The British Mycological Society

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Edited by

CARLETON REA and J. RAMSBOTTOM

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NORWICH FORAY.

June 2nd to 5th, 1922.

The Spring Foray was held during the Whitsuntide holidays, with headquarters at Norwich. On the Friday evening about fifteen members assembled at the Norwich Museum, in the old Castle building, and were welcomed by the Curator, Mr Howard, and members of the Museum Committee. Interesting features of the building were pointed out, and the evening ended with a climb on the battlements from which a magnificent view of Norwich and the country round was obtained.

During the week-end the weather was dry and for the most part hot, as it had been for some time previously. Consequently the harvest of fungi was unusually small, even for a spring foray.

On Saturday, June 3rd, a delightful excursion on the Broads had been planned through the generosity of Mr Adcock, who placed his houseboat at the disposal of the party. Starting from Wroxham, the boat was towed by a small motor-boat as far as Woodbastwick, where a landing was made. The party was met here by Mr John Cator, and under his guidance Woodbastwick marsh was explored. Amongst the first finds was *Puccinia Pringsheimiana*, growing in abundance on wild Black Currant.

After lunch at Horning Ferry, motor-boat and dinghy were requisitioned to take members to South Walsham, where woods belonging to Sir Bartle Frere were worked. Here the only find of note however was a large partial ring of the Giant Puff Ball, *Lycoperdon giganteum*. Two huge specimens were secured for exhibition, and provided some merriment on the homeward journey.

Mr Adcock entertained the members to "high tea" at Horning Ferry Inn, after which a most enjoyable day finished with the boat trip homewards by way of Wroxham Broad.

Sunday morning was free, and many members took the opportunity of being shown over the Museum by the Curator.

In the afternoon a tram was taken out to Trowse, and a raid was made on grounds belonging to Mr and Mrs Colman, by whom the party were entertained to tea. A small gathering of *Hypomyces aureo-nitens* was secured in the woods, and in the garden of Mrs Colman's house Mr A. Adcock detected some lilies attacked by *Uromyces Lilii*.

In the evening Mr Adcock kindly allowed some of the members to inspect his tomato houses, with the result that several species

of fungi parasitic on tomatoes were added to the day's finds. At the house afterwards the President, Mr F. T. Brooks, gave a popular talk on Rusts, and Mr Pearson provided music in the shape of some charming folk-songs.

On Monday, June 5th, Sir Eustace Gurney's woods at Thorpe St Andrew were visited, and the homeward walk was by way of Racecourse Wood. This excursion yielded the largest number of species, though little of rarity. Mr Ramsbottom collected some very fine specimens of *Corticium Galzinii* and *Polyporus nummularius* and *P. radiatus* were among the more uncommon species obtained.

At the close of the Foray very cordial votes of thanks were given to the Museum Committee and Curator, to the various landowners who had given permission for visits to their estates, and especially to Mr Howard and Mr Adcock, who had taken so much trouble to ensure what all agreed was one of the most pleasant spring meetings on record.

N. = Norwich; *W.* = Woodbastwick; *S.W.* = South Walsham; *R.* = Thorpe St Andrew and Racecourse Woods; *H.* = Horning Ferry; *T.* = Trowse and Mrs Colman's garden.

BASIDIOMYCETES.

Armillaria mellea (Vahl) Fr., *S.W.*, *R.* (rhizomorphs).
Tricholoma gambosum Fr., *R.*
Laccaria laccata (Scop.) B. and Br., *R.*
Collybia dryophila (Bull.) Fr., *R.*
Pluteus cervinus (Schaeff.) Fr., *T.*
Entoloma rhodopolium Fr., *R.*
Pholiota praecox (Pers.) Fr., *W.*, aegerita (Porta) Fr., *T.*, mutabilis (Schaeff.) Fr., *R.*
Astrosporina sabuletorum (B. and Curt.) Rea, *R.*
Psaliota xanthoderma Genev., *T.*
Hypholoma fasciculare (Huds.) Fr., *W.*, *R.*, sublateritium (Schaeff.) Fr., *T.*, appendiculatum (Bull.) Fr., *W.*, *R.*
Psathyra fibrillosa (Pers.) Fr., *W.*
Psathyrella disseminata (Pers.) Fr., *R.*
Coprinus plicatilis (Curt.) Fr., *W.*, *R.*
Lenzites betulina (Linn.) Fr., *R.*
Boletus luteus (L.) Fr., *R.*, bovinus (L.) Fr., *R.*, luridus (Schaeff.) Fr., *R.*
Polyporus squamosus (Huds.) Fr., *S.W.* (on ash), *R.* (on *Acer pseudoplatanus*), nummularius (Bull.) Quél., *R.*, sulphureus (Bull.) Fr., *H.* (on willow), *T.*, rutilans (Pers.) Fr., *R.*, adustus (Willd.) Fr., *R.*, hispidus (Bull.) Fr., *R.*, radiatus (Sow.) Fr., *R.*, betulinus (Schrad.) Fr., *W.*, *R.*
Fomes annosus Fr., *T.*, *R.*
Polystictus versicolor (L.) Fr., *W.*, *R.*, abietinus (Dicks.) Fr., *T.*
Irpex obliquus (Schrad.) Fr., *W.*, *T.*, *R.*
Odontia farinacea (Pers.) Quél., *R.*
Stereum hirsutum (Willd.) Fr., *W.*, *T.*, *R.*, rugosum (Pers.) Fr., *S.W.*, *T.*, *R.*, purpureum (Pers.) Fr., *S.W.*, *R.*, spadiceum Fr., *T.*
Hymenochaete rubiginosa (Dicks.) Lév., *R.*
Corticium Galzinii Bourd., *R.*, Sambuci (Pers.) Fr., *T.*, confine Bourd. and Galz., *T.*, *R.*, confluens Fr., *R.*, porosum B. and Curt., *R.*
Peniophora cremea Bres., *R.*, velutina (DC.) Cooke, *R.*, setigera (Fr.) Bres., *R.*, *T.*, hydnoides C. and M., *R.*, incarnata (Pers.) Cooke, *R.*, and var. hydnoidea (Pers.) Bourd. and Galz., *T.*, cinerea (Fr.) Cooke, *R.*

Hypochnus fuscus (Pers.) Karst., *W.*
Solenia anomala (Pers.) Fr., *W.*, *R.*
Hirneola auricula-Judae (L.) Fr., *S.W.*
Exidia glandulosa (Bull.) Fr., *T.*
Dacryomyces deliquescens (Bull.) Duby, *T.*, *R.*
Calocera viscosa (Pers.) Fr., *R.*
Phallus impudicus (L.) Pers., *R.*
Bovista plumbea Pers., *T.*

UREDINEAE.

Uromyces Valerianae (Schum.) Fuck., *W.*, Scillarum (Grev.) Wint., *T.*, Lilii (Link) Fuck., *T.*
Puccinia Violae (Schum.) DC., *R.*, Malvacearum Mont., *W.*, pulverulenta Grev., *T.*, *R.*, Smyrnii Biv., *R.*, obtegens (Link) Tul., *R.*, Caricis (Schum.) Rebent., *W.*, *R.* (Aecidium on *Urtica*), Pringsheimiana Kleb., *W.*, graminis Pers. (on *Bromus sterilis*), *T.*, coronata Corda (Aecidium on *Rhamnus Frangula*), *W.*, Phragmitis Körn. (Aecidium on *Rumex* spp.), *W.*
Phragmidium violaceum (Schultz.) Wint., *T.*, *R.*
Triphragmium Ulmariae (Schum.) Link, *W.*

USTILAGINEAE.

Ustilago longissima (Sow.) Tul., *H.*, violacea (Pers.) Wint., *W.*
Tilletia debaryana Fisch. v. Waldh. on *Holcus mollis*, *W.*

DISCOMYCETES.

Acetabula vulgaris Fuck., *R.*
Lachnea hemisphaerica (Wigg.) Gill., *R.*
Ciliaria scutellata (L.) Quél., *W.*
Pyronema omphalodes (Bull.) Fuck., *R.*
Exoascus alnitorquus (Tul.) Sadeb., *H.*
Bulgaria inquinans (Pers.) Fr., *R.*
Corynella glabro-virens Boud., *H.*
Orbilia xanthostigma Fr., *R.*
Sclerotinia sclerotiorum (Lib.) Mass., *N.*
Helotium virgultorum (Wahl.) Karst., *W.*
Dasyscypha virginea (Batsch) Fuck., *W.*, *T.*, *R.*
Trichoscypha calycina (Schum.) Boud., *R.*
Mollisia cinerea (Batsch) Karst., *W.*, *R.*

PYRENOMYCETES.

Podosphaera Oxyacanthae (DC.) de By., *T.*
Erysiphe graminis DC. (on barley), *R.*
Nectria ditissima Tul. (on birch), *R.*
Hypomyces aureo-nitens Tul., *T.*
Epichloe typhina (Pers.) Tul., *W.*
Rosellinia aquila (Fr.) de Not., *R.*
Diatrypella quercina (Pers.) Nits., *R.*
Diatrype disciformis (Hoffm.) Fr., *T.*
Hypoxylon multiforme Fr., *T.*, *R.*, coccineum Bull., *S.W.* and conidial stage, *Isaria umbrina*, *R.*, fuscum (Pers.) Fr., *S.W.*
Xylaria Hypoxylon (L.) Grev., *H.*, polymorpha (Pers.) Grev., *R.*
Phyllachora Junci Fuck., *R.*
Dichaena quercina Fr., *W.*, *T.*, *R.*
Rhopographus Pteridis (Sow.) Wint., *R.*

PHYCOMYCETES.

Peronospora parasitica (Pers.) Tul.

SPHAEROPSIDEAE.

Phoma lineolata Desm., *R.* (on larch cones).
Septoria Rubi West., *W.*, *R.*, scabiosicola Desm., *H.*
Leptothyrium Castaneae (Spr.) Sacc., *R.*

HYPHOMYCETES.

Monilia aurea Gmel., *R.*
Ovularia obliqua (Cooke) Oud., *W.*
Botrytis cinerea Pers., *N.*, *W.*, *R.*
Penicillium glaucum Link, *N.*
Botryosporium pulchrum Corda (on tomato), *N.*
Verticillium albo-atrum R. and B. (on tomato), *N.*
Bispora monilioides Corda, *R.*
Cladosporium herbarum (Pers.) Lk., *N.*, fulvum Cooke, *N.*
Helminthosporium graminum Rab. (on barley), *R.*
Heterosporium gracile Sacc. (on iris), *T.*
Graphium rigidum (Pers.) Sacc., *R.*

MYXOMYCETES. (H. J. Howard.)

Badhamia panicea Rost.
Craterium minutum Fries. (weathered).
Diderma spumarioides Fries.
Didymium difforme Duby.
,, squamulosum Fries.
Stemonitis ? fusca Roth (immature).
Reticularia Lycoperdon Bull.
Lycogala epidendrum Fries.
Trichia persimilis Karst.
Arcyria incarnata Pers. var. fulgens Lister.

KESWICK FORAY.

September 15th to 21st, 1922.

The twenty-sixth Autumn Foray and Annual General Meeting, held at Keswick from Sept. 15th to 21st, proved to be a record gathering, over sixty members and friends being present. Owing to the large size of the party it was impossible to accommodate all in one hotel, but fortunately the use was obtained of a room over the public library for the exhibition of specimens and for meetings.

The first day, Saturday Sept. 15th, was given up to a whole-day expedition to Lake Thirlmere, the woods on Fisher Crag and Great How being explored. In spite of rain and rough going, the day yielded a great number of species, many of them particularly interesting. Mr Cheesman picked up a tuber-like growth which subsequently was found to be an unusually fine specimen of *Endogone lactiflua* Berk. Among other noteworthy records were *Synchytrium Taraxaci*, *Gymnosporangium clavariaeforme* and *G. Juniperi*, *Coleosporium Melampyri*, *Thecopsora Vacciniorum*, *Entoloma griseocyaneum*, and *Dictyolus muscigenus*. In the evening the Annual General Meeting was held.

Sunday morning was free, but in the afternoon some of the party visited the pine woods on Latrigg, adding a number of pine-wood species to the list. Both here and in other localities visited members were particularly interested in the abundance

of specimens of *Cordyceps militaris*. There appeared to have been an epidemic amongst Lepidoptera.

On Monday, Sept. 18th, the whole party drove to Lodore, and then split up into three sections. Some members worked through Barrow Wood and Great Wood, others went to Borrowdale, while the remainder returned to Keswick via Manistey Park and Brandlehow on the other side of Derwentwater. The low-lying ground round about Derwentwater proved rich in pasture-loving forms, such as species of Hygrophorus and Clavaria. Specially interesting records on this day were *Trichoglossum hirsutum*, *Elaphomyces granulatus*, *Hygrophorus obrusseus*, *Flammula rubicundula*, *F. scamba*, *Cortinarius armillatus*, *C. bolaris*, and *Clavaria fumosa*.

In the evening the President, Mr F. T. Brooks, delivered his Presidential address on "Some Present-Day Aspects of Mycology."

On Tuesday the party was conveyed by charabanc to the Bassenthwaite district. First of all the woods round Mire House and sawmill were examined, where specimens of *Apostemidium aridula* Karst. were obtained, and then a move was made to Armathwaite, at the head of the lake. The grounds here provided several interesting records, notably *Leotia chlorocephala*, *Cordyceps ophioglossoides*, and *Aleurodiscus amorphus*, the latter being found in quantity on dead limbs of Silver Firs.

In the evening Mr Somerville Hastings gave an interesting account of some observations made by him in the Alps on growth forms of *Anellaria separata*. Professor Buller read a paper on "Luminosity in Panus," and at the close provided a demonstration of luminosity of decaying leaves.

The last expedition, on Wednesday, was to the woods at Wythop and Whinlater. *Spathularia flavida*, *Cheilymenia dalmeniensis*, *Inocybe praetervisa*, *Cortinarius uraceus*, *C. myrtillinus*, *C. largus* and *Radulum mucidum* were among other species added to the lists. Particularly noteworthy was the great abundance of *Bulgaria inquinans* on felled oak logs.

In the evening Miss Wakefield gave a short account of six months spent in mycological work in the West Indies. Dr J. C. Walker, of the United States Department of Agriculture, contributed some remarks on the distribution of *Phoma Lingam* and *Urocystis Cepulae*, as affected by climatic factors. Mr Rea read an amusing paper on "Edible Fungi," and Professor Potter recorded some experiments on the influence of soil reaction on Wart Disease of Potatoes.

At the conclusion of the meeting votes of thanks were recorded to the various landowners who had allowed their estates to be visited, to the proprietors of the Royal Oak Hotel for arranging accommodation, and to the officers of the Society.

For assistance in the preparation of the subjoined list the Secretary is indebted to all the members of the party, but more especially to Mr Carleton Rea, Mr Ramsbottom, Mr Pearson, Dr Bayliss Elliott (Discomycetes) and Sir Henry Hawley (Pyrenomycetes).

Complete List of Species gathered during the Foray.

T. = Thirlmere; *L.* = Latrigg; *D.* = Lodore and Derwentwater; *B.* = Woods in Bassenthwaite district; *W.* = Woods at Wythop and Whinlater. Where no special locality is given the species was found in the Keswick district.

HYMENOMYCETES.

Amanita mappa (Batsch) Fr., *T.*, muscaria (Linn.) Fr., *D.*, spissa Fr., *L.*, *D.*, rubescens (Pers.) Fr., *T.*, *D.*, *B.*

Amanitopsis vaginata (Bull.) Roze, *T.*, *W.*, fulva (Schaeff.) W. G. Sm., *T.*, *D.*, adnata (W. G. Sm.) Sacc.

Armillaria mellea (Vahl) Fr., *D.*

Lepiota granulosa (Batsch) Fr., *T.*, *D.*, amianthina (Scop.) Fr., *T.*, *D.*, *B.*, carcharias (Pers.) Fr., *T.*

Tricholoma fulvum (DC.) Fr., *L.*, albobrunneum (Pers.) Fr., *T.*, *L.*, *D.*, rutilans (Schaeff.) Fr., *L.*, *D.*, psammopum Kalchbr., *L.*, cuneifolium Fr., *T.*, saponaceum Fr., *D.*, leucocephalum Fr., *L.*

Clitocybe clavipes (Pers.) Fr., *D.*, aurantiaca (Wulf.) Studer., *T.*, infundibuliformis (Schaeff.) Fr., geotropa (Bull.) Fr., *T.*, metachroa (Fr.) Berk., *L.*, fragrans (Sow.) Fr., *W.*

Laccaria laccata (Scop.) B. and Br., *T.*, *D.*, and var. amethystina (Vaill.) B. and Br., *T.*, *L.*

Collybia platyphylla (Pers.) Fr., *T.*, distorta Fr., *T.*, *D.*, butyracea (Bull.) Fr., *T.*, *L.*, *W.*, velutipes (Curt.) Fr., *W.*, cirrhata (Schum.) Fr., *W.*, tuberosa (Bull.) Fr., *W.*, rancida Fr., *L.*, ambusta Fr., *L.*, clusilis Fr., *Borrowdale.*

Mycena rubromarginata Fr., *D.*, inclinata Fr., *W.*, ammoniaca Fr., *D.*, filopes (Bull.) Fr., *B.*, Iris Berk., *T.*, haematopus (Pers.) Fr., *B.*, *W.*, sanguinolenta (A. and S.) Fr., *T.*, *L.*, *W.*, galopus (Pers.) Fr., *T.*, *L.*, *D.*, *W.*, and var. nigra Fl. Dan., *D.*, epipterygia (Scop.) Fr., *T.*, *D.*, pelliculosa Fr., *D.*, corticola (Schum.) Fr., *D.*

Omphalia muralis (Sow.) Fr., *T.*, umbellifera (Linn.) Fr., *T.*, and var. citrina Quél., *T.*, fibula (Bull.) Fr., *L.*

Pleurotus mitis (Pers.) Berk., *B.*, *W.*

Hygrophorus hypothejus Fr., *L.*, nemoreus (Lasch) Fr., *L.*, pratensis (Pers.) Fr., *T.*, *L.*, virgineus (Wulf.) Fr., var. roseipes Mass., *B.*, niveus (Scop.) Fr., *D.*, *W.*, ovinus (Bull.) Fr., *L.*, laetus (Pers.) Fr., *T.*, *D.*, *B.*, ceraceus (Wulf.) Fr., *T.*, coccineus (Schaeff.) Fr., *L.*, *D.*, turundus Fr., *B.*, obrusseus Fr., *D.*, conicus (Scop.) Fr., *T.*, *B.*, calyptraeformis Berk., *B.*, chlorophanus Fr., *D.*, *B.*, psittacinus (Schaeff.) Fr., *T.*, *L.*, *W.*, unguinosus Fr., *T.*, *W.*

Lactarius turpis (Weinm.) Fr., *B.*, blennius Fr., *L.*, *B.*, uvidus Fr., *T.*, flavidus Boud., *Portinscale*, piperatus (Scop.) Fr., *T.*, *L.*, deliciosus (Linn.) Fr., *D.*, sanguifluus (Paul.) Fr., *D.*, pallidus (Pers.) Fr., *B.*, quietus Fr., *T.*, *D.*, aurantiacus (Fl. Dan.) Fr., *B.*, vietus Fr., *T.*, rufus (Scop.) Fr., *T.*, glyciosmus Fr., *T.*, *D.*, spinosulus Quél., *Portinscale*, volemus Fr., *D.*, mitissimus Fr., *T.*, *D.*, subdulcis (Pers.) Fr., *T.*, *B.*

Russula nigricans (Bull.) Fr., *D.*, virescens (Schaeff.) Fr., *B.*, azurea Bres., *W.*, lepida Fr., *T.*, *D.*, cyanoxantha (Schaeff.) Fr., *T.*, *D.*, foetens (Pers.) Fr., *T.*, *D.*, *B.*, consobrina Fr., *B.*, and var. sororia (Larb.) Fr., *B.*, pectinata (Bull.) Fr., *W.*, ochroleuca (Pers.) Fr., *D.*, *B.*, fellea Fr., *L.*, *B.*, drimeia Cooke var. Queletii (Fr.) Bataille, *L.*, fragilis (Pers.) Fr., *D.*, and var. fallax (Schaeff.) Mass., *W.*, atropurpurea (Krombh.) Maire, *B.*, roseipes (Secr.) Bres., *B.*, nitida (Pers.) Fr., *B.*, *W.*, vesca Fr., *B.*, mustelina Fr., *B.*, lutea (Huds.) Fr., L.

Cantharellus cibarius Fr., *T.*, tubaeformis Fr. var. lutescens (Bull.) Fr., *L.*

Dictyolus muscigenus (Bull.) Quél., *T.*
Nyctalis parasitica (Bull.) Fr., *W.*
Marasmius peronatus (Bolt.) Fr., *L.*, oreades (Bolt.) Fr., *D.*, hariolorum (DC.) Quél., *T.*, *L.*, dryophilus (Bull.) Karst., *T.*, ramealis (Bull.) Fr., *W.*
Androsaceus androsaceus (Linn.) Pat., *T.*, *B.*
Panus stypticus (Bull.) Fr., *T.*, *D.*
Lentinus cochleatus (Pers.) Fr., *D.*
Pluteus nanus (Pers.) Fr., *D.*
Entoloma griseocyaneum Fr., *T.*, rhodopolium Fr., *T.*, *L.*, nidorosum Fr., *W.*, sericeum (Bull.) Fr., *D.*
Leptonia lampropus Fr., *B.*, chalybaea (Pers.) Fr., *D.*
Nolanea pascua (Pers.) Fr., *T.*, *D.*, *B.*, proletaria Fr., *T.*, *D.*, *B.*
Pholiota aurea (Mattusch) Fr., *D.*, erebia Fr., *L.*, flammans Fr., *T.*, *L.*, mutabilis (Schaeff.) Fr., *T.*, *B.*, *W.*, marginata (Batsch) Fr., *T.*, *L.*
Inocybe rimosa (Bull.) Fr., *L.*, *D.*, *B.*, geophylla (Sow.) Fr., *L.*, *B.*, cervicolor (Pers.) Quél., *T.*, *L.*, Godeyi Gill., *T.*, *B.*, cincinnata Fr., *D.*, calamistrata Fr., *D.*
Astrosporina proximella (Karst.) Rea, *D.*, praetervisa (Quél.) Schroet., *W.*, asterospora (Quél.) Rea, *L.*
Hebeloma glutinosum (Lindgr.) Fr., *T.*, mesophaeum Fr., *T.*, *B.*
Flammula rubicundula Rea, *D.*, inopus Fr., *L.*, *D.*, sapinea Fr., *T.*, scamba Fr., *D.*
Galera hypnorum (Schrank) Fr., *T.*, *D.*, *B.*, mycenopsis Fr., *L.*
Tubaria furfuracea (Pers.) W. G. Sm., *T.*, *L.*
Crepidotus applanatus (Pers.) Fr., *D.*
Cortinarius (Phlegmacium) triumphans Fr., *T.*, largus Fr., *W.*, decolorans (Pers.) Fr., *W.*
—— (Myxacium) elatior Fr., *T.*, *D.*, *B.*
—— (Inoloma) alboviolaceus (Pers.) Fr., *D.*, bolaris (Pers.) Fr., *D.*, pholideus Fr., *T.*, *D.*
—— (Dermocybe) tabularis (Bull.) Fr., *T.*, caninus Fr., *D.*, albocyaneus Fr., *B.*, anomalus Fr., *T.*, lepidopus Cooke, *D.*, myrtillinus Fr., *W.*, semisanguineus (Brig.) Maire, *L.*, cinnabarinus Fr., *B.*, sanguineus (Wulf.) Fr., *L.*, *D.*, cinnamomeus (Linn.) Fr., *T.*, *L.*, *D.*, cotoneus Fr., *D.*
—— (Telamonia) torvus Fr., *T.*, armillatus Fr., *D.*, hemitrichus Fr., *D.*, *W.*, rigidus (Scop.) Fr., *D.*, *W.*, paleaceus (Weinm.) Fr., *D.*, *W.*
—— (Hydrocybe) subferrugineus (Batsch) Fr., *T.*, saturninus Fr., *T.*, uraceus Fr., *W.*, jubarinus Fr., *T.*, dolabratus Fr., *D.*, leucopus (Bull.) Fr., *L.*, scandens Fr., *B.*, obtusus Fr., *T.*
Paxillus involutus (Batsch) Fr., *T.*, *D.*
Psaliota villatica (Brond.) Magn., *L.*, haemorrhoidaria Kalchbr., *B.*
Stropharia aeruginosa (Curt.) Fr., *T.*, *L.*, *D.*, merdaria Fr., *D.*, *B.*, semiglobata (Batsch) Fr., *T.*
Hypholoma sublateritium (Schaeff.) Fr., *T.*, *D.*, fasciculare (Huds.) Fr., *T.*, *L.*, *D.*, dispersum Fr., *B.*, lacrymabundum Fr., *W.*, pilulaeforme (Bull.) Fr., *D.*, hydrophilum (Bull.) Fr., *W.*
Psilocybe sarcocephala Fr., *T.*, ericaea (Pers.) Fr., *T.*, semilanceata Fr., *T.*, *L.*, *D.*, *B.*
Psathyra conopilea Fr., *W.*
Coprinus atramentarius (Bull.) Fr., *D.*, *B.*, picaceus (Bull.) Fr., *W.*, micaceus (Bull.) Fr., *L.*, *D.*, plicatilis (Curt.) Fr., *D.*
Panaeolus campanulatus (Linn.) Fr., *D.*, *W.*
Anellaria separata (Linn.) Karst., *L.*, *B.*
Psathyrella gracilis Fr., *W.*
Gomphidius gracilis B. and Br., *T.*, *L.*
Boletus elegans (Schum.) Fr., *T.*, *L.*, *D.*, viscidus (Linn.) Fr., *L.*, badius Fr., *T.*, *B.*, piperatus (Bull.) Fr., *T.*, chrysenteron (Bull.) Fr., *T.*, edulis (Bull.) Fr., *T.*, calopus Fr., *T.*, *Borrowdale*, porphyrosporus Fr., *D.*, versipellis Fr., *T.*, scaber (Bull.) Fr., *T.*, *D.*, rugosus Fr., *D.*
Polyporus perennis (Linn.) Fr., *T.*, *D.*, varius Fr., *W.*, squamosus (Huds.) Fr., *D.*, betulinus (Bull.) Fr. *T.*, *D.*, amorphus Fr., *B.*

Fomes igniarius (Linn.) Fr., ferruginosus (Schrad.) Mass., *W.*, annosus Fr., *T.*, *W.*
Ganoderma applanatum (Pers.) Pat., *D.*
Polystictus versicolor (Linn.) Fr., *T.*
Poria sanguinolenta (A. and S.) Fr., *L.*, hymenocystis B. and Br., *T.*, *L.*, *D.*, *W.*
Daedalea quercina (Linn.) Fr., *D.*
Hydnum repandum (Linn.) Fr., *T*
Irpex obliquus (Schrad.) Fr., *T.*
Radulum mucidum (Pers.) Bourd. and Galz., *W.*
Phlebia merismoides Fr., *T.*, *D.*, *W.*
Odontia farinacea (Pers.) Quél., *T.*, *W.*
Grandinia granulosa Fr., *W.*
Thelephora palmata (Scop.) Fr., *D.*, anthocephala (Bull.) Fr., *L.*, terrestris (Ehrh.) Fr., *L.*
Stereum hirsutum (Willd.) Fr., *T.*, *W.*, *D.*, purpureum (Pers.) Fr., *D.*, spadiceum Fr., *T.*, *W.*, rugosum (Pers.) Fr., *T.*, sanguinolentum (A. and S.) Fr., *T.*, *D.*, *B.*
Hymenochaete rubiginosa (Dicks.) Lév., *D.*, corrugata (Fr.) Lév., *T.*, *W.*
Aleurodiscus amorphus (Pers.) Rabenh., *B.* (on *Abies*).
Corticium laeve (Pers.) Fr., *T.*, atrovirens Fr., *B.*, Sambuci (Pers.) Fr., *W.*, trigonospermum Bres., *W.*, subcoronatum v. H. and L., *B.*, confluens Fr., *W.*, confine Bourd. and Galz., *B.*, echinosporum Ell., *D.*, porosum B. and C., *B.*
Peniophora glebulosa (Fr.) Bres., *T.*, sanguinea (Fr.) Bres., *T.*, gigantea (Fr.) Mass., *B.*, cinerea (Fr.) Cooke, *W.*
Coniophora puteana (Schum.) Karst., *W.*, arida Fr., *W.*
Hypochnus fuscus (Pers.) Fr., *T.*, *B.*, *W.*, fumosus Fr., *L.*, *D.*, botryoides (Schw.) Burt, *T.*
Clavaria cristata (Holmsk.) Fr., *T.*, cinerea (Bull.) Fr., *T.*, *W.*, rugosa (Bull.) Fr., *L.*, *B.*, Kunzei Fr., *T.*, corniculata (Schaeff.) Fr., *L.*, *W.*, luteoalba Rea, *L.*, inaequalis (Müll.) Fr., *T.*, *L.*, *W.*, vermicularis Fr., *L.*, fumosa (Pers.) Fr., *D.*
Pistillaria quisquiliaris Fr., *D.*, puberula Berk., *D.*
Hirneola auricula-Judae (Linn.) Berk., *W.*
Ecchyna faginea (B. and Br.) Fr., *W.*
Tremella frondosa Fr., *W.*, foliacea (Pers.) Fr., *T.*, *L.*, *D.*, mesenterica (Retz.) Fr., *T.*, *W.*
Exidia glandulosa (Bull.) Fr., *T.*, nucleata (Schw.) Rea, *L.*, *B.*, Thuretiana (Lév.) Fr., *B.*
Dacryomyces deliquescens (Bull.) Duby, *T.*, *L.*
Calocera viscosa (Pers.) Fr., *T.*, *L.*, cornea (Batsch) Fr., *T.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *T.*
Mutinus caninus (Huds.) Fr., *L.*
Lycoperdon caelatum (Bull.) Fr., *B.*, depressum Bon., *D.*, umbrinum Pers., *L.*, *D.*, pyriforme (Schaeff.) Pers., *T.*
Geaster fimbriatus Fr., *T.*
Nidularia confluens Fr , *Portinscale.*
Crucibulum vulgare Tul., *D.*
Scleroderma vulgare (Hornem.) Fr., *L.*, verrucosum (Vaill.) Pers., *D.*
Sphaerobolus stellatus (Tode) Pers., *W.*

UREDINEAE.

Uromyces Trifolii-repentis (Cast.) Lindr., *T.*, Alchemillae (Pers.) Lév., *T.*
Puccinia Violae (Schum.) DC., *T.*, Hieracii (Schum.) Mart., *T.*, Menthae Pers., *B.*, annularis (Str.) Schlecht., *T.*, obscura Schroet., *W.*, holcina Eriks., *T.*, Poarum Niels., *T.*
Gymnosporangium clavariaeforme (Jacq.) Rees, *T.*, *L.*, Juniperi Lk., *T.*
Phragmidium Sanguisorbae (DC.) Schroet., *Portinscale*, subcorticium (Schrank) Wint., *L.*

Xenodochus carbonarius Schlecht., *D.*
Coleosporium Melampyri (Rebent.) Kleb., *T.*, *D.*, Tussilaginis (Pers.) Kleb., *T.*
Pucciniastrum Circaeae (Schum.) Schroet., *T.*, *B.*
Melampsoridium betulinum (Pers.) Kleb., *T.*
Thecopsora Vacciniorum (Link) Karst., *T.*
Milesina Blechni (Syd.) Magn., *D.*, *B.*, Dieteliana Syd., *B.*

PYRENOMYCETES.

Sphaerotheca Castagnei Lév., *D.* (on Burnet).
Podosphaera Oxyacanthae (DC.) de By, *L.*
Microsphaera Grossulariae (Wallr.) Lév.
Phyllactinia suffulta (Rebent.) Sacc., *T.*
Erysiphe Polygoni DC., on *Circaea*, Martii Lév., *T.*
Apiosporium pinophilum (Nees) Fuck., *D.*
Nectria cinnabarina (Tode) Fr., *T.*, *L.*, *W.*, sanguinea Fr., *W.*
Hypomyces rosellus Tul., luteovirens (Fr.) Plowr., *Portinscale.*
Hypocrea rufa (Pers.) Fr.
Cordyceps militaris (L.) Link, *T.*, *L.*, *B.*, ophioglossoides (Ehrb.) Link, *B.*
Claviceps microcephala (Wallr.) Wint., on *Nardus*, *Borrowdale.*
Sordaria fimicola (Rob.) Ces. and de Not. (on rabbit dung).
Sporormia intermedia Auersw. (on rabbit dung).
Bertia moriformis (Tode) de Not.
Rosellinia velutina Fuck.
Melanomma pulvis-pyrius (Pers.) Fuck.
Stigmatea Robertiani Fr., *T.*
Tichothecium erraticum Massal., gemmiferum (Tayl.) Koerb.
Ophiobolus porphyrogonus (Tode) Sacc.
Diaporthe pulla Nke, strumella (Fr.) Fuck., sorbicola (Nke) Schroet, controversa (Desm.) Fuck., revellens Nke, leiphaemia (Fr.) Sacc.
Valsa ambiens Fr., decorticans Fr. (on beech).
Eutypa lata Tul.
Eutypella stellulata (Fr.) Sacc.
Diatrype stigma (Hoffm.) de Not., *W.*, favacea Fr., bullata (Hoffm.) Fr.
Diatrypella quercina (Pers.) Nke, verrucaeformis (Ehrh.) Nke.
Hypoxylon multiforme Fr., *T.*, coccineum Bull., *T.*, fuscum Fr., *W.*, semi-immersum Nke.
Xylaria Hypoxylon (L.) Grev., *L.*
Phyllachora graminis (Pers.) Fuck., *T.*
Plowrightia ribesia Sacc.

HYSTERIACEAE.

Rhopographus Pteridis (Sow.) Wint., *W.*
Hysterium pulicare (Pers.) Fr., *D.*
Lophodermium Pinastri (Schrad.) Chev., *B.*, *D.*
Dichaena faginea Fr., var corylea Fr.

TUBERACEAE.

Elaphomyces granulatus Fr., *B.*, *D.*

DISCOMYCETES.

Rhizina inflata (Schaeff.) Karst., *L.*
Galactinia badia (Pers.) Boud., *T.*
Peziza aurantia Pers., *T.*, *W.*
Ciliaria scutellata (Linn.) Quél., *D.*, trechispora (B. and Br.) Boud., *Borrowdale.*
Cheilymenia dalmeniensis (Cooke) Boud., *W.*, coprinaria (Cooke) Boud., *B.*, *D.*
Coprobia granulata (Bull.) Boud., *T.*
Ascobolus viridulus Phill. and Plowr., *T.*, atrofuscus Phill. and Plowr., *D.*
Taphrina aurea (Pers.) Fr., *T.*
Trichoglossum hirsutum (Pers.) Boud., *D.*
Microglossum viride (Pers.) Gill., *Borrowdale.*
Spathularia clavata (Schaeff.) Sacc., *W.*

Leotia lubrica (Scop.) Pers., *T.*, *D.*, atrovirens Pers., *W.*
Cudoniella acicularis (Bull.) Schroet., *T.*, *D.*
Apostemidium aridula Karst., *B.*
Ombrophila faginea (Pers.) Boud., *B.*
Calycella claroflava (Grev.) Boud., *L.*, *T.*, *D.*, sublenticularis (Fr.) Boud., *W.*
Coryne sarcoides (Jacq.) Tul., *T.*, *L.*
Bulgaria inquinans (Pers.) Fr., *T.*, *D.*, *W.*
Polydesmia pruinosa (B. and Br.) Boud., *L.*, *D.*
Orbilia xanthostigma Fr., *L.*, *W.*, curvatispora Boud., *L.*, *D.*
Sclerotinia Curreyana (Berk.) Karst., *D.*, *W.*
Phialea firma (Pers.) Gill., *T.*, *W.*
Helotium scutula (Pers.) Karst., *D.*
Dasyscypha virginea (Batsch) Fuck., *T.*, *D.*, *W.*
Trichoscypha calycina (Schum.) Boud., *T.*, *L.*, *D.*
Arachnopeziza aurata Fuck., *D.*
Hyaloscypha hyalina (Pers.) Boud., *T.*, *D.*, *B.*
Mollisia cinerea (Batsch) Karst., *T.*
Tapesia caesia (Pers.) Fckl., *D.*
Pezicula rhabarbarina (Berk.) Tul., *D.* (on *Rubus*).
Phacidium multivalve (DC.) Kunze and Schm., *L.*, *D.*
Stegia Ilicis Fr., *T.*
Rhytisma acerinum (Pers.) Fr., *T.*

PHYCOMYCETES.

Endogone lactiflua Berk., *T.*
Synchytrium Taraxaci de By. and Wor., *T.*
Syzygites megalocarpus Ehrb., *D.*

SPHAEROPSIDEAE.

Phoma lineolata Desm., *L.*
Marssonia Potentillae (Desm.) Fisch., var. Tormentillae Trail, *B.*
Leptothyrium quercinum (Lasch) Sacc., *D.*

HYPHOMYCETES.

Oidium alphitoides Griff. and Maubl., *D.*
Trichoderma viride (Pers.) Fr., *T.*, *W.*
Botrytis Tilletii Desm., *D.*
Ramularia Primulae Thuem., *W.*, Taraxaci Karst., *T.*, Armoraciae Fuck.
Ovularia obliqua (Cooke) Oud., *L.*, *D.*
Fumago vagans (Pers.) Fr.
Bispora monilioides Corda, *L.*
Cercospora Mercurialis Passer., *W.*
Isaria arachnophila Ditm., *D.*
Ptychogaster albus Corda, *T.*, *L.*, *D.*

KESWICK LICHENS.

By H. H. Knight, M.A.

In a mountainous country like the Lake District one expects to see plenty of Lichens, and we were not disappointed. In the woods visited during the foray corticolous Lichens were not plentiful except in some of the old woods in the Borrowdale Valley. Here were seen some of the more showy Lichens belonging to the family *Stictaceae*, also *Parmeliella plumbea*.

