rehm, *Ascomyceten*, no. 1287, examined, there was a conidial clava. This was simple, terete, linear, bifurcating at the apex. It had a central core of parallel hyphae, with an exterior palisade layer of basidia. The basidia were $16-24 \mu$ high, 4μ diameter, clavate, with a truncate apex. The conidia were borne singly on each basidium, and were broadly clavate, with a rounded apex, hyaline, thick-walled, $7-9 \times 3.5-4 \mu$. This conidial stage is a *Hymenostilbe*. The cortical cells of the head of the ascigerous stage resemble the basidia of the conidial stage.

Specimens of *C. Ditmari* were also issued in Krieger, *Fungi Saxonici*, no. 1228, on *Vespa vulgaris* Linn., but these are conidial only. The stalk is white, smooth and glabrous, and does not bear any basidia. It terminates in an ovoid or globose head, covered with a palisade layer of basidia. The basidia are 18μ high, 2μ diameter, equal, cylindrical, septate, bearing single hyaline clavate conidia, with obtuse ends, $2.5-3 \times 1.5 \mu$.

A conidial specimen in Herb. Kew., labelled "St Die (Vosges)," has irregular, laterally flattened heads, tuberculate at the edge and margined below. The head is pale yellow, and is covered by a palisade layer of basidia. The basidia are cylindrical, obtuse, $12-18 \mu$ high, 1.5μ diameter, and the conidia hyaline, oval, or pyriform, obtuse below, $2.5-3 \times 1-1.5 \mu$. This agrees with Krieger, 1228.

Assuming that all these specimens of "*C. Ditmari*" are really the same species, then it would appear that its conidial stage can occur in two forms, the one a simple linear *Hymenostilbe*, and the other a capitate clava, with basidia confined to the head, which perhaps becomes perithecial later. But if that is the case, the basidia and conidia of the capitate form are much reduced in size, compared with those of the linear clava. There is, of course, the alternative, that these conidial stages belong to two distinct species of *Cordyceps*.

Quélet stated that *Cordyceps Ditmari* had conidia 10μ long, ellipsoid, at first continuous and "fauve," then one-septate and brown

There is little doubt that his description applies to some intrusive spore. Foreign spores readily adhere to the clava of a *Hymenostilbe*, or *Hirsutella*, etc., and I have examined a specimen of *Hymenostilbe muscaria*, in which the clava was covered with oval, dark brown spores, apparently the ascospores of a *Hypoxylon*.

The exsiccati, Rehm, 1287 and Krieger, 1228, were issued under the name *Cordyceps sphecephila* (Kl.) B. and C., with the synonym, *C. Ditmari* Quélet. This synonymy would appear doubtful. The stalks of the two species are similar, and the colour and surface of the head, and the arrangement of the perithecia are the same, but there are differences in the structure of the cortex and the shape of the head, more especially the definite lower margin of the head of *C. Ditmari*. *C. Ditmari* might rank as a variety of *C. sphecephila*. But until the conidial stage of the latter is known, it is best to leave the question open.

Quélet believed that *C. Ditmari* was the perithecial stage of *Isaria sphecephila* Ditm. Ditmar's figure of his species is an obstacle to the acceptance of this allocation, for he described the clava as pilose at the apex and figured it minutely setulose. As previously pointed out by Speare, Ditmar's figure strongly suggests a *Hirsutella*. It does not agree with a *Hymenostilbe*. But here again, more specimens are required, before any satisfactory conclusion can be reached.

30. *HYMENOSTILBE ARANEARUM* Petch, n.sp.

This species has been found repeatedly at Nuwara Eliya, Ceylon, where it usually occurs on spiders buried in moss or concealed in cracks in the bark of trees, not attached to the substratum. As many as forty clavae may arise from one insect.

Hymenostilbe Araneorum Petch, n.sp. Clavae terete, up to 4 mm. high, 0.1 mm. diameter, usually simple, sometimes forked, attenuated upwards, with a clavate apex, pruinose, brown below, ashy above; basidia clavate or cylindrical, rounded above, attenuated below, about 8 μ high and 4 μ diameter, minutely verrucose above, with a single short obtuse sterigma, up to 0.5 μ high; conidia obclavate, rounded at the base, acute or obtuse at the apex, hyaline, smooth, 6-8 \times 2-2.5 μ . On spiders, Nuwara Eliya, Ceylon.

In very wet weather, the clavae of specimens protected in cracks in the bark of trees appear stouter, owing to the copious development of conidia which then persist in chains, discernible under a low magnification.

31. *ISARIA CRASSA* Pers.

Isaria crassa was described by Persoon in 1797, as "simplicissima, clavula crassa subconica, stipite distincto glabro." Link (*Species Plantarum*, 1825) regarded it as a form of *I. farinosa*, and that view has been generally accepted. Persoon cited, with a query, Fig. a

of Holmskiöld's plate of *I. farinosa*. That figure shows a form with a slender stalk and a clavate, unlobed head. Payer, in *Botanique Cryptogamique*, gave an alleged figure of *I. crassa* (p. 58, Fig. 241 and p. 76, Fig. 353), but his illustration was taken from Ditmar's figure of *I. sphecophila*. Roumeguère also gave a figure of *I. crassa* in *Cryptogamie Illustrée* (Fig. 309), but this is a copy of Ditmar's figure of *I. velutipes* Link.

32. *ISARIA PATTERSONII* Masee

Isaria Pattersonii was described by Masee in *Kew Bulletin* (1912), 358, as "Stroma effusum, crustaceo-tomentellum, matricem totam externe atque interne ambiens, cinereum, ubique ramulos erectos multifidos emittens; ramuli ex hyphis filiformibus densissime constipatis apice plus vel minus liberis efformati; conidia in hypharum apicibus acrogena, numerosissima, globosa, hyalina, 2μ diametro." It was said to be on a scale insect, *Nuzura viridula*, from the Gold Coast. In *Kew Bulletin* (1913), 105, the host and locality were corrected to "on a pentatomid," *Nezera viridula*, from St Vincent, and it was added that specimens had also been received from Grenada.

In the type specimen the synnemata are fasciculate, arising from a tuft or cushion of mycelium, greyish white, up to 2 mm. high, 0.1 mm. diameter, with a cylindric or ovoid farinose head, 0.5 mm. high, 0.25 mm. diameter. The stalk is laterally compressed, loose, composed externally of loosely interwoven hyphae, and loose internally, except in some cases a stouter core towards the base. The heads are sometimes laterally adherent. Some of the conidiophores separate from the stalk below the head, but the head is somewhat compact. The conidiophore is spicarioid, with a main stem, 2μ diameter, expanding above to 4μ , and bearing, at the apex of the terminal segment, three or more short branches, crowned with phialides, or prophialides and phialides. The prophialides are cylindrical, $7 \times 2.5\mu$, and the phialides flask-shaped, $7-8 \times 2.5\mu$. The conidia are catenulate, oblong-oval or subcymbiform, ends obtuse, $2-2.5 \times 1\mu$, or subglobose, $1.5-2\mu$, hyaline, smooth.

This species should be compared with *Isaria edessicola* Speg. (1910), described from a specimen on a Pentatomid (*Edessa meditabunda*) in the Argentine, which was said to have elliptico-cylindric conidia, $2-3 \times 0.75-1\mu$.

35. *HYPOCRELLA PALMICOLA* P. Henn.

Hypocrella palmicola was described by Hennings from a specimen from Madagascar. When preparing my paper on "The Genera *Hypocrella* and *Aschersonia*" (*Ann. Perad.* VII, 167-278), I examined the type in Herb. Berlin, which contained only one stroma. The specimen was rather old, and was blackish brown, dotted with black

ostiola. The centre of the stroma was depressed, and surrounded by pycnidia which opened into the depression. The remainder of the stroma contained crowded perithecia.

Recently, I collected numbers of this species at Nuwara Eliya, Ceylon, generally on an Aleyroidid on bamboo (*Arundinaria debilis* Thw.), but occasionally on other plants, e.g. *Litsea*, *Eugenia*, etc. Old specimens resemble the type in colour, but the younger and less weathered specimens are quite different. The difference in colour is parallel to that in *Aschersonia brunnea* Petch, a species of similar structure, originally described from an old herbarium specimen as dark purple-brown, but found to be yellow-brown in recently collected unweathered specimens (*Ann. Perad.* VII (1922), 326). The following description of *Hypocrella palmicola* has been drawn up from the Ceylon specimens.