There are two types of rock around Keswick, the volcanic rocks to the south of the town, and the slates of Skiddaw and the hills round Bassenthwaite. The hard volcanic rocks are the most suitable for Lichens, the slate rocks not producing so many species. As there is no limestone, many common Lichens are absent from the list. Miss Noel sent three Lichens from Shap in the neighbouring county of Westmorland where the carboniferous limestone occurs. These are included in the list. The Lichen parasites *Ticothecium gemmiferum* Koerb. and *T. erraticum* Massal. were found, the former being common. I am much indebted to Mr R. Paulson for help in making out this list.

Calicium hyperellum Ach.
Sphaerophorus globosus Wain.
S. fragilis Ach.
Ephebe lanata Wain.
Leptogium lacerum S. F. Gray.
Parmeliella plumbea Wain.
Pannaria rubiginosa Del.
var. conoplea Koerb.
Peltigera canina Willd.
P. rufescens Hoffm.
var. praetexta Nyl.
P. polydactyla Hoffm.
P. horizontalis Hoffm.
Sticta fuliginosa Ach.
Lobaria scrobiculata DC.
L. laetevirens A. Zahlbr.
L. pulmonaria Hoffm.
Parmelia physodes Ach.
P. perlata Ach.
P. caperata Ach.
P. scortea Ach.
P. saxatilis Ach.
P. sulcata Ach.
P. dubia Tayl.
P. revoluta Floerke.
P. conspersa Ach.
P. omphalodes Ach.
P. fuliginosa Nyl.
var. laetevirens Nyl.
Cetraria glauca Ach.
C. aculeata Fr.
f. hispida Cromb.
Evernia prunastri Ach.
E. furfuracea Mann, Shap.
Ramalina calicaris Ach.
R. farinacea Ach.
Usnea florida Web.
var. hirta Ach.
Alectoria jubata Ach.
Xanthoria parietina Th. Fr.
X. lychnea Th. Fr.
Placodium ferrugineum Hepp.
var. festivum A. L. Sm.
Candelariella vitellina Müll.-Arg.
Physica pulverulenta Nyl.
P. grisea A. Zahlbr.
Physica hispida Tuckerm.
Rinodina demissa Arn.
R. subarenaria A. L. Sm.
Lecanora subfusca Ach.
var. chlarona Ach.
L. atra Ach.
L. pallida Schaer.
L. subcarnea Ach.
L. varia Ach.
L. symmictera Nyl.
var. aitema Nyl.
L. sulphurea Ach.
L. polytropa Schaer.
L. argopholis Ach.
L. badia Ach.
L. atriseda Nyl.
L. tartarea Ach.
L. subtartarea Nyl.
L. parella Ach.
L. cinerea Sommerf.
L. gibbosa Nyl.
L. subdepressa Nyl.
L. superiuscula Nyl., a form with larger spores than hitherto described.
L. lacustris Th. Fr.
L. Dicksonii Nyl.
L. epulotica Nyl., Shap.
Acarospora fuscata Th. Fr.
Haematomma ventosum Massal.
Pertusaria faginea Leight.
P. lactea Nyl.
P. pertusa Dal. Tor. and Sarnth.
P. dealbata Cromb.
P. leioplaca Schaer.
P. Wulfenii DC.
Diploschistes scruposus Norm.
Baeomyces rufus DC.
B. roseus Pers.
Stereocaulon evolutum Graewe.
S. denudatum Floerke.
var. pulvinatum Th. Fr
Cladonia rangiferina Web.
C. sylvatica Hoffm.
C. uncialis Web.
C. foliacea Willd.

Cladonia pyxidata Hoffm.
C. fimbriata Fr.
C. cervicornis Schaer.
C. gracilis Willd.
C. furcata Schrad.
C. squamosa Hoffm.
C. subsquamosa Nyl.
C. caespiticia Floerke.
C. digitata Hoffm.
C. deformis Hoffm.
C. coccifera Willd.
C. flabelliformis Wain.
C. Floerkeana Fr.
var. carcata Wain.
Coenogonium ebeneum A. L. Sm.
Lecidea ostreata Schaer.
L. confertula Stirt.
L. lucida Ach.
L. coarctata Nyl.
L. granulosa Schaer.
L. flexuosa Nyl.
L. demissa Th. Fr.
L. uliginosa Ach.
L. parasema Ach.
L. sublatypea Leight.
L. paneola Ach.
L. contigua Fr.
f. calcarea Leight.
L. sorediza Nyl.
L. albocoerulescens Ach.
L. crustulata Koerb.
var. meiospora Oliv.
L. confluens Ach.
f. oxydata Leight.
L. plana Nyl.
L. lactea Floerke.
Lecidea fuscoatra Ach.
L. Kochiana Hepp.
var. lygaea Leight.
L. griseoatra Schaer.
L. asperella Stirt.
L. sanguinaria Ach.
Biatorina lenticularis Koerb.
Bilimbia cuprea Massal.
B. sabuletorum Br. and Rostr.
var. simplicior A. L. Sm.
B. lignaria Massal.
Bacidia umbrina Br. and Rostr.
Buellia myriocarpa Mudd.
B. impressula A. L. Sm.
B. disciformis Mudd.
B. colludens Tuckerm.
Rhizocarpum Oederi Koerb.
R. geographicum DC.
R. viridiatrum Koerb.
R. confervoides DC.
R. obscuratum Massal.
Arthonia radiata Ach.
var. Swartziana Sydow.
Lithographa tesserata Nyl.
Opegrapha atra Pers.
Graphis elegans Ach.
Verrucaria aethiobola Wahlenb.
V. submersa Schaer.
V. maculiformis Krempelh.
Staurothele rupifraga Arn., Shap.
Arthopyrenia fallax Arn.
A. spilobola A. L. Sm.
A. submicans A. L. Sm.
Pyrenula nitida Ach.
Melanotheca gelatinosa Nyl.

REPORT ON THE MYCETOZOA FOUND DURING THE FORAY AT KESWICK.

September 15th to 21st, 1922.

By W. N. Cheesman, F.L.S. and W. T. Elliott, F.L.S., F.Z.S.

Rain is proverbial in the Lake District, and on our visit there was no exception to this for on most days it came down heavily and rendered the prospects unfavourable for obtaining Mycetozoa.

Most of the country visited consisted geologically of the Skiddaw slates and was clothed with a thriving vegetation, in contrast with that in which the volcanic Borrowdale series was dominant, where aridity, ruggedness, and destitution of growth were clearly apparent. The alluvial deposits in the fertile

valley connecting Bassenthwaite and Derwentwater appeared to be the most favourable hunting grounds for Mycetozoa, whereas the igneous rocks with a natural swift drainage, excessive wetness, and little depth of soil, may be regarded as unfavourable to their development. The arboreal vegetation was generally of small size and with very little undergrowth. Here and there a copse of hazel could be seen. The trees were mostly conifers, larch being predominant. Beech and oak occurred in a few places in the valley and the holm oak was well represented. Birch also was plentiful in places, particularly at the base of the hills, but elm was almost entirely absent.

In the following list of thirty-seven species it may be observed there is no record of Badhamia and that the prolific genus of Physarum is only represented by two species; most of these gatherings were deficient in lime. In the vicinity of the Falls of Lodore *Leocarpus fragilis* was taken in all stages of development. *Physarum viride, Trichia persimilis,* and *Trichia Botrytis* were also found here in quantity. The Trichiaceae are well represented in the list. It seems that the lime-forming species are not so happy in their development in these surroundings as is the case with the Trichiaceae and Arcyriaceae and those other species that are destitute of lime for it may be observed that the Calcarineae are represented by only eleven species in this list.

In the following list *T.* = Thirlmere; *L.* = Latrigg; *B.* = Borrowdale; *Ba.* = Bassenthwaite; *W.* = Whinlater and Wythop.

Ceratiomyxa fruticulosa Macbr., *B., W.* A beautiful gathering in course of development had been entirely devoured next morning by the larvae of *Phronia basalis* Winn. a dipterous fly of the family Mycetophilidae. A species of Collembola also attacks it with avidity.

Physarum nutans Pers., *T., B., W.* (a slender form was taken in several places), var. leucopheum Lister, *B.* (this was taken in the valley).

P. viride Pers., *L., B.*, var. aurantium Lister, *B.*

Fuligo septica Gmel., *T.* One gathering only.

Craterium minutum Fr., *B., W.*

Leocarpus fragilis Rost., *T., B., Ba.* All gatherings had dark purple brown sporangia.

Diderma deplanatum Lister, *T.*

Didymium melanospermum Macbr., *T.*, nigripes Fr., *B.*, squamulosum Fr., *L.*, difforme Duby, *T.*

Lepidoderma tigrinum Rost., *B.* Developed from orange plasmodium found on damp moss near the Falls of Lodore, the accurately formed stellate scales attached to the sporangium wall in some cases were very conspicuous.

Stemonitis fusca Roth., *T.*, flavogenita Jahn, *B , Ba.*

Comatricha nigra Schroet., *B.*, pulchella Rost., *B.*, laxa Rost., *B.*, typhoides Rost., *T., L., B.* (the stalk and cylindrical sporangia were devoid of the silvery outer growth).

Lamproderma columbinum Rost. var. iridescens G. List.*.

Cribraria vulgaris Schrad., *B.*

Licea flexuosa Pers., *B.* Taken by Mr Knight shewing the outer mottled coat of refuse matter very clearly.

* See p. 32.

Reticularia Lycoperdon Bull., *B.*
Lycogala epidendrum Fr., *B.*, *W.*
Trichia affinis de Bary, *B.*, persimilis Karst., *T.*, *L.*, *B.*, *Ba.*, *W.* (all typical gatherings and very abundant), varia Pers., *T.*, *B.*, scabra Rost., *B.*, decipiens Macbr., *L.*, *B.*, *Ba.* (very plentiful), Botrytis Pers., *T.*, *L.*, *B.*, *Ba.* (the olive brown sporangia in abundance with lines of dehiscence well marked).
Arcyria incarnata Pers., *T.* (an almost sessile gathering was taken), denudata Sheld., *L.*, *B.*, cinerea Pers., *W.*, pomiformis Rost., *T.*, nutans Grev., *B.*
Perichaena corticalis Rost., *T.*

PRESIDENTIAL ADDRESS.

By F. T. Brooks, M.A., F.L.S.

SOME PRESENT-DAY ASPECTS OF MYCOLOGY.

The British Mycological Society may legitimately congratulate itself upon the impetus recently given to the study of mycology in this country, for its members have been largely responsible for the increased attention now given to this branch of botany. Under the able and energetic direction of the general officers, the Society has greatly increased its membership and has extended its activities with success, so that it is now a very vigorous body, meeting frequently in London or elsewhere, throughout the year. I am assured also that the efforts of the Society to assist in the mycological education of botanical students, especially in the field, are warmly appreciated. Another activity which has been supported by the Society is the establishment of a collection of pure cultures of fungi in the National Collection of Type Cultures at the Lister Institute, which, it may be hoped, will in time become the premier collection of its kind in the world. The recent establishment of the Imperial Bureau of Mycology under the directorship of Dr E. J. Butler is another indication of the importance which our subject has assumed in the Dominions and Colonies as well as at home. The publication by the Bureau of the "Review of Applied Mycology" is an event of special importance, and all mycologists are grateful for its appearance.

Mycology is a subject of wide scope, for fungi are aggressive organisms and play a by no means insignificant part in the economy of nature. Our branch of Botany has intimate connections with Cytology, Genetics, Protozoology, Medicine, Biochemistry, Plant Physiology and Plant Pathology. Indeed so close is the association between Mycology and Plant Pathology that the two are often identified in the minds of the scientific public, and although there are certain differences

between them, it is often impossible to say where mycology ends and plant pathology begins. A large part of the credit attributable to the recent progress in plant pathology, must undoubtedly be given to mycologists. During the past few years there has been a considerable influx of plant pathologists into the Society, and I trust it will ever be the aim of the Society to extend a warm welcome to all those scientific workers whose investigations require a knowledge of the life-habits of fungi for their solution.

Members of the Society have also recently been active in the publication of books upon fungi and allied organisms, and the reproach that there were no good modern British books on mycology is no longer valid. It is a pleasure to refer to the literary activity of several of our members: Miss Lorrain Smith's book on Lichens is the culmination of a life-study of this group, and will for many years be the standard work of reference upon these strange plants. Professor Dame Helen Gwynne-Vaughan's book on Fungi fills a much-needed want, and is a mine of information upon some of the most interesting groups. Within the last few months there has also appeared under the auspices of the British Mycological Society Mr Carleton Rea's book on "British Basidiomycetae." It must be a particular pleasure to Mr Rea, as it is to all of the members of the Society to see his monumental work in print, which will be a lasting tribute to his indefatigable zeal and skill in the study of the higher fungi. Mr Ramsbottom has revised the guide to the larger fungi in the British Museum and has provided therein a tale of the exciting adventures of toadstools and cup fungi which will not soon be exhausted. Finally Professor Buller has a second volume of his researches on Fungi on the point of publication, and we are all looking forward to reading the story of the new discoveries of the one who may be well called, without irreverence, the mycological magician. To each one of these authors the British Mycological Society will wish to offer its hearty congratulations.

In all these respects, members of the British Mycological Society have been active in promoting the study of mycology, and the liveliness in this subject which has arisen in consequence, augurs well for the future both of mycology and of our Society.

In the membership of our Society, there has been perhaps a greater influx of professional than amateur workers, and it may perhaps be feared by some that the interests of the amateurs may come to be overlooked. Speaking as a professional worker I trust that will never be. British mycology was fathered by an amateur, the Rev. M. J. Berkeley, and this Society was largely founded also by amateurs including Mr Cheesman and

Mr Carleton Rea, the latter of whom has been its guardian angel ever since. May I add that many of us academic workers owe a deep debt of gratitude to workers like Mr Rea who of their never-failing kindness help us persistently out of our systematic difficulties? I feel confident therefore that the mycological work of amateurs will be as warmly welcome in the future as in the past. The amateur is the salt of the earth, for it is he alone who is impelled to work by the love that is in him. Science is in danger of becoming over-professionalised, and it is only the spirit of the amateur that can preserve the freshness of outlook essential to the intellectual health of the professional investigator. At the last annual foray, the discussion initiated by Dr Butler indicated many of the ways in which amateur workers could be of assistance in promoting the study of fungi, and with the co-operation of both kinds of workers, British mycology has a rich harvest before it.

The Origin and Phylogeny of the Fungi.

I propose now to say a few words about the origin and phylogeny of the fungi. I know that in discussing this subject I am treading on dangerous ground, but I trust you will bear with me in my heterodoxy. I have just come from the meeting of the British Association for the Advancement of Science at Hull where there has been considerable discussion on the subject of Evolution. Anent this discussion Dr D. H. Scott made the remark that the day had passed when biologists thought they knew a great deal about the phylogeny of organisms; in his striking phrase, "phylogeny eludes us." This does not mean that nothing is known about the race-history of the main groups of animals and plants, but that we know far less than was thought only a few years ago. Notwithstanding this change in outlook there is still prevalent in the teaching of elementary botany a view of the origin and development of the fungi, to the exclusion of other possibilities, which I venture to combat. Besides, it is well occasionally to take a broad survey of the group of organisms with which we are dealing, for like all other students of detail, we are sometimes apt to miss the wood for the trees. The fungi are a remarkable group of organisms of which we, as mycologists, are rightly proud, but their unique characters are often overlooked, and many botanists look upon them as a race of degenerate organisms, poor anaemic creatures that have lost the power to photosynthesise. Let us examine this standpoint somewhat critically. Nowhere else in the plant kingdom is there an immense group which is looked upon as having been derived from green organisms by the loss of

chlorophyll. Where saprophytic or parasitic forms occur amongst green plants, their numbers are limited and diversity restricted, as if the loss of pigment and holophytic mode of nutrition had checked their evolutionary impetus. Thus the families of parasitic flowering plants, Orobanchaceae and Rafflesiaceae contain comparatively few genera and species, as if their undoubted degeneracy had brought the inevitable penalty in its train. Likewise the parasitic algae are few in number of species and infrequent in occurrence, pointing to the same truth that loss of a fundamental character leads inevitably to grave handicap in the struggle for existence. The fungi, on the other hand, rival the flowering plants themselves in number of species and diversity of form, and it is altogether against the laws of probability that they have been derived from such groups as the Green and Red Algae by the loss of pigment and development of a saprophytic or parasitic mode of nutrition. Thanks to the researches of Kidston and Lang* we now know that the fungi are at least as old as the Devonian rocks, and it is likely that they date back to that far distant time when the chief groups of lower organisms were becoming differentiated after the dawn of life in the primitive ocean. With their infinite variety, the fungi must have possessed some of that evolutionary driving power which was inherent in the organisms that gave rise to the dominant groups of plants and animals. It has been suggested by Church† that the growth-forms of the fungi, including the lichens, are essentially those of marine algae, and he apparently denies to the group any really independent power of form development. For instance he states‡ that "a higher fungus of the land is in short a skinned seaweed, implying a more or less elaborated algal growth-form, in which in the death and decay of the older metabolic and autotrophic surface layers, the exposed internal heterotrophic tissues continue their heterotrophic existence at the expense of the soluble carbohydrates of the standing and non-aerated medium." Where for instance amongst the algae will be found the growth-forms of *Xylaria*, *Polyporus squamosus*, the common mushroom, or finally of the elegant *Dictyophoras* of the Gasteromycetes? It must not be forgotten that in the higher fungi the conspicuous part is essentially a spore-producing structure which cannot be directly compared with the somatic equipment of the algae.

Church's view is that the fungi have been derived from transmigrant algae by the loss of chlorophyll, such algae being

* Kidston, R. and Lang, W. H. On Old Red Sandstone Plants showing structure, etc. Part v. Trans. Roy. Soc. Edin. LII, p. 855 (1921).

† Journal of Botany, p. 41 (1921).

‡ Church, A. H., Thalassiophyta, p. 59, etc., Oxford (1919).

of a much more generalised type than marine forms at present existing. This is an interesting speculation, but it is not more than a speculation, and even if an agnostic attitude be adopted in regard to it, most mycologists will combat the idea that the fungi, thus derived, possess little or no novelty in form-development.

Although Church's view that fungi have arisen from transmigrant algae is unsatisfying, even more problematical is the outlook, still prevalent among botanists, that the fungi have been derived from algal forms somewhat similar to existing types of Green and Red Algae. This is a reflection of the views of Pringsheim, de Bary, and Sachs, especially of the last named. It may be remembered that Pringsheim actually placed *Saprolegnia* amongst the green algae, as a colourless form. Since the lifetime of these botanists, however, further research has thrown a flood of new light upon the fungi, which makes much more problematical the correctness of their views. It is a commonplace of botanical lecturers to compare *Pythium* with *Vaucheria*, and *Mucor* with *Spirogyra*, and the comparison is not infrequently accompanied by more than a suggestion that the forms may be phylogenetically connected. Again, the Ascomycetes and the Rust Fungi are commonly connected with the Red Algae, in the main, apparently on account of the presence of trichogynes and spermatia. In my opinion the resemblances between these groups of algae and fungi are entirely superficial, and are of no phylogenetic significance whatever. If the comparison is pressed for instance between *Pythium* and *Vaucheria*, enormous differences are found between the two forms; for instance the mode of germination of the zygote, a character probably of considerable ancestral importance, is different, and the characters of the ciliated cells are so diverse that a phylogenetic connection seems out of the question*. It is even more difficult to conceive of a phylogenetic comparison being drawn between *Mucor* and *Spirogyra*, and the sooner such is relegated to the limbo of forgotten things, the better for botanical clarity of vision. As between the Ascomycetes and the Uredineae on the one hand, and the Red Algae on the other, the comparison is usually of a more delicate nature, but it seems equally fallacious. The comparison between the trichogynes of the respective groups can hardly be taken seriously for there are great structural differences between them, while in sexuality

* Since delivering this address, Dr Butler has reminded me of his paper "On *Allomyces*, a new aquatic fungus" (Annals of Botany, xxv, p. 1123, (1911), in which this curious genus of the Leptomitaceae is compared with the algal genus *Dichotomosiphon*. Although the resemblance between the growth forms of these two genera is striking, the profound differences in reproduction appear to me to invalidate any phylogenetic connection between them.

and in nuclear cycle, the differences are profound. Again, the argument is often advanced that in certain groups of existing algae, the phenomenon of parasitism exists, accompanied by the partial or total loss of chlorophyll, as in *Harveyella* and *Chroolepus*, and that this illustrates the way in which fungi have arisen. Although these forms have wholly or partly lost their chlorophyll they still reproduce in a purely algal manner and show no approach to a fungoid nature. Now it is a general belief, and probably a correct one, that parasitism in the fungi is a more recent development than saprophytism. Saprophytic algae are exceedingly rare and show even less approach to mycelial growth than do the parasitic forms. Saprophytism and parasitism in the algae at the present day are exactly the same phenomena as the occasional adoption of these modes of nutrition in other holophytic groups, and have no significance as regards the origin of the fungi, the peculiarities of which must be sought elsewhere. If the fungi had been derived from algae by the loss of chlorophyll, one would expect to find in certain fungal forms at any rate, traces of the same type of carbohydrate metabolism as that existing in the algae. Such in point of fact does not occur, and an entirely different set of carbohydrates is found in the fungi.

The almost universal hyphal development of the fungi is sometimes compared with the filamentous nature of many algae. In most groups of algae, the filamentous types pass over into more complex forms in which longitudinal divisions of the cells occur, and, in the higher forms of algae, tissues are present closely similar in character to those of terrestrial green plants. On the other hand, even in the most highly developed fungi, longitudinal divisions of the cells are almost unknown, and the tissue systems are of a type unique in the plant world. Here again there is a great gulf fixed between the algae and the fungi. If the two groups had been phylogenetically connected, the higher fungi would probably have exhibited some of the types of cell aggregation prevalent in the holophytic algae. The hyphal development of the fungi can be looked upon as a pronounced type of cell expression, potentially present in all living cells, which has been developed to an extreme degree in correlation with peculiar modes of nutrition. Whenever a somatic part of an organism with an essentially absorbent function is embedded in a nutritive medium, be that dead or alive, there is a tendency to a hypha-like type of growth, as, for example, in the rhizoids and root hairs of green terrestrial plants. Again the growth of a pollen tube in the tissues of the style is essentially hypha-like, and the vegetative body of the Rafflesiaceae, a parasitic family of flowering plants, is practically a mycelium. Even in animal

cells, this tendency to hypha-like proliferation in response to a peculiar environment is of common occurrence, as for example in cartilage tissues grown aseptically under artificial conditions. As regards the latter, the parallel is so close to the growth of a fungus mycelium that a friend who was investigating the growth of animal tissues under cultural conditions, at first thought that his cultures had become contaminated by a fungus; the hypha-like threads were in fact nothing but proliferating cartilage cells. Thus the mycelial character of the vegetative body of most fungi must be looked upon as a type of cell development elaborated in connection with special nutritive needs, and not in any way as being mainly the expression of an algal ancestry.

Another marked difference between the fungi and the algae, and indeed all other groups of green plants, lies in the chemical composition of the cell membranes. It has long been known that the cell walls of fungi differ chemically from the cellulose which is the chief constituent of the cell walls of other plants. At first the main constituent of hyphal walls was called "fungus-cellulose," but more recently it has been shown that this substance contains nitrogen whereas true cellulose does not, so that it differs markedly. The main constituent of fungal walls resembles in many ways the chitin of animal cells. Recent investigations tend to emphasise the phylogenetic significance of the chemical constitution of cell membranes, and it seems clear that if the fungi had been derived from the algae there would be closer approximation in the characters of the membranes. For instance, the chemical differences between the cell walls of *Pythium* and *Vaucheria* make it certain that an immense gap lies between them, apart from all other considerations. While mentioning chemical differences between fungi and other plants, it may be pointed out that many fungus pigments are highly peculiar, especially those of the lichens. On the other hand most of the pigments of green plants show close relationships to one another.

With these profound and fundamental differences between the fungi and the algae it may not be unprofitable to consider in some detail the view which has been put forward by Dangeard* and others that the origin of the fungi is to be sought in unicellular protist organisms. Dangeard has had a unique experience as an investigator of the lower forms of life, both plant and animal, and his views are entitled to most serious consideration. In the main I am in harmony with him although I cannot agree with some of his deductions. At the bottom

* Dangeard, P. A., Les ancêtres des champignons supérieurs. Le Botaniste, IX, p. 157 (1903).

of the plant and the animal kingdoms there are large numbers of forms which in some respects show plant characteristics and in others, animal characteristics, *i.e.* are intermediate between the plant and animal kingdoms, as well as innumerable other types which, though predominantly plant or animal-like, can scarcely be regarded as definitely one or the other. The Flagellata, the Mycetozoa, and the Bacteria are groups of this class. Some of the Flagellata are intermediate in character between plants and animals, while others possess almost exclusively animal characteristics. The Mycetozoa are predominantly animal-like in one phase of their existence, and plant-like at another, while the Bacteria are chiefly plant-like throughout their development. Whatever view is taken of the origin of protoplasm, *i.e.* of life on this planet, it is clear, from what is known of evolutionary processes, that at the dawn of life the forms were probably very few, perhaps only one, possessing a mode or modes of nutrition conceivably different from those of the great majority of plants and animals of the present day. Certain forms of bacteria obtain their essential supplies of nitrogen and carbon even now by ways which are neither like those of typical plants nor animals. It is possible, therefore, that the earliest forms of life were generalised types, neither definitely plants nor animals, perhaps possessing peculiar prototrophic modes of nutrition. I mention this possibility as it is sometimes postulated that plant forms must have preceded the evolution of animal organisms. Now it is likely that long before organisms possessing tissue systems had become differentiated, the chief groups of the Protista had come into existence, so that there was no lack of organisms of a saprophytic mode of nutrition available in the sea at the time when the larger seaweeds were being evolved. It is less difficult to conceive of the direct evolution of such unicellular types into forms with hyphae as a response to continued possibilities of existence in vegetable and animal debris, than it is to suppose that the fungi have in the main been evolved directly either from transmigrant algae, or from Green and Red algae somewhat similar to existing types. The fungi undoubtedly possess some of the initial, evolutionary impetus characteristic of all the primary groups of living organisms, which they hold by virtue of an early differentiation from protist organisms.

One of the difficulties encountered by those who derive the fungi from the algae is to account for the Chytridiineae from an algal ancestry. There are few algae to which these peculiar fungi can be even remotely associated, and the group contains several families of great diversity. The simplest types are approximately spherical with no attempt at proliferation, but other forms

show the initiation of hyphal development. Dangeard*, Atkinson† and others who have worked much on the lower forms of life have suggested a connection between the Chytridiineae and certain groups of the protozoa, and there are many points of contact between the two, both as regards cytology and ontogenetic development. Wager‡ called attention to certain protozoan similarities in his investigation of *Polyphagus Euglenae*, and the recent account of the cytology of *Synchytrium endobioticum* by Curtis§ also shows points of resemblance. The absence of cell membranes in many Protozoa is often held to discount the connection between fungi and protist organisms, but large numbers of Protozoa possess well-defined membranes by no means exclusively in the encysted condition, while some fungi are devoid of walls in certain phases of their existence. Thus some of the Foraminifera possess chitinous membranes, and many Radiolarians, Heliozoans and Ciliates have well-defined walls, while in the lower fungi certain stages of the life-cycle are devoid of membranes, and in *Synchytrium endobioticum* the organism is entirely devoid of a wall until a somewhat late stage in development.

Apart from the confusion that formerly existed between certain Chytridiineae and Monads, some organisms are with difficulty classed in the Protozoa or the Chytridiineae, *e.g. Rhinosporidium*‖ in the Haplosporidia, just as there are some types, *e.g. Sappinia pedata*, which may be a connecting link between the Protozoa and the Mycetozoa. Again, the Chytridiineae show marked differences from one another as regards sexuality, but all sexual processes within the group are of a relatively primitive nature and some of these are closely similar to processes of fusion in the Protozoa. The sexuality of the fungi is often looked upon as a residuum, as it were, of the sexual processes existing in the algae. It seems much more reasonable to conclude that like other groups of organisms, both in the plant and in the animal kingdoms, they have initiated their own sexual processes which have been evolved along unique lines in correlation with peculiar environmental conditions. With the development of special methods of reproduction, with the initiation of sexuality, and with the beginnings of hyphal formation, we may see justification for including, as does

* Loc. cit.

† Atkinson, G. F., Some problems in the evolution of the lower fungi. Ann. Myc. VII, p. 441 (1909).

‡ Wager, H., The life-history and cytology of *Polyphagus Euglenae*. Ann. Bot. XXVII, p. 173 (1913).

§ Curtis, K. M., The life-history and cytology of *Synchytrium endobioticum* (Schilb.) Perc. etc. Phil. Trans. Roy. Soc. CCX B, p. 409 (1921).

‖ Prof. J. H. Ashworth in his recent paper on *Rhinosporidium Seeberi* refers this genus to the Chytridiineae (Trans. Roy. Soc. Edin. LIII, p. 301 (1923)).

Lotsy* the Chytridiineae in a primitive group the Archimycetes from which other groups of fungi may be held to have arisen.

In certain members of the Oomycetes and Zygomycetes, the atypical development of the hyphae must have struck everyone. With forms like *Phytophthora* in particular, the hyphae often become vesicular, even under normal conditions, and appear strangely unlike hyphae of the higher fungi. In a new genus (*Caeolomomyces*) recently described by Keilin†, which has a more marked mycelial development than in other Chytridiineae although in most respects it appears to belong to this group, the hyphae are particularly wide and irregularly swollen, and show an intermediate condition between a vesicular and a hyphal mode of development. These aberrant hyphal forms may be the expression of an ancestry from non-hyphal types, such as protozoal or other protist organisms.

There are forms also which are classed with difficulty either as bacteria or as fungi, as *e.g.* species of *Actinomyces* and *Streptothrix*, and the possibility of connection between the higher bacteria and the fungi must not be overlooked, although it is more likely that the relationship is not of a direct nature.

The outlook of the writer upon the fungi is therefore that it is an enormous group of organisms of extreme age and probably of protist origin, which has developed upon independent lines, and which shows the same kind of differences between its constituent divisions as do other large phyla of plants and animals. Theories of evolution are again in the melting pot, and although the facts of evolution are not in dispute, there seems to be more uncertainty than ever as to the manner in which it has been brought about. By some authorities the fungi are considered to be of polyphyletic origin and some who hold to the protist or Chlorophycean origin of the lower fungi, deny this to the higher fungi, deriving the latter from the Rhodophyceae. However little is known about the origin of the fungi, we are equally ignorant of their phylogeny. But if a totally different origin for the lower and the higher fungi be postulated there is evidently a great gap between the Phycomycetes and the Ascomycetes, which is unbridgeable. Now there are sufficient similarities between the Ascomycetes and the Phycomycetes to nullify the hypothesis that there is no conceivable connection between them. By no great stretch of the imagination a form such as *Pyronema confluens* may conceivably be derived from *Albugo Bliti*, although I do not wish to imply that this may actually have happened. Although Brefeld's old group of the Hemiascomycetes will not stand the

* Lotsy, J. P., Vorträge über botanische Stammesgeschichte, Jena (1907).

† Keilin, D., On a new type of fungus: *Caeolomomyces stegomyiae* n. g., n. sp., etc. Parasitology, XIII, p. 225 (1921).

test of enquiry, there are undoubtedly forms such as *Dipodascus* which tend to link the Ascomycetes with the lower fungi. As regards the difference between the non-septate hyphae of the Phycomycetes and the septate hyphae of the Eumycetes, this is often unduly emphasised. Many Phycomycetes are not infrequently septate, *e.g. Spinellus* in the Mucorineae, especially when the hyphae are old, while in the higher fungi, hyphae frequently remain unseptate during active growth. I would suggest rather that the Ascomycetes were evolved from the lower fungi at some far distant time, long before the present forms of the Phycomycetes existed. The Ascomycetes are clearly of one origin, for the structure of the ascus is so uniform throughout the group that it is inconceivable it could have arisen polyphyletically. Church homologises the ascus with the spore mother cells or tetrasporangia of marine algae. The ascus is clearly a spore mother cell, but to grant this does not imply the phylogenetic connection which Church appears to indicate. Wherever sexuality occurs, reduction in the number of chromosomes must necessarily follow, this being most readily achieved by nuclear divisions in a mother cell. Just as the fungi are held to have developed along their own sexual lines, so the spore mother cells or asci in the Ascomycetes, are the necessary counterpart of sexual processes. The peculiar development of ascogenous hyphae with their ultimate formation of asci, is a means of enormously increasing the spore output in relation to sexuality and in correlation with special modes of dispersal and nutrition involving tremendous wastage of reproductive units. Again, the basidium of the Basidiomycetes is often held to have no relationship with the ascus. On the other hand the basidium is essentially the same cytologically as the ascus. In both there is a fusion of nuclei followed by a reduction in the number of chromosomes. There are usually three nuclear divisions in the ascus and two in the basidium, but Juel* has recently demonstrated the existence of more than two divisions in the spore mother cells of many Basidiomycetes. In my opinion the basidium can be held to have been derived from the ascus in correlation with a different type of spore discharge. Buller† has shown that the spores of many Basidiomycetes are violently ejected from the sterigmata. Now whereas in most Ascomycetes each ascus ejects all its spores simultaneously, in the Basidiomycetes each spore is discharged separately from the basidium. If the process of spore formation of a basidium

* Juel, H. O., Cytologische Pilzstudien, I. Die Basidien der Cantharellus, Craterellus, und Clavaria. Nov. Act. Reg. Soc. Sc. Upsala, ser. IV, iv, no. 6 (1916).

† Buller, A. H. R., Researches on Fungi, II. Longmans and Co., London (1922).

is considered in detail, although the differences between basidiospore and ascospore formation are considerable, these are not so profound as might be thought at first sight. The divergence in method of spore formation and spore discharge between the Ascomycetes and the Basidiomycetes is correlated with diversities in style of architecture, but in both groups the spore mother cells are fundamentally the same and are often multiplied indefinitely to provide for an enormous spore output.

The Uredineae and Ustilagineae are peculiar groups of obligate or semi-obligate parasites which show no close relationship with other Basidiomycetes, but which undoubtedly fall within this category. The Uredineae in particular exhibit considerable resemblance to the Ascomycetes. No one who has worked on the cytology of such forms as *Gnomonia*, *Polystigma*, or the lichen fungi can fail to be impressed by their likeness in certain respects to rust fungi. The spermogonia of both and certain features in the development of aecidia and perithecia show a marked resemblance, which may point to ancestry from a common stock or may be of even greater phylogenetic significance. The similarity between certain Ascomycetes and the rust fungi was commented upon by de Bary* many years ago, and I ventured to call attention to it in a paper on *Gnomonia erythrostoma* published in 1910†. The gap between the Basidiomycetes and the Ascomycetes is not unbridgeable, and a common origin for both groups is indicated. The divergence between them is of long standing, and may date back to the time when they, together with early forms of the Phycomycetes, began to be evolved from the first organisms of a definitely fungoid nature. It may be mentioned here in passing that there is much to be said for separating the Smut and the Rust Fungi from all other basidia-producing fungi, and constituting them a group of equal rank with the Ascomycetes and the remainder of the Basidiomycetes.

It is maintained, therefore, that the fungi are a monophyletic group, established in far-distant times from protist organisms, which have evolved along their own lines just like any other large group of plants or animals. In the past a polyphyletic origin for many groups of organisms including fungi has been advanced, but the present trend of opinion is in favour of attributing each phylum to a common ancestry, notwithstanding the existence of great discontinuity of type within the phylum. It is admitted that it is particularly difficult to trace relation-

* de Bary, A., Comparative morphology and biology of the fungi, mycetozoa and bacteria. English translation (1887).

† Brooks, F. T., The Development of *Gnomonia erythrostoma* Pers. Ann. Bot. xxiv, p. 585 (1910).

ships amongst the fungi, largely because their vegetative characters, being almost valueless as a criterion of relationship, cannot be used as in other plants and animals, to supplement comparisons of reproductive organs.

All workers on evolution have been struck by the marked discontinuity of character both between different groups of organisms and also within each group. This discontinuity is one of the most marked features of living organisms, and it is just as much exemplified in the fungi as in other groups of organisms, but there is no more reason for supposing that the liverworts have arisen from several different sources than that the fungi have been so derived.

Thus as against the opinion that the fungi are organisms which have come directly from the algae by the loss of photosynthetic power, arguments have been advanced in favour of the view that the forms from which they came never possessed this power. Organisms which lose such an important character as chorophyll are invariably strictly limited in their power of development, whereas no group of organisms shows more diversity of species than do the fungi. The fungi, possessing some of the original impetus of primitive life, have evolved along their own lines, and have achieved entirely novel types of reproductive mechanism. To elaborate a new style of architecture is not the mark of a decadent civilisation, and the fungi having achieved so much that is unique in the plant kingdom cannot be looked upon as a degenerate race. When the fungi are spoken of as an insignificant race with no power of independent development, I am reminded of a book I read in boyhood, namely, Jules Verne's "Journey to the centre of the earth." It will be remembered that, with the novelist's imagination, he represents the voyagers in the interior of the earth as having to traverse a gigantic mushroom forest where fungi had achieved an arborescent habit of growth. Jules Verne at any rate was alive to the possibilities of fungi, and his outlook is to be preferred to that which holds the group to be devoid of initiation and crippled by degeneracy.

The Relation of Mycology to Plant Pathology.

As most plant diseases are caused by fungi, the relation of mycology to plant pathology is clearly of great importance. An accurate knowledge of pathogenic fungi is indispensable to anyone who attempts to deal with the more general aspects of disease in plants or with its control. Mycology is one of the foundation stones of plant pathology, and indeed Berkeley and de Bary, both eminent mycologists, were the real founders of

the serious study of disease in plants. Just as plant physiology is dependent in part upon systematic botany, so is a knowledge of the fungoid diseases of plants dependent upon systematic mycology for accurate treatment. Whenever one branch of knowledge is intimately connected with another there is usually a mutual reaction of the one upon the other and I trust that plant pathology will be not without influence on systematic mycology. Persons who investigate plant diseases often encounter difficulties in the identification of the pathogen which can only be solved with the aid of the systematic mycologist, and I should like to acknowledge here the great assistance received in my own work from systematic mycologists. But the plant pathologist is often avaricious in his desire for information, and sometimes the particular knowledge he requires from the systematic mycologist is not at present available. The plant pathologist is accustomed to growing pathogenic fungi in pure culture whenever possible, where their behaviour can be followed under carefully controlled conditions. In this way he gets an idea of the range of variability of a species which is often at variance with its formal diagnosis and with that of allied forms. Thus the innumerable forms of *Cladosporium* which have been described in systematic works are meaningless to the plant pathologist, for he finds by experience that they can all be grouped around a few types which are the real units. It is clear that species must be diagnosed upon the basis of characters shown on natural substrata, but the time has come when these descriptions should be supplemented by an accurate account of their behaviour upon standard media under controlled conditions wherever the forms can be readily cultivated. To diverge for a moment; this mode of treatment has become an urgent necessity for the moulds as shown by Thom in the genus *Penicillium* and by Lendner in the Mucorineae, and the time can be foreseen when biochemical reactions will be of fundamental importance in differentiating such types. It may be remarked that it is merely a platitude to urge supplementary descriptions of the species as grown in artificial culture, but it is important to reiterate this necessity, for few systematic mycologists yet realise its significance.

Again, with parasitic genera like *Ramularia, Ovularia, Gloeosporium*, etc., the diagnosis of species is unsatisfactory to the worker on plant diseases. The chances are that if either of these forms is found on a new host, a new species will be created without adequate comparison with existing species. Shear and Wood* have shown that many species of *Gloeosporium* hitherto

* Shear, C. L. and Wood, A. K., Studies of fungous parasites belonging to the genus *Glomerella*. U.S. Dept. Agric., Bureau of Plant Industry, Bull. 252 (1913).

considered distinct are really identical, and it is unquestionable that there should also be a considerable elimination of species in other genera. In parasitic genera of this kind it is only by cross inoculations that proper host relationships can be discovered, so that it is urgent here for the systematist either to become a pathologist for the time being or to work in close co-operation with one. Species diagnosis must at present be primarily based upon structural characters, and however useful physiological characters may be for the separation of distinct strains, physiological differences alone cannot yet be taken as adequate criteria for species differentiation. In many pathogenic fungi there is exhibited the phenomenon of specialised parasitism, *i.e.* the existence of a number of forms differing in host relationships but either only slightly or not at all in structure, within the limits of a single species as ordinarily understood. This phenomenon is particularly well shown in *Puccinia graminis* which comprises many forms of distinct physiological relationship such as the variety *Tritici* confined almost entirely to wheat, and the variety *Secalis* upon rye, couch grass, and a few other grasses. Prof. Stakman of America has recently told me that some of these physiological varieties in America show slight structural differences, for example, in the dimensions of the uredospores and aecidiospores. If these structural differences were more considerable, there would be a strong claim for converting these specialised races into distinct species. In systematic work there will always exist, both the "lumper" and the "splitter," for in the main it is a matter of opinion as to what degree of difference constitutes specific differentiation. To the plant pathologist it does not much matter whether the species have been diagnosed by a "lumper" or a "splitter" as long as the basis of distinction is clearly set forth in language that he can understand. I must confess a preference for the methods of the "lumper" for, as stated in another place*, mycological systematy will become altogether too unwieldy if fungus species are set within too narrow limits.

Another difficulty encountered by the plant pathologist is that even the generic limitations hitherto imposed by systematists not infrequently break down in practice. In the Fungi Imperfecti in particular this difficulty is often met with, and it was pointed out a short time ago in dealing with certain tomato diseases* how the generic distinctions between *Phoma*, *Phyllosticta*, *Ascochyta* and *Diplodina* broke down. There cannot be any doubt but that many genera in this group are entirely artificial, and one looks forward to the time when some systema-

* Brooks, F. T. and Searle, G. O., An investigation of some tomato diseases. Trans. Brit. Myc. Soc. VII, p. 191 (1921).

tist will have the courage to eliminate many of these so-called genera, or establish a more adequate classification.

No branch of systematic botany should be divorced from the study of living plants, and just as those who classify flowering plants cannot but be assisted in their labours by following the work of geneticists and by watching the behaviour of the living plants under different environmental conditions, so, I think, it will be of advantage if systematic mycologists will actually grow certain groups of fungi under artificial conditions and will keep in intimate touch with plant pathologists. An instance of the lack of co-operation between fungal systematy and plant pathology is afforded by the separation of the species *Stereum rugosiusculum* from *Stereum purpureum* by Burt*. This distinction is supported by Rea in his "British Basidiomycetae." *Stereum purpureum* is the primary cause of silver-leaf disease of fruit trees in this country, and has hitherto been held to include the form *rugosiusculum* now separated by these authorities. Since Burt published his monograph on the genus *Stereum* I have examined many collections of this fungus from different substrata, and as far as investigation has proceeded, the chief distinction between the two species according to Burt, namely the presence of hymenial cystidia in *rugosiusculum* and not in *purpureum*, seems to be an inadequate criterion. In none of the specimens have the cystidia been so abundant as figured by Burt for *rugosiusculum*, but, apart from this, there has been every possible intergrade between forms possessing many hymenial cystidia and forms devoid of them. Indeed, within the limits of a single sporophore there are great differences in the distribution of these hymenial hairs. From the pathogenic standpoint I believe *S. rugosiusculum* and *S. purpureum* are one, and with all deference to Burt and to the author of "The British Basidiomycetae," I think doubt must remain as to whether *S. rugosiusculum* is a valid species until more adequate evidence is forthcoming as to its structural peculiarities. *S. purpureum* and *S. rugosiusculum* would probably never have been separated if the systematist had co-operated with a plant pathologist.

There are innumerable other relations between mycology and plant pathology, but only the briefest reference can be made to these. The day has passed when it was considered sufficient in investigating a plant disease of parasitic origin to determine the causative agent. Nowadays that is merely the beginning of a new series of investigations to elucidate precisely the conditions under which the pathogen can effect an entrance into the host, the exact mode of penetration, and the relationships

* Burt, E. A., The Thelephoraceae of North America, XII. Ann. Missouri Bot. Gard. VII, p. 127 (1920).

existing between the parasite and the surrounding tissues. Mycology therefore must be directed towards the study of the physiology of fungi as well as towards their morphology. Plant pathology is essentially abnormal plant physiology, in which a parasite is often the disturbing agency. Acting upon both host and parasite are environmental conditions which sometimes favour the one and sometimes the other. As Butler has indicated in his "Fungi and Disease in Plants" these external factors are often of critical importance in the establishment of disease. Several mycologists are now engaged upon an intensive physiological study of certain pathogenic fungi, and already at the hands of Brown, Wiltshire, and others, results of great importance have been obtained. For several years I have been engaged upon an intensive study of *Stereum purpureum*, and with the help of my colleagues, light is now being shed upon the exact manner in which this fungus causes infection of fruit trees. In the study of fungous diseases of plants, so many factors are involved that it is often supremely difficult to determine their relative importance, but it is certain that unless the physiology of the parasite be studied in detail, no considerable progress will be made in the fundamental elucidation of disease.

The Training of Mycologists and Plant Pathologists.

On this occasion it may perhaps be opportune to say a few words about the training of mycologists and plant pathologists. As regards training, it is hardly worth while to draw a distinction between mycology and plant pathology, for although there are important differences between the two classes of work in some spheres of activity, from the point of view of the men who are trained to occupy technical posts of this nature in various parts of the Empire, the work of most mycologists is essentially plant pathology, *i.e.* the investigation of plant diseases and their control. It is important to consider this matter carefully, because in distant parts of the Empire the mycologist is often a person of no mean importance; he has often been the first scientific officer to be sought by the cultivator on account of disease becoming a serious menace. If the mycologist sent out has been a suitable man and has been of assistance to the plant industry which invoked his aid, his success has often led to the formation of extensive agricultural and botanical departments which have become active centres of research and guidance in the many diverse branches of tropical agriculture.

In my opinion the mycologist must be essentially a botanist. Just as a doctor must be thoroughly familiar with all parts of

the human body so must the mycologist have a broad training in the general principles of botany, and apart from a special knowledge of fungi, his mind must be imbued with the importance of plant physiology. Without a clear insight into plant functions, a mycologist will often fail to see the most important aspects of disease in plants. With plant physiology of such great significance, the botanist who is going to become a mycologist must have received an adequate training in chemistry and physics, for without these foundations, the biologist in general and the mycologist in particular will be severely limited unless his work happens to be of an entirely morphological nature. By this emphasis upon the study of chemistry and physics even for the mycologist, I do not wish to minimise the importance of the study of natural history. Many of us, myself included, were led into scientific studies through the naturalist instinct, and for training in observation and discrimination there can be no finer introduction than the cultivation of this instinct. For the plant pathologist, the outlook of the naturalist is a splendid asset, but by itself it is not enough for the solution of the intricate problems of plant disease. Our young mycologist then should be a trained botanist with a physiological outlook and with the instinct of the naturalist perhaps in addition. He may now proceed to obtain a wider acquaintance with fungi and plant diseases, and may perhaps take short courses in bacteriology and entomology. Even then his training in my opinion will fall short of what is desirable. At this stage he may go abroad and take up a post as mycologist and plant pathologist. If he has been living in contact with the land his outlook upon the plant industry he has been sent to aid will probably be sound, but if he has not been brought into contact with growing crops, he will be gravely handicapped in dealing with diseases of economic importance. He may be supremely expert in laboratory investigation, but may utterly fail when brought into contact with a practical problem, because a sense of crop values has never been inculcated in him. Cultivators sometimes make the complaint that the remedy is worse than the disease, but where such remedies are suggested, they are always based upon ignorance of crops and their economics. Again as already indicated, the influence of environment as a serious factor in the causation of plant disease is of immense importance, and unless the investigator has his attention fixed upon all aspects of the crop, as well as upon the pathogen, his efforts will often be doomed to failure. I suggest, therefore, that during the later stages of his training, the embryo mycologist be given some familiarity with the growth of crop plants, especially as regards the influence of cultural and climatic

factors upon them, and also as regards crop values. It is not necessary to attend formal classes in agriculture to get the requisite point of view, and in many ways the proper outlook is best inculcated through practical instruction in the field by a competent plant pathologist. It may be thought that I have outlined an ideal impossible of accomplishment; I do not think so, and having had considerable experience in the training of mycologists, I have not suggested more than is actually attainable in practice. I have ventured to place this matter before you, because there is a tendency in some quarters to divorce mycology and plant pathology from botany. That I am sure is a profound mistake, and I trust that any tendency in that direction will be resisted to the uttermost in this country.

LAMPRODERMA COLUMBINUM ROST. AND ITS VARIETIES.

By G. Lister, F.L.S.

Lamproderma columbinum (Pers.) Rost. is in its typical state a beautiful and well-marked species. It is distinguished by having ovoid or globose iridescent sporangia on long stalks; dark capillitium radiating from a cylindrical columella and composed of acutely branching threads which end in slender colourless branchlets, and form a dense brush or pile at the surface. The spores are dark purplish-grey, closely spinulose, and 11 to 14μ in diameter. This is the usual form, appearing on dead coniferous wood, and widely distributed in temperate regions.

Two other forms, connected with the typical one by gatherings intermediate in character, and having typical spores, occur on moss or wet rocks, on Sphagnum, and less frequently on fir wood.

One, which may be named var. *brevipes*, is not infrequent in this country, and probably on the continent also. The globose sporangia have short and often slender stalks, 0·7 mm. or less in height; the capillitium in some instances can hardly be distinguished from that of typical *L. columbinum*, but is usually less dense; in other examples it consists of purplish mottled threads, tubular and flattened near the base, branching repeatedly and becoming very slender above where they anastomose to form an irregular network; in some developments a curious knotted effect is produced by the presence of dark broad expansions in the axils of some of the branches.

This variety has been obtained many times in a wooded

ravine near Llanymawddwy, North Wales, by Lady Bradford and myself, from Hexham by Miss E. K. Higgins, from Porlock by Mr N. G. Hadden, from Keswick by Mr W. N. Cheesman, from Aberdeenshire by the Rev. W. Cran, from near Berlin by Dr Jahn, from the Vosges mountains by M. Demange and from the Jura by M. Ch. Meylan*.

The other form has globose sporangia, with either long or short cylindrical stalks, and rather lax flaccid colourless capillitium. A specimen of this having almost sessile sporangia, gathered by Richard Spruce in the Pyrenees in 1851, was named by Berkeley *Physarum iridescens*†, and by Rostafinski *Lamproderma iridescens*‡. It has been found several times in North Wales, usually with long stalks and associated with var. *brevipes*. In the field it has the aspect of typical *L. columbinum* of which it is apparently a weak development. A feature suggesting weakness is that the stalks are not solid below but enclose a loose sponge-like network of interwoven strands.

In both editions of the British Museum Catalogue of Mycetozoa this form is included under *L. columbinum* var. *sessile* Lister. The variety was established to cover an assemblage of doubtful specimens, two of which have proved to be new species belonging to entirely different genera, namely *Diachea cerifera* G. Lister and *Leptoderma iridescens* G. Lister. It would seem well therefore to drop the name *sessile*, and restore Berkeley's name *iridescens* for the variety of *L. columbinum* with colourless capillitium.

The colour of the plasmodium in this species is usually watery-white, but it may also be opaque-white or yellow. Miss A. M. Davidson writes that in woods near Aberdeen she has observed the form with obovoid sporangia maturing from watery-white plasmodium "nearly fifty times," and less frequently globose sporangia maturing from opaque-white plasmodium, "like a streak of white enamel paint." Another specimen from the same woods, approaching var. *brevipes* in capillitium, had "canary yellow plasmodium"; the var. *brevipes* from North Wales and Keswick had watery-white plasmodium; typical ovoid sporangia sometimes have plasmodium of a dull yellow colour.

M. Ch. Meylan has described a new species, *L. Cruchetii*§, from specimens found on Le Chasseron, Jura Mountains, on

* It is probable that *Lamproderma Staszcii* Raciborski (Hedwigia, vol. 28, p. 116 (1886)) from the Tatra Mountains, "Poland," may be an extreme form of var. *brevipes*. The sporangia are described as violet-black, on very short stout stalks, with broad flattened capillitium threads, 30μ wide below, dichotomously branched and narrowing above till towards the surface they are very slender; spores 12·5 to 15μ.

† Hooker's Journal of Botany, III, p. 20 (1851).

‡ Monograph of Mycetozoa, Appendix, p. 25 (1876).

§ Bull. Soc. Vaud. Sc. Nat. no. 52, p. 96 (1918).

dead fir wood. The globose sporangia have stalks 1 mm. high or less, and capillitium closely resembling that of *L. columbinum*. M. Meylan lays emphasis on the colour of the plasmodium having been yellow, but as yellow plasmodium occurs sometimes in *L. columbinum*, it may be found that *L. Cruchetii* is a form of that species approaching var. *brevipes*.

In conclusion the two varieties above referred to may be defined as follows:

var. **brevipes**. Sporangia globose; stalks short, usually slender; capillitium of purplish threads, tubular and flattened below, slender and forming an irregular network above.

var. **iridescens**. Sporangia globose; stalks short or long; capillitium lax, colourless.

AN ALPINE FORM OF ANELLARIA SEPARATA.

By Somerville Hastings, M.S., F.R.C.S.

Each region on the earth's surface has its own particular flora, the characteristics of which appear to be determined to a large extent by the physical conditions present. Flowering plants growing at high altitudes, have generally the following characteristics:

(1) They are stunted and dwarfed. Trees are rarely found in Switzerland above 7000 feet. The alpine willow for instance, creeps over the rocks and is rarely more than a few inches high.

(2) Perennials are relatively more numerous at high altitudes than in the plains. Owing to the shortness of the alpine season, the plants tend to produce their flowers directly the snow melts; flowers of the Crocus and Snowbell are actually seen piercing the snow.

It is also interesting to note that,

(3) When a species which grows in the plains is found in the Alps also, its flowers tend to be both brighter in colour and larger in size at the high altitude. Professor G. Bonnier was able to produce these changes experimentally by transplanting lowland plants to high mountains.

During the first three weeks in June, 1922, the writer was collecting plants round Grindelwald, Switzerland. To the south, east, and west of this village are alps or mountain pastures where cows are taken to feed during the summer months. The season was late and no cattle had yet reached these pastures. Already, however, a good many fungi had appeared and it

1. *Anellaria separata*. $\times \frac{1}{3}$

2. *Anellaria separata*. $\times \frac{1}{2}$

seemed to the writer that similar characteristics to those described above for alpine flowering plants, had been acquired by some of these. Many specimens of *Anellaria separata* were found in the alps on all three sides of Grindelwald, between 6000 and 8000 feet, and in all not less than 200 were examined. In all cases the cow-dung on which they grew must have been deposited the previous summer, as no cows had yet reached the pastures.

It was observed that,

(1) All the specimens of *Anellaria separata* seen, had short stalks, and in no case were the stalks longer than twice the diameter of the cap.

(2) Owing to the lateness of the season, and the fact that the cow-dung cannot have been free from snow for more than a few weeks, it would appear almost certain that the mycelium must have passed through a resting stage during the winter months.

(3) The caps appeared definitely larger than those familiar to the writer in England. Unfortunately no measurements were taken.

The two photographs reproduced were taken at about 7400 feet on the slopes of the Lauberhorn, close to the little Scheidegg Pass, on June 22nd, 1922. There was unmelted snow quite near them, and they could not have been bare of snow for more than two or three weeks.

EDIBLE FUNGI.

By Carleton Rea, B.C.L., M.A., Hon. Member British Mycological Society, membre d'honneur de la Société mycologique de l'Est, etc.

It is unnecessary for a would-be mycophagist to determine his species as accurately as a systematist, but at the same time it is necessary that he should get approximately near the plant that he has in view or he may suffer himself for the erroneous determination. In this case however he has the comfort of knowing that he has only misled himself. I consider a student of our larger fungi is really making some progress when he feels competent to identify the species and to back his opinion further by eating it. This is a much better way to acquire a knowledge of their edible qualities than one I saw described in the obituary notice of our late member, the Rev. D. C. O.

Adams. His wife and son gathered some examples of a fungus and insisted on the father alone partaking of it at the evening meal: next morning after ascertaining from the prover that no ill-effect had resulted the son exclaimed, "Hurrah, mother, we have discovered another edible fungus." This story I fancy is older than Adams and like many others related about Mr Gladstone were previously applied to Talleyrand. In my recent work on the British Basidiomycetae I have enumerated all those that were known to be edible and in the majority of cases this was based on personal experience. I consider a fungus described as edible should also connote that it is palatable. Some years ago we had the good fortune to find a few examples of the rather rare *Hygrophorus russula*, and after we had duly studied the same we ventured on cooking it, as it is considered quite a dainty on the Continent. Guess our surprise to find when served at dinner it had a most disgusting bitter taste and we proceeded no further with it, although I revel in the taste of quinine and am not adverse to a gin or sherry and bitters as an appetiser. Either foreigners have a different palate to my own or the fungus has a different flavour in foreign climes. This may be true because we know of several cases in systematic mycology, especially amongst the Russulae, where such a variation is attributed to the habitat. I am not quite certain that all our tastes are alike and perhaps that is lucky, as otherwise, as Punch said, "they would all have wanted to marry my old woman." I know of no standard of taste and until the British Association have settled our colour standard referred to them by us many years ago I see no useful purpose in asking them to deal with this as a matter of pressing, national importance. Until a saporometre is invented I fear we shall have only to record our individual appreciation of the qualities each fungus possesses from a gastronomic point of view. Our common mushrooms in my opinion are coarse in flavour, and not to be compared with the delicate taste of *Amanitopsis vaginata*, a dish fit for the most fastidious epicure. In a review that I read lately the writer complained of the absence of any English names for our fungi and I admit that I cannot give you one for the Amanitopsis. But what do I mean when I use the word common mushrooms? I fear I have no special one in view, but generally the collective assortment exposed for sale in our shops and markets. When I address a learned body like yourselves I can assert that *Psaliota haemorrhoidaria* and *exserta* have a much finer flavour than either *Psaliota campestris* or *arvensis* and are easily recognised by the sanguineous coloured juice, but I should hesitate to popularise their name by the term used by Bernard Shaw in his "Pygmalion." With regard to

Amanitopsis vaginata, fulva and *strangulata* I have no compunction in indorsing the art critic's remarks concerning a classical figure of Tademas that "we should like to see some more of you," because its flavour is so refined and delicate. If anybody is dyspeptic, then I strongly advise them to avoid those mushrooms that turn yellow when bruised or handled. I am referring to *Psaliota xanthoderma* and *flavescens* more especially because owing to a personal idiosyncrasy some people are unable to digest these without grave inconvenience. Some authors would add to these *Psaliota arvensis*, the horse mushroom, or Abrahams, as they are called by the rustics in Worcestershire, but I think this is largely due to confusion with the other two species or to an excessive indulgence in the repast. From Psaliota we naturally pass on to Lepiota because these two genera have the same form being only differentiated from each other by the colour of their spores. This brings us to a consideration of the Parasol mushrooms, *Lepiota procera, L. prominens, L. rhacodes, L. puellaris, L. permixta, L. excoriata, L. gracilenta* and *L. mastoidea*. These are all easily known amongst the Lepiotae by their large or comparatively large size, their floccose flesh and the presence of a distinct cartilaginous collar at the apex of the stem separating it from the free gills. All of these are equally edible but I consider those in which the flesh reddens on exposure to the air of a better and more refined flavour than the others. *Lepiota procera* is characterized by the snake-like markings on the stem and its white flesh; these markings on the stem are due to the sudden elongation of the stem and the external stocking or cuticle is unequal to the strain and so becomes cracked transversely. *Lepiota rhacodes* has coarser scales or patches on the pileus, a smooth stem and red flesh. *Lepiota permixta*, as its trivial name denotes, resembles *L. procera* in the markings on the stem but has the reddish flesh of *L. rhacodes*. *Lepiota gracilenta* possesses smaller innate scales on the pileus, the markings on the stem arise from distinct yellowish scales and the flesh is white. *Lepiota prominens* resembles *L. procera* in the scales of the pileus and prominent umbo, but resembles *L. gracilenta* in the squamules on the stem and white flesh. *Lepiota puellaris* is entirely white and the smooth stem is mealy at the apex and the flesh is white or only slightly tinged with red. *Lepiota mastoidea* is whitish like *L. puellaris* but acutely umbonate and much thinner, the stem is obsoletely squamulose and the flesh white. *Lepiota excoriata* is easily differentiated from the preceding Lepiotae by the cuticle of the pileus breaking up into large patches or scales and appearing as if it had been drawn inwards from the fimbriate margin, and by the smooth stem and white flesh. I have

previously mentioned the floccose nature of the flesh, and it is this character which makes these species such delicious esculents. I personally advise that all edible fungi should be cooked in an earthen casserole having a lid, with a plentiful supply of butter, margarine or other fats, and the addition of some salt and pepper. To appreciate thoroughly the distinctive flavour of different species I advocate that each species should be cooked separately whilst the lid will retain the aroma in the food, and when served either from the casserole itself or very hot on toast will constitute the *βρῶμα θεῖον* of the ancients. The length of time necessary for the cooking of different species varies enormously, from ten to fifteen minutes for *Amanitopsis vaginata* to over five hours for *Marasmius oreades*, but a little experience will soon enable the cook to judge the approximate time that should be allowed for each species. In practice it is often quite impossible to restrict the trial to one species and then one should deal with nearly related forms, such as Lactarii, Russulae, Hydni, Boleti and Cantharelli. It is not to be presumed that I guarantee the harmlessness of the fluid in which the fungi have been cooked, because we all know that the water in which *Helvella crispa* has been cooked contains a dangerous poison; you might as well expect consumers of gas to indulge in its deleterious by-products. So beware of what you add to your soup.

The Italians prefer *Lepiota procera* to our common mushrooms; it is because the floccose flesh absorbs an abundant supply of olive oil, and then the addition of a small bit of garlic completes the dish. I think it is an error to say that mushrooms are excluded from the Italian markets, though we all know that the worst wish an Italian can express against his foe is "that he may die of a Pratiola," which I should interpret as meaning any Agaric.

Amongst the smaller Lepiotae I can recommend *Lepiota amianthina* and the less common *L. granulosa.*

Amanita strobiliformis and *A. solitaria* are excellent and delicious esculents, but it is only in a few favoured districts in the south of England that these are found in any quantity. Elsewhere we only meet with *Amanita rubescens* in any abundance and its flavour does not appeal to me to recommend it, as I consider it is too soft and mushy, or as we colloquially say in Worcestershire, too mawsey to be palatable. I really draw your attention to the Amanitae in order that you may know what to avoid in the future, as one of our members did in the case of a particular brand of Scotch whiskey. It is absolutely necessary that no collector of fungi for the table should include any one of these in his gathering. They contain deadly and

insidious poisons that only attack their victims some hours after ingestion, and then only very rarely can any cure be effected. The greater number of these poisonous Amanitae are known by the large volva at the base of the stem, which the American mycologists have so aptly termed the poison cup, and it is absolutely necessary for the beginner to gather all his specimens with this intact so that he can satisfy himself as to its presence or absence. In *Amanita muscaria* the volva is friable and does not form a distinct cup, but a very little experience will enable one to recognize this species, and even the dark umber forms can be easily distinguished by the yellow flesh just below the epidermis. The danger in advocating the use of *Amanitopsis vaginata* as an esculent is the fact that this also has a free volva at the base, but it consists of a free, lax, sheathing membrane, and there is no ring on the stem. One must be very careful not to mix it up with *Amanita pantherina*, in which the ring is often evanescent, but the volva is quite different and is not lax and sheathing. The pink-spored Volvariae, which in form resemble Amanitopsis, should equally be avoided. René Maire has recently proved that the African form of *Volvaria speciosa* is edible though this fact remains to be proved for it elsewhere.

Tricholomas give us many delicious esculents, and amongst these I can recommend *T. portentosum*, *T. gambosum*, *T. Georgii* and *T. nudum* as being a welcome addition to the evening meal, but *T. personatum* and *T. sordidum* I do not rate so highly. *Hypholoma appendiculatum*, though of fragile consistency, is an appetizing morsel and can often be collected in sufficient quantity to form a dish. The large Clitocybes, *C. nebularis*, *C. odora*, *C. viridis*, *C. geotropa*, together with *Cantharellus cibarius*, *Hydnum repandum* and *Pholiota aegerita* make very substantial and enjoyable meals and I think many of the modern text books do not attribute enough value to their nitrogenous qualities or calorific worth, being led away by the fact that a number of analyses show them to contain from eighty to ninety per cent. of water. They seem to forget that we do not eat them in this state any more than vegetables, but only after the same has been dissipated by cooking. My daughter informs me that the efficient cooking of these large fleshy species is greatly facilitated by cutting them up into strips or slices. The smaller Clitocybes, *C. infundibuliformis*, *C. dealbata*, *C. fragrans* and the polymorphous *Laccaria laccata* are tender and delicious esculents, and the last is available for many months in the late summer and autumn. *Collybia velutipes* generally does not grow in any abundance until the night frosts are somewhat severe and many times on Boxing Day I have gathered this tasty morsel.

I think it is safer to refrain from the pink spored species, but *Clitopilus prunulus* forms an exception, and is very good eating indeed. I have only tried the viscid Hygrophori a few times, but in the other sections I have enjoyed many an excellent dish of *Hygrophorus pratensis, H. virgineus, H. niveus, H. russo-coriaceus, H. puniceus, H. chlorophanus* and *H. psittacinus.* Many of these are rather small in size, but they decrease very little in the cooking, and can easily be collected in great numbers in the late autumn. I have tried *Gomphidius viscidus* on several occasions and enjoyed it, but some people find it rather hard of digestion, and I only take it home when nothing better is about. The Pleuroti often occur in such great abundance on a fallen trunk that it is an easy matter to secure a sufficiency. These include *Pleurotus corticatus, P. dryinus, P. ulmarius, P. sapidus,* and *P. ostreatus.* All of these are excellent esculents but I think *Pleurotus sapidus* has the best flavour. The Russulae constitute one of our best groups of fungi for the table. Their flesh is tender and delicate in flavour and they can be obtained often from early summer to the winter months. I include the following in my list of delicious esculents, *Russula lactea, R. incarnata, R. virescens, R. lepida, R. azurea, R. cyanoxantha, R. heterophylla, R. galochroa, R. integra, R. xerampelina, R. alutacea, R. vesca, R. punctata* and *R. lutea.* Some people seem to experience a difficulty in distinguishing the species of Russulae, but in many cases this is unnecessary for the mycophagist, as it would make no difference if he lumped the first five mentioned under one species or failed to differentiate *R. cyanoxantha* either from *R. vesca* or the mild tasting form of *R. atropurpurea* which is equally edible. In fact, I think that all the bright coloured species with mild tasting flesh when raw, may be safely indulged in with impunity. Two of the Lactarii are equally delicious, namely *Lactarius deliciosus* and *L. volemus,* but it is only rarely that we have the good luck to meet with the latter in sufficient quantity for the table. *Lactarius glyciosmus* and *L. subdulcis* are also very good eating, the former being the better of the two. Both *Coprinus comatus* and *C. atramentarius* are excellent esculents, and should be eaten the day they are gathered, as their autodigestive habit will allow of no delay. I remember once having had the former served to a party of sportsmen at a dinner and they imagined they had partaken of some unknown fish. The Americans also consume *Coprinus micaceus,* but up to the present I have not tried it, and so cannot say whether it is palatable or not.

I have already referred to the long time necessary to cook *Marasmius oreades* efficiently and although it is an excellent esculent I think it is much better to dry the same in an air current

and reserve it for winter use or as a flavouring to soups. *Lentinus cochleatus* is a toothsome morsel when it is thoroughly cooked and deserves a trial for its excellent flavour. For some years I refrained from trying *Craterellus cornucopioides* as its appearance did not appeal to me, but when once tasted all my prejudices vanished and I now rank it amongst one of the best. In my early days I was inclined to think that it only grew at the close of the fungus season but since then I have gathered several collections of it as early as July or August. Having passed in brief review the leading esculents included in the Agaricineae I will now say a few words about those included under the Boletineae. Personally I do not favour *Paxillus involutus* as an edible because I rank it in the same category with *Amanita rubescens* and consider it too soft to be palatable. It is very probable that I am wrong as to this and that both of these may be very highly esteemed by other people. *Paxillus giganteus* on the contrary is a great favourite and I only regret that I so seldom find a large ring of it in good condition. I fear I should only weary you if I were to extol the excellent qualities of the greater number of the Boleti because they are all so very good in their way, of splendid flavour and nice consistency. Before they are cooked I recommend that the tubes should be removed. This I generally do in the field when collecting and it is also advisable, especially with the very viscid kinds, to remove the pellicle of the pileus which is generally easily separable. After the tubes have been removed you will often find that there is comparatively little flesh left to the pileus and so I would urge every one to bring home all the sound stems as well, because if these are cut into thin transverse sections they will cook in the same time as the rest of the pileus, and in fact cannot be distinguished from it. In this way a few specimens of *Boletus edulis* will make quite a nice dish. I certainly consider the members of the edules group the greatest dainties and thereunder would include *Boletus edulis, B. pinicola, B. reticulatus, B. aestivalis, B. aereus,* and *B. impolitus.* Next in order I would rank *Boletus versipellis, B. scaber, B. badius* and *B. granulatus,* and in a lower category *B. luteus, B. elegans, B. bovinus, B. chrysenteron* and *B. subtomentosus. Gyroporus castaneus* is nearly as delicious as *Boletus edulis* but it is very seldom that one finds it in sufficient quantity for the pot. Amongst the Polyporaceae there are comparatively only a few that I can with any confidence recommend, but perhaps it is my own lack of experience in this section, because I have not emulated Mrs Hussey in partaking of *Polyporus squamosus,* which she says is like eating saddle-flaps. Under this head I would enumerate *Polyporus umbellatus, P. frondosus* and *P. intybaceus,* but I consider

the last is by far the best. The beef steak fungus, *Fistulina hepatica,* is well known to you all, but when cooked it has no appreciable flavour unless it has been gathered too young when it is too astringent for words from its tannin contents. I consider the best way to deal with it is to cut it up into pieces and place the same in vinegar, much in the same way as we do with beetroot. I have already mentioned that it is advisable to cut *Hydnum repandum* up into slices before cooking, and we often find that both this and *Cantharellus cibarius* are greatly improved by being soaked for a time in milk. I have only tasted one other Hydnum, namely *H. imbricatum,* which has a very fine flavour and is far superior as an esculent to the common *H. repandum.* It is fairly common in the north of Scotland but scarce I believe elsewhere. *Sparassis crispa* and *S. laminosa* are the only members of the Thelephoraceae that I have ever eaten; they are both excellent in flavour and a single specimen is enough for one meal. A great number of the Clavariae are edible but with the exception of the large branched species it is comparatively seldom that one is tempted to try their esculent qualities. The very brittle *Clavaria vermicularis* has a taste like cheese straws when cooked, but although I have many times tasted it when raw, I have failed to find this flavour. I have also enjoyed several cookings of *Clavaria pistillaris,* but on one occasion I found it very bitter and distasteful, and came to the conclusion that it must have been affected by some parasitic Hypomyces. With regard to the smaller Clavariae such as *C. cristata, C. cinerea, C. rugosa,* and *C. corniculata,* I only recommend their trial when they are in a fresh growing condition and not dried by wind or exposure to the sun, because in this state they are rather leathery and tough. *Clavaria amethystina, C. Krombholzii, C. Kunzei, C. botrytis, C. flava, C. aurea,* and *C. formosa* are all delicious and can often be found in abundance. With regard to *Clavaria formosa* Messieurs Heim et Malençon state that it produced violent diarrhœa and should be classed "non comme une espèce comestible, mais bien comme un agréable et très efficace purgatif." This does not accord with my experience as I have consumed it without any inconvenience. I have tried the Jew's Ear, *Auricularia auricula-Judae,* but it is rather tasteless, though undoubtedly highly nutritious. All the puff balls are excellent eating; they are very tender and delicate in flavour and taste very much like cooked brains. They should be gathered only when the flesh is quite white inside and cut into thin sections about a quarter of an inch thick. The exterior skins and sterile bases should be peeled and rejected before they are cooked. It is only *Lycoperdon giganteum, L. caelatum, L. saccatum,* and *L. excipuliforme* that are really large enough

to furnish a meal, but the smaller ones when so treated as above set out will make a welcome addition to other edible fungi. We know that all the species of Morchellae and Helvellae are very delicious esculents, but I think the flavour of these is greatly improved and their flesh made more tender if they are cooked in some good stock and then served on toast, because they are of a somewhat cartilaginous consistency. I have previously insisted on the necessity of rejecting the liquid in which *Helvella crispa* has been cooked and I think this should always be done with all the edible Discomycetae. These should never be eaten raw as grave inconvenience has been caused to persons partaking of them in this condition. In some years in the spring we meet with great numbers of *Disciotis venosa* and *Sarcosphaera coronaria*, and again later on specimens of *Aleuria vesiculosa, Otidea onotica, Otidea leporina* and *Peziza aurantia* are abundant. These are all highly pleasing to the taste and of a delicate consistency. I have now passed in brief review the principal esculent fungi that I have personally tested. They are all of excellent flavour and form a very valuable addition to our somewhat limited cuisine. In recent years many of us have been unable to afford many dainties and meatless days were often the rule, especially at hotels during the war. These appetizing morsels are open to us all and it only requires a little knowledge to identify the greater number of these. There is an old saying about mushroom eaters that those who eat them many times "nil amplius edit" (eats no more of anything), and I dare say many of our members feel inclined to wish that I had done the same before inflicting this long paper upon you. Lastly I may express the hope that some of our members who came to scoff will remain to prey.

NEW BRITISH DISCOMYCETES.

By W. D. Buckley.

The study of Discomycetes pursued as a recreation while on business journeys in many parts of the country has brought several interesting species under observation. The working out of the details from notes made at the time and specimens preserved has had to be deferred until opportunity could be found to consult the literature. The present notes and records relate to some of the most interesting species so far identified. A visit to Scotland for fourteen weeks convinced me that the mild and

humid sub-alpine districts of the west and north would well repay close investigation. The extensive forest fires which occurred in 1920 and 1921 left burnt ground on which many interesting Discomycetes were found. I have to thank my friend Mr J. Ramsbottom of the British Museum for his continued kind encouragement to give attention to the scientific side of the subject and to him I owe a debt of gratitude which I cannot sufficiently express for the benefit of his critical advice.

RAMSBOTTOMIA nov. gen.

Ascomata terrestria, plerumque laeticoloria, parva, lata primum orbicularia dein plana vel lenticularia, externe pilosa, pilis coloratis; asci ampli, maturitate prominentes, operculati, iodo non caerulescentes, octospori; sporidia globosa vel ovata, aspera vel echinulata, hyalina; paraphyses conspicui, iodo atrovirescentes, granulas coloratas continentes.

This genus is best placed immediately following *Boudierella* Sacc. in the Pseudo-Ascoboleae of Boudier's classification.

R. lamprosporoidea n. sp.

Ascomatibus dispersis vel gregariis, primum turbinatis dein planis regularibusque, in majoribus speciminibus explanatis lobatisque, externe pilis longibus, tubulosis, pallide brunneis dense vestitis, pilis ultra marginem non exstantibus, 160–285 × 11–18 μ, ramosis, septatis, interdum ad septa constrictis; hymenio sordide luteo; excipulo parenchymatico, e cellulis amplis, polygonatis vel cuneatis composito, ascis magnis cylindraceis, apicibus late rotundatis, ad basim gradatim attenuatis, 220–325 × 21–29 μ, octosporis, iodo non caerulescentibus; sporidiis uniseriatis, hyalinis, rotundatis vel interdum late ovatis, ad maturitatem guttula magna una ornatis, 18–20μ diam., reticulatis, echinulatis, spinulis longitudine inter sese valde irregularibus 2–5 μ long.; paraphysibus cylindraceis, clavatis, sparse septatis, 340–350 × 2–3·5 μ, ad apicem 6 μ diam., granulis aurantiacis repletis, iodo atrovirescentibus.

Hab. ad terram argillaceam nudam vel inter muscos in collibus. Dunoon, Argyllshire. May 1921.

This well-marked species was found in some numbers in a small area at Dunoon. It much resembles *Lamprospora Crec'hqueraultii* (Cr.) Boud., but is abundantly distinct in the densely pilose exterior. The hairs are very long, tubular, thin-walled, and arranged in branching fascicles.

Lamprospora campylopodis n. sp.