Hypocrella palmicola P. Henn. in Voeltzkow, *Reise Ost-Afrika*, III, (1908), 29. Stroma circular, up to 3 mm. diameter, flattened pulvinate, margin rounded, yellow-brown or brownish yellow, subtranslucent (when fresh), yellowish grey or greenish grey (when dry), becoming brown and finally purple-brown with age, pruinose, becoming glabrous, internally pale yellow. Stromata perithecial, or pycnidial, or both. Pycnidium either central, a depressed circular cavity about one-half the diameter of the stroma, or a horse-shoe groove, sometimes interrupted, running concentrically midway between the centre and the circumference; groove, in section, either widely open, 0.5 mm. broad above, 0.25 mm. deep, with a convoluted base, or perithecioid, 0.25 mm. deep, 0.2 mm. broad in the middle, contracted to a narrow opening, 0.05 mm. across. Pycnospores fusoid, inequilateral, or subcymbiform, ends obtuse or subacute, $5-7 \times 1 \mu$, extruded into a central orange mass; paraphyses linear, up to 120μ long, but sometimes only 40μ . Perithecia crowded, flask-shaped, 0.1 mm. deep, 0.05 mm. diameter, wall yellow, ostiola not projecting, red-brown, becoming dark brown and ultimately not evident; asci 80–100 μ long, 3–4 μ diameter, four-spored; part-spores cylindrical, ends obtuse, $6-10 \times 1 \mu$. Madagascar, in Herb. Berlin. Ceylon, on an Aleyroidid on bamboo, etc., Nuwara Eliya, 1926–28.

In one gathering on *Eugenia* sp. from Nuwara Eliya, the Aleyroidid is surrounded by a marginal, light brown, swollen ring, sometimes extending outwards as a narrow byssoid hypothallus. On this ring are situated close-set tubercles, laterally compressed, dark brown, minutely tomentose or pruinose, laterally ovoid, sometimes confluent. In one example, these tubercles cover the insect completely, but in general, the insect is exposed in the centre of the stroma. Each tubercle contains a vertically ovoid pycnidium, 0.4 mm. high, 0.25 mm. diameter, with an impressed ostiolum. The pycnospores measure $6-8 \times 1.5 \mu$, and the paraphyses are up to 80 μ long. Similar

stromata have also been found in company with normal stromata of *Hypocrella palmicola*, and they are no doubt abnormal forms of that species.

In "The Genera *Hypocrella* and *Aschersonia*," a gathering from Trinidad, made by Professor Thaxter, was referred to *Hypocrella palmicola*. In the light of these later Ceylon specimens, in better condition than the type, that reference was incorrect. The Trinidad specimens are a distinct species, differing, *inter alia*, in the shape of the pycnidia and perithecia.

34. *HYPOCRELLA CASTANEA* Petch, n.sp.

This species was collected by Professor R. Thaxter, on an Aleyrodid on *Adiantum* sp., St Ann's, Port of Spain, Trinidad, and was referred to *Hypocrella palmicola* P. Henn., in *Ann. Perad.* VII (1921), 237.

Hypocrella castanea Petch, n.sp. Stromata dark chestnut-brown, circular, discoid, minutely rugose, up to 1.5 mm. diam., 0.8 mm. thick in the centre, thinning slightly towards the margin, internally pallid or brownish. Perithecia moderately crowded, globose with a conical neck, 200–250 μ high, 110–130 μ diameter, ostiola not projecting; asci and spores of the genus; part-spores cylindric, ends obtuse, 5–7 \times 1–1.5 μ .

Aschersonia stage: stromata of the same colour, circular, flattened pulvinate or subdiscoid, 0.8–1 mm. diameter, up to 0.6 mm. thick, even, or umbilicate in the centre; pycnidium single, central, laterally oval, 0.3 mm. diameter, 0.2 mm. high; pycnosporos fusoid, ends not produced, 4–6 \times 1.5 μ ; paraphyses linear, up to 130 μ long. On an Aleyrodid on *Adiantum* sp., Trinidad.

Figs. 31 and 32, Plate III, vol. VII, *Annals R.B.G. Peradeniya*, are the *Hypocrella* and *Aschersonia* stages respectively of this species.

35. *TORRUBIELLA ALBA* Petch, n.sp.

This species, on spiders on the living leaves of various plants, was collected at Nuwara Eliya, Ceylon, on several occasions during 1927–8. It forms a rather loose white web over the insect and spreads out in a byssoid film over the leaf. The perithecia are scattered, or clustered in lines or patches, on the mycelium on the insect, and scattered over the film on the leaf. In the majority of instances, it is associated with a *Cephalosporium*, which is apparently the conidial stage, and the same *Cephalosporium* has been found occurring alone on spiders.

The perithecia are clothed almost to the apex with white mycelium. If the *Cephalosporium* is absent, the hyphae on the perithecial wall towards the apex are rigid, curled, and here and there verrucose, but when the *Cephalosporium* is present, these hyphae are less evident,

and the covering on the perithecium consists largely of the mycelium and conidiophores of the latter. *Acrostalagmus*, as well as *Cephalosporium* conidiophores are produced. The conidiophores occur in loose tufts, and in one example, a clava, 8 mm. high, 0.15 mm. diameter, bearing loose tufts of conidiophores, is present.

When these specimens were collected, it appeared possible to divide them into two species, one having perithecia with a hyaline apex, and the other having perithecia with a brown apex. The *Cephalosporium* occurred in many of the examples of the former, but in none of the latter. When perithecia from fresh examples of the latter were mounted, however, they did not show any colour in the apex, the wall in all cases being uniformly hyaline. In general, the perithecial wall is so thin that the asci and the paraphyses are clearly visible when specimens are mounted in water, but occasionally it is stouter and the asci are not so clearly seen.

In the dry state, the apex of the perithecium is pale to dark amber, or, in one specimen, dark brown. But the apex of the latter was noted as hyaline when collected. The perithecium wall in this specimen is now pale yellow.

It has not been found possible to maintain the suggested division into two species on the character of the perithecium or the presence of *Cephalosporium* conidiophores.

Raciborski described *Barya montana* from a specimen on a spider in Java. From his description, it is evidently a *Torrubiella*, and must be known as *Torrubiella montana*. Raciborski stated that the insect was covered with a floccoso-pulverulent white mycelium, which at first bore a white, stilboid conidial clava, 4.5 mm. high, 0.5 mm. diameter, and then elongated-oval, free perithecia. He did not describe the conidial stage.

The Ceylon species differs in the shape of the perithecia, and especially in their size and texture. The Javan species was described as having perithecia with a stout wall, and 750–900 μ long and 400 μ broad. In the Ceylon species the perithecial wall is membranous, and the height does not exceed 500 μ , most of the perithecia being about 250 μ high.

The Ceylon species has a small number of linear paraphyses. Raciborski stated that *Barya montana* lacked paraphyses. It is not, however, advisable to lay much stress on that difference, as paraphyses in *Torrubiella* are often overlooked. As the genus *Torrubiella* now stands, it includes species which have, and species which, according to the descriptions, lack, paraphyses. But as the paraphyses in *Torrubiella* are evanescent and usually atypical, it would merely cause confusion if an attempt were made to divide the genus on that basis.

It is not possible to assign the Ceylon species to *Torrubiella montana*, or to any of the other species of *Torrubiella* known to occur on spiders.

Torrubiella alba Petch, n.sp. Mycelium white, loose, covering the insect and spreading in a byssoid film over the leaf. Perithecia scattered or crowded on the insect, and scattered on the film on the leaf, superficial, flask-shaped with a short neck, or conoid, 140–500 μ high, 55–200 μ diameter, clothed with white mycelium almost to the apex; apex rounded, thickened, pale or dark amber (in dry specimens); perithecial wall usually thin and translucent, hyaline, sometimes thicker and pale yellow; paraphyses few, linear, 0.5 μ diameter, as long as the asci, often showing light and dark lengths, diffluent; asci cylindrical, 3 μ diameter, up to 200 μ long, eight-spored, apex capitate; ascospores linear, as long as the ascus, 0.75 μ diameter, multiseptate, dividing into cylindrical, truncate part-spores, 2–4 \times 0.75 μ . On spiders, Nuwara Eliya, Ceylon.

The conidial stage may be known as *Cephalosporium Araneorum*.

Cephalosporium (Acrostalagmus) Araneorum Petch, n.sp. Mycelium white, loose, covering the insect and spreading in a byssoid film over the leaf. Conidiophores in loose tufts, sometimes on a clava, simple, conoid, continuous or one-septate, up to 28 μ high, 1.5 μ diameter at the base, tapering regularly upwards, or acrostalagmoid, up to 150 μ high, 2 μ diameter below, with two whorls of phialides, 16 μ long, 1.5 μ diameter below, slightly flask-shaped, tapering to the apex. Heads of conidia small, 4–8 μ diameter, usually 4 μ , persistent. Conidia narrow-oval or cymbiform, straight or slightly curved, ends obtuse, hyaline, continuous, 1.5–4.5 \times 0.75–1.5 μ . On spiders, Nuwara Eliya, Ceylon, sometimes accompanied by *Torrubiella alba*.

36. *CALONECTRIA PRUINOSA* Petch, n.sp.

This species was found at Nuwara Eliya, Ceylon, on a leaf-hopper on bamboo and other plants. Its conidial stage was recorded for Ceylon in *Trans. Brit. Myc. Soc.* x (1924), 44, as *Hirsutella floccosa* Speare, but a comparison with specimens of the latter from Trinidad, etc., has shown that identification to be incorrect.