Ascomatibus gregariis vel dispersis, unicoloribus, flavidis sessilibus, glabris, lenticularibus, minutis usque ad 1 mm. latis, ad maturitatem expansis, tenuissime et laceratim marginatis, cortice parenchymatico, e cellulis polygonatis mediocribus, ad

marginem longioribus composito; ascis cylindraceis, clavatis, ad apicem rotundatis ad basim attenuatis octosporis 180–215 × 18 μ, iodo non caerulescentibus; sporidiis globosis, valde et regulariter reticulatis, 15–18 μ diam.; paraphysibus filiformibus, ad apicem vix vel haud ampliatis, septatis, quam ascis multo longioribus, 230–240 × 2 μ, granulis aurantiacis repletis, iodo viridescentibus.

Hab. ad terram inter muscos (*Campylopus fragilis*) ad radices Pini truncorum in locis humidis. Dunoon, May 1921.

This extremely minute species is closely allied to *L. miniata* (Cr.) de Not. and *L. areolata* Seav. It differs from the former in its constantly minute size and more regular finer network on the spores and from the latter in the absence of the peripheral flange on the spore and in the paraphyses greatly exceeding the asci and not being thickened above: it differs, moreover, from both species in colour.

Ciliaria caudata n. sp.

Ascomatibus congestis, sessilibus, primum orbicularibus, clausis dein poro patescentibus, demum in discum planum explanatis, crassis, ad 4 mm. diam., brunneis, externe pilis brunneolis, pachydermaticis, acutis, ad basim attenuatis et plerumque bifurcatis sparse vestitis, densioribus brevioribusque juxta marginem, ultra quod vix excedent, usque ad 185 × 14–18 μ; hymenio rubro excipulo corticeque parenchymatico, cellulis amplis, brunneolis; ascis cylindraceis ad apicem rotundatis, pedicellis bifurcatis, paulum angustatis, octosporis, 290–320 × 21 μ; sporidiis ellipticis, hyalinis, 25–29 × 16–18 μ, primum biguttulatis utrinque obtusis, intra folliculum grosse reticulatis, appendiculatis, cauda tenuissima, recta vel curvata, ad 18 μ longa; paraphysibus cylindraceis, clavatis, saepe ad apicem furcatis, septatis, usque ad 270 × 3·5–4 μ, granulis aurantiacis repletis, iodo colore vineo vel viride tinctis.

Hab. ad terram inter muscos in locis humidis collinis. Dunoon, May and June 1921.

This species which macroscopically resembles *C. umbrorum* (Fr.) Boud., is well marked by the extremely coarse and large reta on the spores which are enclosed each in a separate follicle and by the presence in the fresh condition of a long fine cilium such as occurs in the spores of *Peziza aurantia* Pers. Hennings in Warburg's Monsunia, 1, 1879, p. 35 has described two species of Lachnea from Java, *L. appendiculata* and *L. Fleischeriana*, and von Höhnel in Sitzungsber. k. Akad. Wiss. Math.-Nat. Kl. CXVIII, Abt. 1 (1909), p. 396, a third species, *L. folliculata*, also from Java, which exhibit similar spore characters—gross reticulations, with a follicle and appendages. von Höhnel remarks:

"Indessen ist höchst auffallend, dass bisher anderswo *Lachnea*-Arten mit derartig gebauten Sporen nicht gefunden wurden. Ich halte es daher nicht für unmöglich dass diese drei Arten in den Formenkreis einer gehören."

Neotiella Hetieri Boud. in Bull. Soc. Mycol. Fr. XII, p. 12 (1896), pl. III, f. 2.

Apothecia gregarious, opening by a pore, hemispherical, then plane, bright yellow, 1–2 mm. broad, externally densely clothed with long, slender, flexuous white hairs, rarely septate; furnished towards the margin with numerous white, pointed, rigid 2–4 septate white hairs 140–180 μ long × 5–9 μ broad, usually arising in pairs from a common cell; excipulum parenchymatous, cells polygonal, small about 7–10 μ in diam., becoming longer and clavate at the margin. Asci cylindrical, apex rounded, base gradually tapering 215–230 μ long × 11–16 μ broad, 8-spored, spores obliquely uniseriate 16 μ long × 9–11 μ broad, smooth, hyaline, broadly elliptical containing one large central gutta. Paraphyses filiform becoming clavate and frequently 2–4 times branched towards the apex, containing orange granulations, septate, up to 235 μ long × 2–3 μ broad (7–9 μ at the apex).

Amongst moss on burnt ground in Pine woods. Inverness, N.B., March 1921; Oxshott, Surrey, Oct. 1922, and Farnham, Bucks., Febr. 1923.

This species is at once recognised by the two kinds of hairs, those on the excipulum being long and flexuous and usually non-septate whilst the marginal ones are pointed and rigid. The colour of the hymenium in my specimens was uniformly yellow and not orange-red as figured by Boudier. The asci, moreover, are constantly somewhat longer than in the original description, where they are recorded as 200–210 μ in length. A character not mentioned by Boudier is the branching of the paraphyses. Boudier placed the species near to *N. albo-cincta* (B. and Br.) and *N. albicans* (Fuckel). It would appear to resemble *N. nivea* (Romell) even more closely.

Lamprospora dictydiola Boud., Hist. et Class. d. Discomycetes d'Europe, p. 68 (1907); Icon. Mycol., pl. 403.

Apothecia scattered, 3–5 mm. broad, orange red, marginal flange paler and dentate. Asci cylindrical, hyaline, apex rounded, base long and tapering, 230–300 μ long, 13–15 μ broad, 8-spored, spores uniseriate, round, hyaline, very finely reticulate, containing one large gutta, 16 μ in diam. Paraphyses filiform, apex slightly thickened, up to 6–7 μ broad, filled with reddish contents, septate and forked at the base.

On burnt ground amongst Moss. Farnham, Bucks., Febr. 1922; near Mere, Wilts., May 1923.

This species is distinguished from its allies by the extreme fineness of the reticulations on the spores. A comparatively large species it is easily seen on account of its brilliant colour. Seaver records (Mycologia, VI, p. 9 (1914)) that in two small gatherings of this fungus in America the apothecia were only about 1 mm. across.

Saccobolus globulifer Boud. in Ann. Sci. Nat., 5th ser., X, p. 232 (1869), pl. 9, fig. XXI.

A number of specimens of this Discomycete came up on what appeared to be horse dung taken from a manure heap at Leeds in April 1922. Macroscopically it is indistinguishable from *S. violascens* Boud. with which it was growing. Characterized by the balling of the spores which when separated are seen to be wedge-shaped, rough on the outside and smooth on the two inner sides of the wedge, it is easily recognised under the microscope. The specimens examined agree closely with Rehm's description and illustration in Rabenhorst's Kryptogamen-Flora, III (1894), pp. 1111 and 1119.

Apothecia scattered or gregarious, sessile, cinereous violet 0·5 mm. broad. Asci clavate, apex blunt, base prolonged into a stem, 70–90 μ long × 20–30 μ broad, 8-spored. Spores wedge-shaped, smooth on the two inner sides, rough on the outside, at first hyaline, passing through violet to brown when mature, 14–16 μ long × 7–8 μ broad, at first combined in a ball and afterwards separating; the secondary membrane typical of the Saccobolaceae not seen. Paraphyses filiform, septate, clavate upwards, 3 μ broad (× 5–7 at the apex), colourless.

As pointed out by Rehm, his description does not wholly agree with the figures in Boudier's classical monograph on the Ascobolaceae.

REMARKS ON THE NATURE AND DEFINITION OF SPECIES.

By R. C. McLean.

The radical difficulty besetting all classification, the delimitation of the units employed, is nowhere more prominent or more acutely felt than in mycology, where the study of the subject organisms has arrived at a higher degree of intensity than prevails in possibly any other plant group. This very intensity of study has led to the expression of opinions antagonistic to those prevailing among the majority of systematists in other

groups, regarding the worth of the traditional concept of specific entity, a result which is bound to cause the reflective mind to ponder on the possible consequences to systematic Botany as a whole of the extension of the methods of study by cultural and hereditary observation which have led to the pronouncement of these protestant doctrines among mycologists. Not that similar signs are altogether wanting elsewhere. The geneticist has long been at war with the systematist among the Angiosperms and yet the systematist, though much battered, stoutly maintains the essentials of his position. It is worth while enquiring how this comes to be. The answer will not be without general interest.

The arguments against the current method of systematic mycology and particularly against its morphological bias have been urged within the last few years by Brierley*. Fortunately it need not concern us, from the present point of view, to dispute the theoretical soundness of the position taken up by those of this school, but it is vitally necessary to consider the relevance of their contentions to the work of the descriptive systematist.

Cut down to the bone the charge against current systematic is simply that its "species" are not homogeneous units, and further, that morphological comparison alone is incapable of delimiting such units. For such a charge to have any revolutionary effect it is plainly necessary for those who uphold it to demonstrate that there exist, *per contra*, certain homogeneous units, demonstrable experimentally by some means, to which the unit term species should be transferred. If this can be satisfactorily done, then, it is contended, the morphologically established groups would have to be re-christened with a substitute appellation and their heterogeneous nature confessed. It is surely, however, pertinent to enquire whether any systematist at the present day, when giving a new name, does seriously imagine that in his new "species" he has defined an immutable and inflexible unit, and, whether ingeniously elaborated argument to the contrary is not to a large extent knocking at an already open door? The problem, so far as the systematist is concerned, remains open; it is his critics who have taken up an exclusive position demanding rigid justification.

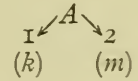
Continued analysis of the species concept has led these critics to the formulation of an ideal unit, which shall be, like a metre measure, intrinsically invariable wherever found, although (to carry on the analogy) its material manifestation (as of wood, steel and so forth) may vary circumstantially; and this is averred to be the biological unit without which any systematic biology is hopeless. This ideal unit is depicted as consisting of a per-

* Brierley, W. B., Some concepts in mycology—an attempt at synthesis. Trans. Brit. Mycol. Soc. VI, p. 204 (1918).

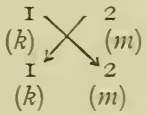
sistent specific framework, liable, it is true, to phenotypic distortion or to mutational collapse, but itself incapable of any permanent alteration from without.

Now it cannot be too strongly insisted that such an ideal is wholly chimerical. All experience, now confirmed and substantiated by physico-mathematical demonstration, leads to the conclusion that there are no units in nature which possess an absolute value, without relation to the circumstances in which they occur and that to search for them is a waste of time. It is only another phase of the secular Quest of the Absolute, as illusory as the Philosopher's Stone. To accept such an ideal is to abstract the species from its environment and endow it with a transcendental entity of its own, in the guise of a pure force-system divorced from all relation to the material substrate. Moreover this system, admittedly involving an almost infinite complexity of interactions, is figured as permanent, but in a wholly transcendental mode, as a mediate factor threading through a complex series of immediate changes in the growth form, never directly demonstrable but always present as an abstract bond, linking together all the phases of the change-series.

It may be objected that permanency of constitution is demonstrable by permanence of reaction under standardised conditions. Supposing then a certain organism *A* to be grown under two distinct sets of conditions 1 and 2, in which it develops with two distinguishable facies *k* and *m*.



If transplanted, reversal occurs;



and it may be argued that in this way the constitution of the organism is shown to be unchanged throughout. This however is a pure assumption under the circumstances. All that our observation shows us is that the strain is capable of certain changes, that in one set of circumstances these changes may be reversed and that in another set of circumstances they may be perpetuated. What the nature of these changes may be and whether they leave unaffected any permanent specific framework underlying them is not brought into the evidence at all. We cannot go beyond the observed fact that the organism is

plastic and interacts with a given environment to produce a given result; but whether any part of the interacting force-system "Organism" remains unmodified by its successive contacts with a series of other force-systems "Environment 1," "Environment 2," and so forth, is unproven and perhaps unprovable. It is moreover antecedently improbable. The only factor possessing any demonstrable rigidity is the standardised environment and it is much more economical of hypothesis to suppose that constancy of reaction is assured by the conformation of the plastic living constitution to it. The possibility of such conformation will naturally govern the viability of the organism in that environment and the act of conformation moulds it into the appropriate form, but neither form nor conformation have any individuality apart from the environment which elicits them from the organism; while the latter, primordially amorphous, responds in a series of symmetrical fashions to every external impress *within the limits of its inherent plasticity*. Each fashion of response represents one of the despised "evanescent morphological facies," which however exist and which alone have been demonstrated to exist.

The unproven assumption of a permanent physiological constitution (implying of course genetic constitution) underlying all phenotypic changes, permeates and vitiates the whole concept of the ideally pure species. The generations of a pure line are supposedly linked together by some character or characters which do not change and are therefore the true "specific indices," but it is logically impossible to prove that any such characters are altogether inaccessible to external influences. Experimental evidence, be it never so searching, is necessarily inconclusive, since whatever character we select for test the negative cannot be proved. Yet even within the limits of available experimental evidence there is material enough to support the positive, that every unit character, or, to confine ourselves strictly to demonstrabilities, the degree of expression of every unit character, is thus amenable to environmental control. Whether there is any absolute constant behind this "degree of expression" is exactly what has been called into question as unproven. The morphological facies is indeed the outward and visible sign of the metabolic rhythm, but is not this in its turn largely the reflection of its circumstances and neither the form of the one nor the other wholly self-existent? That the protoplasm does indeed maintain throughout all the situations in which it may find itself, some elements of continuity, relatively stable over moderate periods of time, is obvious; but these elements are, in general, much more fundamental than the unit distinctions of species, involving the degree of complexity of the plasma

relatively to that of other organisms. That is to say they involve constructional limitations such that the range of factors, material or dynamic, to which any given organism is capable of responding is intrinsically limited. No possible method of culture can change a bacillus directly into a *Botrytis*, but even in regard to the broad features which separate group from group, the fundamentals of structure or *hypomorphs*, as we may call them, in distinction from allelomorphs—these factors of constitution which rough-hew the generic and familial outlines of the organism—it still remains to assess the full effect of environmental pressure acting over long periods of time.

That which is passed from generation to generation is not *form* but *habit*, the fixity of which is in direct proportion to its previous duration; and on the extent to which this is compatible with a new environment will depend the continued survival of the organism. Habit being inevitably of finite duration can never attain to an infinite degree of fixity.

Inseparable from the enquiry into the possibility of physiological change is that into educability, a postulate which has been far too lightly accepted. It must be admitted at this present time, that much of the collected evidence supposed to uphold the idea is explicable on the ground of selection in mixed populations and that experience with pure lines under strictly standardized conditions renders it dubious. I have already pointed out that the mass of evidence illustrating that a given organism generally reacts to the same environment in the same morphological manner offers no evidence on the crucial point of the maintenance, throughout its history, of an identical constitution, but only suffices to show that its reaction in face of so and so is such and such, nothing more. Even the invariability of the organism in this restricted sense is, however, by no means certain and when we are offered growth on potato or onion as examples of the rigidly standardized conditions under which organismal reactions have been observed by its upholders, we may be permitted, perhaps, to doubt whether the alleged constancy rests on quite so sound a basis as we are expected to believe.

The converse problem, that of the nature of the alterations induced by environmental change is likewise often prejudiced by the presence of the same assumption of the self-existence of the specific form. Brierley's clear analysis has done much to resolve the issues and has emphasized the fallacious nature of much of the evidence adduced, particularly among the bacteria; where my own results in attempting to educate a pure line of a spore bearing anaerobe into toleration of flavine entirely bear out his negative experiences with *Botrytis cinerea*. The belief

that an organism can be so remodelled by its contact with a certain set of external factors that it refuses to return to its original fashion when returned to its original environment is unsupported by any conclusive evidence. It is, in any case, not to be apprehended *a priori* that an organism which has once clearly shown itself to be plastic by responding to a change of conditions, should suddenly become aplastically fixed in a new posture. Until such an eventuality be unequivocally demonstrated to occur we may safely leave it out of account in our specific determinations.

This negation is not to be regarded as excluding the possibility of spontaneous mutation; a kind of collapse—as we have already described it—of the specific framework; but nevertheless the same caveat as before must be entered against this proposition also. The manifold sequelae of heterozygosis must not be overlooked; which implies a more thorough scrutiny of possibilities than has been carried out in the cases of most observed "mutations."

On the environmental hypothesis of specific form which is here suggested, a pure mutation, should such a thing be shown to occur, would be held to alter the capacity of the protoplasm for response to the environmental factors, either in the direction of diminishing or in extending its sensitiveness to include new influences which previously did not perceptibly affect it. Within the limits of such an extension of the range of factors, whether climatic, edaphic or biotic, with which the organism is in sensitive contact, evolution, judged thermodynamically, will have advanced a material step through the mutation.

There is, however, another aspect of educability, often neglected, which suggests considerable possibilities when taken side by side with the hypothesis of pure mutation. Although it may not prove possible to alter experimentally the intrinsic capacity of a pure line with respect to some new factor, yet it is certainly possible to "acclimatise" even a pure strain to new conditions by the well-known procedure of moving by slow degrees. Instances of such occurrences are easy to procure at first hand in the laboratory and are on record from almost all groups of plants. Nothing, we may assume, has been permanently added to the constitution of the species by acclimatization. We have only suceeded in straining its powers of response to their utmost limit by avoiding destructive shock. There is nothing specially vital in such a process, for mechanics is full of similar effects. Thus, a wire will support a certain weight added to it in small increments, while the same weight suddenly applied breaks the wire. Again, a horizontal, suspended bar is acted upon by a longitudinal pressure, slowly applied: the bar

is moved as a whole without generation of heat. Apply the same force at a blow and the energy is resolved into molecular vibrations, maybe even disruptively, with much internal heat and no motion as a whole.

In extreme cases acclimatization may affect even the visible structure, particularly in organisms with many delicately correlated parts. Changes of this sort have been very generally ignored in the post-Darwinian discussion of evolution, because it is said, rightly enough in all probability, that none of them are permanent. By this is intended that if the organism or its offspring be removed to the old habitat the old form will reappear. Naturally; what else is to be expected in a plastic organism? But surely the fact merits serious consideration that *so long as the plant endures the new conditions* so long will its new facies remain constant; while in its offspring, each generation, if it does not suffer any mutation, may respond in the same fashion—so long as it remains under the same conditions. If then, the organism were to die out in its original habitat (as is happening for example to *Cupressus macrocarpa*, which has been carried to endless new habitats in cultivation) what would be left to distinguish our "ecad" from a species? All that we should know about it is what we know about any species, that in its normal habitat it had one form, observably constant under constant conditions, and that when moved it showed a liability to display other, apparently latent capabilities of development.

True, to go back to the beginning again, during the first few generations under the new conditions the new character might be, to an observer, obviously superposed during development on an originally different habit, manifested in the juveniles. But the living organism is not restricted to the passivity of our strained metallic wire. A fruit stalk thickens as the weight upon it grows heavy, a wire cannot. The plant has a plastic organization, governed by that mysterious process called "facilitation by repetition," mysterious in its cause but plainly manifest in its effects; through the operation of which we find the new characters of our ecad appearing earlier and earlier in each successive generation until they may even eventually show themselves in the embryo. The change-over is complete, our "ecad" has become a "species."

This fascinating idea, closely bound up with the phenomenon of embryonic recapitulation, is too big a matter to enter into here in the detail which its importance to the theory of plant evolution deserves; but this simple sketch of the principles involved will help to emphasize the view here taken, that *the organism is a crystallized habit.* Permanence, as applied to

organismal characters is a purely relative term and the apparent stability of some characters, generic and familial characters for instance, is accounted for, in the first place, by their more fundamental nature and the consequently greater length of time during which the organism has been in the habit of producing them, and secondly, by the restricted experimental possibilities, chiefly from the point of view of the required time, which limit us in attacking these primordial habits. Given sufficient time to produce acclimatization to fundamentally different conditions it would be difficult to set a theoretical limit to the extent to which we could mould the habit of our species.

It helps us likewise to emphasize the fallacy of the hunt for a wholly objective definition of the term species; a wild-goose chase after that illusion the pure species, which, apparently alone in the universe, maintains an aristocratic reserve of constitution, chemical or otherwise, relative to no basis but itself.

Chemical analogies, indeed, of the reaction of organism and environment are somewhat dangerous. Even if it be true that each species has a particular chemical composition, a specific protein, it is impossible to imagine that this modern version of the idioplasm undergoes no tautomeric changes in relation to its environment. The very elements are no longer the immutable constants that they once seemed. If such analogies really illustrate anything it is that both parties to the reaction, *i.e.* both protoplasm and environment, in our terminology, enter in greater or less degree into the actual constitution of the final product—the visible organism.

Nor is there any particular stage in its life-history at which a species may be considered as having withdrawn its constitution entirely from contact with the environment. There is no gonidium so dormant that it is wholly unresponsive to such fundamental factors as light and temperature: some indeed are quite remarkably sensitive. Moreover it is needless to labour the fact that the form of the mature individual is never wholly predetermined by the constitution of the antecedent gonidium.

Over against all such considerations we have to recognize the very high degree of constancy exhibited by many species in nature, a constancy to which the systematist is justified in pointing as a vindication of his general morphological usage in dealing with species.

There is no necessary contradiction between this observed fact and the foregoing ideas about the specific form as an environmental reflex. Many species are accurate environmental indicators; the given organism is never found apart from the given conditions, so that the recognition and description of the species are immediately possible without recourse to physio-

logical analysis. Into this class fall, no doubt, many fungi, since their secondary, dependent modes of nutrition render them less capable of existence under a wide range of conditions than the autotrophic plant. On the other hand there are many plants even among the fungi, which seem to preserve their identity closely over a wide selection of habitats. There is no real difficulty involved; these forms may indeed actually be in the first category though responsive only to a limited range of factors, common to all their habitats. No organism is sensitive to every one of the almost infinite number of the complexities of a natural habitat and many are extremely restricted, depending only on the co-existence of a small number of widely distributed influences and unaffected by a considerable latitude in those to which they are not sensitive. The result from the point of view of practical systematics is the same as before. These types can be recognized as morphological entities with a definite, though limited, physiological background. Whether they are made up of a mixture of convergent races is another question, which will only yield to physiological, or let us rather call it, ecological analysis; but we have already contested the assumption that such races are themselves a whit less dependent upon environment for their apparent constancy than is the aggregate form.

To the conception of the organism as a physiological equilibration functioning about a constant point we must oppose the modified conception of the organism in which nothing is absolutely constant, but in which those morphological features which have a relatively high quality of constancy derived from extremely ancient habit, form the basis upon which the specific character is superposed by the environment.

Such a resurgence of Lamarckianism into evolutionary thought will not surprise those who are acquainted with the work of Perrier and Gravier on Tachygenesis* and the exposition on "Mutations and Evolution" by Gates†; but those who wish to see how the importance of somatogenic characters has impressed itself on a mutationist should turn to the latter series of papers‡.

Brierley, in the paper already mentioned, draws a contrast between the dynamic and static ideas of the species, into which it would be idle to enter critically without essaying an analysis of the meaning to be assigned to the term "existence." Suffice it to say that if we accept the concept of organic form outlined

* Perrier, E. and Gravier, C. L., La Tachygénèse. Ann. Sci. Nat. Zool. XVI, p. 133 (1902).

† Gates, R. R., Mutations and Evolution. New Phytologist, XIX, p. 26 (1920).

‡ Now reprinted in book form.

above we perceive the species to be both event and thing, an event giving rise to a thing, a dynamic process resulting in a static equilibrium which is inherently stable. As the event, the intimate process by which environment acts upon protoplasm and hence upon gross form, is at present beyond our reach, we must be content to accept the result, the thing, as a sort of algebraical symbol for the unanalysed process which precedes it and is its proximate cause.

From these considerations we find ourselves led back to the morphological basis of specific distinction and it may be useful to reflect now, that the species is historically a morphological idea and to protest against the unjustified transference of an understood and accepted epithet to a hypothetical and possibly non-existent unit. Whether the group of individuals be big or little, diagnosed by a syndrome of characters or by a single one, the term *species* is rightly applied to it if it remains visibly constant under constant conditions. But, when we go beyond this to seek for imagined immutabilities abstractable from such a group by experimental analysis we pass to a region of new concepts demanding the employment of new terminology. Where morphological data are of the simplest order it is only natural that physiological criteria should predominate in the discrimination of groups; but no bacteriologist would pretend that types thus delimited are fixed entities any more than the others. On the other hand where morphological data are abundant they will naturally influence the student most. To draw a hard and fast line between the two procedures or to attempt to oppose them to each other in distinct categories, as has been done, is logically impossible. The student of higher groups knows, as a general rule, little directly about their physiological make-up. He has had to be content to rely upon their morphology as an eidolon of the inner mysteries; but where systematic biochemistry has come to his aid it is gratifying to observe how little it has found it necessary to amend the existing order; a striking vindication of an implicit assumption, venerable from age but none the less an assumption, that form is an index of constitution, which has not perhaps been allowed its full significance.

The species is properly a four-dimensional concept whatever the characters by which it is marked off. The time factor enters into it either in consideration of its stability, on the one hand, or as affecting, on the other hand, the sequence of events, determined by the impressionability of the organism in face of varying environments, which provide the material the dynamic phyleticist works with. Even were the organism a veritable Proteus, every phase which achieves a static existence becomes

in its turn the subject matter of the systematist and needs its label. It is of little moment to him that *Leontopodium alpinum* changes in a changed habitat; that does not affect the primary fact that *Leontopodium alpinum* exists and continues to exist so long as the appropriate environment offers itself.

To the present day systematist species are no more than a series of packets into which he sorts objects. About x, the intimate constitution of these objects, he makes neither assumptions nor prophecies; but, if $x \times y$ (the environment) $= xy$ (the observed object), he needs only to define the two latter terms as clearly as possible, and, if he can develop quantitative methods of assessment with which to do it, so much the better. Do not let it be thought however that it is any more scientific or that it assists in the delimitation of the species, to describe the various ecads formed by the organism in an arbitrary selection of different environments out of the innumerable possibilities, rather than to confine oneself to the most rigid possible definition of the exact natural habitat or habitats in which the form in question *spontaneously* occurs. These ecads may be the beginnings of independent species, as we have seen, and there must be infinite gradations of rank between one extreme and the other.

Classification is confessedly a subjective matter; but our intellectual limitations require it in order that we may view this universe through some sort of *grille* of co-ordinate axes, which will enable us to relate its multifarious outlines as harmoniously as possible to those elementary ideas with which alone we are capable of dealing. That there never is, nor can be, a perfect correspondence, need not put us greatly about so long as our end is served; for, in the ordinary acceptation of that term, Natural System is there none.

The expressions made use of by Farlow* are as true to-day as they were a quarter of a century ago and they convey the same opinions as those here maintained, so forcibly that some of his phrases may be effectively quoted in the present connection:

"Our so-called species are merely snap-shots at the procession of nature as it passes along before us. The picture may be clear or obscure, natural or distorted, according to our skill and care, but in any case it represents a temporary phase, and in a short time will no longer be a faithful picture of what really lies before us, for we must not forget that the procession is moving constantly onward and at a more rapid rate than some suspect."

"We should not allow ourselves to be deluded by the hope

* Farlow, W. G., The conception of species as affected by recent investigations on fungi. Bot. Sect. Amer. Ass. Adv. Sci. (1898).

of finding absolute standards, but it should be our object to arrange what is really known, so that it may be easily grasped and utilized."

"Utility may perhaps sound strange,...but in the end utility will carry the day in this case, for systematic botany is a means not an end."

It is a truism of philosophy that only that knowledge imports to man that relates to man. To pure intellect all facts are of equal value, interest and potentiality; but our gradations of value are individual, subjective and depend upon our human interest.

The formation of a classificatory system or the discovery of the Natural System, did it exist, is of no moment to a single human being apart from its human use. It is a tool simply, to be applied to certain material for the furtherance of our interests as living beings, with needs to be served in the examination of other living beings. By their suitability for their given purpose must all our tools be judged.

The final analysis of the systematist's groups into their constituent elements, profoundly important as its implications are from the physiological standpoint, takes place outside the limits innate in systematic thus subjectively conceived, and need not subvert its traditional method.

ECOLOGY AND PHENOLOGY OF SURREY MYCETOZOA.

By the Rev. P. J. Alexander, C.J.

The following notes on the Mycetozoa of Surrey are the result of ten years' systematic study, combined with assiduous hunting and careful annotation of the habitat of the species, the date of their appearance and the previous weather conditions. All information as to previous records, etc. that I was unable to obtain first hand has been kindly supplied by Miss G. Lister, F.L.S.

The ground covered is practically the whole county, with special attention to the central portion, within a ten mile radius of Weybridge. I am of opinion that one obtains better results, by a more concentrated attention to a restricted area, than by going further afield. Having a limited amount of leisure, I found myself compelled, by circumstances, to hunt for the greater

part of the year in a confined space, namely, the wonderful grounds of St George's College, Weybridge, known locally as Woburn Park. Here, in an area of just under a hundred acres, no less than 90 different species and 18 varieties have been recorded*.

There have been many notable forerunners in the same field. I have no knowledge of the extent of the work of Messrs Massee and Phillips, but no doubt many of their specimens were obtained in this county. The late Mr Arthur Lister, his daughter Miss G. Lister—the chief authority on the subject to-day—her sister Mrs Phear, and the latter's sister-in-law Miss Margaret Phear, have also made many notable finds especially in the south-west of the county; Mr E. S. Salmon has furnished useful records of the Reigate neighbourhood, and Miss A. Hibbert-Ware and Prof. Farmer have also been successful hunters in Surrey: so that we now have the record number of 128 species and 19 varieties, or two-thirds of the known British species.

The present list is of particular interest as it includes one species new to Europe: *Didymium anomalum*; one new to Britain: *Trichia alpina*; two new to England: *Physarum globuliferum* and *Ph. crateriforme*; Miss Lister's recently published species: *Didymium trachysporum*; and nearly thirty new to Surrey.

I gladly take this opportunity of expressing my grateful thanks to Miss G. Lister, F.L.S., for all her help in examining my finds and checking my results, and for the valuable information and directions contained in her various writings which have been my guide throughout.

My experience has taught me that much precious time may be lost by looking for specimens at times of the year when they are not likely to be found, or in situations where they have never yet been met with. It thus occurred to me that records of dates and habitats would be a useful—though not infallible—guide to others who find their pleasure in like pursuits†.

1. *Ceratiomyxa fruticulosa* Macbr. is very frequent from May to October on rotting lime, alder, birch and pine wood and appeared oozing out of the ground in great masses of slime in October, on a pathway thick with old pine sawdust at Weybridge.

2. *Badhamia capsulifera* Berk. appears in late autumn every year and has been found in November on fir, oak, alder and lime branches; in the last case the plasmodium was feeding on *Exidia glandulosa*.

* Any mycologist wishing to hunt over the same ground will always be very welcome.

† Those species marked with an asterisk were first recorded for Surrey by the writer, those marked † were first found by Miss G. Lister, F.L.S.

*3. *B. utricularis* Berk. A very common species. In March it was noticed on rotting willow slips, and from April to November in its classic haunt on leathery fungi. The plasmodium has also been observed among poplar logs feeding on *Pleurotus ostreatus*.

4. *B. nitens* Berk. A fine healthy growth of this species was found in May 1920 on a fallen oak branch, in the grounds of the Royal Horticultural Society's Gardens at Wisley. At first glance it could hardly be distinguished from the golden yellow lichen on which it was growing.

*5. *B. macrocarpa* Rost. may be met with every year in late autumn. A sturdy stalked form, very like a robust *Physarum pusillum*, appeared in November 1922 after a month of remarkably low rainfall, on the bark of white poplar logs in the grounds of St George's College, Weybridge.

†6. *B. panicea* Rost. occurs frequently throughout the year. It has been recorded in January, March, April, July, August and plentifully in autumn. It would seem to have a preference for poplar logs but often creeps over adjacent leaves, etc. and has also been found on elder and tulip tree (*Liriodendron*).

†7. *B. foliicola* Lister was first gathered on a lawn near Witley in July 1908. It is not, however, uncommon and has since been found in February and March on beech leaves, on an oak trunk in June, on laurel and poplar sticks in a heap of faggots in October and on poplar and sweet chestnut leaves in November.

*8. *Physarum globuliferum* Pers. Although already recorded for Scotland by the Rev. W. Cran it was not obtained in England until September 1922 when a large growth was found in St George's Hills, Weybridge, on the bark of an old pine stump kept moist by overhanging bracken. This clustered form is bigger and has shorter stalks than the elegant American and tropical species.

†9. *P. viride* Pers. Has been found fresh in March on a laurel branch and also on alder and pine in September and October. A growth with sporangia varying from bright yellow to red (var. *aurantiaca*) was collected by Miss Lister in Richmond Park in August 1892.

10. *P. galbeum* Wing. This charming species is by no means of frequent occurrence. It was first recorded for the county at Witley on dead twigs in September. It has also been obtained in July, after twelve days of incessant rain, and again in December. On each of these occasions dead bramble stems provided the habitat.

11. *P. nutans* Pers. Abundant throughout the year but is most puzzling in some of its protean forms.

var. *leucophaeum* is almost as common between January and July.

var. *robustum* is frequent and has been found on laurel in May and on elm in November and throughout the winter and spring. It is nearly always on rotting wood.

*12. *P. crateriforme* Petch. After an exceptionally wet period this species was found for the first time in England, growing among lichens and associated with *Cribraria aurantiaca*, on an old pine stump on St George's Hills, in September 1921. The sporangia were so minute, and blended so well with the white tops of lichen, that they could not be distinguished with the naked eye, and it was only the appearance of some strange looking spores among those of the *Cribraria* that provoked a further examination of its well-concealed lurking place.

†13. *P. pusillum* Lister. A minute slender form of this species is frequently met with in heaps of old straw. In August and September a sturdy, robust form appeared in great profusion, on old pieces of white poplar bark, and in October it was again met with on the leaves of *Agave americana*.

*14. *P. compressum* Alb. and Schw. can be found at almost any time of the year. In February it occurred on the straw thatch of a haystack, in July a less robust form was running wild over dead ivy leaves, in September a stout growth appeared on willow bark and lime logs. A black stalk instead of a white one is sometimes met with, while sessile sporangia of a light brown colour are not unfrequent, and limeless sporangia have been noticed in December.

*15. *P. straminipes* Lister. has only once been encountered, although it is probably not uncommon in heaps of rotting straw. One good gathering of this species was made during a very wet July at Horsley, on the edge of a straw heap just where it mingled with the surrounding grass. It is like *P. didermoides* in the field, but its identity is instantly revealed under the microscope by the unmistakable patches of warts on the spore.

*16. *P. didermoides* Rost. This is much more frequent than the last named species and occurs in similar situations from June to early autumn. It has also been found in August on horse manure on a flower bed.

17. *P. cinereum* Pers. though especially a spring species may be found at other seasons also; but from March onward it has occurred plentifully on dead leaves of oak, beech, sweet chestnut, sycamore, holly, pine, poplar and bramble. Limeless sporangia almost black and iridescent are frequently met with in conjunction with the typical form.

18. *P. vernum* Somm. has been gathered in January, March and April on old leaf beds. In the spring of this year (1923) there appeared a form looking very like *Diderma spumarioides* externally; it was densely charged with lime and much nearer

the typical robust alpine kind than we usually get in England. The var. *iridescens* appeared at Oxshott and Weybridge on bramble leaves and stems in October.

19. *P. sinuosum* Weinm. The plasmodium of this species may be found fresh and preparing to fruit at least at two periods of the year, in March and October, particularly on bramble but also on the dead leaves of the horse-chestnut, sweet chestnut and beech.

20. *P. bitectum* Lister is common throughout the year on the same habitat as the preceding. It has been recorded from January to April and from July to October. A very striking and puzzling limeless form was frequently met with in April 1922 and 1923 at Weybridge and Horsley. The sporangium wall was shining iridescent, reticulated, with angular ridges and the spores were very dark and rough. It occurred on poplar and elder bark, but more usually on dead leaves especially those of sweet chestnut, beech, laurel and oak.

21. *P. contextum* Pers. and 22. *P. conglomeratum* Rost. are apparently rare and have only once been recorded in Surrey in November 1898 and September 1897 respectively, when Miss Margaret Phear found them on dead leaves at Witley.

†23. *P. mutabile* Lister was found abundantly on straw heaps near Witley in August 1905 and by Mr J. Saunders at Haslemere in 1914. It is by no means of frequent occurrence.

†24. *P. virescens* Ditmar var. *nitens* Lister. The only Surrey record of this species was made by Miss Lister at Haslemere in October 1905. It occurs on dead leaves, moss, etc.

25. *Fuligo septica* Gmel. is of common occurrence from May to October. It has been found on oak, beech, poplar, elm, pine, laurel, hornbeam, fir, bracken, grass and moss and on living alder.

var. *candida* Lister. Favours sawdust heaps of coniferous wood.

var. *rufa* Lister prefers beech and elm: the plasmodium of this variety is sometimes a pale cream colour almost white, but more often it is rich canary yellow. It has been observed in June, after six weeks drought, emerging from an apparently bone dry elm stump. The presence and thickness of the cortex depend on the atmospheric conditions prevailing at the time of development. Plasmodium maturing in sheltered situations produces no cortex; but in the open the outer sporangia wither and form a protection for the deeper layers.

†26. *F. muscorum* Alb. and Schw. flourishes on moist moorland in autumn. Two gatherings of this species have been made in Sept. 1905 at Haslemere and Morley Common on rushes, bracken and sticks.

*27. *F. cinerea* Morg. Towards the end of July 1920 a fine

development of this was noticed maturing on the stalks of living grass sprouting from an old dung heap.

28. *Craterium minutum* Fries occurs throughout the year on all sorts of decaying foliage. It has been gathered on pine needles, holly, horse-chestnut, beech, laurel, bramble, lime petioles, yew and on cones.

29. *C. leucocephalum* Ditm. appeared in July on holly leaves and abundantly in October on laurel, ivy and *Agave* stalks.

†30. *C. aureum* Rost. This beautiful little species was abundant below Hindhead in August 1917 and in July 1920 when it occurred in some profusion on alder twigs at Weybridge.

31. *Leocarpus fragilis* Link is a conspicuous species in spring and autumn growing over all kinds of dead leaves, grass and bramble. It seems to have a preference, however, for pine and fir needles.

32. *Diderma spumarioides* Fr. crops up repeatedly on rotting foliage. Especially prevalent in spring and early summer, it has been found on oak, beech, alder, bramble and laurel leaves.

33. *D. hemisphericum* Hornem. occurs on beech and horse-chestnut leaves in damp situations in April, on old straw in September and copiously on alder and bramble in October.

*34. *D. effusum* Morg. is conspicuous in February and April on sweet chestnut and rotting laurel leaves and in May on *Quercus Ilex*; in July it was very abundant on wood in a moist ditch filled with black decaying leaves, in September on birch wood and in October on rotting leaves and also among faggots.