Calonectria pruinosa Petch, n.sp. Mycelium covering the insect with a compact dark ochraceous stroma of interwoven hyphae and spreading in a byssoid radiating mat over the leaf; stroma minutely pulverulent; subjacent hyphae white. Perithecia on, or partly embedded in, the stroma, dark red, pruinose with dark ochraceous mycelium almost to the apex, conoid, 0.1 mm. diameter, ostiolum papillate. Asci 150 μ long, 6–10 μ diameter, narrow-clavate, eight-spored, spores at first obliquely uniseriate, then uniseriate, or uniseriate below and irregularly biseriate above; apex of the ascus solid, 8–18 μ long, 6 μ diameter, truncate, sometimes depressed in the centre, perforated by a narrow canal. Paraphyses linear, shorter than the asci. Ascospores fusoid, seven-septate, apex obtuse, lower end attenuated and aseptate for 6–10 μ , hyaline, 18–28 μ long, 5–6 μ

diameter, sometimes with a mucilaginous coat, $1\ \mu$ thick. On a leaf-hopper on bamboo (*Arundinaria debilis*), etc., Nuwara Eliya, Ceylon.

The mycelium bears *Hirsutella* phialides, fairly close together, about $8\ \mu$ apart, and very variable in shape. The perithecial stroma is coloured only superficially, the underlying tissue being white. Stromata which bear conidia only are at first arachnoid and greyish white, becoming compact, white, or pale to dark ochraceous, or greyish brown. In one conidial example the stroma was deep orange-yellow.

This species differs from *H. floccosa* in colour and in the shape of the conidia. It may be known as *H. versicolor*.

Hirsutella versicolor Petch, n.sp. Stromata on the insect at first arachnoid, greyish white, becoming compact, white, then pale or dark ochraceous, or greyish brown, or orange-yellow, spreading in a byssoid radiating mat over the leaf. Phialides lateral on the hyphae, simple, conoid or flask-shaped, $8\text{--}20\ \mu$ high, $2.5\text{--}3\ \mu$ diameter, attenuated above into a long sterigma, or ovoid, $6 \times 3\ \mu$, narrowed abruptly into the sterigma, or compound, up to $26\ \mu$ high, septate and bearing lateral phialides below, frequently with two or three sterigmata on one phialide. Sterigmata up to $20\ \mu$ long. Conidia adherent, soon separating, narrow-cymbiform or narrow-oval, ends acute, hyaline, $4\text{--}8 \times 0.75\text{--}1.5\ \mu$. Sessile globose pseudo-conidia, $3\text{--}4\ \mu$ diameter, also occur on the mycelium. On a leaf-hopper, Nuwara Eliya, Ceylon.

Like *Hirsutella floccosa*, this species does not form a clava. Its conidia soon separate, and may be found adhering to the mycelium.

37. *BYSSOSTILBE TOMENTOSA* Petch

Byssostilbe tomentosa, a fungus parasitic on *Cordyceps dipterigena*, was described in *Trans. Brit. Myc. Soc.* VIII (1923), 211. In further collections of parasitised specimens of *Cordyceps dipterigena*, the *Byssostilbe* has been accompanied by two other fungi which are most probably stages of it.

One of these forms white, even patches, consisting of crowded *Cephalosporium* conidiophores, on the *Cordyceps* or on the insect, the latter being, of course, permeated by the mycelium of the *Cordyceps*. In one example, in which the body of the insect has been broken, the *Cephalosporium* covers the exposed surface with an even white pile. In addition, slender, white, conico-cylindric clavae, up to $1.5\ \text{mm}$. high and $0.25\ \text{mm}$. diameter at the base, are produced, on the insect and on the clavae of the *Cordyceps*, sometimes arising at right angles to the latter. These white clavae have a solid central core, formed by parallel hyphae of the *Cephalosporium*, and bear *Cephalosporium* conidiophores laterally, perpendicular to the clava and forming a rather loose peripheral layer. The conidiophores are simple, $16\text{--}20\ \mu$

high, $2\ \mu$ diameter near the base, flask-shaped and septate below, attenuated in the upper half or one-third. The conidia are oblong-oval or sub-fusoid, $3\text{--}4 \times 1.5\ \mu$, persistent in globose heads up to $8\ \mu$ diameter. The conidiophores and conidia on the clavae are identical with those which occur on the *Cordyceps* directly, and it is clear that the fungus can take both *Cephalosporium* and *Tilachlidium* forms.

With the foregoing fungus are minute, yellow, subtranslucent, columnar masses, which at first sight appear to be developing perithecia. They occur in groups, partly embedded in the pile of conidiophores on the insect or on the *Tilachlidium* clavae. On examination these prove to be masses of conidia. The yellow masses are up to 0.25 mm. high, 0.1 mm. diameter, or larger by confluence. The embedded base is concave below, sub-hemispherical, up to $200\ \mu$ diameter and $160\ \mu$ high, yellow, and consists of parallel hyphae which divide above and terminate in stout basidia, $2\text{--}3\ \mu$ diameter, septate, verrucose, rounded above, each furnished with a thin, central, conical sterigma, up to $10\ \mu$ long. The conidia are hyaline, continuous, oval, with acute ends, $2\text{--}2.5 \times 1.5\ \mu$. It would appear that this form should be placed in the Tuberculariaceae, in or near *Dendrodochium*.

Two other specimens, collected at Nuwara Eliya, have been referred provisionally to *Byssostilbe tomentosa*. Both are conidial only. One is on a caterpillar and the other, as far as can be determined, apparently on a fly. Whether the insects have been previously attacked by other fungi cannot now be decided. The *Tilachlidium* clavae are cylindrical, white, up to 1 mm. high, 0.1 mm. diameter below, with a central core of parallel hyphae and a peripheral layer of *Cephalosporium* conidiophores which project irregularly from the clava. On the upper part of the clava, the conidiophores are simple, up to $24\ \mu$ high, stout, elongated conical, but in the lower part they are up to $54\ \mu$ high and irregularly branched. The core of the clava is fuscous externally, but it would seem probable that this darkening of the external layer of the core is due to weathering during an arrest of growth of the clava before the conidiophores were produced—a view which finds support in the fact that, on one clava examined, numerous uredospores were found adhering to the core of the clava, at the base of the layer of conidiophores. The conidia are narrow-oval or sub-fusoid, ends obtuse, $3.5\text{--}4.5 \times 1.5\text{--}2\ \mu$.

With these clavae are short, white, columnar protuberances, about 0.25 mm. in height and diameter, bearing at the apex a minute hyaline globule of conidia. These conidia are narrow-oval, ends acute, $2\text{--}2.5 \times 1\ \mu$. The hyphae of the column are parallel, curving outwards above, the outer terminating in rough clavate tips, while the inner terminate in conidiophores as in *Byssostilbe tomentosa*, the mass of conidia being partly sunk in the apex of the column.

No perithecia occurred with these latter specimens, and consequently their reference to *Byssostilbe tomentosa* is uncertain. The *Cephalosporium* conidiophores, and the colour of the masses of conidia, differ from those of *Byssostilbe tomentosa*, and it is possible that they may belong to another species of *Byssostilbe*.

38. *EMPUSA LECANII* Zimm.

A disease of *Lecanium viride* occurs in Ceylon, South India and Java, and is known in South India as the "grey fungus" to distinguish it from the white fungus disease, caused by *Cephalosporium Lecanii*. Zimmermann, who investigated the disease in Java, attributed it to an *Empusa*, which he named *E. Lecanii*.

An account of this disease was published in *Trans. Brit. Myc. Soc.* xi (1926), 254-8, where it was recorded that the colour of the dead scale is due principally to the secondary growth of *Cladosporium* and other Dematiæ. A fine hyaline mycelium was also found on the dead insect, and this bore conidia which resembled the sporangia of a *Pythium*.

I have recently received from Dr G. O. Ocfemia, Philippine Islands, specimens of an aphid, *Aphis sacchari* Zehnt. in a similar condition. The dead insects are covered with *Cladosporium*, and among it are fine hyphae, bearing sporangia similar to those figured on p. 257 (*loc. cit.*). Dr Ocfemia states that the disease has killed 80-95 per cent. of the aphids in insect-proof cages used in experiments on the transmission of the Fiji banana disease.

A comparison of the figures referred to above with those on Plate XVI of Thaxter's *Entomophthoræ of the United States* will show clearly that the supposed sporangia are the secondary conidia of an *Empusa*, which, from the details available, should apparently be referred to *E. Fresenii* Nowak.

39. *VERTICILLIUM*, *CLADOBOTRYUM* and *CALCARISPORIUM*

In *Trans. Brit. Myc. Soc.* xi (1926), 251-4, I discussed the species which have been known as *Verticillium heterocladium* Penzig, and pointed out that it scarcely seemed possible that the fungus known under that name in Florida could be the same as the species described by Penzig from Italy, more especially as the former was figured with one conidium at the apex of each phialide, whereas Penzig particularly stated that his species had one to three conidia at the apex of a phialide. Penzig suggested that his species should rather be referred to the genus *Cladobotryum* Corda, because of the arrangement of the conidia.

I have since collected at Nuwara Eliya, Ceylon, a Hyphomycete which bears a close resemblance to *Verticillium heterocladium*, as described and figured by Penzig. It occurred in one instance on a frog-hopper on bamboo, together with an indeterminable fungus and a

Cladosporium, and in another instance on an insect wing attached to a leaf.

In the specimen on a frog-hopper, the fungus produces conidiophores on the insect, and runs widely over the leaf, on which the insect is seated, in single hyphae which bear erect, rigid conidiophores, scattered, or sometimes clustered in small white tufts. The conidiophores are up to $320\ \mu$ high, $2\ \mu$ diameter below, with nine whorls of phialides in the upper $120\ \mu$, but usually about $120\ \mu$ high, $1.5\ \mu$ diameter below, with whorls of phialides, $10\text{--}13\ \mu$ apart, and sometimes solitary phialides below. The phialides are up to five in a whorl, narrow flask-shaped, $5\text{--}8\ \mu$ long, $1\text{--}1.5\ \mu$ diameter below, and bear minute cylindrical sterigmata, usually simple, sometimes bifurcate, towards the apex. In some cases the apex is slightly inflated and the sterigmata radiate from the apex only. The conidia are oval or oblong-oval, sometimes slightly attenuated to one end, sometimes acute below and occasionally apiculate, $3\text{--}5 \times 1.5\text{--}2\ \mu$, not persistent on the phialide.

In culture on Quaker Oat agar, the slant is covered with a rather dense white felt of mycelium and conidiophores, which becomes pinkish in the centre. The agar is not coloured. The sterigmata in culture are often elongated and branched.

In culture on Dox agar, the fungus produces compact, circular, flattened pulvinate stromata, at first pale purple-brown with a flat, white, tomentose margin. The reverse is then yellow. The stromata then become dark purple-brown towards the margin, and the reverse ochraceous. Finally, adjacent stromata coalesce and cover the whole slant, and become white owing to the development of conidiophores everywhere. The agar is not coloured.

This Ceylon species agrees with Penzig's *Verticillium heterocladium* in its verticillate phialides, and in having several conidia at or near the apex of a phialide. Neither is a typical *Verticillium*, but both have affinities with *Cladobotryum* and *Calcarisporium*.

On the other hand, the Florida species assigned to *Verticillium heterocladium* is, in the specimens I have examined, a true *Verticillium*.

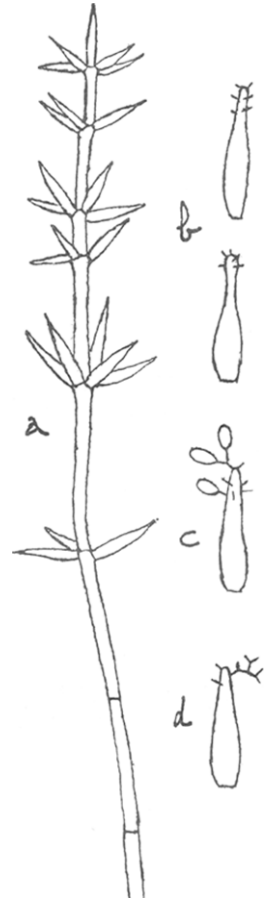


Fig. 2. *Cladobotryum ovalisporum*. a, conidiophore. $\times 1000$; b, phialides; c, phialide with conidia; d, phialide with branched sterigma. $\times 2000$.

The genus *Cladobotryum* was instituted by Nees in 1816 as conidiophore erect or decumbent, almost corymbosely branched above, with large oval or cylindrical spores round the apex of each branch, white. After stating that *Botrytis agaricina* and *B. macrospora* Link should be placed in this new genus, he described and figured *Cladobotryum varium* Nees. His figure shows a branched decumbent conidiophore, the branches bearing one to three conidia at the apex.

Fries (*Systema*, III (1832), 414) discarded Nees' genus, and placed *Botrytis macrospora*, *B. agaricina*, and *Cladobotryum varium* in the genus *Dactylium* Nees, regarding *Cladobotryum varium* as a form of *Botrytis macrospora*.

Thus, owing to Nees' unfortunate inclusion of two old species (with one of which he was admittedly unacquainted) in his new genus, and the consequent implication that his new species was similar to them, it might be considered necessary, in a complete treatment of the subject, to discuss *Botrytis agaricina* and *B. macrospora*—whether these two really have septate conidia, and whether they should be classed as *Verticillium*, or *Dactylium*, or *Diplocladium*, questions which involve citation from the mycological literature of more than a century. As, however, I propose to take *Cladobotryum* Nees as a genus having continuous spores, I have discarded four pages of manuscript dealing with these points. Nees apparently referred these two species to his new genus, because of the arrangement of their conidia.

Corda adopted Nees' genus *Cladobotryum*, and stated (*Ic. Fung.* 1 (1837), 21) that the merging of *Cladobotryum* in *Dactylium* was in the highest degree unnatural, because the latter genus had septate spores. But Corda emended Nees' description in such a manner that it may be taken to mean something quite different from Nees' idea, as expressed by his description and figure.

Saccardo (*Michelia*, II (1880), 18) again emended the generic description of *Cladobotryum*, and remarked (*Sylloge Fungorum*, IV, 161) that *Cladobotryum varium* Nees (which was Nees' type species) scarcely belonged to the genus!

Thus, *Cladobotryum* Nees, *Cladobotryum* Corda, and *Cladobotryum* Saccardo are three different things.

As I read Nees' description, *Cladobotryum* should have verticillately branched conidiophores with phialides in whorls, the phialides bearing apical and subapical sterigmata which bear solitary, continuous conidia. The phialide terminates in a slender apiculus (Corda), only when the terminal conidium has fallen off, leaving the short slender sterigma, while the later formed conidia are produced from similar sterigmata on the phialide, not at the base (Corda) or apex of the apical sterigma, and they are not "*aegre secedentia*" (Saccardo).

Another possible genus for Penzig's species is *Calcarisporium* Preuss,

which was instituted by Preuss in *Linnaea*, xxiv (1851), 124, and described as "Stipes erectus, septatus, hyphopodio ramoso suffultus, supra ramosus apice capitato verrucosus; verrucis sporas solitarias gerentibus. Sporae simplices basi hilo instructae." His single species was *Calcarisporium arbuscula*, and only one other (which does not wholly comply with the generic description) has been included in the *Sylloge Fungorum* up to the present time. The conidia, according to the generic description, should be beaked at the base, the name of the genus being based on that feature. One would expect that this refers to the conidia after abscission, not to the conidia while still attached to the phialide.

Calcarisporium arbuscula was re-described and figured by Miss A. L. Smith in *Trans. Brit. Myc. Soc.* III (1909), 120, Pl. VI, fig. 7, *a, b*, from specimens on decaying fungi from Swarraton, Hants. The figure shows somewhat flask-shaped phialides with a globose head which is rough with the points of attachment of the conidia, and the description states that the conidia have "sometimes a minute beak at place of insertion."

In "Studien ueber Hyphomyzeten" (*Centralb. f. Bakt.*, etc., Abt. 2, LX (1924), 1-26) von Höhnel stated that it was questionable whether *Cladobotryum* Sacc. (*non* Nees) was sufficiently distinct from *Calcarisporium* Preuss. He had collected on two occasions a Hyphomycete which he considered to be *Calcarisporium arbuscula* Preuss. It differed generically from *Verticillium*, only in having several conidia at the tips of the phialides, and in the tips of the phialides not being simple, but inflated into a head, about 3.5μ broad, covered with stellately arranged, pointed warts, on which the very shortly stalked conidia were situated. On well-developed specimens, the phialides bore in addition a number of these warts below the head, so that a short spike of conidia was produced. On poorly developed specimens, the head was lacking and the phialide bore only one or two conidia at the apex. The conidia were hyaline, continuous, oval, pointed below, with a very short and thin pedicel.

It would appear from these descriptions that in *Calcarisporium arbuscula* the apex of the phialide may be capitate or not, while the conidium may or may not be beaked. It is not clear from these accounts whether the pedicel or sterigma remains attached to the spore after abscission or not.

Von Höhnel does not appear to have published any views on the genus *Cladobotryum*, and consequently one is at a loss to know why he considered that *Calcarisporium* was equivalent to *Cladobotryum* Sacc., not to *Cladobotryum* Nees. It does not answer to Saccardo's generic description, unless the conidia remain attached to the phialide.