*35. *D. deplanatum* Fr. Only once have I met this species, in the early days of my interest in Mycetozoa, when I gathered it under the impression that it was an unusually robust form of *D. difforme*. It was seated on an old oak stick and approached *D. niveum* in character, with rather more columella developed than usual.

*36. *D. montanum* Meyl. is rather a misleading name for a species not confined to mountains. The present specimen occurred on a dead pine branch lying among wet grass in October, in the woods surrounding the lake at Virginia Water. It closely resembles *D. radiatum* var. *umbilicatum* Meylan, but is distinguished by its smaller size and spores which are apt to be paler.

†37. *D. testaceum* Pers. has only once been found in Surrey when Mr Arthur Lister came across it at Witley on dead leaves in October 1896.

38. *D. floriforme* Pers. though not uncommon under oak trees in autumn, this species has only twice been recorded for Surrey, in 1906 by Professor Farmer at Wimbledon and in 1912 by Miss G. Lister at Weybridge.

*39. *D. asteroides* Lister matures from a pale creamy yellow plasmodium tinged with green. This fact was first noticed at Weybridge in a mixed leaf heap at the end of March and the beginning of April 1923. The young sporangia are of the same colour, but after twenty-four hours they turn to a bright orange yellow like those of *Badhamia foliicola*, which gives place to a *café-au-lait* tint; the sporangium on drying finally assumes a pinkish buff appearance. The outer sporangium wall is usually covered with purple tigrine mottlings which, if very numerous, may give a purple brown effect to the whole growth. Two or three hundred sporangia were found an inch or two below the surface, especially on hornbeam, beech and deciduous cypress foliage of the preceding fall.

40. *Diachea leucopoda* Rost. is of frequent occurrence between August and December on dead leaves of holly, holm oak, yew and bramble and even on dead grass. Some of the sporangia show a yellowish brown stalk.

41. *Didymium difforme* Duby. Grows commonly the whole year round on all decaying vegetable matter but seems to show a preference for sycamore leaves.

var. *repandum* G. Lister appears in Spring abundantly on sycamore, thistle and lime leaves. In March 1922 when the season was very backward a form occurred with strong warts and spines 1–3 μ long on the capillitium and spores 14 μ.

42. *D. vaccinum* Dur. and Mont. has been found in March, June and September on very rotten straw at Horsley. Most probably it could have been obtained at the same spot during the intervening months, but the distance was too great to permit more frequent visits. It was first recorded for the county by Mr E. S. Salmon on old straw at Reigate.

*43. *D. trachysporum* G. Lister has recently been published as a new species. It has been observed for the last twenty-six years and was first described under the name of *D. trochus* var. *tenue* G. Lister. It is not unfrequent among dead leaves and rotting straw from February to July but is possibly often overlooked on account of its close resemblance to *D. difforme*. The sporangia are circular or pulvinate, rather flat, sometimes forming branching plasmodiocarps. The outer sporangial wall is very frail and eggshell-like, smooth or slightly wrinkled, breaking away with the inner hyaline wall adhering to it. The spores are very dark and rough, sometimes with a prominent marked ridge; they vary in size from 8 to 12 μ; some have a very prickly aspect and in others the spines are connected at their bases by low ridges, giving an appearance, when highly magnified, of a much broken reticulation. The capillitium is variable, colourless or dark olive brown, simple, beaded, with

elliptical tips, or branching, usually with broad attachments below. This species has been found in heaps of dead leaves, especially on elm and beech, lime petioles, lime and holm oak leaves.

†44. *D. dubium* Rost. forms flat, plate-like, hemispherical sporangia or recurved plasmodiocarps of a creamy colour, rarely white, on clotted decayed leaves, especially those of ivy and less often lime and elm. The outer loose crust of crystals falls off when the inner sporangial wall enclosing the spore and capillitium contracts on maturing. In specimens gathered at Weybridge in March, April and May the capillitium was quite colourless whereas that of the type form from Lyme Regis is dark and rigid.

*45. *D. anomalum* Sturgis. This is the first European record of a species which hitherto had been found only in Colorado and near Philadelphia. In 1922 it was most plentiful from August to October on sticks of white poplar lying in faggots on the ground. The sporangia are quite sessile and pulvinate, forming irregular plasmodiocarps of from 1–15 mm. diam. The capillitium consists of a number of tubular columns enclosing small calcareous crystals, and connecting the upper and lower surface walls in such a way as to produce a striking "upholstered" appearance. The sporangial wall is firm and contains little lime, thus it is frequently of a dull chocolate colour. The spores are purple pink, spinulose, ovoid or sub-elliptical 9–12 μ. Large polygonal crystals are often present. It is strange that such a remarkable species has not been met with more frequently.

46. *D. Clavus* Rost. is frequently encountered in February, August, October and November on lime leaves. A sessile form has been found growing on moss, and a limeless form of a shining bronze colour on dead bramble was easily recognised by its small spores.

47. *D. melanospermum* Macbr. frequents coniferous woods and was abundant on pine needles at Oxshott in October 1920 and 1922.

var. *minus* Lister once appeared in August on a rotten birch branch but is more usual on dead leaves, such as those of holly, in October.

48. *D. nigripes* Fr. Has been obtained in April on beech leaves and on holly leaves and pine needles constantly in August, September and October.

var. *eximium* Lister was very prevalent at Oxshott in October 1917. It was also one of the species discovered during two hours spent on top of a haystack examining straw thatch, which is often rain sodden and rotten in places.

var. *xanthopus* Fr. is common on dead leaves in autumn

and has been found abundantly in September on the leaves of black poplar.

49. *D. squamulosum* Fr. Even this—perhaps the commonest of the Mycetozoa—is by no means always easily recognised, by reason of its extraordinary variety of forms. A completely limeless form was not unfrequent on bramble in March 1922 and near by, on old oak leaves, the same species appeared in another disguise, as flat cakes with a blue metallic sporangial wall. Quite recently I have noticed it maturing from large quantities of dull pinkish red plasmodium. A slender ridge has sometimes been seen on the spore wall.

50. *D. anellus* Morg. Only twice have I come across this species; once in October on poplar leaves among faggots, and once in March on dead holly leaves. This latter was a limeless form. It has also been recorded at Witley on rotting sycamore leaves.

*51. *D. crustaceum* Fr. has so far only been gathered once in Surrey—in April 1922—in a heap of dead leaves, selecting as its habitat pine needles, oak leaves and the foliage of *Sequoia gigantea*. The capillitium was frequently net-like as in the following species.

52. *Mucilago spongiosa* Morg. This common species should, I think, be described as common locally, or periodically, as it has only once been found in Surrey, as far back as 1898, when Miss Margaret Phear collected it at Witley in November.

*53. *Colloderma oculatum* G. Lister is best sought for in wet weather, when its opaque white or yellowish plasmodium shines out conspicuously from among darker surroundings. The mature sporangia, when of a dull dark colour, are easily passed unnoticed; but sometimes they are shining silver grey, or even brilliantly coloured in kingfisher blue. A favourite habitat of this species is on the moss *Campylopus pyriformis*, but it is also frequent on the soil between the roots of old pine stumps; on moss, liverworts and algae on pine branches, and even on bare spruce bark. On one occasion I found it on a dead leaf of Spanish chestnut. The spores are often ovoid and very variable in size. The capillitium threads have a dark purple brown interior with a hyaline sheath. The sporangia grow singly or in small clusters of three or four, or in good growths, of seven to nine. It has been recorded for every month in the year, but is especially prevalent in autumn.

54. *Stemonitis fusca* Roth. is common throughout the year especially on coniferous wood. It is one of the very few species that I have met with on Rhododendron wood.

var. *flaccida* Lister has appeared in autumn and winter on sycamore stumps.

var. *confluens* Lister. Was seen forming-up on an old horse-chestnut stump in spite of a hot August sun.

55. *S. splendens* Rost. var. *flaccida* Lister occurred in August on fir stumps near Guildford and at Witley, and on old decayed black poplar at Weybridge.

†56. *S. confluens* Cooke and Ellis. In late November 1920 the white plasmodium was noticed emerging from a piece of old bark of Lombardy poplar lying among wet grass and damp leaves. It eventually matured into three beautifully neat fascicles with the tips of the component sporangia clearly showing.

57. *S. herbatica* Peck has been found abundantly at Witley on pine stumps.

58. *S. flavogenita* Jahn was gathered in June and July on rotten fir wood, and on ground-ivy (*Nepeta Glechoma*), where the plasmodium had most probably crept from some rotting timber.

59. *S. ferruginea* Ehrenb. is frequent from May to October especially on coniferous wood. It has been reported from Weybridge and Woking, Guildford, Reigate and Oxshott.

60. *S. hyperopta* Meyl. The specific name is most appropriate as this species is surely often overlooked. On the uprooted pine stumps near the St George's Hill Golf Course, Weybridge, it has been found repeatedly in September and October. The sharp patches of reticulation on the small spores give the clue to its correct determination.

61. *Comatricha nigra* Schroet. may be gathered any day of the year on dead twigs and wood.

var. *alta* Lister is common enough in the winter months on beech and poplar branches.

62. *C. laxa* Rost. has been frequently found from March to November on old bramble stems.

†63. *C. fimbriata* G. Lister and Cran. The first Surrey record of this minute and delicate species was made near Hindhead in August 1917. In Weybridge it has been found in conjunction with *C. elegans* on a lichen covered larch stick in October, and the following month some forty sporangia were found on a decorticated pine stick. By keeping the stick moist in a tin box, further large crops were reared every month in the year. It has also been gathered on a rhododendron branch.

64. *C. elegans* Lister occurred in April on rotting ivy leaves but has more often been noticed on dead wood, especially oak, ash and larch.

65. *C. lurida* Lister. This unfrequent species has been met with but twice; in October 1896 at Reigate, and in January 1897 on dead holly leaves heaped in dry ditches.

66. *C. typhoides* Rost. is very common on rotten wood from April throughout the summer. It has been noted on poplar, alder and laurel.

67. *C. microspora* G. Lister. The only record we have of this uncommon species is due to Mr E. S. Salmon who found it on dead leaves at Reigate in October 1897.

68. *C. pulchella* Rost. Large regiments of this neat little species are of frequent occurrence in summer on dead leaves and twigs, notably those of yew and *Tsuga canadensis*.

var. *fusca* Lister has only once been met with, on the naked bark of a fallen pine branch in May.

69. *C. tenerrima* G. Lister is fairly common though less conspicuous than the last species. It has occurred on rotting grass in August, on old straw in September, on dead bramble in November, and inside dead herbaceous stems.

†70. *C. rubens* Lister. This is usually a winter species and by no means common. The only Surrey record of it was on holly and ivy leaves at Witley in October 1896.

71. *Enerthenema papillatum* Bowman seems to have a preference for rotting oak wood but is not uncommon on pine, white poplar, lime and even rhododendron. It has been found in January and March and from July to September, and also on living oak at Hindhead, five feet up the trunk.

†72. *Lamproderma scintillans* Morg. is a hardy flourishing little species not particular when or where it appears. It grows in great profusion, from January to October, covering several square yards and forming-up on anything that happens to be in its path: leaves, wood, stones, brick, etc., and even on top of other mycetozoa, *e.g. Diderma difforme* and *D. squamulosum*.

73. *L. violaceum* Rost. was seen emerging from a rotten hollow stump of Lombardy poplar in January, March and December. The delicate points of iridescent blue covering the surrounding moss, ivy leaves and sticks produced a most striking picture.

†74. *Amaurochaete fuliginosa* Rost. was observed oozing out of the parched and cracked fir and pine stumps on Oxshott heath in September and October 1921, in spite of the severe drought of that year. It was first recorded for the county at Woking, among the pines on the Common, and has since been obtained from Haslemere, Witley, Byfleet and Weybridge.

75. *Brefeldia maxima* Rost. The plasmodium of this species has been noticed in great creeping masses in April, May and June, but it is more often on the move in October and November. In no case have I met it on any but elm and poplar stumps.

†76. *Linbladia effusa* Rost. The first Surrey record of this un-

common species was made by Miss G. Lister in October 1922. At a spot on Oxshott heath where the ground is thick with pine sawdust, the dark sepia plasmodium was welling up and forming large aethalia as big as a man's hand, but so dark that, in the field, they might have been mistaken for *Brefeldia*. The month of October was exceptionally dry that year, and, had the mild weather continued, a plentiful crop would have been obtained in the following month. As it was the early frosts of November put an end to its appearance, at least for that season. This sawdust heap has yielded sheets of *Licea flexuosa* which carpeted vast areas of the ground; large patches of *Tubifera* and *Dictydium* were scattered here and there, while there was an abundance of *Cribraria argillacea*, *C. rufa*, *Ceratiomyxa* and *Trichia decipiens* together with another record for Surrey: *Cribraria pyriformis* var. *notabilis*.

77. *Cribraria argillacea* Pers. is common from July to October especially on pine and fir. In August I have found it on a yew stump year after year. A long stalked form appeared in October maturing from a lavender blue plasmodium, and large sessile sporangia, 2 mm. diam., were abundant on pine sawdust, but showed little or no appearance of net on the strong persistent cup.

78. *C. rufa* Rost. when met with is usually in large quantities. Old rotting pine wood or sawdust is its usual habitat from September to November; but at both Weybridge and Oxshott it has occurred on sweet chestnut wood and leaves.

79. *C. vulgaris* Schrad. This species is slightly earlier than the last and may be met with from August to October, not only on coniferous wood but also occasionally on yew and alder. It is by no means always an easy species to recognise, as forms with small round nodes, and large, flat, dark or pale nodes may arise in one development; but all have ochre-yellow spores and small (1 μ) plasmodic granules.

var. *aurantiaca* Pers. flourishes at the same time and on the same habitats as the typical form.

80. *C. tenella* Schrad. is a very striking and beautiful species but much less common than the last two. The tall stem, nodding sporangia and spores canary yellow in mass, at once strike the eye as something unusual. It has been found on pine in July after a fair spell of rain and also in September. Colonies of sporangia often extend over several square inches, and have been noticed intermingling with those of *Dictydium cancellatum*.

†81. *C. pyriformis* Schrad. var. *notabilis* Rex. The first Surrey record of this elusive species was made by Miss G. Lister on the prolific pine sawdust heaps at Oxshott in September 1921. The long prominent ribs make it very like *Dictydium cancellatum*

when moist, but it is always recognisable by the pink colour of the fresh spores. Throughout the whole of October last year it could be gathered in the same spot, until the beginning of November when it became attacked by mould.

82. *Dictydium cancellatum* Macbr. does not feed only on pine wood, though it is most often found there. It is of earlier appearance than the last species. In June it was found forming-up on an old alder log, supporting a melon frame. I was informed that the log had lain in the same spot exposed to the weather for over twenty years. In July, after much rain, it appeared on pine, in August on poplar, in September on beech, and in October it stretched like a carpet for several square feet over sawdust on the ground. The plasmodium, when about to fruit, was subjected to heavy rains, and irregular, though persistent, cups were formed of a beautiful transparent purple, resembling in colour the "Blue John" of Derbyshire.

var. *fuscum* Lister occurred on pine wood during a remarkably mild December in 1918.

†83. *Licea flexuosa* Pers. Every month from September to March this frequent species can be met with on moist coniferous wood. Sometimes the sporangial wall is clean, translucent and glossy but more often it is enveloped in a coating of dark refuse matter. It thrives particularly well on old pine sawdust, where I have seen it covering several square yards in close snake-like masses, folding about and blackening the soil.

†84. *Licea pusilla* Schrad. This minute and most inconspicuous species was first recorded for the county in October 1912, on St George's Hills, Weybridge. In November ten years later it was again found in that neighbourhood, on the same piece of naked pine bark as two other members of the same genus, viz. *L. minima* and *L. flexuosa*. The sporangium wall under a pocket lens frequently appears merely dull black and so faithfully agrees with the colour of the surrounding habitat as to produce a very effective camouflage. The spores were often only 14 μ, sometimes 16 μ and more.

85. *Licea minima* Fr. is not unfrequent wherever there are pines. I first noticed it in September on dead *Merulius* that had spread over a disintegrating pine log. The sporangial wall was deep purple brown, nearly black. In the following April a form with light brown sporangia was found near Hanscombe, the plasmodic granules on the border being almost colourless or wanting. In October and November last year, this species was very plentiful on old pine fencing lying on the ground.

86. *Tubifera ferruginosa* Gmel. It is not generally known that the plasmodium of this species may sometimes be white or

yellow though usually rose. It is abundant in September and October on pine sawdust and stumps. When old and discoloured it may resemble robust forms of *Dictydiaethalium plumbeum* or a dull ochraceous *Lindbladia*.

87. *Dictydiaethalium plumbeum* Rost. In September 1916 the beautiful pink plasmodium of this species was conspicuous, in patches over two inches in diameter, on the soft rotten trunk of an old beech. It developed into a very sturdy aethalium, being as much as 3 mm. thick in parts; the threads were very jagged on one side and occasionally had a slight frill of persistent sporangial wall. On the other hand very minute forms, no bigger than a pin's head, appeared in October on laurel faggots. In November it has been noticed on lime wood, in December on ash used as bean sticks and in April on a thick rotten stem of ivy.

†88. *Enteridium olivaceum* Ehrenb. Indistinguishable from the last in the plasmodial stage, the aethalium sometimes appears as a mere speck composed of no more than two or three sporangia or again it may extend to five or six centimetres. This latter form I have found on pine logs in November, the former on lime and larch branches in October. A glossy bottle green variety is frequent enough on lime branches; it has not the usual depressed form but is composed of rather heaped convex sporangia; it is somewhat brittle and the contents get shaken out leaving nought but the green translucent walls; in other ways it agrees with the typical form and therefore cannot claim any specific difference.

†89. *E. liceoides* Lister. This somewhat rare species has been recorded three times in Surrey: at Haslemere in October 1905, at Oxshott in 1917 and at Weybridge in September 1920 on a decorticated pine stick. The outer sporangial wall was mottled, the inner brown and glossy.

90. *Reticularia Lycoperdon* Bull. As regular as clockwork, as soon as March comes round, so soon this species appears, and from then until August it may be found frequently, on a variety of trees. I have noticed it on alder, willow, pine, poplar, cedar and birch.

†91. *Liceopsis lobata* Torrend. A crumbling old pine log half buried in the soil yielded a handsome crop of this beautiful species in September 1920. Some of the sporangia were solitary and supported on a twisted strand of hypothallus. In August 1892 it was recorded for the first time for the county, near Woking. In Weybridge it was still appearing in November and the following April another development was found within twenty yards of the former; but it was only by lifting the log out of the soil that it was discovered, as in each case it was

growing on the underside of a half buried piece of rotten pine.

*92. *Lycogala flavofuscum* Rost. On the southern side of an immense elm tree, among the little shoots at the base, the pale pink plasmodium of this species could be seen oozing out, during the third week of September in spite of nine months of phenomenal drought. It later matured into five large healthy aethalia, very inconspicuous against the silver grey bark of the tree. The following year, almost day for day, another group appeared, no longer on the living bole but inside an old hollow stump full of touch wood.

93. *L. epidendrum* Fr. A very common and attractive species and one of the earliest to be found. If the weather be not too dry it may be seen any time between March and October on decayed wood of lime, poplar, pine, chestnut, alder, etc.

*94. *Trichia verrucosa* Berk. has only twice been obtained in Surrey; at Oxshott in October 1904 and at Weybridge in March 1921. In each case it was on fir wood; the March specimens consisted of some thirty sessile sporangia, closely clustered and very suggestive of *T. favoginea*; but the granular deposits on the sporangial wall, the slender elaters and smaller meshes of the spore net, put the identification beyond a doubt.

95. *T. affinis* de Bary though common all the year round, is more plentiful in early spring and autumn on lime and poplar wood. "Hemitrichia" forms, collected after the first frosts had started in November, showed considerable variety in spore and capillitium. One had a denser network and thick-walled elaters, another extremely thick-walled elaters with a more constant series of spiral bands. The thicker elater was darker and browner than the thinner one. The reticulation of the spore though typical was traced out by very slender and shallow bands.

96. *T. persimilis* Karst. is more common even than the last. Some years it has been so abundant that one could be sure of finding it on every lime log one examined.

97. *T. scabra* Rost. This is more of a winter species and is of frequent occurrence throughout the county from October to March, especially on the wood of lime, poplar and oak.

98. *T. varia* Pers. In keeping with the specific name of this most common species one occasionally comes across some very strange forms. Not unfrequently the elaters have a double point at the end. I have seen some that branched acutely like a clothes peg, others with two prongs at right angles or again with a rounded end and two little growths like ears. In one case even some of the spores had wing-like appendages.

99. *T. contorta* Rost. has been found at Reigate and Weybridge on the bark of an overturned white poplar. It is not so

frequent as var. *inconspicua* which is fairly common in March and has even been recorded as late as May on the wood of poplar, laurel, *Acer platanoides* and especially on holly. Specimens of *Hemitrichia Karstenii*, *Perichaena corticalis* and *T. contorta* var. *inconspicua* were all found growing together on the same log of holly wood, looking so much alike that it was impossible to say, with the unaided eye, which was which.

*100. *T. alpina* R. E. Fries (= *T. contorta* Rost. var. *alpina* R. E. Fr.). It is unusual to come across an Alpine species in the lowlands of Surrey, but such was the case last April, when the first British record of this remarkable species was found on black rotting laurel leaves, in a damp ditch at Weybridge. Hitherto it has been recorded only from the mountainous heights of Sweden, Switzerland and Austria. It was not plentiful, in fact there was only one small group, consisting of three plasmodiocarps and two sporangia. It was a black, thick-walled specimen, with bright yellow, rather thick, rugged capillitium, often forming loops. The sporangium wall was composed of three layers: the innermost pale yellow and membranous, spinose or papillose; the middle one brown and horny and the outermost merely a crust of dark granular matter. The plasmodium was rich orange red; the spores 12–18 μ, minutely warted; the capillitium orange yellow 4–5 μ wide furnished with small spines and spirals studded with warts.

*101. *T. lutescens* Lister. This is one of the rarer mycetozoa and has been recorded from only five other counties so far, viz. Somerset, Worcester, Devon, Norfolk and Yorkshire. It was first found in Surrey at the end of November 1920, on a bitterly cold day with a strong north-easter blowing and frost on the ground. Nothing but the arrival of a fellow enthusiast would have induced me to go out. The little gold specks gleaming through the ice caught my eye and, eventually, some forty or more sporangia were found, scattered over a thoroughly rotten alder branch. In December the same year another large colony was discovered on the bark, and between the bark and the outer skin of waterlogged and rotten alder branches. Nearly each individual sporangium had to be cut off separately, as they are scattered and never more than three or four come together in an occasional cluster.

102. *T. decipiens* Macbr. may be gathered any month of the year on rotten wood of lime, beech, oak, etc.

103. *T. Botrytis* Pers. Common. A profuse gathering of an almost sessile and clustered form in January, on rotten alder stumps, showed a wonderful variety of tints and shades from crimson to purple black. In February the usual purple brown gregarious sporangia occurred on laurel branches, in March on

rotten lime wood and ivy leaves, and also in May, July and from October to December. The long stalked almost black specimens are more frequent on coniferous wood.

var. *flavicoma* Lister is a very instructive and interesting variety that makes two distinct appearances in the year. The spring variety is more abundant and robust than that occurring in autumn. The sporangia are sometimes mottled with dark spots, nearly always sessile, scattered or in small clusters. The plasmodium is watery white. The spores measure normally 11–12 μ and are warted, but not unfrequently they vary from 12–20 μ. The sporangium wall is mottled with granular refuse matter. The elater points taper from 20–40 μ. This variety is very abundant in April and has been gathered on leaves of beech, ivy, lime, oak, holly, beech mast, oats and twigs of gorse.

The autumn growth is usually a very tiny solitary sporangium. It has occurred on pine needles and leaves of yew, laurel and rhododendron. Very minute sporangia, invisible to the naked eye, were detected in November on dead leaves of sycamore, along the ribs on the underside of the leaf.

var. *munda* Lister. Laurel bark and old bramble stems provide the chief habitats of this variety which is frequently found in the winter months.

†104. *T. Botrytis* Pers. var. *cerifera* G. Lister was found at Horsley in October and at Weybridge in February and November, always on coniferous wood. Sometimes the sporangia are pale brown without much wax, at other times very dark, almost black, with thick deposits of wax.

†105. *T. floriformis* G. Lister. The only Surrey record of this uncommon species was made in October 1922 at Virginia Water, where it was found mixed up in delightful confusion with *Hemitrichia Vesparium*, to which it bears a very striking superficial resemblance.

†106. *Oligonema nitens* Rost. By no means unfrequent if one looks for it in the right habitat. The chief haunt of this species is wood occasionally submerged or waterlogged, but it is not averse to leaves. In Weybridge it has been found no less than twelve times. It was first reported for the county at Royal Common, where it occurred on dead oak leaves in the bed of a dry pond. It has since been found in every month of the year with the exception of January, March and April, sometimes on sodden branches of silver birch, sometimes on elder, but more frequently on alder, spreading thence for a square inch or more on to fresh grass. In October 1922 a great quantity appeared in a damp ditch on alder leaves in spite of the presence of plenty of rotting branches all round it. Some irregular developments show quite long elaters and monstrous spores completely

covered with a close reticulation of small mesh. *O. flavidum*, which should be met with in similar situations, has so far eluded the vigilance of all hunters in the county.

*107. *Hemitrichia Vesparium* Macbr. has been found at Weybridge in November, inside a decayed stump of Lombardy poplar, at Virginia Water in October and at Horsley in January on an old beech stump.

108. *H. leiotricha* Lister has only once been reported in the county, on a dead beech leaf at Witley in December 1898.

109. *H. clavata* Rost. was discovered in April at Reigate and once, but then plentifully, at Weybridge in October, on a rotting horse-chestnut trunk.

†110. *H. abietina* Lister has made only one recorded appearance in Surrey, on the trunk of a living oak, at Hindhead.

*111. *H. minor* G. Lister var. *pardina* Minakata was first met with in this county in March and April 1922, after a wet spring. The sporangia were growing on rotten stems of ivy among overhanging foliage on a rockery; on another occasion they were on rotting ivy leaves and stems lying on the ground under trees.

112. *H. Karstenii* Lister is frequently encountered on holly bark and the decaying bark of lime sticks especially in November. This species is very variable internally: some specimens collected had faint spirals on the stout walled brown capillitium, while others had pale yellow spores and capillitium, the latter, though very slender and irregular, being marked by distinct spirals.

113. *Arcyria ferruginea* Sauter is of common occurrence in autumn and winter. It has been found from March to May and from October to January on the wood of pine, cypress, oak, alder, fir, yew and larch. I once saw a pine log 4 ft. long and 9 inches in diameter almost covered with thousands of sporangia of this species, yellow forms and the more usual orange-red occurring in the same development.

114. *A. cinerea* Pers. has been met with regularly from February to November, more commonly on lime wood but also on dead leaves and even on old straw.

*115. *A. carnea* G. Lister appeared in October on rotting elder bark and lime sticks, resembling pale forms of *A. incarnata* but distinguishable by the capillitium remaining attached to the cup.

116. *A. pomiformis* Rost. At first glance this is very like a yellow form of *A. cinerea*, but the looser network of the capillitium is diagnostic and the species shows a preference for oak wood. It is frequent from May onwards and has even been recorded on living oak.

117. *A. denudata* Wettstein may be gathered any month of

the year, usually on rotten wood, sometimes on dead leaves or leathery fungi, *e.g. Polystictus versicolor* and *Trametes suaveolens*, also once recorded on living birch and once on living *Acer platanoides*.

118. *A. incarnata* Pers. has frequently been found from November to January and in March, May and July on rotten lime wood, oak or pine, etc.

var. *fulgens* Lister appears regularly every year in November and December in large patches of crimson sporangia on rotten beech.

119. *A. stipata* Lister has only once been noticed in Surrey when Mr E. S. Salmon found it on dead wood at Reigate in 1894.

120. *A. nutans* Grev. is common from June to October more especially on oak wood but also on pine, birch, rhododendron and alder.

*121. *A. Œrstedtii* Rost. makes only a brief autumnal appearance each year. It has twice occurred at Weybridge in September, once on an old pine stump and once on a piece of square cut pine timber and on adjacent leaves.

122. *Lachnobolus congestus* Lister. From January to March and from August to November this species has cropped up more than a dozen times in Weybridge. Only once was it on willow bark and in every other case it was on rotten wood of either white or Lombardy poplar. In August the fresh plasmodium was found and nursed into maturity, thus establishing its colour as opaque white, and corroborating the experience of other observers. Its favourite resort is similar to that of *O. nitens*, except that it prefers poplar wood to alder; twice it has been noticed at a height of two or three feet from the ground. The sporangia are usually heaped, rarely scattered; even then they retain a polygonal shape, showing that this feature is not necessarily due to mutual pressure.

123. *Perichaena depressa* Libert has been found frequently from February to April and from July to December on poplar bark and slender stems of yew twigs.

124. *P. corticalis* Rost. is recorded for every month except May and June. Usually it is on poplar wood but it has occurred also on rotten beech, under the bark on ash sticks and on a dead ivy stem 15 ft. up a tree.

125. *P. vermicularis* Rost. This is distinctly a winter species and has been frequently noticed every year between December and April developing from a watery pink plasmodium. It has appeared on nettle, elm leaves, hops, and the foliage of yew, bramble, holly and beech. A specimen found on a thistle, on top of a haystack, had large spores measuring 15–20 μ.

126. *Margarita metallica* Lister. This little gem is of frequent

occurrence every year from December to April, on bramble stems and wood of rhododendron, willow, laurel and pine.

*127. *Dianema depressum* Lister. I have never been successful in finding this on its favourite haunt, on ash sticks. I have even collected ash sticks in various stages of decay, and kept them in long wet grass for several years, examining them regularly, but "myxo-traps" are not usually successful. I did, at last, come across this species but only once; in March 1921 I found some five or six sporangia on a beech stick lying deep in beech leaves, under a low-growing box bush—just the place where I was hoping to find *Lamproderma atrosporum* Meyl. var. *anglicum* G. Lister and Howard. I have yet to meet the latter elusive species although I have turned over bushels of beech leaves.

*128. *Prototrichia metallica* Mass. has been gathered at Weybridge, on the bark of a fallen laurel branch in November, and on dead bramble stems in December.

The devotees of the Mycetozoa are few in number, but that is possibly because others do not realise what an absorbingly interesting study they make. No other could be more truly called an all-the-year-round hobby than this form of recreation, which, from the multifarious habitats of these little creatures, may be indulged in almost anywhere. I have lifted the snow to find *Lamproderma scintillans, Craterium minutum* and *Didymium squamulosum*; I have seen the little gold specks of *Tr. lutescens* shining through the icy coating of a rotten alder branch; in dripping rain, but clad accordingly, I have collected *Tr. alpina, Margarita* and *Colloderma*, and under a burning sun *Lycogala flavofuscum, Amaurochaete* and *Fuligo*; even the bleak winds of March and April fail to prevent the appearance of *Dianema depressum, Diderma asteroides* and *Lamproderma anglicum*.

Apart, however, from the physical and intellectual benefits, one must not forget to mention the social advantages, for the study of the Mycetozoa has introduced me to a number of fellow enthusiasts whom I am proud to rank among my very best friends. Surely, with such a hobby, one need never know a dull moment.

BRITISH LABOULBENIACEAE.

A CATALOGUE OF THE BRITISH SPECIMENS IN THE THAXTER COLLECTION AT THE BRITISH MUSEUM.

By Winifrede L. Hake.

Up to the present time there have been only two species of the Laboulbeniaceae recorded in British mycological writings, namely *Stigmatomyces purpureus* Thaxt. and *Laboulbenia vulgaris* Peyr. which were noted by Biffen in Trans. Brit. Mycol. Soc. III (1909), p. 83. There is, however, a large collection of slides of the Laboulbeniaceae in the British Museum which were presented by Professor Roland Thaxter in 1909, consisting of specimens from all parts of the world. In this collection there are twenty-six British species, five of which have so far only been found in this country, making a total of twenty-eight species. A large proportion of the specimens were collected in the suburbs of London and it seems probable that there may be many more species as yet undiscovered.

The hosts are mainly small beetles belonging to the family Staphylinidae of which the common Devil's Coach Horse beetle is perhaps the most familiar example, and others of the Caratidae which is the family that includes all the ordinary Ground beetles.

Thaxter in his 1896 Monograph describes the likely places to find the hosts, which is in the vicinity of water, under stones, rubbish, among grass roots and so on, and he further states that "5 to 50 per cent. of the hosts will be infected."

The following list gives the details of each slide and is arranged according to Thaxter's order in his second monograph. Species which have so far been recorded only from this country are indicated by an asterisk.

In order to economise space in the references "Mon. (1896)" and "Mon. (1908)" are used to refer to Thaxter's "Monograph of the Laboulbeniaceae" in the Memoirs of the American Academy of Arts and Sciences, XII (1896), and "Contribution toward a monograph of the Laboulbeniaceae, Part II," in the same publication, XIII (1908), respectively.

DICHOMYCES.

D. vulgatus Thaxt. in Proc. Amer. Acad. Arts and Sci. XXXV (1900), p. 424; Mon. (1908), p. 251, pl. XXXI, figs. 5–9.

On *Philonthus varians* Peck. Ealing. B.M. No. 359.

In the collection there are two slides both numbered 359, one of which is a co-type. The perithecium in this genus may have a "slightly recurved ear-like outgrowth," as seen in two specimens on No. 359 co-type or this outgrowth may not be developed as in the five specimens on the second slide.

[On *P. dimidiatus* Erich. Notting Hill, England. B.M. No. 761: not in the collection.]

D. hybridus Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 423; Mon. (1908), p. 253, pl. xxxi, figs. 15–19.

On *Philonthus ventralis* Grav. Ealing. B.M. No. 360.

There are three specimens on the slide showing only one type of perithecium without the ear-like outgrowths characteristic of the smaller kind.

D. biformis Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 422; Mon. (1908), p. 254, pl. xxxiii, figs. 1–5.

On *Philonthus umbratilis* Grav. Leicester. B.M. No. 362.

There is only one specimen on the slide which is stated to be immature.

CHITONOMYCES.

C. melanurus Peyr. in Sitz. k. Akad. Wissen. Wien, lxviii, Abt. i, 8 (1874), p. 250, pl. iii, figs. 30–34; Thaxt. Mon. (1896), p. 289, pl. xxvi, fig. 19; Proc. Amer. Acad. lii (1916), p. 4.

On *Laccophilus minutus* Sturm. England. B.M. No. 487. Co-type.

In all six specimens no appendages are present except that in one case broken remains of one are seen on the terminal cell of the receptacle.

C. paradoxus (Peyr.) Thaxt. in Proc. Amer. Acad. xxvii (1893), p. 32. *Heimatomyces paradoxus* Peyr. in Sitz. k. Akad. Wissen. Wien, lxviii, Abt. i, 8. (1874), p. 251, pl. iii, figs. 35–39; Thaxt. Mon. (1896), p. 287, pl. viii, figs. 17–21.

On *Laccophilus minutus* Sturm. England. B.M. No. 487 bis. Co-type.

Of the seven specimens, one shows the characteristic horn-like outgrowth of the perithecium particularly well.

MONOICOMYCES.

**M. Brittanicus* Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 413; Mon. (1908), p. 269, pl. xxxv, figs. 3 and 4.

On *Homalota insecta* Thom. Paisley. B.M. No. 455. Co-type.

The slide in the collection has four specimens.

"This species is nearly related to *M. Homalotae* and may prove only a variety. It differs in its more slender form and apparently also in the characters of the primary appendage, but more abundant and better material is needed to determine to what extent these characters are constant."

HAPLOMYCES.

H. Texanus Thaxt. in Proc. Amer. Acad. xxviii (1893), p. 160; Mon. (1896), p. 270, pl. vii, figs. 5 and 6; Mon. (1908), p. 275.

On *Bledius opacus* Bloch. Isle of Wight. B.M. No. 448. Co-type.

There are two specimens on the slide, one very perfect showing the "spine-like process" of the antheridium.

EUHAPLOMYCES.

**E. Ancyrophori* Thaxt. in Proc. Amer. Acad. xxxvii (1902), p. 25; Mon. (1908), p. 281, pl. xxxvii, figs. 19–21.

On *Ancyrophorus aureus* Fauv. Dumfriesshire. B.M. No. 1091. (Sharp collection.)

There are two species on the slide.

CANTHEROMYCES.

**C. Platystethi* Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 415; Mon. (1908), p. 282, pl. xxxvii, figs. 5–6.

On *Platystethus cornutus* Grav. Kilburn. B.M. No. 449. Co-type.

Three specimens are mounted on the slide, one perfect, showing a perithecium and a small antheridium.

"This species is most nearly related to *C. occidentalis*, which it closely resembles in general form. It is distinguished however by the greatly reduced antheridium which can hardly be made out in mature specimens, as well as by the distal enlargement of basal cell of the appendage."

POLYASCOMYCES.

**P. Trichophyae* Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 415; Mon. (1908), p. 300, pl. xxxvii, figs. 1 and 2.
On *Trichophya pilicornis* Gyl. Farnham. B.M. No. 453. Co-type.
One specimen is mounted on the slide showing the numerous asci in the perithecium and a well developed appendage.

IDIOMYCES.

I. Peyritschii Thaxt. in Proc. Amer. Acad. xxviii (1893), p. 162; Mon. (1896), p. 302, pl. ix, figs. 16–21; Mon. (1908), p. 314.
(i) On *Deleaster dichrous* Grav. British. B.M. No. 223. (Hope Coll., Oxford.)
This slide has three specimens.
(ii) Croydon. B.M. No. 451. Co-type.
This slide is not mentioned in the Monographs.

SYMPLECTROMYCES.

S. vulgaris Thaxt. Mon. (1908), p. 315, pl. l, figs. 14–16. *Teratomyces vulgaris* Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 431.
On *Quedius truncicolus* Fair. British. B.M. No. 435. Co-type.
The slide has five specimens, four of them having perithecia, antheridia and sterile appendages, the fifth lacking perithecia.

TERATOMYCES.

T. Actobii Thaxt. in Proc. Amer. Acad. xxix (1894), p. 98; Mon. (1896), p. 356, pl. x, figs. 9–17; Mon. (1908), p. 316.
On *Actobius signaticornis* Rey. Cowley. B.M. No. 439. Co-type.
"*T. Actobii* has been found in the British Museum on *Actobius cinerascens* Gr. from Merton, England, No. 438." No. 438 is not in the collection, and No. 439 is not mentioned in the Monographs.