Verticillium heterocladum Penzig and the corresponding Ceylon species both have phialides in whorls on the main axis, and one or more

conidia at the apex of a phialide. In the Ceylon species, the conidia are attached by short sterigmata, which persist on the phialide, the conidia, as a rule, not being beaked. Penzig stated that in *V. heterocladium* the conidia were generally borne on very short pedicels, but he did not describe them as pedicellate or beaked. The phialides in the Ceylon species are not, as a rule, inflated at the apex.

It would appear, however, that neither the inflated apex of the phialide, nor the presence of a beak or pedicel on the detached spore,—features which characterise the genus *Calcarisporium*—is constant. *Calcarisporium* Preuss should therefore be considered equivalent to *Cladobotryum* Nees. But even if that is not admitted, *Verticillium heterocladium* and the corresponding Ceylon species should be placed in *Cladobotryum* Nees.

The Florida fungus attributed to *Verticillium heterocladium* is certainly not that species. In the specimens from Florida which I have examined, it is a typical *Verticillium* with solitary terminal conidia on the phialides and no warts or sterigmata. It also differs in having some of the whorls of phialides on short lateral branches, whereas *V. heterocladium* (from Penzig's figure and description) and the Ceylon species have phialides arising in whorls from the main axis.

The following names are proposed for the species considered in this note:

Verticillium cinnamomeum Petch, nom.nov.; *Verticillium heterocladium* Fawcett non Penzig, *Fungi parasitic on Aleyrodes citri*, June, 1908. Stromata cinnamon-brown becoming ashy brown, pulverulent, flattened pulvinate, up to 2 mm. diameter and 0.6 mm. thick, compact, with a byssoid or strigose margin which merges into a thin, whitish, byssoid or pulverulent film extending over the leaf. Conidiophores arising on the stroma or on the film, hyaline, erect, slender, up to 240 μ high, 2–3 μ diameter, bearing in the upper part whorls of phialides or of short branches which bear phialides at the apex; lateral branches cylindrical, 6–9 μ long, 2 μ diameter; phialides elongated-oval, attenuated above, somewhat inequilateral, curving upwards, 6–12 μ long, 2 μ diameter; conidia terminal, solitary, narrow-oval, hyaline, continuous, 3.5–6 \times 1.5–2.5 μ . On *Aleyrodes citri*, etc., Florida.

Cladobotryum heterocladium (Penz.) Petch, comb.nov.; *Verticillium heterocladium* Penzig in *Michelia*, 11 (1882), 462.

Cladobotryum ovalisporum Petch, n.sp. Conidiophores borne on the host insect and on repent hyphae extending over the leaf, erect, scattered or clustered, hyaline, 120–320 μ high, 1.5–2 μ diameter below, with whorls of phialides in the upper half, and sometimes solitary phialides below; phialides up to five in a whorl, narrow flask-shaped, 5–8 μ long, 1–1.5 μ diameter below, bearing minute cylindrical sterigmata, sometimes forked, towards the apex; conidia

oval or oblong-oval, sometimes slightly attenuated to one end, sometimes acute below and occasionally apiculate, hyaline, continuous, not persistent on the phialide, $3-5 \times 1.5-2 \mu$. On a frog-hopper, together with an indeterminable fungus, Nuwara Eliya, Ceylon, January 2nd, 1927.

This species apparently differs from *Cladobotryum heterocladum* in its smaller spores, but I have not seen a specimen of the latter. The details given by Penzig are insufficient for a closer comparison.

40. *CEPHALOSPORIUM* ON *ALEYRODES*

In *Trans. Brit. Myc. Soc.* x (1925), 154, *Cephalosporium Lecanii* Zimm. was recorded as occurring on a black Aleyrodid in Ceylon. During 1927-8, three more collections of this fungus on Aleyrodids were made at Nuwara Eliya, Ceylon.

Cephalosporium longisporum Petch, described from specimens on *Icerya purchasi*, Ceylon, has been found on an Aleyrodid on *Ocotea leucoxyton* (Sz.) Mez., Maricao, Porto Rico, collected March 23rd, 1916.

Neither of these species agrees with the description of *Cephalosporium Lefroyi* Horne, found on *Aleyrodes vaporariorum* at Wisley, England.

41. *CEPHALOSPORIUM* ON *THRIPS*

Cephalosporium (Acrostalagmus) Thripidium Petch, n.sp. Mycelium covering the insect with a loose white web. Simple conidiophores conical, up to 20μ high; *Acrostalagmus* conidiophores up to 160μ high, with one or two whorls of phialides towards the apex; phialides narrow flask-shaped, up to 24μ long. Heads of conidia persistent, $8-14 \mu$ diameter; conidia oblong-oval, ends obtuse, $3-6 \times 1-2 \mu$. On *Thrips* spp., Nuwara Eliya, Ceylon, July 22nd, 1928, etc.

On Quaker Oat agar, the growth is white, thin and fleecy, and the agar is slightly reddened. On Dox agar, the growth is white, with a pale yellow reverse, and the agar is not coloured.

42. *CEPHALOSPORIUM INDICUM* Petch, n.sp.

This species was sent to me in September, 1924, by Mr S. Sundaraman in culture from caterpillars on *Indigofera*, Mooply Valley, South India. Subsequently I received it from Mr C. S. Misra, of the Indian Lac Research Institute, Namkum, Ranchi, May, 1926, on larvae of *Eublemma amabilis*.

The larva is covered with a white felt of mycelium, the hyphae being $2.5-3 \mu$ diameter. The conidiophores are lateral, scattered along the hyphae, sometimes opposite, either simple or branched. In nature, the simple conidiophores are elongated flask-shaped or elongated conoid, $8-12 \mu$ high, 2.5μ diameter below, but in culture they may be up to 50μ high; sometimes they are one-septate. The

branched conidiophores usually have a single lateral branch, arising below a septum. Abnormal forms are common in culture; these have an inflated base, one or two-celled, up to 20μ high and 7μ diameter, from the apex of which arise several irregular conidiophores, which branch sympodially, the successive apices of the conidiophore being left as short conical projections.

The total height of these irregular forms is up to 65μ . The conidia form a loose head and soon separate; in nature they are hyaline, continuous, oblong-oval, one end usually acute, $4-9 \times 2-2.5\mu$; in culture, they are oblong-oval, usually attenuated towards one end or sub-fusoid, rounded at the apex, truncate at the base, $5-10 \times 1.5-2.5\mu$. The heads of conidia in hanging drops of Quaker Oat agar are oval, about 10μ high and 6μ diameter; sometimes the conidia occur in short chains, attached, not merely adherent. One conidium was seen in culture, which measured $12 \times 2\mu$ and was one-septate.

In culture on Quaker Oat agar, the fungus fills the tube with a white fleecy mass of mycelium, the conidiophores tending to be grouped in tufts; the agar is coloured salmon pink at first, becoming pale purple. On Dox agar the growth is of the same character, but the agar is not coloured; the reverse is cream-coloured.

Both on Quaker Oat agar and on Dox agar, minute black points appear at the edge of the slant in contact with the glass. These are minute brown or black-brown sclerotoid bodies.

The entomogenous species of *Cephalosporium* hitherto described have "persistent" heads, *i.e.* the conidia usually remain adherent for a considerable time. In the present species, the conidia soon separate.

Cephalosporium indicum Petch, n.sp. Mycelium $2.5-3\mu$ diameter, covering the insect with a white felt. Conidiophores lateral, scattered, elongated flask-shaped or elongated conoid, 2.5μ diameter below, simple, $8-12\mu$ high, or branched, up to 20μ high, with a single lateral branch; head oval, $10 \times 6\mu$, soon separating; conidia hyaline, continuous, oblong-oval, one end usually acute, $4-9 \times 2-2.5\mu$. On larvae of *Eublemma amabilis*, Namkum, India.

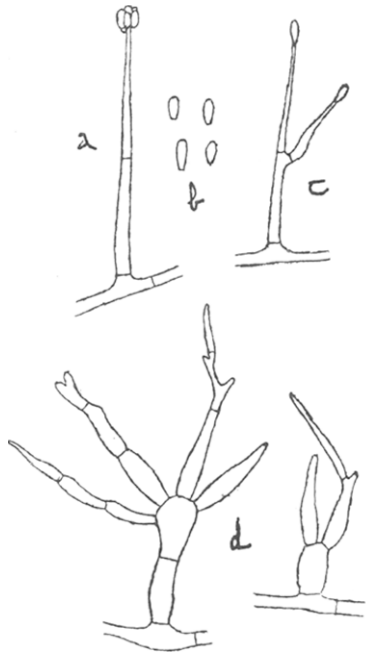


Fig. 3. *Cephalosporium indicum*. a and c, conidiophores; b, conidia; d, abnormal conidiophores from culture. $\times 650$.

43. *CEPHALOSPORIUM ZEYLANICUM* Petch, n.sp.

This species is similar to *Cephalosporium indicum* in type of conidiophore and head, but differs from that species in its conidia and its behaviour in culture. On Quaker Oat agar, the mycelium covers the slant with an even, white, compact tomentose layer and the agar is not coloured. On Dox agar, it forms small scattered tufts which are ultimately united by a thin subtransparent layer, white and pulverulent; the reverse is cream, becoming buff, and the agar is not coloured.

Cephalosporium zeylanicum Petch, n.sp. Insect covered by a thin yellow film of mycelium, over which are scattered minute white tufts. Conidiophore simple, elongated conoid, 12–16 μ high, 2 μ diameter below, continuous, occasionally one-septate, or sometimes branched, up to 24 μ high, with a single lateral branch; conidia narrow-oval, both ends acute, hyaline, continuous, 3–4 \times 1.5 μ . On a leaf-hopper, Nuwara Eliya, Ceylon, October 24th, 1926.

44. *TORRUBIELLA HEMIPTERIGENA*
Petch, n.sp.

This species was common at Nuwara Eliya, Ceylon, during 1926–8, on a leaf-hopper, usually on bamboo (*Arundinaria debilis* Thw.), but occasionally on *Psychotria* and other plants. Most of the specimens bear only the conidial stage, which is a *Verticillium*.

Torrubiella hemipterigena Petch, n.sp. Insect covered by a dense yellow web of mycelium, which spreads out in a whitish or greyish film over the leaf; sometimes with an erect yellow tomentose clava, cylindrical, tapering upwards, up to 9 mm. high, 0.5 mm. diameter, arising from the anterior end of the insect. Mycelium of two kinds, pale lemon-yellow, 2–2.5 μ diameter, minutely spinulose, with lateral, sessile, oval, rough, spore-like bodies, 4–7 \times 2.5–5 μ , singly below a node, and smooth, hyaline, 1.5 μ diameter, bearing conidiophores. Perithecia scattered, superficial, on the stroma on the body of the insect, flask-shaped, 0.8 mm. high, 0.3 mm. diameter below, with a cylindrical neck, 0.2 mm. high, 0.05 mm. diameter, clothed with a thin layer of yellow tomentum up to two-thirds their height, apex translucent amber. Asci 750 μ long, eight-

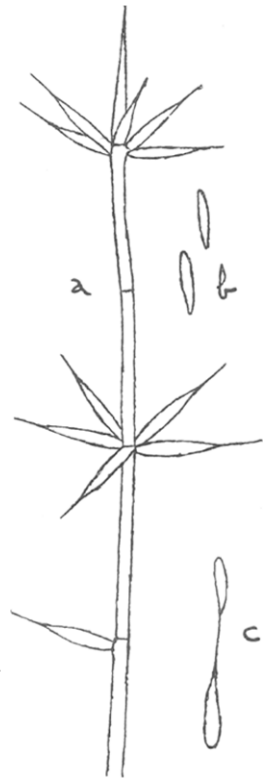


Fig. 4. *Verticillium hemipterigenum*. a, conidiophore; b, conidia; c, phialide with conidium. \times 1000.

spored, capitate, 4μ diameter; ascospores linear, 1μ diameter, as long as the ascus, with septa, $8-13\mu$ apart; mature part-spores not seen. Conidiophores (*Verticillium hemipterigenum* Petch, n.sp.) on the stroma, the film on the leaf, the clavae, and the perithecia, scattered or clustered, up to 150μ high, 1.5μ diameter, with whorls of phialides in the upper part. Phialides up to six in a whorl, elongated flask-shaped, attenuated into a long thin tip, $12-16\mu$ long, 1μ diameter below; conidia narrow-oval, or fusoid, or sub-falcate, ends acute, hyaline, continuous, $5-8 \times 1\mu$, usually solitary, occasionally two in a parallel bundle. On a leaf-hopper on bamboo (*Arundinaria debilis*), etc., Nuwara Eliya, Ceylon.

The grey film spreading over the leaf is composed partly of hyaline hyphae, with rough, lateral, spore-like bodies, like those on the yellow mycelium on the insect, and partly of the finer, smooth hyphae bearing conidiophores. Some specimens have a clava, others bear perithecia but no clava, while others have both.

On dried herbarium specimens, the perithecia appear dark red.

45. *SPICARIA*

In *Trans. Brit. Myc. Soc.* x (1925), 186, 187, I described a Ceylon species of *Spicaria* on a spider, which I attributed to *Spicaria Araneae* Sawada.

Through the kindness of Professor Ito, I have received a translation of the description of *Spicaria Araneae*, which was published in Japanese, from which it appears that the Ceylon species is not the same as that described by Sawada from Formosa. The description of the latter is as follows:

"*Spicaria Araneae* Sawada, *Bot. Mag.*, Tokyo, xxviii, no. 331, p. (309), 1914. Body of the insect covered with a purple-grey cottony mass, not extending to the legs. Hyphae hyaline at first, pale brownish grey when old, septate, $4-5\mu$ diameter. Conidiophores hyaline, septate, about 500μ high, $3-4\mu$ diameter, simple or rarely branched, with three to five whorls of prophialides and phialides towards the apex. Phialides flask-shaped, $7-8 \times 2-2.5\mu$. Conidia catenulate, long ellipsoidal or short cylindrical, ends rounded, hyaline, with two guttae, $3.5-5.5 \times 2-2.5\mu$.

"On the dead body of a spider, Formosa. Differs from *Spicaria prasina* (Maubl.) Saw. in colour, stouter conidiophores and shape of conidia."

Subsequently, I collected another coloured *Spicaria* on a spider at Nuwara Eliya, Ceylon, which differs from the previous Ceylon specimens in colour and in its larger phialides and conidia. The two Ceylon species resemble the Formosan species in their stout coloured mycelium, but differ from the latter in habit. *Spicaria Araneae* Saw. is said to cover the insect with a purple-grey cottony mass; in the

two Ceylon species the conidiophores form a dense even pile over the body of the insect, so even that at first sight one is liable to overlook the fact that the insect is covered by a fungus. In one of these Ceylon species the fungus is rose or purple-rose, becoming rose-purple when dry; in the other it is purple-grey to ashy.

All the Ceylon specimens differ from *Spicaria Araneae* in the shape of the phialides, which in the latter are described as flask-shaped. In dealing with other tropical species of *Spicaria*, it has been found that the shape of the phialides is a fairly constant character by which species may be differentiated, and consequently it is considered that this difference, taken with other characters, justifies the description of the Ceylon fungi as new species.

Spicaria velutiformis Petch, n.sp. Bright rose or purple-rose, becoming rose-purple when dry. Mycelium stout, 3–5 μ diameter, purple-brown. Conidiophores erect, crowded, covering the insect with a dense pile, about 100 μ high, stout, 3–4 μ diameter, septate, with several whorls of prophialides and phialides, 16–25 μ apart; prophialides oblong-oval or clavate, 4–5 \times 2–3 μ ; phialides cylindrical, narrow-oval or clavate, apex obtuse, 4–4.5 \times 2–2.5 μ ; conidia hyaline, continuous, oblong-oval or narrow-oval, ends obtuse, 3–5 \times 1.5–2.5 μ , or globose, 2–2.5 μ . On a spider, Vavuniya, Ceylon, December, 1923; ditto, Hakgala, Ceylon, May, 1912; ditto, Nuwara Eliya, Ceylon, January 1st, 1928 and July 15th, 1928.

The cultural details given in *Trans. Brit. Myc. Soc., loc. cit.*, were derived from cultures from the specimen from Vavuniya.

Spicaria clavulifera Petch, n.sp. Purple-grey to ashy. Mycelium stout, 3–5 μ diameter, pale purple-brown. Conidiophores erect, crowded, covering the insect with a dense even pile, about 60 μ high, stout, 3 μ diameter below, expanding to 5 μ above, two or three-septate, terminating in a cylindrical head composed of an apical cluster of phialides, and usually a whorl of prophialides and phialides at the top of the penultimate segment, the phialides usually becoming parallel to one another; prophialides subcylindrical, 8–12 \times 3–5 μ ; phialides cylindrico-clavate, 12–20 \times 2.5–4 μ , narrowing above into a broad, conical, obtuse apex; conidia narrow-oval or oblong-oval, hyaline, continuous, ends obtuse, 5–7 \times 1.5–2 μ . On a spider, Nuwara Eliya, Ceylon, October 3rd, 1926.

In culture on Quaker Oat agar, *Spicaria clavulifera* produced circular, white, rather compact patches, which developed purple-grey tufts of conidiophores from the centre outwards until each patch became a pulvinate mass. The type of growth was exactly similar to that of *Spicaria velutiformis*, and, as in the case of the latter, the agar was not coloured. Measurements of the phialides, etc., in culture were identical with those of the natural specimen. In culture, some of the old phialides had a stout cylindrical sterigma.

Spicaria clavulifera differs from *S. velutiformis* especially in the shape and size of its phialides. In general appearance the conidiophores of the two species are quite distinct, that of the latter having, in addition to the terminal, whorls of phialides some distance apart along the stalk, with divergent phialides, while on that of the former the cluster of phialides is apical, with at most one branch or whorl close below, and the phialides, though sometimes divergent, usually form a parallel bundle. Owing to the latter feature, the head somewhat resembles that of a *Penicillium*.