RHADINOMYCES.

R. pallidus Thaxt. in Proc. Amer. Acad. xxviii (1893), p. 180; Mon. (1896), p. 306, pl. ix, figs. 7–11; Mon. (1908), p. 318.
(i) On *Lathrobium angustatum* Lac. Folkestone. B.M. No. 441.
Unfortunately this slide has dried and the four specimens are scarcely distinguishable.
(ii) On *Lathrobium quadratum* Puyk. Notting Hill. B.M. No. 444.
There are twenty-one specimens on this slide, one of which shows the remains of a trichogyne.

LABOULBENIA.

L. fasciculata Peyr. in Sitz. k. Akad. Wissen. Wien, lxviii, Abt. i, 8 (1874), p. 248, pl. i, figs. 8–9. *L. brachiata* Thaxt. in Proc. Amer. Acad. xxv (1890), p. 11; Mon. (1896), p. 350; Mon. (1908), p. 330.
On *Patrobus rufipes* Fabr. Britain. B.M. No. 638.
The slide has fourteen specimens mounted on it.

L. Nebria Peyr. in Sitz. k. Akad. Wissen. Wien, lxiv, Abt. i (1871), p. 455, *idem*, lxviii, Abt. i, 8 (1874), p. 249, pl. iii, fig. 29; Thaxt. in Proc. Amer. Acad. xxvii (1893), p. 45; Mon. (1896), p. 320, pl. xiii, figs. 19–21; Mon. (1908), p. 335.
On *Nebria Gyllenhalli* Sch. Whallen. B.M. No. 458.

L. stilici Thaxt. in Mon. (1908), p. 336; var. of *L. subterranea* Thaxt. in Proc. Amer. Acad. xxviii (1893), p. 163; Mon. (1896), p. 320, pl. xiii, figs. 9–11; Mon. (1908), p. 335.
On *Stilicus similis* Ev. Rathay. B.M. No. 446. Co-type.
Of the three specimens mounted one shows an antheridial appendage.

L. pedicillata Thaxt. in Proc. Amer. Acad. xxvii (1893), p. 44; Mon. (1896), p. 319, pl. xiii, figs. 4–8; Mon. (1908), p. 344.
On *Dyschirius globosus* Herbst. England. B.M. No. 349. Co-type.

Four specimens are mounted on this slide, all being of the short form as distinguished from the other form with the elongated perithecial stalk.

L. Rougetii Mont. and Robin in Robin, Hist. Nat. Veg. Par. (1853), p. 622 and Atlas, pl. x, fig. 2; Mont., Syll. Crypt. (1856), p. 250. *L. europaea* Thaxt. in Proc. Amer. Acad. xxviii (1893), p. 167; Mon. (1896), p. 310; Mon. (1908), p. 351.

On *Brachinus crepitans* Linn. England. B.M. No. 347.

Three specimens are mounted on the slide, one of which shows an antheridium on the inner appendage.

"It seems quite certain that what I previously described as *L. europaea* is in reality the species figured by Robin, although the plates are quite misleading, apparently representing individuals in which the appendages have become more or less abnormal through injury. So large a number of European Brachini have been examined on which *L. europaea* is the common species, that there seems no doubt as to the correctness of the reference." Thaxter, 1908.

**L. dubia* Thaxt. in Proc. Amer. Acad. xxxviii (1902), p. 35; Mon. (1908), p. 353, pl. lv, fig. 1.

On *Philonthus politus* Fabr. Alverstoke. B.M. No. 363. Co-type.

Of the six specimens mounted one shows the antheridia very well developed. *L. dubia* "is perhaps too near *L. rigida*, but differs in its copious appendages and in the often pronounced sub-terminal enlargement of the perithecium."

L. Cafii Thaxt. in Proc. Amer. Acad. xxxv (1899), p. 162; Mon. (1908), p. 406, pl. lxiii, figs. 1 and 2.

On *Cafia siriceus* Holme. Britain. B.M. No. 437. Co-type.

There are two specimens, one less mature, of which the antheridial appendages are very short.

"The species is well marked, being clearly distinguished by its appendages, the outer and inner eventually so displaced that they lie nearly side by side, and consisting each of a single series of somewhat obliquely superposed cells which give rise externally to simple single branches, somewhat as in the appendages of the Galerita type.... The species is remarkably constant considering its very wide distribution and is not nearly allied to any other described form."

L. Clivinalis Thaxt. in Proc. Amer. Acad. xxxv (1899), p. 165; Mon. (1908), p. 407, pl. lxi, figs. 5 and 6.

(i) On *Clivina collaris* Herbst. England. B.M. No. 348. Co-type.

This slide has six specimens, one with the appendages very well developed bearing two branchlets at the tip.

(ii) Hammersmith. B.M. No. 456. Co-type.

Two specimens on the slide.

(iii) On *Clivina fossor* Linn. England. B.M. No. 353. Co-type. (Hope Coll., Oxford.)

Six specimens on the slide.

RHACHOMYCES.

R. Philonthinus Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 435; Mon. (1908), p. 424, pl. xliv, figs. 3 and 4.

On *Philonthus* sp. British. B.M. No. 225. (Hope Coll., Oxford.)

The slide has two beautiful specimens both showing the characteristic "stigmatal markings" in the uppper cells of the main axis of the receptacle.

COMPSOMYCES.

C. Lestevi Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 439; Mon. (1908), p. 428, pl. xliii, figs. 9–12.

On *Lesteva sicula* Erich. Redhill. B.M. No. 453.

There are two specimens on the slide No. 453 (neither with antheridia).

[On *Lesteva sicula* Erich. Paisley. B.M. No. 452: not in the collection.]

MISGOMYCES.

M. Dyschirii Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 443; Mon. (1908), p. 430, pl. lxx, figs. 9–10.

On *Dyschirius globosus* Herbst. England. B.M. No. 349. Co-type. (Hope Coll., Oxford.)

EUZODIOMYCES.

E. Lathrobii Thaxt. in Proc. Amer. Acad. xxxv (1900), p. 449; Mon. (1908), p. 444, pl. LXXI, fig. 23.
On *Lathrobium punctatum* Zett. Notting Hill. B.M. No. 442. Co-type.

In concluding I wish to acknowledge my great indebtedness to Mr J. Ramsbottom for the kindly help and advice that he has given me in the preparation of this paper.

THE FUNGUS PRESENT IN LUNULARIA CRUCIATA (L.) DUM.

By W. F. F. Ridler, M.Sc.

With six figures in the text.

Historical Notes.

Kny (1879) recorded that rhizoids of Lunularia and Marchantia were frequently traversed by fungal hyphae, which possessed cross walls, branched occasionally, and were sterile. These hyphae did not reach the thallus tissue except in plants growing on rich humus, where they entered the thallus and ramified through it.

Golenkin (1902) examined numerous species of Marchantiaceae, and recorded the occurrence of endotrophic mycorrhiza in *Marchantia palmata* Nees, *M. paleacea* Bert., *Preissia commutata* Nees, *Targionia hypophylla* L., *Plagiochasma elongatum* Lindenb. and Gottsche and *Fegatella conica* Corda. He observed that cultivated plants of Lunularia as well as other members of the order were quite free from fungus and remained so although infected plants of *Marchantia palmata* and *M. paleacea* were grown in close proximity to them.

Czapek (1889) stated that Fegatella, Marchantia, and Lunularia contain an antiseptic substance "Sphagnol" in combination with the cell walls, which exerts an inhibitory influence on the growth of bacteria and moulds; Cavers (1903) suggested that the Sphagnol may serve to regulate the growth of the fungus, and so prevent symbiosis from passing into parasitism.

Presence of the Fungus.

The examination of plants of *Lunularia cruciata* from various situations has shown that, unlike those of Pellia which are always inhabited by a fungus (Ridler, 1922), they may be heavily or slightly infected by the fungus or quite free from it.

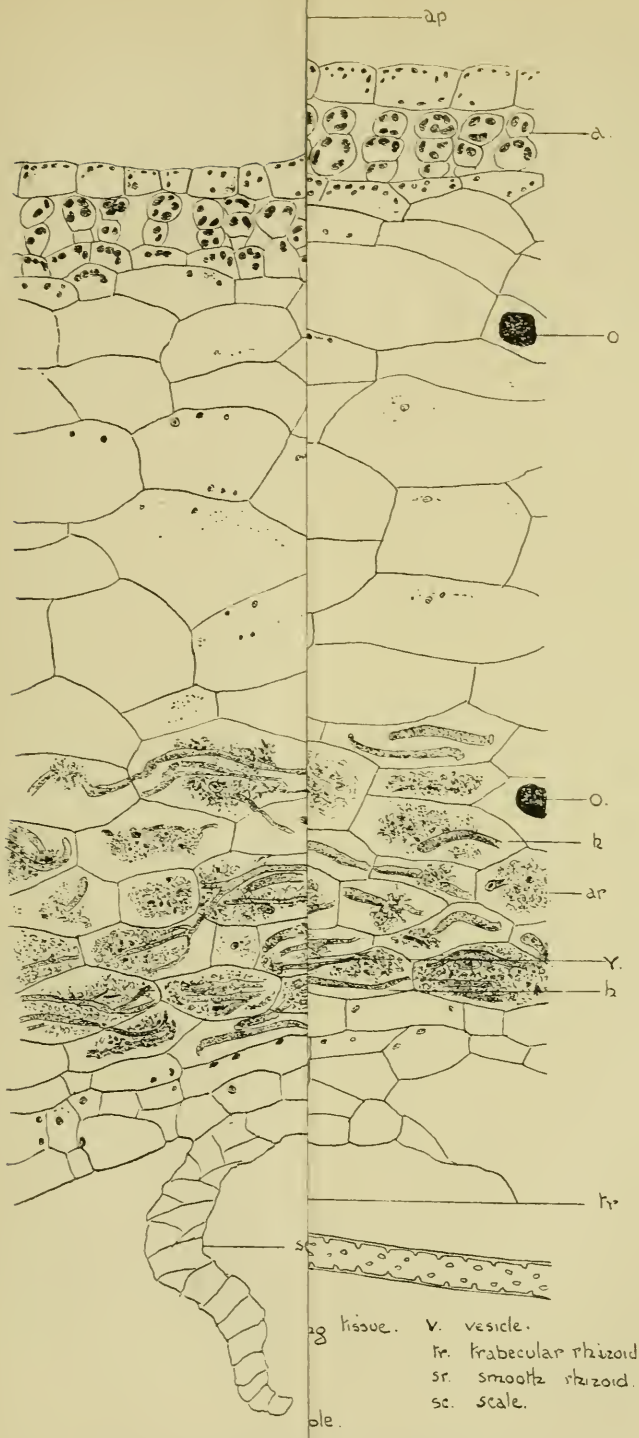


Fig. 1. Longitudinal n of the fungus. × 310.

Fig. 1. Longitudinal section through the thallus of *Lunularia cruciata* showing structure of the thallus and distribution of the fungus. × 310.

Plants growing on a decayed tree-stump in Leigh Woods, Somerset, were found to be heavily infected, but others growing in close proximity to them on a steep bank were quite free from the fungus. Some plants at a short distance from these on a gravelly path were slightly infected, but in others of the same group the fungus was absent. Plants growing on the ground among mosses in Blaize Castle Woods, Gloucestershire, were quite free from infection. Small plants of Lunularia of brownish colour from a yard of the Bristol Museum were heavily infected; the substratum upon which these were growing consisted chiefly of the dead remains of plants of the same species.

The hydrogen ion concentrations of several samples of soil upon which Lunularia was growing were measured by the colorimetric method, the experimental procedure for obtaining the soil solution used being originally described by Golas and quoted by Cavers (1914). All the soils thus tested were black loamy soils. The figures for the P_H values obtained were as follows:

Material	Method of obtaining soil solution	Indication	P_H value
From Museum (infected)	Displacement method	Phenol Red	7·8–8·0
Leigh Woods (uninfected)	,, ,,	,, ,,	7·6–7·8
Leigh Woods (infected)	,, ,,	,, ,,	7·4–7·6
		Brom-thymol-blue	

The presence or absence of infection has apparently no connection with the degree of acidity or alkalinity of the soil. Sections of the thallus when tested showed that the P_H value of both infected and uninfected tissue were about 6·4.

The presence or absence of the fungus in Lunularia is apparently not determined by any environmental factor and its occurrence appears to be merely by chance.

Distribution of the Fungus in the Plant.

In longitudinal sections cut through the midrib of well-infected plants, the region occupied by the fungus is conspicuous as a very definite zone of brownish cells parallel to the lower surface, and in sharp contrast to the remaining colourless cells of the ventral tissue (Fig. 1). In transverse sections this fungus region is seen to consist of a single strand occupying a considerable portion of the ventral tissue of the midrib.

The hyphae enter the thallus through the rhizoids. Usually only the smooth rhizoids contain hyphae, but occasionally they have been observed in the trabecular rhizoids. In a few cases

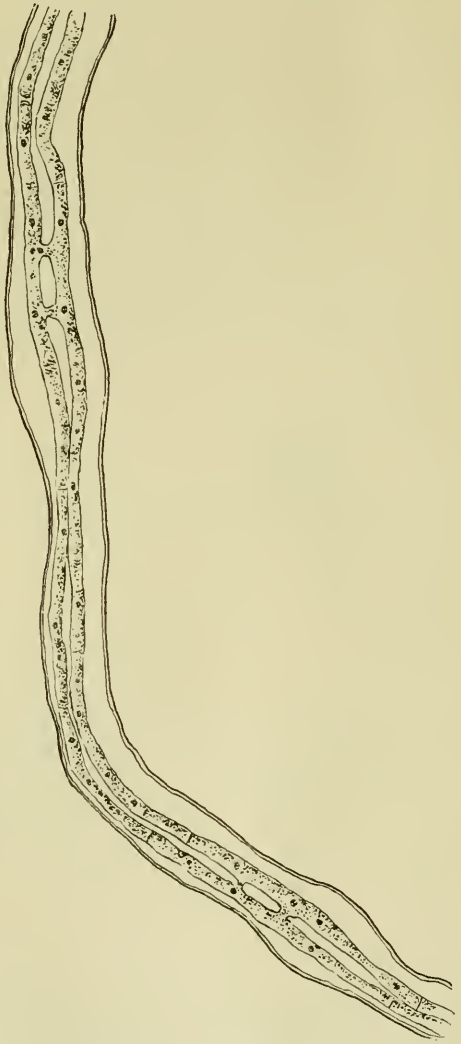


Fig. 2. Anastomosing hyphae in a rhizoid. × 770.

when infected trabecular rhizoids have been examined these have been found to be "smooth" towards the extremity where the hyphae entered, the peg-like thickenings only being de-

veloped near the thallus. Several hyphae may pass up one rhizoid, as many as five having been observed. Cross walls are present at rather long intervals and ladder-like fusions frequently occur (Fig. 2). The fungus branches as soon as it reaches the thallus (Fig. 1), ramifies in it, and, in heavily infected plants, may extend to within 2–3 mm. from the growing point.

In slightly infected plants isolated patches of infected cells occur. These result from the entrance of hyphae into the thallus through a rhizoid immediately beneath the infected tissue. The appearance of the fungus is exactly similar to that in more heavily infected material.

Young plants, not more than 2–3 mm. in length, and developed from gemmae, were found to be heavily infected and the hyphae were similar to those in mature plants. In transverse section of such plants the fungus is seen to occupy the whole of the central portion, in some cases reaching to the base of the assimilating tissue.

Mature plants of Lunularia are normally from 20–25 cells in thickness in the thickened central portion. The lowest three or four layers of cells contain starch grains and are not occupied by the fungus except where hyphae are entering through a rhizoid. With the exception of the oil cells the six to nine layers of cells immediately above contain the fungus. From the remaining six to ten layers of cells of the ventral tissue the fungus is absent (Fig. 1). In very heavily infected plants, the infected zone may reach the base of the assimilating tissue at the wings of the midrib. The assimilating tissue is never entered by the fungus even after the plant is dead. The fungus does not occur among the gemmae. No reproductive organs of the fungus have been found on the material examined.

Behaviour of the Fungus in the Cells of the Thallus.

When sections of infected plants are examined under a high power magnification numerous hyphae are visible, passing from cell to cell. These are relatively massive, measuring from 3·5–7·5 μ in diameter, with granular contents, and are septate at long and irregular intervals. The mode of growth of these hyphae is normally parallel with the lower surface of the thallus. Apparently the cell walls of the liverwort are not injured by the fungus except at the point of penetration. The hyphae usually become constricted before piercing the cell-wall (Fig. 3), so that it is probable that penetration is effected by mechanical means, and that the cell-wall is not dissolved by a cellulose destroying enzyme.

From the main hyphae arise fine, profusely branched hyphal threads, or "arbuscules" (Bernard, 1911; Magrou, 1921) which degenerate into irregular granular masses or "sporangioles" surrounding the main hyphae (Figs. 4 and 5). This granular substance is insoluble in all the ordinary solvents, with chlor-zinc-iodine it turns a reddish-brown colour, and with iodine a yellowish-brown. The Mycosin test for chitin (Wisselingh, 1898) was tried, and after this treatment the "arbuscules," "sporan-

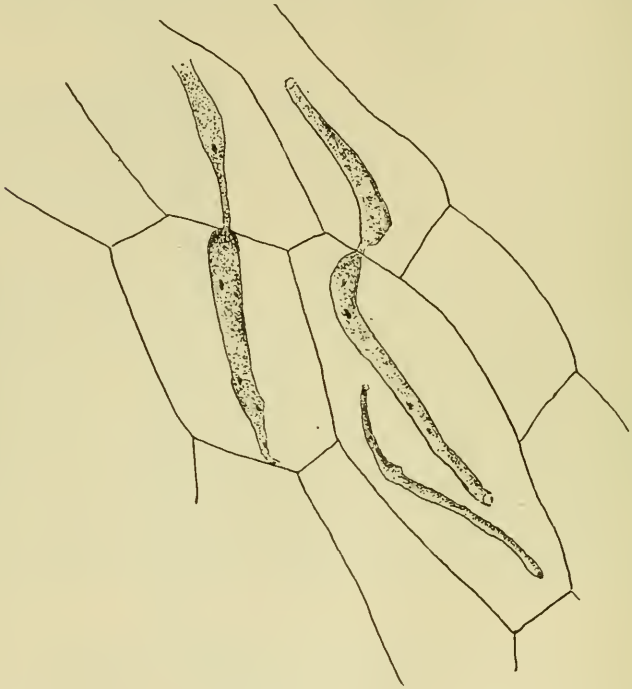


Fig. 3. Hyphae in the cells of the thallus showing method of penetration of the cell-walls. × 770.

gioles" as well as the walls of the main hyphae turned reddish-violet with chlor-zinc-iodine, while the walls of the liverwort turned blue, a similar result being obtained with iodine and a trace of sulphuric acid.

The growth of the fungus is restricted by the formation of the "arbuscules" and their subsequent conversion into "sporangioles." The infected zone is thus strictly localised, and the fungus is prevented from becoming harmfully parasitic. No marked activity of the nuclei in infected cells has been observed as has been described by Burgeff (1909), Magnus (1900) and

others as occurring in the Orchids, and by Shibata (1902) in Podocarpus. In infected cells of Lunularia however they are slightly larger than those in uninfected cells, the former measuring from 3·5–8·0 μ in diameter, and the latter from 3·5–6·5 μ, the average size in the former case being 6·3 μ, while in the latter it is 4·6 μ. In infected cells the nuclei are sometimes slightly deformed.

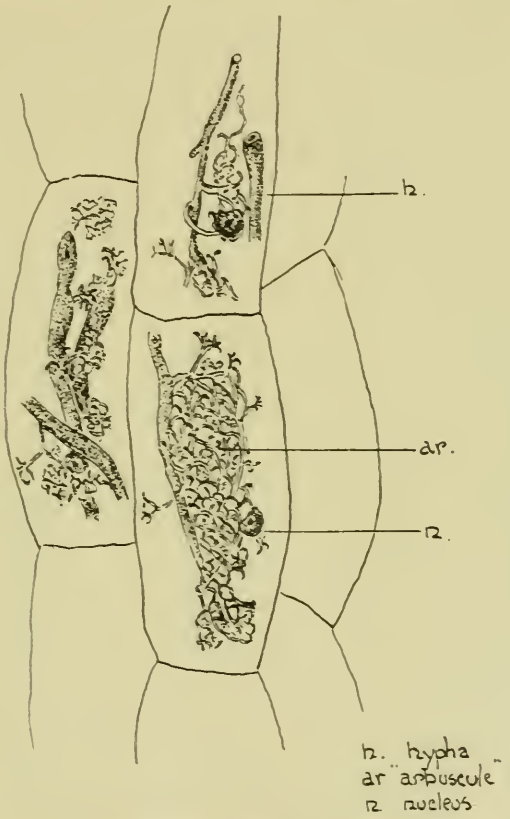


Fig. 4. Cells of *Lunularia* containing "arbuscules." × 435.

In some of the cells of the liverwort large swollen vescicles with dense contents occur, which in younger plants contain oil. In dead thalli these bodies are present in considerable numbers and possess very thick walls and dense contents. It is possible that on the decomposition of dead plants they enter the soil and germinate. When examining the rhizoids of very young plants, similar bodies were observed in close contact with them;

these had lost their contents and had germinated, sending out hyphal threads that penetrated the rhizoids and were growing in them (Fig. 6). This would seem to afford proof of the suggestion that the vescicles form a means of propagating the fungus and infecting the plants. Very few hyphae remain in the thalli of dead plants, and those that are present are for the most part devoid of contents and in various stages of disintegration.

The ventral tissue of uninfected plants of Lunularia was found to contain considerable quantities of starch. When infected thalli were examined, it was found that the cells immediately below, and those immediately above the infected cells contained starch, the infected cells themselves however contained none; it would appear therefore that the presence of the fungus is responsible for this disappearance of the starch. Stahl (1900) in his "Sinn der Mycorhizenbildung" connected the formation of starch in the thalli of Marchantiaceae with a highly developed transpiratory organisation, and the complete absence or at any rate meagre development of a mycorrhiza; while in the case of the Jungermanniaceae he connected the formation of sugar in the leaves with low transpiratory activity, and the extensive occurrence of mycorrhiza. It is now certain, however, that the occurrence of mycorrhiza in the Marchantiaceae is as frequent as in the Jungermanniaceae. Moreover, the large quantities of starch present in the former group, and also in Pellia, Fossombronia and other members of the anacrogynous Jungermanniales and which indicates, according to Stahl, vigorous transpiratory activity, does not seem to bear out his hypothesis that the amount of transpiratory activity is connected with the presence or absence of a mycorrhiza in the Hepaticae.

The presence of Sphagnol in the thallus was tested for, but it was found only in the walls of the upper epidermal cells in both infected and uninfected material; it is unlikely therefore that it has anything to do in this case with the regulation of the growth of the endophytic fungus, but more probably serves to prevent bacteria and moulds from penetrating the upper surface and causing disease.

Isolation of the Fungus.

Pieces of the thallus were teased out with a sterilised platinum needle, immersed in 1 per cent. mercuric chloride solution, washed in sterilised distilled water and placed on plates containing agar and some nutrient substance. Thick sections of the liverwort were also placed on nutrient media without previous sterilisation. All cultures were kept in the dark at

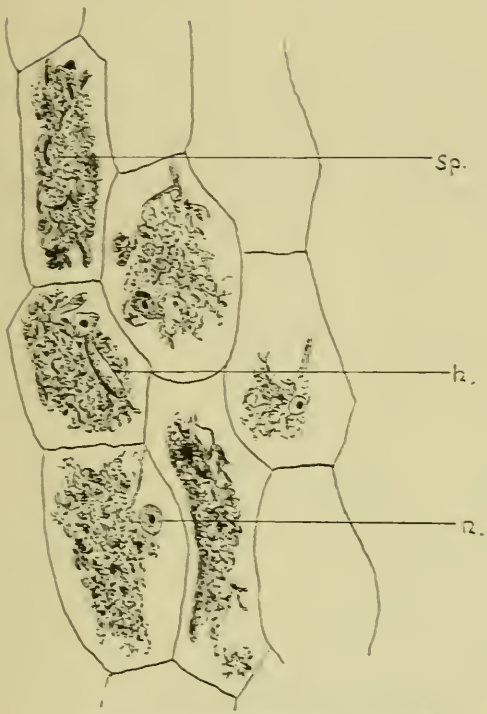


Fig. 5. Cells of *Lunularia* containing "sporangioles." × 435.

Fig. 6. Infection of young rhizoid from germinating vesicle. × 770.

room temperature. A pycnidia-producing fungus was constantly isolated during these trials. This fungus was identified as a species of Phoma but it is not the same species as that isolated from the sporophyte of *Pellia epiphylla* as its behaviour on artificial media, and the shapes and dimensions of the spores are dissimilar. Numerous attempts have been made to re-inoculate the fungus thus isolated into uninfected plants of Lunularia but these have not yet proved successful. Notwithstanding the constant isolation of the fungus in the cultures it is not certain that it is the true endophyte.

Isolation and Culture of Lunularia.

The gemmae of Lunularia being quite free from the fungus, it was found possible to obtain pure cultures of the liverwort from them. For this purpose, large test-tubes 1½ inches in diameter, were used. A quantity of nutrient liquid medium was placed in the bottom of the tube, and a strip of filter paper was introduced, which dipped into the liquid at the bottom, and covered about half the surface of the tube. The tubes were plugged tightly with cotton wool and sterilised in the autoclave.

The liquid medium used was one of those employed by Servettaz (1913) in his experiments on the development of mosses on sterilised media, namely the solution of Knop modified, as given below:

Calcium nitrate	1 gr.	Potassium phosphate	0·5 gr.
Potassium nitrate	0·5 gr.	Ferrous sulphate	0·5 gr.
Magnesium sulphate	0·5 gr.	Distilled water	1000 c.c.

Gemmae were removed from their cups with a platinum needle and sown with aseptic precautions on the strips of filter paper described above. The tubes were then placed in front of a window which faced north, so that they might be in the most favourable position with regard to light.

This method proved very successful. The gemmae were sown in December 1921, by May 1922, that is six months afterwards, they had produced very healthy thalli which in turn bore gemmae cups. By the beginning of June the gemmae produced on these plants had become scattered over the surface of the filter paper and glass sides of the tubes and in their turn had begun to germinate.

The plants on examination proved to be quite free of fungus. It is therefore certain that the liverwort can grow as well without as with it. The plants produced by this method of cultivation were larger and more healthy in appearance than any of the infected material examined. The artificial conditions of culture however might account for this. The thalli measured

from 25–35 mm. long and from 8–12 mm. broad and were bright green in colour.

Discussion.

It is very difficult to determine whether or not the fungus is of any actual use to the liverwort. The fungus apparently obtains some carbohydrate material from the liverwort; on the other hand, the partial digestion of the fungus, and the possible absorption of the contents of the latter may compensate for the loss.

The fact that the association is not constant indicates that at any rate under certain conditions in nature the fungus is not necessary for the growth of the plant, that is, the association is not obligate, but purely facultative. Reproductive organs of this liverwort are very rare, and none have been found either on infected or uninfected material used in the present investigation, so that apparently the presence or absence of the fungus has no effect on their formation. Gemmae cups are as frequent on infected as on uninfected plants. Neither is there any very definite evidence that the presence of the fungus has any effect on the size of the plants.

From these facts it appears that the fungus is of little or no use to the liverwort, and must be regarded as a harmless parasite.

Summary.

1. The cells of the thallus of *Lunularia cruciata* contain a fungus which occurs in a single strand of cells along the thickened median portion or midrib, towards the ventral surface of the thallus. The occurrence of the fungus however is not constant.

2. The fungus present undergoes partial digestion by the liverwort, ending in the formation of "arbuscules" and "sporangioles"; its growth and consequent distribution in the thallus is thus restricted.

3. Starch disappears from the cells after the entrance of the fungus.

4. A fungus has been isolated from the thallus and identified as a species of Phoma, but it is not yet certain whether this is the true endophyte.

5. Uninfected plants of Lunularia have been grown on an artificial medium.

6. The fungus obtains carbohydrate material from the thallus as a source of food material. The liverwort, on the other hand, is not apparently benefited by the presence of the fungus.

7. The association between the fungus and the liverwort is considered to be harmless parasitism on the part of the fungus.

My thanks are due to Mr C. T. Gimingham for information regarding the displacement method of obtaining soil solutions; to Mr C. Hunter for much valuable help and advice; and to Professor O. V. Darbishire for his interest in the work. During the progress of this investigation I have been in receipt of a maintenance grant from the Department of Scientific and Industrial Research.

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THE GENUS TRICHOSTERIGMA PETCH.

By T. Petch.

In the Transactions of the British Mycological Society, VIII, p. 215, the writer proposed a new genus of *Stilbaceae*, Trichosterigma, for the reception of three species of fungi parasitic on insects. It has since, however, transpired that a genus was founded on a fungus similar to these several years ago, and the name Trichosterigma must consequently be discarded.

In 1912, Speare published an account of the fungi parasitic upon insects injurious to sugar-cane in Hawaii (Bull. No. 12, Pathological and Physiological Series, Hawaiian Sugar Planters' Association), in which he described and figured, under the heading "Sterile Cordyceps," a conidial fungus parasitic on a leaf hopper. Subsequently, Speare further investigated this and other similar fungi, and came to the conclusion that they should be included in the genus Hirsutella Pat. Speare's account of these species of Hirsutella was published in a paper entitled "On certain entomogenous fungi," in Mycologia, XII (pp. 62–76, 1920).

The genus Hirsutella was established by Patouillard in 1892 (Rev. Myc. XIV, p. 69) on a species, *Hirsutella entomophila*, which was found on an undetermined coleopteron in Ecuador. The fungus formed erect clavae, covered with scattered ovoid basidia, each basidium bearing a single elongated sterigma, with a single terminal, lemon-shaped spore. Patouillard noted that the basidia were scattered, and that there was no subhymenium, but he nevertheless regarded the fungus as a Basidiomycete, and included in the *Clavariaceae*. In his Essai Taxonomique (1900), Patouillard extended the genus to include species with tetrasporous basidia.

There does not appear to be any doubt that Speare's conclusion is correct, and that *Hirsutella entomophila*, the type species of the genus, is a Hyphomycete. Speare has also shown that the actual spore is elongated or fusiform, and that the "citriform" appearance is due to a covering of mucus deposited round the spore in such a way as to render it uniformly lemon-shaped. Spores may be found lacking this mucous covering, or it may have sagged down to the base of the spore so that the whole appears obcordate.

Trichosterigma Petch is synonymous with Hirsutella Pat. Of the species described by me (*loc. cit.*), *Trichosterigma attenuatum* Petch = *Hirsutella citriformis* Speare. *Trichosterigma clavisporum* Petch and *Trichosterigma arachnophilum* Petch must be known as *Hirsutella clavispora* and *Hirsutella arachnophila* respectively.

Throughout the tropics there occurs a fungus, parasitic on hornets, which manifests itself as long black hairs projecting in all directions from the body of the insect. This has usually been regarded as an Isaria, but solely from the fact that it grew on an insect, no one having observed any form of fructification on it. Cooke named it *Isaria Saussurei*. Speare has found that this fungus in Hawaii, California, and the West Indies is a Hirsutella, and has adopted the name *Hirsutella Saussurei* for it. The corresponding Ceylon form is also a Hirsutella, and apparently the same species. It might be considered doubtful whether this species is identical with *Isaria Saussurei*, since the clavae of the latter were said to be orange, but it would seem most probable that the colour was wrongly described.

As noted by Speare, no ascigerous stage has hitherto been recorded for any species of Hirsutella, though he considers that these forms are probably the imperfect stages of Cordyceps or an allied type. During a recent examination of a collection of Ceylon species of Cordyceps, it was found that *Cordyceps unilateralis* (Tul.) Sacc. has a Hirsutella conidial stage, the apex of the clava being at first conidial. Further, *Hirsutella arachnophila* has been found in association with a Torrubiella, and though the two have not been found together on the same stroma there is little doubt that the Hirsutella and the Torrubiella are stages of the same fungus. Speare's surmise is consequently correct.

SPORE FORMATION IN RHACODIUM CELLARE PERS.

By J. H. V. Charles.

Rhacodium cellare Pers., the fungus which covers bottles in wine cellars as with cobwebs, has been classified in standard works on fungi, *e.g.* Rabenhorst's Kryptogamen Flora, Saccardo's Sylloge Fungorum, and Engler and Prantl's Pflanzenfamilien, as one of the "Mycelia sterilia."

The volume of Rabenhorst's Kryptogamen Flora containing the description of this fungus was published in 1910, and it is somewhat remarkable that no mention is made therein of a long paper on *Rhacodium cellare* by Guéguen which appeared in the Bulletin de la Société Mycologique de France for 1906*. Guéguen clearly described a process of spore formation in this

* Attention was directed to this paper by Mr J. Ramsbottom.

fungus, thus removing the fungus from the category of "Mycelia sterilia" to the Dematiaceae.

Some time ago Mr F. T. Brooks handed me a specimen of this fungus for cultural study, and the object of this note is to call attention to Guéguen's important paper upon it and to confirm his observations upon the process of spore formation.

Spore production is readily observed in hanging-drop cultures established from a fragment of mycelium. The conidiophores are branched and bear oval conidia sometimes abstricted in chains. These conidia are capable of germination. The conidiophores are somewhat like those of *Cladosporium*, but, as with the vegetative mycelium of *Rhacodium cellare*, there is always a tendency for the constituent parts of the conidiophores to break asunder and to form independent propagative units. Figures of the spores and conidiophores are given in Guéguen's paper.

A LIST OF FUNGI &c. MAINTAINED IN THE NATIONAL COLLECTION OF TYPE CULTURES.

By R. St John Brooks, M.D., D.P.H., M.A.
and Mabel Rhodes.

In the Transactions of the British Mycological Society, VII (1922), p. 237 a note appeared regarding the work of the National Collection of Type Cultures and its extension from the purely medical and veterinary side so as to include representative fungi derived from various sources. The scope of the mycological collection was made to include cultures of fungi of importance in phytopathology, medical and veterinary science, technical and soil biology, types useful for teaching purposes and any rare or interesting species.

Through the efforts of the standing committee appointed by the British Mycological Society to advise and assist the staff of the Collection in all questions appertaining to fungi, and of mycologists in various parts of the country a considerable amount of progress has already been made. The following list of fungi and of bacteria of economic interest at present maintained in the National Collection has been prepared so that the resources of the Bureau may be made available to as wide a circle as possible. The staff of the Collection are fully conscious of many important omissions and will be glad to have the assistance of members of the Society in filling in these lacunae.

The numbers given are the reference numbers of the cultures maintained in the Collection and should be quoted in all application for type cultures. A small charge is made in most cases, to cover packing and postage expenses.

All communications should be addressed to the Curator, National Collection of Type Cultures, Lister Institute, Chelsea Gardens, London, S.W. 1.