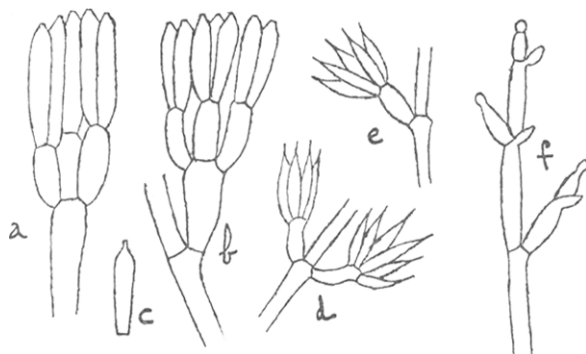


Fig. 5. *a*, *Spicaria clavulifera*, terminal cluster; *b*, *S. clavulifera*, lateral cluster; *c*, *S. clavulifera*, old phialide; *d*, *S. violacea*; *e*, *S. gracilis*; *f*, developing conidiophore of *S. gracilis*. $\times 1000$.

Another coloured *Spicaria* was found on a Tineid case at Nuwara Eliya, forming a violet-grey pulverulent patch on the exterior. Its description is as follows.

Spicaria violacea Petch, n.sp. Mycelium purple-brown. Conidiophores clustered, up to $300\ \mu$ high, forming a violet-grey pulverulent patch; stalk septate, pale violet, $3\text{--}4\ \mu$ diameter, usually smooth, sometimes minutely rough; prophialides arising from the upper two to four nodes in whorls rather close together, sometimes the lowest whorl on short branches, the whole forming a globose head, about $40\ \mu$ diameter, or an ovoid head, about $60\ \mu$ high, $40\ \mu$ diameter; prophialides irregularly cylindrical, expanded above, $6\text{--}8 \times 3\ \mu$; phialides flask-shaped, attenuated above somewhat abruptly, $8 \times 2\ \mu$; conidia globose, $1.5\text{--}2.5\ \mu$ diameter, or broadly oval, $2\text{--}2.5 \times 1.5\ \mu$, smooth, pale purple-grey, almost hyaline. On a Tineid case, Nuwara Eliya, Ceylon, December 3rd, 1927 (Fig. 5 *d*).

On Quaker Oat agar, growth extends over the whole slant, the culture being reddish purple and pulverulent. The reverse of the stroma is yellow, and the agar is coloured chrome-yellow at first, then orange-yellow to greenish yellow. Yellow elongated conical clavæ are produced, at the margin of the slant or anywhere over

its surface; these ultimately become reddish purple, owing to the development of conidiophores on them.

Coremium gracile Petch was described in *Trans. Brit. Myc. Soc.* xi (1926), 260, from Ceylon specimens on spiders. The name is ante-dated by *Coremium gracile* Macbride in *Mycologia*, xviii (1926), 125-31, a species from New Zealand.

In the original specimens of the Ceylon species the insect was enclosed in a silk web, the coremia developing on the web. A large number of specimens have since been collected at Nuwara Eliya, where it is one of the commonest entomogenous fungi, and these show that it is not confined to spiders, nor does it usually form coremia.

When the spider is enclosed in a web, the mycelium of the fungus emerges through the web and may form coremia, in addition to scattered or clustered conidiophores on repent strands. Conidiophores are also produced on the body or legs of the insect, inside the web. If the insect is situated between two leaves, fastened together by silken threads, the fungus produces conidiophores on the insect, and strands of mycelium which extend to the junction of the leaves and there give rise to coremia externally. But if the insect is merely attached to the leaf without any cover, the conidiophores are produced, singly or in clusters, anywhere on the insect or on strands of mycelium which spread from it over the leaf.

Coremium gracile Petch has also been found on lepidopterous larvae and pupae, on Tineid cases, and on *Lecanium* spp. On lepidopterous larvae it produces scattered conidiophores at first, and ultimately a continuous covering of mycelium and conidiophores. On pupae and Tineid cases it usually forms white pulverulent patches of crowded conidiophores. But if the pupa is embedded in wood or moss, one or more strands of mycelium emerge from the wood or moss and expand into a pulvinate tuft on the surface. Thus, on dissecting out the pupa in such cases, one obtains a more or less typical *Isaria*. On *Lecanium*, the fungus may form small coremia, or a loose fringe round the scale.

The identity of these various forms has been determined by culture. No coremia have been obtained in culture, the fungus in all cases producing an even pulverulent stroma.

In dealing with entomogenous fungi one soon learns that Hyphomycetes which normally are Mucedinaceae, e.g. *Beauveria Bassiana*, frequently produce coremia or Isarioid forms which would entitle them to be classed as Stilbaceae. Conversely, entomogenous species reckoned as Stilbaceae, e.g. *Isaria*, *Gibellula* and *Hirsutella*, usually produce, in addition to the compound form, conidiophores on the mycelium which covers the insect, and thus behave as normal Mucedinaceae.

The classification of such dimorphic species is, in general, governed by considerations of convenience. In the case of *Coremium gracile* Petch, the fungus is usually a Mucedine, the coremia or *Isaria* forms depending to a great extent on peculiarities of occurrence. As the ultimate conidiophore is a *Spicaria*, it would seem preferable to place the species in that genus, as *Spicaria gracilis* comb.nov.

It may be noted that the genus *Isaria* is a heterogeneous mixture of species which have little in common, except that they produce erect fascicles of conidiophores. As regards the entomogenous species, it is not possible to identify them, or to classify them in homogeneous groups, from their descriptions, because the actual conidiophore, *i.e.* the ultimate branch of the fascicle, has, in general, not been described. It is highly desirable that these species should be classified on the character of the conidiophore, *i.e.* not as *Isaria*, but as aggregate forms of *Oospora*, *Sporotrichum*, *Spicaria*, etc.

Coremium breve Petch in *Trans. Brit. Myc. Soc.* XI (1926), 259, on *Lecanium* sp., is *Spicaria gracilis*.

Spicaria gracilis Petch, comb.nov.; *Coremium gracile* Petch in *Trans. Brit. Myc. Soc.* XI (1926), 260; *Coremium breve* Petch, *op. cit.* p. 259. Conidiophores scattered, or forming white pulverulent tufts, or sometimes synnemata up to 1.5 mm. high, 0.4 mm. diameter below, with an irregularly ovoid head. Mycelium white, often forming repent strands. Conidiophores up to 120 μ high, 2.5–3 μ diameter, simple, or branched once at about half the height, or with two or three short branches forming the lowest whorl of the head. Head 20–50 μ high, of two to four whorls of prophialides and phialides and a terminal cluster. Prophialides cylindrical, 5–6 \times 2.5 μ ; phialides distinctly flask-shaped, 6–9 μ high, 2.5 μ diameter below, attenuated from about half the height into a thin neck. Conidia in chains, hyaline, smooth, narrow-oval, ends acute, 1.5–3 \times 1–1.5 μ , a few subglobose, 1–1.5 μ diameter. On a spider, Peradeniya, Ceylon, July, 1921; ditto, Hakgala, Ceylon, March, 1922. On *Lecanium* sp., Hakgala, Ceylon, March, 1922. On spiders, lepidopterous larvae and pupae, Tineid cases, and *Lecanium hemisphaericum*, Nuwara Eliya, Ceylon, 1926–28 (Fig. 5 e).

In culture on Quaker Oat agar, *Spicaria gracilis* forms an even pulverulent stroma, the conidiophores tending to be clustered in small tufts at first. The colour is white to cream, and the agar becomes yellow to orange-yellow in old cultures. On Dox agar, the reverse is orange-yellow, and the agar is not coloured.

Spicaria gracilis differs from *S. javanica* in the shape of its phialides, the size of the conidia, and the colour of the masses of conidia in culture, which in *S. javanica* is violet-grey.

A specimen on *Lecanium hemisphaericum*, collected at Nuwara Eliya, Ceylon, June 21st, 1927, is of interest. The fungus forms a narrow

white fringe round the scale, but is readily distinguished from *Cephalosporium Lecanii* by the fact that the hyphae, of which the fringe is composed, are more or less erect. The fringe in the only available specimen contains developing conidiophores, and the latter bear, at the upper septa, one or two developing phialides, or a prophialide with one or two immature phialides, or a branch with a cluster of phialides at the apex. The specimen was not at first recognised as *Spicaria gracilis*, but on taking it into culture it proved to be that species.

The interesting point is that these conidiophores and phialides (Fig. 5*f*) bear a close resemblance to the figure given by Johnston for *Spicaria Aleyrodis* (*Mem. Soc. Cubana Hist. Nat. "Felipe Poey" III* (1918), 79), and hence it would appear probable that the latter was a juvenile form of a species which may present a different appearance in a more mature state. It is not intended to suggest that *Spicaria Aleyrodis* is the same as *S. gracilis*.

Vuillemin (*Canadian Entom. LVII* (1925), 4, 97-9) has described another species of *Spicaria*, *S. canadensis*, on the larvae and pupae of *Stilpnotia salicis*. It is white, with pyriform phialides, $8-17 \times 3 \mu$, and oblong conidia, $4-5.4 \times 2.8-3 \mu$. This is evidently different from *Spicaria gracilis*.

46. *ACREMONIUM ARANEARUM* Petch, n.sp.

This species is fairly common at Nuwara Eliya, Ceylon, on spiders, which it covers with a white, loose, more or less pulvinate mass. The mycelium bears phialides laterally, either at a node or scattered along the hyphae, sometimes only 2μ apart. These phialides are elongated flask-shaped, or conoid, with an obtuse apex, or oval, with a fine short sterigma, solitary, or they may arise in pairs from an oval prophialide. Each phialide bears a single oval conidium, and after the abscission of the conidium, it collapses into a very fine thread, arising from the scar of attachment.

A similar fungus occurs as a parasite on Mycetozoa in England. I have had specimens on *Comatricha nigra*, North Wootton, on *Cribraria* sp., Bawsey, and on *Arcyria cinerea*, Whitby. It has solitary oval conidia on flask-shaped phialides, which collapse into threads after maturity. I have not seen pairs of phialides on a prophialide in this species. I take this to be *Acremonium album* Preuss. It agrees with Preuss's figure, except that the latter shows simple sterigmata instead of phialides.

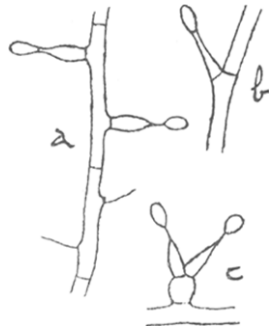


Fig. 6. *Acremonium Araneorum*. a, hypha bearing turgid and collapsed phialides; b, a phialide at a node; c, two phialides on a globose prophialide. $\times 1000$.

Rhinotrichum doliolum Pound & Clem., found on an undetermined Myxomycete in America, is, from the description, apparently the same as *Acremonium album* Preuss, though the describers give larger dimensions, stating that the hyphae are $5\ \mu$ in diameter. Their fungus is clearly not a *Rhinotrichum*.

These species differ from *Acremonium* in their evanescent phialides. That character does not appear to have been previously recorded. As it may be of common occurrence, and not peculiar to the species under discussion, they may be left in *Acremonium* until further evidence is available.

Acremonium Araneorum Petch, n.sp. Mycelium $1.5\text{--}2\ \mu$ diameter, regular, septate, covering the insect with a loose, white, pulvinate mass. Phialides lateral, at a node or scattered, elongated flask-shaped or conoid, $6\text{--}8\ \mu$ high, $1.5\text{--}2\ \mu$ diameter below, or oval, $2 \times 1.5\ \mu$, with a fine sterigma, $1\ \mu$ long; sometimes arising in pairs from an oval prophialide, $3 \times 2\ \mu$. Conidia hyaline, continuous, apical, solitary, oval, $2\text{--}5 \times 1.5\text{--}3\ \mu$. After abscission of the conidium, the phialide collapses into a fine thread. On spiders, Nuwara Eliya, Ceylon, March 29th, 1927, etc.

In culture on Quaker Oat agar, the growth is white and loose, and the agar is coloured purple-red. No plate-like spores, such as are recorded by Thaxter for *Desmidiospora*, have been found in nature, or in tube cultures and hanging drops.

47. *RHINOTRICHUM PARVISPORUM* Petch, n.sp.

This species was first found in Ceylon on *Aspidiotus* and *Lecanium*. It occurred in a collection on leaves of *Hevea*, in which some of the *Aspidiotus* were attacked by *Pseudomicrocera Henningsii* and some of the *Lecanium* by *Aschersonia marginata*, but these fungi were not evident on the scales which bore the *Rhinotrichum*. The latter forms a white fringe round the scale, and spreads over it in a loose web.

Another example of this species was found on an effete *Gibellula* on a spider.

The mycelium is $1.5\ \mu$ diameter, with lateral or terminal, simple conidiophores, occasionally in whorls or groups of three, up to $30\ \mu$ high. The conidiophores are $1.5\ \mu$ diameter, equal, attenuated above, or, more generally, $1.5\ \mu$ diameter below, becoming irregularly inflated up to $2\ \mu$ diameter, and thence attenuated and irregularly flexuose. In the specimen on *Aspidiotus*, etc., they bear fine sterigmata, each arising from a small conical base, total height up to $2\ \mu$, over their whole length. In the example on a spider, the sterigmata are more crowded together, and almost all near the apex of the conidiophore, which is sometimes



Fig. 7. *Rhinotrichum parvisporum*. Conidiophore. $\times 1000$.

acute and curved, sometimes slightly inflated. The conidia are borne singly on the sterigmata, and are hyaline, subglobose, $1-1.5\mu$ diameter, or broadly oval, $1 \times 1.5\mu$, shortly pedicellate.

In culture on Quaker Oat agar, the slant was covered by a continuous white felted stroma, pulverulent with conidiophores and conidia. The agar was not coloured. The conidiophores frequently occurred in groups on the mycelium, so that the fungus might have been taken for a *Cladobotryum* with decumbent conidiophores. The simple conidiophores in culture were up to 40μ long, 2μ diameter and slightly inflated below, tapering and becoming irregularly flexuose above, and bearing sterigmata on conical bases in the upper two-thirds.

Rhinotrichum parvisporum Petch, n.sp. Mycelium forming a white fringe round the insect and spreading over it in a loose web. Conidiophores hyaline, simple, lateral or terminal, up to 30μ high, 1.5μ diameter below, equal, or irregularly inflated to 2μ , and thence attenuated and irregularly flexuose; sterigmata linear, with a conical base, total height up to 2μ , over the whole length of the conidiophore or near the apex; conidia hyaline, subglobose, $1-1.5\mu$ diameter, or broadly oval, $1 \times 1.5\mu$, shortly pedicellate. On *Aspidiotus* and *Lecanium*, attacked by other fungi (?), on *Hevea brasiliensis*, Dewalakande, Ceylon, January, 1928.

48. *ASPERGILLUS DEPAUPERATUS* Petch, n.sp.

This fungus occurred rather abundantly on *Lepidosaphes ulmi* on hawthorn at Hunstanton, Norfolk, in February, 1921, forming thin, white, byssoid patches extending partly over the insect and partly over the adjacent bark. As it was considered probably an abnormal state of some larger species, it was left unrecorded until a further investigation could be made. In 1928, it was collected at Nuwara Eliya, Ceylon, on an *Aspidiotus*, on which it formed minute white patches at the margin of the scale.

The conidiophores are clustered, up to 50μ high, $2-2.5\mu$ diameter below, stalk smooth, often irregularly curved, expanding gradually above into a pyriform or clavate head, $4-5\mu$ diameter, somewhat flattened above. Sometimes the conidiophore is inflated to 3.5μ diameter below, contracting above, and then expanding into the head. The mycelium is septate, but the conidiophore is not. The head bears two to four chains of conidia directly, *i.e.* without any basidia or phialides. All the conidia fall away, leaving the empty head with two to four minute conical projections. The conidia are

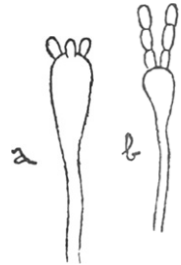


Fig. 8. *Aspergillus depauperatus*. a, conidiophore with developing conidia; b, *A. depauperatus*, with chains of conidia. $\times 1000$.

oval, hyaline, smooth, $2-4 \times 1.5-2.5 \mu$, with a few globose, $1.5-2 \mu$ diameter.

In culture on Quaker Oat agar, the fungus forms minute white cushions, which coalesce into a continuous white crust. The fungus remains white, while the agar is coloured pink. The conidiophores in culture were not larger than in nature. The chains of conidia adhered laterally.

Though the head is small, the fungus appears to be an *Aspergillus*. It does not agree with *Spinalia* Vuill., *Dispira* v. Tiegh., or *Dimargaris* v. Tiegh. It has no sterigmata (phialides), and the lowest spore is the youngest, as in *Aspergillus*. *Briarea* Corda should differ in having a septate stalk, and in not having the apex of the stalk inflated.

Aspergillus depauperatus Petch, n.sp. White; conidiophores clustered, up to 50μ high; stalk $2-2.5 \mu$ diameter, smooth, not septate, often irregularly curved and inflated below, expanding above into a pyriform or clavate head, $4-5 \mu$ diameter, flattened above; phialides none; chains of conidia two to four, sessile; conidia hyaline, oval, smooth, $2-4 \times 1.5-2.5 \mu$, with a few globose, $1.5-2 \mu$ diameter. On *Lepidosaphes ulmi*, Hunstanton, England, and on *Aspidiotus* sp., Nuwara Eliya, Ceylon.