1453 Absidia cylindrospora Hagem
1312 Acanthorynchus Vaccinii Shear
789 Achorion Schoenleinii Leb.
706 Acladium Castellanii Pinoy
1491 Acrospeira mirabilis B. & Br.
1268 Acrostalagmus cinnabarinus Corda
1578 Actinomyces albosporeus Kr. [Waks. & Curt.]
1575 A. albus Kr. [Waks. & Curt.]
1574 A. aureus Waks. & Curt.
1559 A. bobili Waks. & Curt.
600 A. bovis Harz
1561 A. californicus Waks. & Curt.
659 A. caprae Silb.
1569 A. chromogenus Gasp.
1579 A. citreus Kr. [Waks. & Curt.]
1556 A. diastaticus Kr. [Waks. & Curt.]
1573 A. flavus Kr. [Waks. & Curt.]
1564 A. Fradii Waks. & Curt.
1583 A. griseus Kr. [Waks. & Curt.]
1568 A. Halstedii Waks. & Curt.
1572 A. lavendulae Waks. & Curt.
1585 A. Lipmanii Waks. & Curt.
1566 A. pheochromogenus Conn
1570 A. purpeochromogenus Waks. & Curt.
1565 A. reticuli Waks. & Curt.
1555 A. reticulus-ruber Waks.
1558 A. roseus Kr. [Waks. & Curt.]
1562 A. rutgersensis Waks. & Curt.
1563 A. scabies (Thaxter) Güssow
1577 A. Verne Waks. & Curt.
1557 A. violaceus-caesari Waks. & Curt.
1567 A. violaceus-ruber Waks. & Curt.
1582 A. 104 Waks.
1586 A. 145 Waks.
1584 A. 128 Waks.
576 A. 161 Waks.
581 A. 168 Waks.
560 A. 206 Waks.
571 A. 218 Waks.
313 Allescheria Boydii Shear
300 Alternaria panax Whetz.
301 A. Solani (Ell. & Mart.) Jones & Grout
314 Anthostomella destruens Shear
778 Aplanobacter michiganense E. F. Sm.
595 Aspergillus candidus Link
1325 A. carbonarius (Bainier) Thom
978 A. clavatus Desm.
973 A. effusus Tiraboschi
596 A. flavus Bref.
982 A. fumigatus Fres.
1326 A. fumigatus Fres. (Ascosporic)
1017 A. luchuensis T. Inui
795 A. nidulans Eidam
594 A. niger v. Tieghem
979 A. ochraceus Wilh.
598 A. Oryzae (Ahlburg) Cohn
975 A. parasiticus Speare
1324 A. pulverulentus Thom
794 A. repens de Bary
980 A. Sydowii Bain. & Sart.
599 A. tamari Kita.
981 A. terreus Thom
974 A. terricola March. v. americana March.
597 A. Wentii Wehm.
1078 Azotobacter chroococcum Beij.
Bacterium, Bacillus.
612 B. aceti Hansen
1068 B. acetoethylicum Northrop
413 B. acidi lactici Hueppe
1283 B. acidophilus Bjeloussow
1229 B. angulatum
1623 B. aptatum N.A.Br.
76 B. bulgaricus Luerssen & Kuhn
619 B. butylicus Weizm.
1650 B. butyricus Hueppe
386 B. caratovorus Jones
1381 B. caryocyaneus
1232 B. citri Hasse
1652 B. corallinus Heff.
927 B. dendroides Holzm.
1385 B. denitrofluorescens liquefaciens
1656 B. denitrificans Burri & Stutz.
912 B. fluorescens non liquefaciens Lehm. & Neum.
950 B. fluorescens liquefaciens Flügge
1174 B. fulvum Zimm.
661 B. Guentheri Lehm. & Neum.
614 B. Kuetzingianum Hans.
389 B. Lathyri Manns & Tauberhaus
1646 B. Malvacearum E. F. Sm.
1243 B. marginale N. A. Br.
654 B. megatherium de Bary

656 B. mesentericus (Flügge) Migula
1023 B. mesentericus Jordan Lloyd Type A
1024 B. mesentericus Jordan Lloyd Type B
1025 B. mesentericus Jordan Lloyd Type C
1026 B. mesentericus Jordan Lloyd Type D
1027 B. mesentericus Jordan Lloyd Type E
962 B. mesentericus panis viscosi Vogel
1098 B. mesentericus ruber Globig
1097 B. mesentericus vulgatis Flügge
1360 B. methanicus Söhn
957 B. mori Boyer & Lamb
926 B. mycoides Flügge
613 B. Pasteurianum Hansen
1543 B. phosphorescens Fischer
1404 B. prodigiosus (Ehrb.) Lehm. & Neum.
403 B. proteus mirabilis Hauser
401 B. proteus vulgaris Kruse
1376 B. radiobacter (Beij.) Lohnis
1655 B. rossicum Kell.
385 B. solanisaprus Harrison
85 B. subtilis (Ehrb.) Cohn
1231 B. tabacum Wolf & Foster
1237 B tumefaciens Smith & Townsend
1490 B. Truffautii Truffaut
1654 B. ureae Leube
1010 B. vesicatorium
1539 B. violaceus (Schroet.) Lehm. & Neum.
1242 B. viridilividum N.A.Br.
1244 B. vitians N.A.Br.
620 B. volutans Thaysen
972 B. "X" A.Br.
1375 B. xylinum A.Br.
1659 Beauveria densa (Link) Picard
1642 Blastomyces "Sydney." Human Pathogen
1641 B. "M. H." Human Pathogen
1261 Botryosporium longibrachiatum (Oud.) Maire
1494 Botrytis Allii Munn
1142 B. Bassiana Bals.
852 B. cinerea Pers.
1189 B. cinerea Pers. Biological strain (Fig)
1075 B. cinerea Pers. Biological strain (Quince)
1138 B. Paeoniae Oud.
1448 B. pyramidalis (Sacc.) Johnson
1496 B. Tulipae (Lib.) Hopk.
1222 Catenularia fuliginea Saïto
1603 Cephalosporium Asteris Dowson
1145 C. Sacchari Butl.
1131 Cephalothecium roseum Corda
1315 Ceuthospora lunata Shear
606 Citromyces B. Wehm.
1182 Cladosporium fulvum Cooke
1649 Clostridium Pasteurianum Winogr.
884 Coccidioides immitis Rixf. & Gilchr.
1606 Colletotrichum Lindemuthianum (Sacc.) Bres.
1194 C. lincolum Pethyb. & Laff.
1130 C. phomoides (Sacc.) Chester
767 Cryptococcus farcinosus Rivolta
1204 Cytosporina ludibunda Sacc.
1184 C. Ribis P.Magn.
477 Debaryomyces globosus Klöck.
1547 Dematium pullulans de Bary
1358 Diplodia Corchori Syd.
1474 D. natalensis Evans
1133 Diplodina Lycopersici (Cooke) Hollós
703 Endodermophyton indicum Castell.
1420 Epidermophyton Pernetii Castell.
702 E. rubrum Castell.
986 Fumago vagans Pers.
1096 Fusarium coeruleum (Lib.) Sacc.
1136 F. Dianthi Prill. & Del.
1082 F. Lini Bolley
1296 F. sporotrichoides Sherb.
1454 Gliocladium penicillioides Corda
1465 Gloeosporium caulivorum Kirchn.
1317 Glomerella rufomaculans Vaccinii Shear
1318 Guignardia Vaccinii Shear
816 Hansenia apiculata Schmitz
817 H. apiculata Rees
478 Hanseniaspora valbyensis Klöck.
1319 Helminthosporium inaequale Shear
1357 H. Sacchari Butl.
705 Hemispora rugosa Castell.
1137 Heterosporium echinulatum (Berk.) Cooke
947 Lactobacillus pentoaceticus Fred, Peterson & Davenport
925 Leptothrix. Human Pathogen
1660 Metarrhizium Anisopliae (Metsch.) Sor.
1630 Micrococcus aurantiacus Cohn
1027 M. badius Lehm. & Neum.
1657 M. candicans Flügge
1628 M. concentricus Zimm.
1629 M. flavus (Flügge) Lehm. & Neum.
195 M. roseus (Rumm) Lehm. & Neum.
1631 M. sulphureus Zimm.

1489 Microsporum pubescens flavescens Kaps.
714 Monilia albicans (Robin) Zopf.
922 M. candida Bon.
698 M. krusei Castell.
697 M. macedoniensis Castell.
707 M. Pinoyi Castell.
1063 M. psilosis Ashford
696 M. tropicalis Castell.
797 M. variabilis Lindner
699 M. zeylanica Castell.
1124 Mucor hiemalis (+) Wehm.
1125 M. hiemalis (−) Wehm.
1121 M. lusitanicus Brüderlein
1120 M. mucedo Linn.
1123 M. plumbeus Bon.
1122 M. racemosus Fres.
921 M. Rouxii Wehm.
1126 M. sphaerosporus Hagem
1446 Monosporium acuminatum Bon. v. terrestre Sacc.
1470 Mycobacterium album Sohn.
1472 M. lacticola Sohn.
1469 M. luteum Sohn.
1471 M. phlei Sohn.
1468 M. rubrum Sohn.
819 Mycoderma cerevisiae Desm.
1143 Nectria diversispora Petch
1040 Nocardia indica Kanth.
576 N. lutea Christop. & Arch.
700 Oidium asteroides Castell.
701 O. rotundatum Castell.
923 O. lactis Fres.
1661 Oospora crustacea (Bull.) Sacc.
1062 Parasaccharomyces Ashfordii And.
580 Penicillium brevicaule Sacc.
581 P. brevicaule Sacc. v. album Thom
582 P. camemberti Thom
583 P. camemberti Thom v. Rogeri Thom
602 P. candidum Link
589 P. chrysogenum Thom
590 P. divaricatum Thom
593 P. expansum Link
763 P. glaucum Link
584 P. lilacinum Thom
585 P. luteum Zukal
983 P. oxalicum Currie & Thom
1151 P. pinophilum Hedg.
586 P. purpurogenum Fleroff.
588 P. Roquefortii Thom
1290 P. roseum Link
592 P. rugulosum Thom
591 P. spinulosum Thom
1321 Pestalozzia Guepinii Vaccinii Shear
1135 Phoma alterniariaceum Brooks & Searle
1383 Photobacterium phosphorium
1444 Phyllosticta prunicola Sacc.
1457 Phytophthora Cactorum (Cohn and Lebert) Schroet.
1192 P. erythroseptica Peth.
1462 P. Fagi Hart.
1463 P. infestans de Bary
1426 P. palmivora Butl.
1188 P. parasitica Dastur
1461 P. Syringae Kleb.
481 Pichia alcoholophila Klöck.
483 P. calliphorae Klöck.
901 P. farinosa Lind.
479 P. membranifaciens Hansen
480 P. polymorpha Klöck.
482 P. suaveolens Klöck.
1451 Pleurage verruculosis Jensen
1195 Polyspora Lini Laff.
1427 Pseudomonas citriputeale Sacc.
393 P. Barkeri
388 P. campestris Pammel
387 P. Hyacinthi Wakk.
958 P. Phaseoli E.F.Sm.
394 P. proteomaculans Paine
1645 P. radicicola Beij.
392 P. Tolaasii Paine
933 P. Denitrifying
499 Pseudosaccharomyces africanus Klöck.
490 P. antillarum Klöck.
497 P. apiculatus (Rees) Klöck.
492 P. austriacus Klöck.
485 P. corticis Klöck.
491 P. germanicus Klöck.
487 P. indicus Klöck.
498 P. javanicus Klöck.
494 P. Jensenii Klöck.
489 P. Lafarii Klöck.
484 P. malaianus Klöck.
496 P. Muelleri Klöck.
486 P. occidentalis Klöck.
493 P. santacruzensis Klöck.
488 P. Willii Klöck.
1308 Pyronema confluens Tul.
1175 Rhizoctonia destruens Tassi
1077 R. Solani Kuhn.
1087 Rhizopus nigricans Ehrb.
742 Saccharomyces carlsbergensis Hansen
466 S. cerevisiae Hansen (Brewing Yeast)
815 S. cerevisiae Hansen (Baking Yeast)
903 S. cerevisiae Hansen. Frohberg
909 S. cerevisiae Hansen. Logos
906 S. cerevisiae Hansen. Saaz
467 S. ellipsoideus Hansen
812 S. exiguus Hansen
905 S. fragilis Jörgensen
469 S. intermedius Hansen
472 S. marxianus Hansen
743 S. monacensis Hansen
468 S. Pastorianus Hansen
1071 S. pyriformis Ward.

1015 S. sake Yabe
792 S. thermantitonum Johnson
471 S. turbidans Hansen
470 S. validus Hansen
473 Saccharomycodes Ludwigii Hansen
814 Saccharomycopsis capsularis Schionn.
952 Sarcina aurantiaca Flügge
611 S. lutea Flügge
1323 Schizoparme straminea Shear
1014 Schizosaccharomyces mellacei Jörg.
382 S. octosporus Beij.
902 S. pombe Lindn.
476 Schwanniomyces occidentalis Klöck.
1238 Sclerotinia cinerea Schroet. forma Mali
1239 S. cinerea Schroet. forma Pruni
1072 S. fructigena (Pers.) Schroet.
1074 S. sclerotiorum (Lib.) Bref.
1593 S. Trifoliorum Erikss.
1076 Sclerotium cepivorum Berk.
1262 S. Rolfsii Sacc.
1497 S. Tuliparum Kleb.
1595 Septoria nodorum Berk.
1309 Sporodinia grandis Link
406 Sporotrichum Schenkii Hekt. & Perk.
882 S. Councilmanii Walb.
744 S. Gougerotii Matr.
1450 Stachybotrys alternans Don.
963 Staphylococcus cremoris viscosi Hammer & Cordes
1183 Stereum purpureum Fr.
662 Streptococcus acidi lactici Grot.
553 S. bulgaricus Lindn.
1304 S. citrovorus Hammer
628 Streptothrix cameli Mason
658 S. Birt-Leishman
1129 Stysanus stemonites (Pers.) Corda
1128 Thamnidium chaetocladioides Bref.
1127 T. elegans Link
1196 Thielavia basicola Zopf
1223 Thielaviopsis ethaceticus Went.
1260 T. paradoxa (de Seynes) von Höhn.
1134 Torula convoluta Harz.
1302 T. cremoris Hammer & Cordes
1492 T. histolytica Freeman & Weisman
811 Torula pulcherrima Lind.
1303 T. sphaerica Hammer & Cordes
885 T. Horse Pathogen
886 T. Human Pathogen
1452 Trichoderma Koningii Oud.
704 Trichophyton balcaneum Castell.
1116 Tyrothrix tenuis Duclaux
1181 Venturia inaequalis Aderh.
1180 V. pirina Aderh.
1545 Willia anomala Hansen
1546 W. belgica Lindn.
475 W. saturnus Klöck.
904 Yeast. "Kefir"
1639 Y. Mahua, India.
1467 Y. Mineral "Futtehefe"
608 Y. Sternberg "675"
404 Zopfius Zenkeri Rettger
813 Zygosaccharomyces Barkeri Sacc. & Syd.

ON DEMATIUM PULLULANS DE BARY.

By Ismé A. Hoggan, Bathurst Student of Newnham College, Cambridge.

In the course of certain cultural work on fungi, the writer has frequently encountered the form *Dematium pullulans* de Bary. In view of the uncertainty prevalent in recent mycological literature as to the identity of this fungus, the following note was written on the suggestion of Mr F. T. Brooks.

I. Morphological Characters of the Fungus.

The name *Dematium pullulans* was given by de Bary(1) to a fungus commonly occurring on the surface of plants and characterised by small ellipsoid conidia which were abstricted in large numbers in water or in sugar solutions from colourless, branched, septate hyphae, and which budded in the liquid after the manner of yeast cells. When the food supply was exhausted, both hyphae and bud-spores passed into a resting stage; the individual cells became rounded, with thick, dark-coloured membranes, and one or more oil-drops developed. On transference to fresh medium, the resting cells germinated after a short period, each cell sending out a single germ-tube which gave rise to hyaline hyphae abstricting fresh conidia.

The following year Loew(2) published a fuller account of the same fungus, including details of the origin and development of the conidia and the formation of resting cells, or "gemmae," in a medium such as grape-juice. The yeast-like budding of the conidia ceased with failure of the food-supply. In certain of the spores a constriction appeared in the centre, and a transverse septum arose dividing the spore into two cells. Frequently other cross-walls followed, giving rise to a chain of from three to six cells. Other spores increased greatly in size but remained aseptate. The protoplasm became vacuolate and frequently developed a characteristic oil-globule at either pole. While these changes were taking place, the cell-wall gradually thickened and darkened, assuming first a golden, then olive-green or brown hue; numerous drops of oil appeared in the protoplasm. The final stage was reached after about five or six days' culture in grape-juice.

The individual cells of the hyphae underwent similar changes. On transference to fresh medium both these and the gemmae proper sent out hyaline hyphae which rapidly proceeded to abstriction of conidia after the characteristic *Dematium* manner.

II. Systematic Position of the Fungus.

(*a*) *Relationship to* Cladosporium herbarum.

De Bary(3) does not attempt to classify the fungus beyond suggesting that it is probably nearly related to *Fumago* or *Pleospora*.

Loew (*loc. cit.*) draws attention to the striking resemblance between the uniseptate gemmae of *Dematium* and the spores of *Penicillium cladosporioides* Fres. (= *Cladosporium herbarum* Link), adding that they may be distinguished by the small papilla at the base of the *Cladosporium* spore, which is absent from the gemma; or, more surely, by their respective behaviour on transference to fresh medium. Loew further remarks upon the similarity of the resting mycelium of *Dematium* to the hyphae of *Cladosporium*. He did not, however, find any indication of a genetic relationship between the two forms, nor did he succeed in obtaining any *Cladosporium* in cultures of *Dematium*, nor *vice versa*.

These observations have a direct bearing upon the view since held by various mycologists that *Cladosporium herbarum* and *Dematium pullulans* are different forms of one and the same fungus. Thus we find that Saccardo(4) gives the latter as a stage of *Cladosporium herbarum*. In the words of Laurent(5), however, "Cette opinion n'est basée, d'après ce que m'a écrit le botaniste italien que sur l'aspect des filaments myceliens," which cannot be considered as proof of identity.

Laurent is nevertheless of the same opinion as the previous author, and sets forth at length the reasons which led him to adopt this view. His evidence has been reviewed so thoroughly by Planchon(6), however, that it seems best here to repeat in outline the latter's criticisms and refer the reader for details to the original work.

Laurent bases his conclusions on the assertions:

(i) That he observed on several occasions aerial conidiophores of *Cladosporium* developing from the mycelium of *Dematium pullulans* in culture, and

(ii) That he obtained growths of *Dematium* from cultures of spores of *Cladosporium* sown in tubes containing beerwort and placed in sunlight, while similar tubes retained in the dark gave rise to *Cladosporium*.

He also figures a conidiophore of *Cladosporium* in organic connection with a hypha of *Dematium* bearing spores (Fig. 8, p. 585); and he infers that *Dematium pullulans* is "un état affaibli du *Penicillium cladosporioides*."

Planchon examines and questions the purity of Laurent's cultures. He comes to the conclusion that the latter was in

reality dealing with a mixture of the two fungi, and shows that the results cited above are compatible with this hypothesis. For example, Laurent states that on one occasion he found conidiophores of *Cladosporium* arising from mycelium of *Dematium* in cultures of pollen grains in sugar solution, "avec lesquelles il n'était pas possible d'éviter l'envahissement par le *Dematium* des chambres humides placées sous le microscope." The *Dematium* arose as a laboratory contamination; is it not conceivable that *Cladosporium* should originate from a similar cause? The apparent development of one form into the other would doubtless be enhanced by the striking similarity between the two mycelia, to which reference has already been made. These and other facts recorded by Planchon cast grave doubts upon the purity of the cultures.

As to the development of *Dematium* mycelium in the beer-wort tube cultures of *Cladosporium* spores, similar experiments repeated by Janczewski and by Planchon gave negative results. Here again Planchon invokes the hypothesis of a mixed culture; he suggests that *Cladosporium* loses its vitality relatively rapidly and supposes that this fungus perished during the prolonged exposure to sunlight so that the more resistant *Dematium* developed alone.

The more delicate task is to offer an explanation of Laurent's figure of a *Cladosporium* conidiophore in organic connection with a hypha of *Dematium*; this Planchon achieves by asserting the occurrence of growths of *Cladosporium* in which the conidia assumed an abnormal arrangement resembling *Dematium pullulans*. That is to say, the figure is believed to be based on a misinterpretation of the observed facts.

Finally Planchon argues that if *Dematium* be a weakened form of *Cladosporium*, cultivation of either type on similar media should be expected to lead in time to a convergence in the growth forms, which is contrary to fact.

In short, Laurent's evidence alone is not considered sufficiently satisfactory to warrant the assumption of a genetic relationship between the two fungi in question. It now remains to examine any further evidence brought forward in this connection.

Massee(7) ascribes a gummosis of *Prunus japonica* to an undetermined species of *Cladosporium*, and states that the disease was reproduced by inoculation of wounds with the spores of this fungus. The gummy masses exuding from the bark were found to contain hyaline hyphae and also chains of irregular dark cells, the latter on germination producing budding spores. In hanging drops and in flask cultures these brown cells gave rise to a stout, hyaline mycelium abstricting budding spores, and identified as *Dematium pullulans*. Finally, the author

asserts that fragments of sporophores of *Cladosporium* when placed in water also gave origin to the *Dematium* form of reproduction. It must be confessed, however, that this account suggests itself to the writer as one based upon a mistaken identity, in which the brown cells ascribed to *Cladosporium* were in reality the superficially similar gemmae or resting mycelium of *Dematium*. The latter fungus, being particularly abundant on the surface of plants, would be a probable contamination in these circumstances, and in the resting condition would be distinguished only with difficulty from the mycelium of *Cladosporium*.

Other writers(8, 9, 10) assert the identity of the two forms without adducing further proof.

On the other hand, Schostakowitsch(11) never found any trace of *Dematium* in cultures of *Cladosporium* or *Hormodendron*, though these were grown under varying conditions, neither did he obtain the reverse effect. Nor was Berlese(12) any more successful, and this author suggests that the discrepancy in the results of other investigators is due to contamination of the source of supply of the spores. He does not, however, deny the possibility of such relationship.

Planchon (*loc. cit.*) failed equally to establish any connection between the two forms, and, more recently F. T. Brooks(13), in a systematic study of numerous strains of *Cladosporium* isolated from "black spot" of meat and from other sources, found no indication of any connection of this fungus with *Dematium pullulans*.

The writer's own observations point to the same conclusion. Cultures of several strains of *Dematium pullulans* have been studied for some months on various artificial media without disclosing any trace of associated *Cladosporium*.

To sum up, the evidence which has been brought forward as indicating a genetic relationship between the two fungi is dismissed; the existence of such a relationship is denied.

(*b*) *Relationships with Ascomycetous Fungi.*

Turning now to another class of fungi, we find certain forms among the Pyrenomycetes which possess a stage in the life-cycle so closely resembling *Dematium pullulans* as to suggest something more than a mere superficial resemblance between the two.

Such a fungus is *Plowrightia ribesia* Sacc. According to Brefeld(14) the ascospores of this fungus give rise in culture to an abundant mycelium which rapidly develops oval conidia and which presents an appearance strikingly similar to a typical growth of *Dematium*. Moreover the conidia may bud in a yeast-like manner, and, on exhaustion of the medium, gemma-forma-

tion proceeds and the hyphae assume a resting condition upon lines so closely analogous to those previously indicated when speaking of *Dematium pullulans* that Brefeld's account might be applied as truthfully to either fungus.

Similar stages occur in the life-cycles of *Sphaerulina intermixta* (B. & Br.) Sacc. and *Fumago vagans* Pers.

In dealing with *Plowrightia* Brefeld remarks: "Diese Nebenfruchtformen bieten wiederum die grösste Uebereinstimmung mit den vielgenannten *Dematium pullulans*, welches hiermit als ein Sammelname für die Conidienformen verschiedener Ascomyceten erweist"—and, in a footnote—"Dieses *Dematium*, bisher als selbständige Pilzform beschrieben, fügt sich also nicht bloss der *Sphaerulina intermixta*, sondern auch anderen Ascomyceten als Entwicklungsglied ein." That is to say, *Dematium pullulans* as such is no longer regarded as a distinct entity, but as a collective name for the conidial stage of several Ascomycetes. A similar view held by Berlese (*loc. cit.* p. 69) is expressed in the following words: "D'après les études faites, il me semble cependant qu'on puisse plus sûrement affirmer que *Dematium pullulans* est une forme collective, un état spécial d'un certain nombre de champignons non seulement sphériacés mais appartenant aussi à d'autres groupes."

To take the third-mentioned fungus first, Zopf(15) has shown that in the case of *Fumago vagans* the resemblance is a limited one, and the two fungi must therefore not be confused. The agreement is close up to the final stages of gemma-formation, but here the comparison ends. When transferred to fresh medium, the *Fumago* gemmae gave rise to a mycelium bearing pycnidia; in Zopf's words: "...nie aber gelang uns, trotz vielfach modificirter Versuche, sie" (the gemmae) "zu hefeartigen Sprossung zu bewegen; hierdurch unterschieden sie sich wesentlich von den überaus leicht sprossenden Gemmenbildung des *Dematium pullulans*, denen sie in Uebrigen täuschend ähnlich sind." This disposes of *Fumago*.

During the past year the present writer has been working with the fungus *Plowrightia ribesia*, and has attempted an investigation of the relations of this form with *Dematium pullulans*. To this end, cultures of *Dematium* were obtained from various sources—from the surface of oak twigs, from leaves of *Vinca minor*, from isolations from slime fluxes occurring in different localities, and from an old laboratory culture. All strains were grown upon various media side by side with strains of *Plowrightia ribesia* isolated from red and black currant bushes. The cultures were established in nearly all cases from the bud spores.

The six *Dematium* strains corresponded so closely in behaviour

and in morphological characters to the *Dematium pullulans* of Loew and Laurent as to leave no doubt in the mind of the writer that she was dealing with the same fungus. Slight variations in behaviour were noted at times among the different strains, but these were not considered sufficiently marked to necessitate any separation into species as Berlese suggested. On the other hand several striking differences, both macroscopic and microscopic, have been observed between the *Dematium* cultures and those of *Plowrightia*; so that, although the work is still in progress, it is hoped that a preliminary account of the cultures of *Plowrightia* will not be out of place.

(i) *Cultures on currant wood blocks.* The difference in macroscopic appearance of the two forms was here very striking. *Dematium* spores budded in great profusion on the wood, forming a white, slimy mass, which later became almost entirely black as gemma-formation proceeded. Very little or no mycelium developed; this, if present, remained sparse and white.

Plowrightia spores, on the other hand, immediately gave rise to an abundant mycelium extending over the whole surface of the wood, becoming rapidly greyish green or brown in colour and long and fluffy in texture. No trace of budding spores was found. Later, black, club-shaped organs, one to several millimetres long, appeared, possibly perithecial in nature. Nothing corresponding to this was observed in the *Dematium* cultures.

(ii) *Cultures on Dox's agar. Dematium* spores budded for several days forming a white, waxy mass almost bacterial in appearance. Later, hyphae developed on the surface of the slant, bearing masses of conidia. The cultures remained white for several months, or occasionally a slight blackening of the hyphae was observed.

Plowrightia spores behaved similarly at first, but the developing hyphae bore fewer or no conidia. The waxy masses rapidly coloured to a dirty yellow or black, so that the cultures could readily be distinguished from those of the former fungus.

(iii) *Cultures on currant wood-extract agar. Dematium* spores budded for several days, after which a superficial mycelium developed bearing masses of conidia.

Plowrightia spores behaved similarly. After about a fortnight the hyphae and spores had become very dark in colour, contrasting with the still colourless growths of *Dematium*.

Cultures were also made from portions of mycelium placed at the top of the agar slant. The subsequent growth in the case of *Dematium* was confined to the surface of the medium or deeper layers, and consisted of hyphae bearing numerous conidia. In time the mycelium darkened somewhat.

Plowrightia gave rise in addition to a dense, greenish, aerial

mycelium on the upper half of the slant, which had no counterpart in the *Dematium* tubes. The superficial mycelium darkened much more rapidly; after a few days the formation of conidia on the hyphae ceased, and in old cultures the greater part of the mycelium was found to be completely sterile.

(iv) *Cultures on beerwort agar.* These cultures also presented strikingly different appearances to the naked eye. Old *Dematium* cultures showed a black, leathery layer covering the surface of the agar, and consisting of dark-coloured hyphae and numerous gemmae. Scattered over this black layer were white, slimy masses of bud spores, and isolated patches of a short, downy, white mycelium.

The *Plowrightia* cultures also showed a black surface layer, but this consisted entirely of dark-coloured hyphae, no gemmae being observed in any part. In addition, the layer was covered by a dense, greenish, fluffy mycelium, amongst which numerous greenish or black, spherical or club-shaped pustules had developed. Other similar black pustules had arisen on the under surface of the shrunken agar.

(v) *Hanging drop cultures.* (*a*) *Currant wood-extract agar.* On agar drops *Dematium* spores budded in great profusion forming dense masses of bud cells, which spread with great rapidity over the surface of the agar. No trace of mycelium was observed until, after several days, the drop began to dry up, when a few fine poorly-developed hyphae appeared on the edge of the agar.

Plowrightia spores gave rise immediately to an abundant mycelium which soon abstricted numerous conidia.

(*b*) *Beerwort drops. Dematium* spores gave rise to a profuse, stout, hyaline mycelium abstricting masses of conidia which budded in the liquid. Gemma formation proceeded on the edge of the drop, apparently where this was beginning to dry up. In the centre of the liquid the fungus remained hyaline for a week or more.

Plowrightia spores gave rise similarly to mycelium and conidia, but these darkened rapidly throughout the liquid, and in two or three days the transformation into gemmae and resting mycelium was complete throughout.

From these observations it appears that *Dematium pullulans* and the conidial stage of *Plowrightia ribesia* are not identical. The differences shown between the two forms in culture are considered sufficiently striking to warrant the retention of the specific name for the former fungus, and recognition of it as a distinct entity.

With regard to *Sphaerulina intermixta,* the writer has not yet succeeded in obtaining material with which to carry out a similar investigation; hence the possibility of the identity of *Dematium pullulans* with this fungus is not excluded.

III. Conclusion.

The relationship of the fungus known as *Dematium pullulans* to *Cladosporium*, *Plowrightia* and *Fumago* having been examined, it is claimed that no direct connection between them exists. Reasons have been advanced for ascribing a distinct individuality to *Dematium pullulans*. To speculate as to whether there is some other perfect stage, so far undetermined, to which this fungus may eventually be ascribed, is premature, and must be left, at least, until the relations with *Sphaerulina* have been cleared up. The writer would therefore be grateful for any material of this fungus, or for suggestions of possible localities in which to search.

Finally, she desires to record her thanks to Mr F. T. Brooks for constant supervision of the work, and for much helpful advice and criticism. She is also indebted to Mr L. Ogilvie and Mr A. Smith, who supplied cultures of *Dematium pullulans*.

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STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate II and five figures in text.)

III. TORRUBIELLA.

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

The genus *Torrubiella* was founded by Boudier in Revue Mycologique, VII (1885), pp. 226–7, the following generic description being given.

Torrubiella Boud. Perithecia superficial, sessile, on a thin, byssoid, membranous stroma, not borne on a clava. Paraphyses conspicuous, very slender, thickened at the apex. Other details as in the entomogenous species of *Cordyceps*.

The type specimen was collected on a spider at Montmorency in France. It was described as:

Torrubiella aranicida Boud. Perithecia elongated-conoid, subflexuose, 0·65–0·70 mm. high, 0·3–0·35 mm. diam., smooth, ochraceous or ochraceous orange, scattered or caespitose, on a thin, white, byssoid stroma. Paraphyses conspicuous, as long as the asci, very slender, apex clavate and 3 μ thick. Asci linear, very long, eight-spored, 330–350 × 5–6 μ, apex rounded and not swollen; ascospores filiform, very slender, as long as or longer than the asci, 300–400 × 0·5–2 μ, obscurely septate and granular.

Since 1885, the following species have been added to the genus:

Torrubiella tomentosa Pat. in Bull. Soc. Myc. France, VIII (1892), p. 133. On an insect (spider?) on a leaf, Ecuador. Dr Patouillard informs me that this species is on a coccid.

T. rubra Pat. and Lagh., *op. cit.* IX (1893), p. 134. On a coccid on *Melastoma* and *Solanum*, Ecuador.

T. luteorostrata Zimm. in Centralb. f. Bakt. Abt. 2, VII (1901), p. 872. On a coccid, Buitenzorg, Java.

T. rostrata P. Henn. in Hedwigia (1902), p. 167. On a moth, South America.

T. ochracea Pat. in Bull. Soc. Myc. France, XXII (1906), p. 58. On a Lepidopteron, Papeenoo, Tahiti.

T. brunnea v. Keissl. in Ann. Myc. VII (1909), p. 292. On a coccid on leaves of *Melicope*, Upolu, C. Rechinger, 5274 (Herb. Mus. Palat. Vindob.).

T. sericicola v. Höhnel in Sitz. k. Akad. Wiss. Wien, CXVIII, Abt. I (1909), p. 302. On cocoons of a moth, *Cricula fenestrata* Illf., Buitenzorg, Java.

T. Lecanii Johnst. in Mem. Soc. Cubana Hist. Nat. "Felipe

Poey," III (1918), p. 80. On a scale insect, *Saissetia hemisphaerica*, on *Achras Sapota*, Cuba.

T. tenuis Petch in Ann. Perad. VII (1922), p. 323. On *Aspidiotus*, *Aleyrodes*, etc., Ceylon.

T. sublintea Petch, *loc. cit.* p. 324. On an Aleyrodid, Corral, Chili.

T. barda Petch, *loc. cit.* On an Aleyrodid, Corral, Chili.

Torrubiella is a *Cordyceps* (*Torrubia*) without a clava, the perithecia being borne on a weft of hyphae, instead of being embedded in a fleshy stroma. The generic description does not reveal much difference from *Ophionectria*, and it would be expected that specimens which came into the hands of the earlier mycologists, especially those on scale insects where the entomogenous nature of the fungus is not always immediately evident, would have been placed in *Nectria*, or later in *Ophionectria*. But I have failed to detect any species of *Torrubiella* among the *Nectriae* in the herbaria of Kew and the British Museum.

On the other hand, the resemblance of the perithecia and spores to those of *Cordyceps*, coupled with the occurrence of the fungus on insects, may have led to the inclusion of species of *Torrubiella* in that genus.

Möller (Phycomyceten und Ascomyceten, 1901) declined to admit the validity of Boudier's genus *Torrubiella*. He stated (p. 144) that Boudier had separated from *Cordyceps*, as *Torrubiella*, those species which did not form a stroma outside the insect, but produced only perithecia or a loose weft of hyphae. He objected to that on the ground that there were only few such species in comparison with the total number of *Cordyceps* recorded, and nothing was gained by the separation. Of the species of *Cordyceps* described and figured by Möller, *Cordyceps flavo-viridis*, *C. cristata*, *C. rhynchoticola*, and *C. gonylepticida* appear to be *Torrubiella*. According to Möller, the last-named species has not the smallest trace of a stroma, the perithecia occurring on the insect without any film of mycelium; hence he concluded that his species was different from *Torrubiella aranicida* Boud. Perithecia which have only a very slight basal weft of hyphae do, however, occur in species which have normally a well-developed byssoid stroma, and so the character on which Möller relied may not be constant.

Möller further objected that the genus *Torrubiella* was not well founded, because of the existence of transitional forms between *Torrubiella* and *Cordyceps*. In *Cordyceps flavo-viridis*, the perithecia are situated on repent strands of mycelium spreading from the floccose stroma which covers the host insect; Möller pointed out that in this condition the fungus was *Torru-*

biella, but if the strands should happen to become erect it would be *Cordyceps*. He also described and figured a species, which had been named *Cordyceps Moelleri* by Hennings, in which the clavae were composed of parallel hyphae, and the perithecia were not sunk in the clava.

Support of Möller's objection is afforded by a species, *Torrubiella ochracea* Pat., which occurs on an undetermined Noctuid in Ceylon. In three examples of this species, collected on different occasions, there are no clavae; the perithecia are situated on a weft of hyphae which covers parts of the insect, or on places where no external stroma is visible. In another example, however, sixteen processes arise from the insect. These are up to 5 mm. high, usually laterally compressed, up to 1 mm. broad, with dense clusters of perithecia at their apices. The processes are composed of more or less parallel hyphae, firmly adherent to one another, and the perithecia are superficial. In other respects, including the conidial stage, the specimens are identical, and there does not appear to be any room for doubt that they are the same species (Plate II, figs. 11, 12).

From Möller's figures, *Cordyceps cristata* Möller and *C. Moelleri* P. Henn. would appear to offer a parallel case. Both are on a Noctuid and have yellow perithecia. The perithecia differ in size, those of *C. cristata* being 300–500 μ high, according to Möller, and those of *C. Moelleri* up to 700 μ high, but this variation is not greater than that in the *Torrubiella* forms of *T. ochracea*. In *C. cristata* the perithecia are situated on a loose stroma overrunning the body of the insect; in *C. Moelleri* they are grouped on erect clavae, up to 1·5 cm. long, composed of parallel hyphae. In Möller's figure 80 (*C. Moelleri*) the perithecia are clustered and appear free, but the description states that they are more or less embedded in the clava, up to one-third their height.

Tranzschel, in Hedwigia (1899), p. (11), instituted the genus *Helminthascus* for a fungus found on a spider in Russia. The perithecia were totally immersed in a flattened pulvinate stroma. Saccardo, in Sylloge Fungorum, XVI (1902), p. 616, wrote that the genus "fere absque dubio cum gen. Torrubiella collidit": that would appear to depend upon the character of the structure described as a stroma (cf. *Torrubiella barda* and *T. sublintea*).

Barya montana Rac. in Bull. Acad. Sci. Cracovie (1907), p. 909, would appear from the description to be *Torrubiella*. Raciborski placed it in *Barya*, in preference to *Torrubiella*, because it had no paraphyses. It occurred on a spider in Java, and was said to have a *Stilbum* conidial stage. The common conidial fungus on spiders in Ceylon is *Gibellula*, but it has not been possible to connect that with any *Torrubiella*. On the other hand, *Torrubiella flava*, which occurs on spiders, has

a *Stilbum*-like conidial stage, which belongs to the genus *Hirsutella*.

There are known, therefore, the following species, which have either been recorded as *Torrubiella*, or should probably be referred to that genus.

On spiders—*Torrubiella aranicida* Boud., *T. flava* Petch, *Cordyceps gonylepticida* Möller, *Helminthascus arachnophthorus* Transzch., and *Barya montana* Rac.

On *Lepidoptera*—*Torrubiella rostrata* P. Henn., *T. ochracea* Pat., *T. sericicola* v. Höhnel, and *Cordyceps cristata* Möller.

On *Rhynchota*—*Cordyceps rhynchoticola* Möller.

On undetermined insects—*Cordyceps flavo-viridis* Möller.

On "Coccids"—*Torrubiella tomentosa* Pat., *T. rubra* Pat. and Lagh., *T. luteorostrata* Zimm., *T. brunnea* v. Keissl., *T. Lecanii* Johnst., *T. tenuis* Petch, *T. sublintea* Petch, and *T. barda* Petch.

The present account deals chiefly with the last group. It is based on a series of specimens collected in Ceylon and the Eastern Tropics, and others from South America kindly furnished by Professor Thaxter.

Very many of the species of the genus *Cordyceps* have been described from single specimens, and, except in the case of a few well-known species, the herbarium material is scanty, or is represented in one herbarium only. The host insect, in many cases, is not gregarious, and it may happen that only one example of the fungus can be found. The same is true of the species of *Torrubiella* on *Lepidoptera* and *Arachnida*. The latter are usually found, in the tropics, on the under side of leaves, attached to the leaf by a weft of mycelium, and under such circumstances, seeing that the insects can travel about at random, it is scarcely to be expected that a number of examples of the fungus will be found together.

In one locality in Ceylon, however, there is a marked exception to the theory just enunciated. The species concerned is *Cordyceps dipterigena* B. and Br. It is found in the jungle at Hakgala, where it occurs on flies which are, as a rule, attached to the lower side of small branches or the under surface of leaves, and if one searches carefully, if one be found, there are usually at least half a dozen. That has been my experience on several occasions during the last twelve years, and circumstances suggest that the insects are infected during the period when they are in close association, *i.e.* in the larval stage.

Species of *Torrubiella* on scale insects (including *Aleyrodidae*) can usually be collected in fair quantity, when they do occur, because, in general, large numbers of the insects occur together on the same host plant.

As illustrative of the scantiness of the herbarium material of *Torrubiella*, it may be noted that up to the end of 1920, neither the Kew nor the British Museum herbarium contained a specimen under that name, nor, apparently, under any other genus, notwithstanding the richness of both herbaria in tropical fungi.

I have not seen the type specimen of the genus *Torrubiella*, *T. aranicida* Boud. The other species which have been placed in Boudier's genus do not appear to agree with the original generic description on several points, though it is scarcely to be doubted that they are co-generic. Only a re-examination of the type can decide whether these discrepancies are real or not.

Boudier described his species as having paraphyses, and included the presence of paraphyses as a generic character. Patouillard described *T. tomentosa* Pat. and *T. rubra* Pat. and Lagh. as not having paraphyses, and did not refer to paraphyses in *T. ochracea* Pat. Zimmermann did not mention paraphyses in the description of *T. luteorostrata*, nor did Hennings in the description of *T. rostrata*. von Keissler stated that *T. brunnea* had few, filiform paraphyses, sparsely guttulate, with a slightly capitate apex. von Höhnel described *T. sericicola* as having very delicate evanescent paraphyses, shorter than the asci, and added that paraphyses were present, but were not typically developed. Möller did not mention paraphyses in his descriptions of *Cordyceps gonylepticida*, *C. rhynchoticola*, and *C. cristata*, and Tranzschel stated that he did not observe paraphyses in *Helminthascus arachnophthorus*.

I have not been able to identify paraphyses in any of the species which are parasitic on scale insects. The paraphyses described by von Keissler for *T. brunnea* would appear to be immature asci. But in *Torrubiella flava*, which is parasitic on spiders, there are thin-walled paraphyses, as long as the asci, lax, collapsing, with protoplasmic contents, expanding to a breadth of 3μ at the apex. They resemble immature asci, but they do not possess a thickened cap.

The perithecium of *Torrubiella*, in some species, contains a comparatively large amount of an amorphous jelly-like substance, in which are embedded minute fusoid granules and sometimes more or less spherical cells. This substance at first sight might be regarded as the product of diffluent paraphyses. If, however, the perithecium is subjected to pressure under a cover glass, the mass of asci, if ripe enough, will be extruded through the base; and it is then found that the amorphous substance forms a continuous layer round the asci, and prevents them from spreading out separately, or in the usual fan-shaped manner, on the slide. It does not occur between the asci. At

the same time, the contents of the neck of the perithecium may be forced through the ostiolum, and these may issue in the form of a continuous sheet in which the periphyses are clearly distinct. It would appear from these observations that the amorphous mass is formed by the disintegration of the inner layer of the wall of the perithecium, not from a peripheral zone of paraphyses.

Boudier described the apex of the ascus as rounded and "non-tumente." The apex of the ascus in the species available to me is capitate, as in *Cordyceps* and *Hypocrella*, *i.e.* it is strongly thickened, with a more or less transverse base. In the original descriptions of *T. tomentosa*, *T. rubra*, and *T. ochracea*, the apex is described as capitate; in *T. rostrata*, as tunicate; in *T. luteorostrata*, as thickly tunicate; in *T. brunnea*, as thickened; and in *T. sericicola*, as a hemispherical slime cap, 3 μ broad. Tranzschel stated that in *Helminthascus arachnophthorus* the apex of the ascus was thickened, while Raciborski described that of *Barya montana* as thick-walled and conical.

The perithecium in the available specimens of *Torrubiella* is usually elongated conoid, or elongated flask-shaped, in the latter case with a comparatively long neck, which in the dried specimens often becomes recurved or irregularly bent, as noted by Zimmermann in *T. luteorostrata*, and by Hennings in *T. rostrata*. The perithecium is usually clothed for about two-thirds its height with hyphae, arising both from the stroma and the wall of the perithecium. If this covering is removed, the wall, when mounted, is found to be composed of interwoven hyphae, which form a parenchymatous tissue, but run more or less circumferentially round the perithecium. Probably because of that, the perithecia readily break transversely; and old herbarium specimens may have lost the upper part of the neck (and hence exhibit a "widely open ostiolum"), or may retain only the cup-shaped base of the perithecium. The inner layer of the perithecium wall is usually thick, hyaline, and obscure in structure.

On *Lepidoptera* and *Arachnida*, *Torrubiella* usually permeates the body of the insect and clothes it with a weft of hyphae; and the perithecia are produced on this weft, embedded in it to various depths up to about two-thirds their height, or on parts of the insect which do not show any superficial mycelium, except a slight weft at the base of the perithecium. On scale insects, these fungi similarly permeate the host insect, and then form over it a stroma of loosely interwoven hyphae, which may be pulvinate, up to 3 mm. in diameter, with a broad, spreading hypothallus. The perithecia may be borne on the stroma, or at its margin on the hypothallus, or anywhere on the hypo-

thallus. But on the same leaf there may occur perithecia which have no visible stroma, but only a slight attaching weft of hyphae at the base. Barren stromata of *Torrubiella* are most annoyingly common.

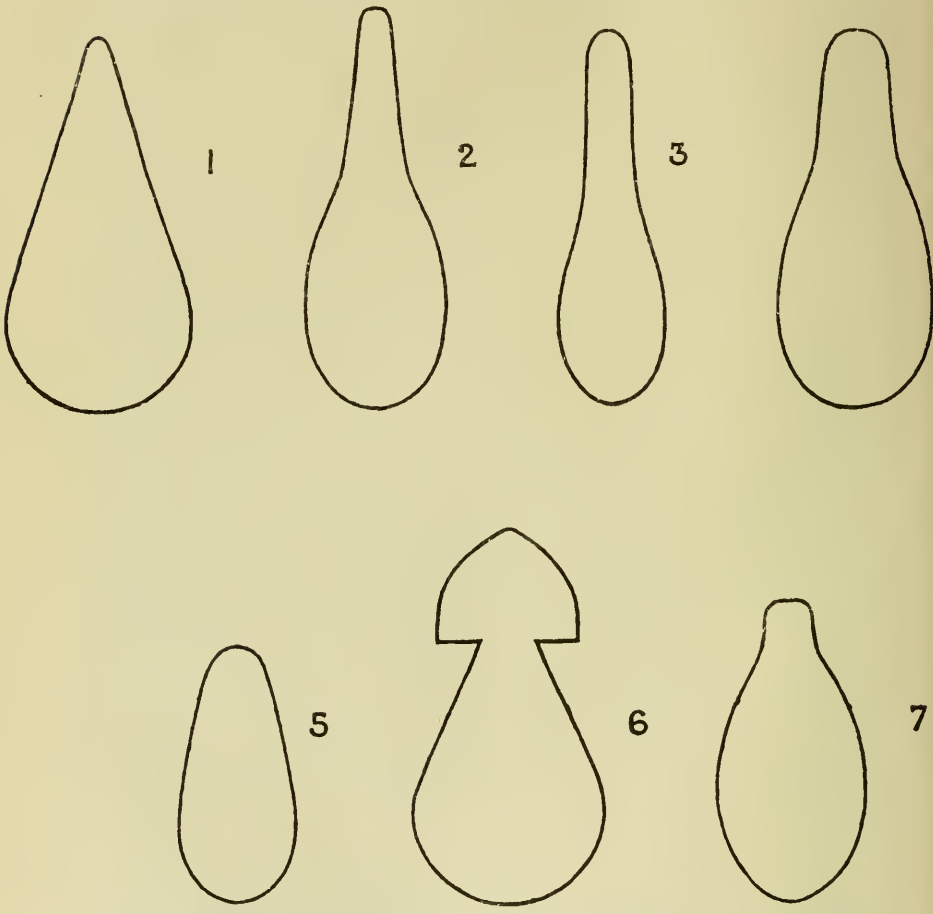


Fig. 1. Perithecia of *Torrubiella*. 1. *T. rubra*; 2. *T. luteorostrata*; 3. *T. tenuis*; 4. *T. sublintea*; 5. *T. tomentosa*; 6. *T. barda*; 7. *T. ochracea*. All ×33.

In the first stage of formation of the stroma in the scale-insect species of *Torrubiella*, the hyphae are thin-walled, about 2 μ diameter, with numerous very fine hyphae, 0·5–1 μ in diameter, encrusted with globose, hyaline granules. These fuse into a membranous sheet, here and there hyaline and amorphous, which constitutes a basal disc which attaches the fungus to the leaf. The hypothallus retains this structure, with the addition

of some thick-walled hyphae, but the mass of the pulvinate stroma subsequently formed consists, in general, of thick-walled hyphae, flexuose and irregularly intertwined. In some cases, the hyphae on the surface of the stroma tend to fuse into a continuous, glabrous sheet; this is well-marked in species from the American tropics. In the only available species on *Lepidoptera*, the hyphae of the stroma are thin-walled.

The asci are very long, cylindric, narrow, with a capitate apex. They contain usually eight linear ascospores, more or less spirally arranged, and as long as the ascus. These become septate and subsequently divide into cylindrical part-spores, which may become rounded at the ends and narrow-oval. This division into part-spores has been recorded in *T. tomentosa*, *T. rubra*, *T. sericicola*, *T. ochracea*, *T. Lecanii*, *Barya montana*, and *Helminthascus arachnophthorus*. On the other hand, Boudier did not find part-spores in *T. aranicida*, nor did Hennings in *T. rostrata*. Zimmermann stated that he did not observe septation or the formation of part-spores in *T. luteorostrata*, and von Keissler recorded the ascospores of *T. brunnea* as continuous and apparently not dividing.

Among the many unexplained phenomena attending fungi parasitic on scale insects, perhaps the most notable from the systematic standpoint are the comparative rarity of the ascigerous stage in *Hypocrella* and *Sphaerostilbe*, and the rarity of occurrence of fully ripe perithecia when the ascigerous stage is found in *Hypocrella* and *Torrubiella*. In the latter two genera the hyphae of the stromata are sclerotioid and adapted to withstand periods of drought; it may, perhaps, be suggested that these fungi may be subject to, and survive, a cessation of growth at any stage, and that the spores are only matured and ejected from the perithecium under certain limited weather conditions. Certainly, the majority of the collections of *Hypocrella* and those of *Torrubiella* on scale insects contain only immature asci. Under such circumstances, descriptions of the ascospores based on a single collection can be correct only by a lucky chance.

In the specimens examined by me, septate ascospores have been commonly observed. Loose part-spores have been seen, *i.e.* not in an ascus, and also part-spores in asci, the greater part of the contents of which appeared to have become disorganised. But I have not been able to find the stage which was expected, that which has been frequently seen in *Hypocrella*, in which the separate part-spores are arranged in the asci in lines corresponding to the original undivided ascospores. It appears, however, to be quite certain that the ascospores of *Torrubiella* divide into part-spores within the ascus.

In Revue Mycologique (1887), p. 158, Boudier described

a conidial form, *Isaria cuneispora*, on a spider, from the same locality as *Torrubiella aranicida*. The fungus covered the insect with a white, effused weft of mycelium, composed of interwoven, branching, septate, minutely granular hyphae. The sporiferous hyphae were erect, 600–700 μ high, 2–3 μ diameter, simple, or branched once or twice, and bore solitary hyaline conidia, elongated conical, 12–14 × 2–2·5 μ, attached at the thicker end. The description of the spore suggests *Hirsutella*.

Conidia were recorded by von Höhnel in *Torrubiella rostrata*. They occurred on ovoid, apiculate, conidiophores on the upper part of the perithecium, and were yellowish, ellipsoid, 3·5 × 3 μ.

Conidia have been observed by me in five species, viz. *T. rubra*, *T. sublintea*, *T. tomentosa*, *T. ochracea* and *T. flava*. In the first of these they are borne laterally on repent hyphae, densely crowded along the hyphae, and are hyaline, oval, 3 × 1·5 μ, or spherical, 2 μ diameter. In the second, the conidia are very variable in shape, fusoid, three-septate, ends acute but not produced, 18–24 × 4 μ, or five-septate, with tips strongly attenuated and slightly curved, 36–46 × 3–4 μ, or seven-septate, falcate, ends equally curved and attenuated, 43 × 4 μ, the last being a typical, uniformly curved *Fusarium* spore; they are borne laterally on simple hyphae, sometimes close together and forming a cluster. In the third and fourth species the conidia occur laterally on the hyphae, and are oval or globose, and spinulose. In the fifth species, the conidiophore is *Stilbum*-like, and belongs to the genus *Hirsutella*.

Of the species of *Torrubiella* parasitic on scale insects, *T. brunnea* v. Keissl. appears to be identical with *T. luteorostrata* Zimm. It has not been possible to compare the species on scale insects with those recorded on spiders, *Lepidoptera*, etc., owing to the inaccessibility of the type specimens of the latter. The species which occur on scale insects in Ceylon are different from the species discovered on other insects in that country, viz. *T. ochracea* Pat. and *T. flava* Petch.

The species on scale insects may be arranged as follows:

Perithecia purple-red, elongated conoid; stroma pinkish becoming pale brown.	*T. rubra*
Perithecia purple-red, elongated flask-shaped; stroma purple-red (rarely white), becoming purple-brown, yellow-brown, or Sanford brown.	*T. luteorostrata*
Perithecia pale ochraceous or amber, elongated flask-shaped; stroma white.	*T. tenuis*
Perithecia brownish-yellow, elongated conoid; stroma white.	*T. sublintea*
Perithecia yellow, ovato-conoid; mycelium on perithecium with free clavate tips.	*T. tomentosa*

Perithecia orange-yellow, conoid; apex red-brown, capitate; stroma orange-yellow. *T. barda*

Perithecia vivid yellow, conoid. *T. Lecanii*

Torrubiella rubra Pat. and Lagh. in Bull. Soc. Myc. France, IX (1893), p. 154.

Stromata flattened pulvinate, up to 2·5 mm. diam. pinkish red, usually with a thin, white, superficial layer, becoming pale brown, tomentose, compact internally, generally surrounded by a thin, white, powdery hypothallus which extends over the leaf for several millimetres.

Perithecia produced on the hypothallus, irregularly distributed, solitary or in groups (but not united), elongated conoid, 0·65–0·8 mm. high, 0·3–0·4 mm. diameter below, purple-red, dark-red by transmitted light, apex brownish, clothed below with interwoven hyphae arising from the stroma and from the perithecium wall up to two-thirds the height of the perithecium, the hyphae from the perithecial wall tending to be moniliform; asci long, cylindrical, capitate, eight-spored, 7 μ diameter; spores filiform, as long as the ascus, septate, dividing into cylindrical part-spores, 4–6 × 1·5–2 μ.

Conidia on repent hyphae, 2 μ diameter, on the surface of the stroma and hypothallus, lateral, solitary on minute crowded pedicels, hyaline, oval, 3 × 1·5 μ, or spherical, 1–2 μ diameter.

Fig. 2. Conidia of *T. rubra*. ×2000.

Ecuador, on a coccid on *Melastoma* and *Solanum* (Patouillard and Lagerheim). Corral, Chili, on an Aleyrodid, December 1905 (Thaxter). (Plate II, fig. 1.)

The above description is drawn up from Thaxter's specimen; only one stroma bore the conidial stage, but the conidia on that were so abundant that in places they were massed together in flakes; the collection contained numerous barren stromata.

Patouillard and Lagerheim gave the dimensions of the asci as 700–800 × 6–7 μ, the part-spores 3–5 μ long, and the perithecia, up to 1 mm. high; they stated that the stroma was white, then rose, red, or rufous-brown. In describing the colour as above, the sequence has been deduced from the changes in the corresponding Ceylon species.

The stroma consists of interwoven hyphae which are not fused into a solid or parenchymatous tissue. The hyphae in the interior are thick-walled or almost solid, flexuose, 3–4 μ diameter, irregular, sometimes attaining a diameter of 5 μ, generally rough with minute granules. At the exterior the hyphae are of the same character, 2–5 μ, occasionally 6 μ diameter, with, in addition, very fine hyphae 0·75 μ diameter. The fine hyphae

and the granules tend to fuse into a hyaline sheet, as in the hypothallus, but this is not continuous over the stroma in the available specimens, and the surface of the stroma usually appears tomentose. The inner hyphae are more densely interwoven than those at the exterior.

By transmitted light, the hyphae appear only feebly coloured. In the pink stromata, they are red or red-brown in mass, but only faintly tinged pale red when isolated. In the brown stromata, the hyphae are faintly tinged yellow. The hyphae on the perithecium are often closely septate.

Torrubiella luteorostrata Zimm. in Centralb. f. Bakt. Abt. 2, VII (1901), p. 872; *Torrubiella brunnea* v. Keissl. in Annales Mycologici, VII (1909), p. 292.

Stromata pulvinate, flattened pulvinate, ring-shaped, or discoid, up to 1·5 mm. diameter, purple-red, becoming purple-brown, yellow-brown, or Sanford brown, rarely white, tomentose, rather loose internally, surrounded by a white, byssoid or powdery hypothallus.

Perithecia produced on the stroma or the hypothallus, scattered or clustered, sometimes solitary without any stroma except a slight basal weft of hyphae, elongated flask-shaped or elongated conoid, 0·6–0·9 mm. high, 0·25–0·3 mm. diameter, purple-red, red-brown by transmitted light; neck 0·08 mm. diameter, at first dark purple-red, becoming yellow when mature, decurved or twisted in herbarium specimens; perithecia usually clothed with purple-red hyphae up to two-thirds their height, rarely almost glabrous; asci long, cylindrical, capitate, eight-spored, 7 μ diameter; spores filiform, as long as the ascus, septate, dividing into cylindrical part-spores, 3–6 × 1 μ.

Java; on a coccid, Buitenzorg (Zimmermann). Upolu; on a coccid on leaves of *Melicope* (*T. brunnea* v. Keissl.) C. Rechinger No. 5274, Herb. Mus. Palat. Vindob. (von Keissler). Ceylon; on an Aleyrodid on *Tetranthera*, Pundaluoya, Feb. 1889, coll. E. E. Green (Parkin, Torrubiella, 1, p. 18); on *Aspidiotus* on *Strobilanthes* sp., Hakgala, Sept. 1908; on *Fiorinia rubrolineata* on *Saprosma zeylanicum* Bedd., Hakgala, May 1910; on *Aspidiotus destructor* on *Loranthus* sp., Hakgala, May 1910; on *Fiorinia* on *Murraya exotica* L., Hakgala, May 1910, April 1917; on an Aleyrodid on *Saprosma zeylanicum* Bedd., Hakgala, May 1912; on an Aleyrodid on *Allophylus zeylanicus* L., Hakgala, May 1912; on a black Aleyrodid on *Pavetta indica* L., Hakgala, January 1914; on an Aleyrodid on an undetermined host plant, Hakgala, April 1917; on a black Aleyrodid on *Hedyotis verticillaris* W. and A., Nuwara Eliya, December 1917; on an Aleyrodid on *Psychotria elongata* Hk. f., Hakgala, April 1919. Seychelles, on an Aleyrodid on *Cyperus* sp., Mahe, coll. R. Dupont (Plate II, figs. 2–5).

I have not seen the type specimen from Java, nor Rechinger 5274, nor the specimen recorded by Parkin (p. 19), on an Aleyrodid on a jungle tree, Pusella, Ceylon, February 1899.

Immature examples of the perithecia of this species are not as tall as the mature form, and the apex, as noted by Parkin, is dark purple, almost black. The characteristic yellow subtranslucent apex apparently is not developed until the perithecium is nearly mature (Plate II, fig. 3).

The stroma is looser than in *T. rubra*. The exterior hyphae are flexuose, contorted, thick-walled to almost solid, 3–5 μ diameter, vivid purple-red to almost hyaline. In some hyphae the colour is confined to the contents, the thick wall being hyaline. A few fine hyphae, 0·5 μ diameter, are present. Here and there, the thick hyphae are fused together side by side in small patches. The hyphae appear to be more rigid than in *T. rubra*, and they tend to break up into short lengths; they are almost smooth, or minutely pitted. In the interior of the stroma the hyphae have more deeply coloured walls. At the base of the stroma, thick-walled hyaline hyphae occur, which are encrusted with granules. Some thick-walled, repent hyphae in the hypothallus are minutely spinulose.

The perithecia usually have a thick weft of hyphae at the base and up to two-thirds their height, which makes them appear conoid. These hyphae are vivid purple-red.

When a stroma has turned brown, the hyphae are pale yellow when mounted; the colour is contained in the cell wall, not concentrated in the plasma. The hyphae appear to bear more granules than those in the purple-red forms. Fig. 5, Plate II, shows a stroma which is changing colour from the centre outwards.

In one collection from Hakgala, April 1917, on *Murraya exotica*, some stromata are pure white, with dull brown perithecia, yellow-brown at the apex, and traces of purple-brown in the stroma round the perithecia. The structure of the stroma is different from that of the normally white Ceylon species.

When the stroma turns brown, the perithecia may remain purple-red; and if the perithecia also become brown, traces of purple-red usually remain in the hyphae at their bases. The specimen from the Seychelles has stromata varying from Sanford brown to pale purple-brown. Their hyphae are red-brown to almost hyaline, strongly encrusted with red-brown granules, while brown amorphous masses occur among them. The perithecium wall retains traces of purple-red at the base. I had assigned this specimen to *T. brunnea* v. Keissl., but on comparison with the other available specimens it appears to be undoubtedly *T. luteorostrata*, and I am of opinion that *T. brunnea* was based on a similar specimen.

The white superficial layer (cf. *T. rubra*), noted by Zimmermann, appears to be of rare occurrence. It occurs in a collection on an Aleyrodid on *Hedyotis verticillaris*, Nuwara Eliya, December 1917.

In a collection on *Fiorinia rubrolineata* on *Saprosma zeylanicum* Bedd., Hakgala, May 1910, there is a thin, dense, hyaline region at the base of the stroma, succeeded by a loose yellow-brown zone, then a more compact, narrow, red-brown zone, followed by another loose yellow-brown zone, and finally a red-brown external layer. Thus, in vertical section the stroma exhibits zonation, which perhaps indicates a periodic stoppage of growth.

The purple-red colour of the hyphae is discharged by lactic acid. Dilute hydrochloric acid turns the hyphae brown. This action of acids may account for the natural colour change of the stroma.

Torrubiella tenuis Petch in Ann. Perad. VII (1922), p. 323.

Stromata pulvinate, flattened pulvinate, or almost plane, up to 1·5 mm. diameter, white, tomentose, rather loose internally, sometimes surrounded by a broad, white, fibrillose margin or hypothallus.

Perithecia usually produced on the thicker part of the stroma, sometimes on the margin or hypothallus, sometimes occurring singly on scales which do not bear any stroma except a slight weft of hyphae at the base of the perithecium, scattered or clustered, elongated flask-shaped or elongated conoid, 0·65–0·9 mm. high, 0·2–0·25 mm. diameter below, pale amber to pale yellow-brown, pale yellow or yellow-brown by transmitted light, subtranslucent, clothed with hyphae up to two-thirds their height, or almost glabrous; asci long, cylindrical, capitate, eight-spored, 7 μ diameter; spores filiform, as long as the ascus, septate, dividing into cylindrical part-spores, 3–6 × 1 μ.

Ceylon; on *Aspidiotus destructor* on a jungle tree, Pundaluoya, coll. E. E. Green, 1899 (Parkin, type 2, p. 19); on a black Aleyrodid on *Sarcococca pruniformis* Lindl., Hakgala, May 1912; on a scale on *Hedyotis Lessertiana* Arn., Hakgala, January 1914; on *Aleyrodes* on *Lasianthus Walkerianus* Wight and *Psychotria elongata* Hk. f., Hakgala, January 1914 (Plate II, fig. 6).

The stromata in this species are usually smaller than in *T. luteorostrata*, and the perithecia in pulvinate examples are situated more usually on the thicker central area of the stroma, and more embedded in it. Old herbarium specimens may acquire a slight brownish tint. Parkin compared this species to *T. tomentosa*, from which it differs in its very slender perithecia.

The hyphae of the stroma are flexuose, thick-walled or almost solid, generally stout, 3·5–5 μ diameter, with a few 2·5 μ diameter. Very fine hyphae, less than 1 μ diameter, have been

observed only in the basal sheet. The external layer of the stroma may in places be a continuous sheet of thick-walled hyphae, more or less parallel, fused together side by side. The hyphae, in general, are not, or only slightly, rough with adherent granules; they are frequently closely septate, and with the wall and septa thickened so that only spherical cavities remain. Short broken lengths of hyphae with thickened walls and close-set septa resemble conidia under a low magnification, but a higher magnification reveals the broken wall at the ends. The hyphae on the perithecia are loosely interwoven, 2–4 μ diameter, thick-walled or almost solid.

Torrubiella sublintea Petch in Ann. Perad. VII (1922), p. 324.

Stromata circular, up to 3 mm. diameter, compact, pulvinate in the centre, with a broad margin, white, margin somewhat floccose, centre acquiring a matted surface which becomes a more or less glabrous wrinkled sheet.

Perithecia situated round the thickened centre, singly or more usually in groups, tomentose up to two-thirds their height, or clothed with mycelium which forms a common covering to two or three perithecia and acquires a glabrous external layer, elongated conoid, slightly attenuated above, 0·75 mm. high, 0·33 mm. diameter below, brownish yellow, darker brown at the apex, subtranslucent, by transmitted light pale yellow to brownish yellow, slightly brown towards the apex; asci long, cylindrical, capitate, eight-spored, 6–8 μ diameter; spores filiform, as long as the ascus, septate, dividing into cylindrical part-spores, 3–6 × 1·25 μ.

Conidia on the stroma or on the perithecia, arising laterally from regular simple hyphae, either fusoid, three-septate, ends acute but not produced, 18–24 × 4 μ, or five-septate, ends strongly attenuated and slightly curved, 36–46 × 3–4 μ, or seven-septate, falcate, ends equally curved and attenuated, 48 × 4 μ.

Fig. 3. Conidia of *T. sublintea*. × 600.

Chili; on an Aleyrodid on an undetermined leaf, Corral, December 1905, coll. Thaxter (Plate II, fig. 7).

The stroma in this species is more compact than in *T. tenuis*. It consists of hyphae, 2–2·5 μ diameter, some thick-walled, slightly rough, others thin-walled, with numerous finer hyphae, 0·75–1 μ diameter. The more compact nature of the stroma is probably due to the fact that the hyphae are thinner than in other species. The tendency of the exterior hyphae to form a continuous layer is very marked, and on some examples the stroma is covered with a glabrous, wrinkled sheet. The stroma sometimes shows traces of pale yellow.

The hyphae at the base of the perithecium are identical with those in the stroma. The hyphae round the perithecium do not exceed 2 μ in diameter, are usually thin-walled, and form a dense outer layer. When two or three perithecia occur in a group, the hyphae of the stroma may ascend almost to their apices, so that the perithecia are deeply embedded in the stroma. Viewed macroscopically, isolated perithecia appear more attenuated above than they prove to be when dissected out, owing to the termination of the external tomentum some distance below the apex.

When first examined this species was thought to be identical with *Torrubiella tomentosa* Pat., but examples of the perithecia from the type of the latter show that it is distinct, though very close. The perithecia are rather similar, but differ slightly in shape and colour, those of *T. tomentosa* being ovato-conoid, not attenuated, with a wall hyaline when mounted, and those of *T. sublintea* elongated-conoid, slightly attenuated at about two-thirds their height, with a pale yellow to brownish-yellow wall. The conidial stages of the two are quite different. Perhaps the most ready means of distinction between them is the occurrence of numerous free, clavate tips on the hyphae which cover the perithecia of *T. tomentosa*.

Torrubiella tomentosa Pat. in Bull. Soc. Myc. France, VIII (1892), p. 133.

Stromata thin, woolly, ochraceous. Perithecia on the stroma, scattered or caespitose, ovato-conical, 0·5 mm. high, 0·3 mm. diameter, pale yellow-brown, slightly darker at the apex, clothed up to the apex with floccose, white (herb. specimen) tomentum; apex obtuse, subtranslucent. Wall of perithecium when mounted almost hyaline with traces of yellow at the apex; tomentum with numerous free, clavate, verrucose tips, and rough with crystalloid masses. Asci long, capitate, cylindrical, tapering below, 6–8 μ diameter, eight-spored. Part-spores cylindrical, tapering slightly towards the ends, 4–7 × 0·75 μ.

Ecuador; on a scale insect on an unknown leaf, Puento de Chimbo (Lagerheim).

In the original description of this species, it was suggested, with a query, that the fungus was parasitic on a spider. Dr Patouillard, who has kindly furnished me with perithecia from the type, informs me that it is certainly parasitic on a coccid.

The foregoing description is drawn up in part from the perithecia examined. The original description gives the perithecia as 1 mm. high and the part-spores 10 × 1 μ. The height of the perithecium given above was taken from an isolated perithecium examined dry; when in water under a cover glass it was 0·75 × 0·35 mm. The hyphae at the base of the perithecium and those forming the tomentose covering are 3–4 μ diameter, with

only slightly thickened walls, strongly verrucose with minute granules, and bear a large number of free clavate ends, up to 5 μ diameter, also strongly verrucose. These hyphae bear spherical or oval, verrucose conidia, 4–6 × 3–5 μ, laterally, in the same manner as that figured for *T. ochracea*. The wall of the perithecium, by transmitted light, appears to be studded rather closely with irregular crystalloid bodies, which are really situated on the external mycelium; they are not soluble in hydrochloric acid.

Torrubiella barda Petch in Ann. Perad. VII (1922), p. 324.

Stromata up to 3 mm. diameter, compact, pulvinate, lacunose, sometimes with a broad, thin hypothallus, orange-yellow, egg yellow, or becoming whitish, more or less tomentose but with the surface layer matted and tending to become membranous and glabrous.

Perithecia round the base of the pulvinate part of the stroma, solitary or clustered, usually surrounded by a weft of hyphae of the same colour as the stroma so that only the ostiola project. Isolated perithecia conoid, yellow, with an outer coat of interwoven yellow hyphae, 0·1 mm. thick, extending nearly to the apex, which is red-brown and conoid; after removal of the tomentose coat, the perithecia are conoid, 0·75 mm. high, 0·35 mm. diameter, suddenly expanding above into a thickened capitate apex; wall of perithecium thick; by transmitted light the wall of the perithecium is yellow and the thickened apex orange or reddish-yellow. Asci long, cylindrical, capitate, eight-spored, 6–7 μ diameter; part-spores cylindric, becoming somewhat narrow-oval with obtuse ends, 4–7 × 1·5 μ.

Chili; on an Aleyrodid on an undetermined leaf, Corral, December 1905, R. Thaxter (Plate II, fig. 8).

In some instances all the perithecia are embedded in the stroma, which then resembles a *Hypocrea*, dotted with red-brown ostiola. The structure of the perithecium is quite distinct from that of the other species of *Torrubiella* found on scale insects. At first sight, it appears regularly conoid, tomentose below, glabrous at the apex. The tomentose layer, however, can be easily peeled off, and it is then found that the wall of the perithecium suddenly expands at right angles at the upper limit of the tomentum, so that a thick solid apex is formed.

The hyphae in the tomentose layer on the perithecium are thick-walled, almost solid, closely interwoven; this layer is yellow, but becomes pale or white internally. The hyphae of the stroma are usually stout, generally 4–5 μ diameter, but with some 2–3 μ diameter, thick-walled, flexuose, encrusted with granules, greenish yellow to hyaline; they tend to fuse into a continuous superficial sheet.

The type of *Acremonium araucanum* Speg. has been kindly

lent me by Dr Spegazzini. This is on an *Aspidiotus* on *Drymis Winteri*, collected at Bahia de Corral, Chili. The fungus forms a more or less pulvinate, lemon yellow stroma over the scale, with a thin spreading margin, composed of thick-walled, yellow or hyaline, irregular hyphae, often closely verrucose. There is no doubt that these are the stromata of a *Torrubiella*, and in one example a developing perithecium was present. They appear to be undoubtedly the stromata of *T. barda*. Numerous conidia, hyaline or yellowish, verrucose, oval, 4–5 × 3 μ, or globose, 3–4 μ diameter, were seen, usually singly, sometimes in chains, but these all arose from thin-walled, hyaline hyphae, 1·5 μ diameter, which did not appear to be connected with the hyphae of the stroma. Spegazzini described the conidia as ellipsoid, 7–8 × 6 μ; it is probable that he saw other conidia which are those of the conidial stage of *Torrubiella barda*.

Torrubiella Lecanii Johnst. in Mem. Soc. Cubana Hist. Nat. "Felipe Poey," III (1918), p. 80.

Perithecia vivid yellow, erect, conical, scattered or confluent, 350 μ high, 125 μ diameter. Asci linear, 175–245 μ long. Ascospores dividing into cylindrical part-spores with rounded ends, 3·32 × 1·66 μ.

Cuba; on, or with, *Cephalosporium Lecanii* on *Saissetia hemispherica* on *Achras Sapota*.

The above is Johnston's description. I have not seen a specimen. Mr Johnston, *in litt.*, states that the perithecia were yellow, with rather translucent yellow ostiola, and necks somewhat tapering or rounded at the apex; isolated perithecia were yellow-tomentose, but when several grew close together they were invested by yellow mycelium. On the characters of the apex of the perithecium, *T. Lecanii* would appear to be quite distinct from *T. barda*.

To afford a comparison with the species of *Torrubiella* which are parasitic on other insects, the following account of the other known Ceylon species is included. One of these, which occurs on an undetermined Noctuid, appears to be *T. ochracea* Pat. The other, which is apparently a new species, occurs on spiders; it is described below as *Torrubiella flava*.

Torrubiella ochracea Pat. In two examples of this species, collected on different occasions on the perfect insect, a rather loose pale yellow weft of hyphae extends along the body and the legs of the insect and binds them to the leaf. This mycelium does not cover the wings, but it fastens the wings to the body, and comes just up to, or slightly over their margins. When old the colour of the mycelium fades to almost white. The perithecia occur anywhere on the mycelium, but more particularly along the margins of the wings and along the legs; they may be scat-

tered or in groups of up to a dozen (Plate II, fig. 11). In another example, on a caterpillar, the perithecia are situated on the mycelium which covers it.

In two other examples, the insect bears a denser weft of hyphae, and from this there arise erect processes, up to 5 mm. high, usually laterally compressed and up to 1 mm. broad. These processes are composed of adherent longitudinal hyphae, and they do not contain any remains of the insect which might serve as a foundation. The perithecia are superficial, crowded together at the apices of the processes. In both these examples, the mycelium and the processes are white. One specimen bears sixteen of these processes (Plate II, fig. 12).

The perithecia are pale yellow when fresh, becoming ochraceous or reddish-brown when old; they are subtranslucent, oval or conoid, with an obtuse or papillate apex, 0·35–0·65 mm. high, and 0·2–0·3 mm. diameter below. The perithecial wall is pruinose above, clothed with pale yellow hyphae below; when mounted, it appears pale yellow, membranous, of indistinct structure. The asci are 4–5 μ diameter, and the part-spores cylindrical, tapering slightly to the rounded ends, 5–7 × 1–1·25 μ.

The hyphae in the weft of mycelium are generally regular, septate, 1·5–2·5 μ diameter, thin-walled or with a slightly thickened wall, with occasional oval inflations up to 6 μ broad. The septa are 15–28 μ apart. The hyphae bear spinulose, hyaline conidia, either globose, 2·5–3·5 μ diameter, or oval, 4 × 3 μ. These occur laterally and singly, widely separated along the hyphae, usually each immediately below a septum, in the position of a lateral branch. In some cases, both a branch and a conidium are produced just below a septumin the main hypha.

Occasionally short lengths of the hyphae are closely septate, with septa as little as 4 μ apart. The lateral branches are frequently short, with some of the cells inflated, and terminate in an oval cell furnished with a solid, acuminate tip.

The *Torrubiella* and the *Cordyceps* forms agree in the structure of the hyphae, the conidial stage, the colour and structure of the perithecia, and the dimensions of the part-spores. In the *Cordyceps* form, the mycelium grows into erect solid processes, while in the *Torrubiella* form it is only a rather loose weft of hyphae. This difference in the development of the mycelium may possibly be due to differences in the conditions under which these examples grew. The *Torrubiella* form was collected on living leaves, but the *Cordyceps* form was found, unattached, among dead leaves on the ground.

These specimens of *T. ochracea* support Möller's contention that the genus *Torrubiella* is not distinct from *Cordyceps*, because of the existence of transitional forms. Nevertheless, it may be considered advisable to retain it for those species which

do not form a clava, while agreeing that the two genera are united by species which, in their different forms, combine the characteristics of both.

Reference has already been made to the probability that *Cordyceps Moelleri* P. Henn. and *C. cristata* Möll. are forms of the same species, parallel to the two forms of *Torrubiella ochracea* Pat. Lloyd has suggested that *Cordyceps Moelleri* P. Henn. is identical with *C. Sphingum* Tul., and that suggestion would appear to be correct. The question then arises whether *Torrubiella ochracea* is not also identical with *Cordyceps Sphingum*. Macroscopically, the two differ in the shape of the processes, those of *Cordyceps Sphingum* tapering upwards and

Fig. 4. Conidia of *T. ochracea*. × 800.

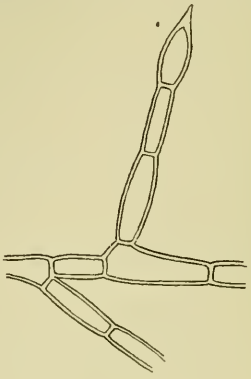


Fig. 5. Hyphae of *T. ochracea*. × 1000.

having the perithecia scattered or clustered at some distance below the apex, so that the clava terminates in a long barren point, while those of *Torrubiella ochracea* are more or less obtuse and have the perithecia clustered at the apex in the available examples. But it is probable that this difference will prove not to be constant. The other differences are slight. *Cordyceps Moelleri* is described as pale yellow, while the species of *Torrubiella ochracea* which possess clavae have a white stroma, but it is known that the yellow colour of the *Torrubiella* forms of the latter fades to white. The perithecia of both species appear to be the same shape, while the length of the part-spores is 5–6 μ in *Cordyceps Moelleri*, 4 μ in *C. cristata* (both according to Möller), and 5–7 μ in *Torrubiella ochracea*. Only Hennings gives the diameter of the spore of *Cordyceps Moelleri* (0·5 μ), and it would appear that he did not see the mature part-spores.

It would seem probable, therefore, that *Torrubiella ochracea* is identical with *Cordyceps Sphingum*, but a final decision on the point must be deferred until a comparison can be made with authentic specimens of the latter.

Torrubiella flava Petch, n.sp. This species (Plate II, fig. 9) occurs at Hakgala, Ceylon, on spiders. In the specimens hitherto collected, the insect is attached by the mycelium of the fungus to the under surface of living leaves. The fungus clothes the body of the insect with pale yellow mycelium, forming a flattened-pulvinate, tomentose, somewhat spongy stroma, with a fimbriate margin spreading slightly over the leaf. The hyphae of the stroma are 2·5–3 μ diameter, usually thin-walled, but sometimes with walls up to 0·5 μ thick, especially towards the free ends of the hyphae. The perithecia are seated on the stroma, superficial, ultimately crowded, tomentose with a rather thick, separable layer of tomentum, pale yellow, with a yellow-brown translucent apex, ovoid, 0·8 mm. high, 0·4 mm. diameter. The hyphae of the tomentum are 2–2·5 μ diameter, moderately thick-walled, and minutely granular. The asci are long, cylindric, capitate, 5–6 μ diameter, four or eight-spored. The ascospores are as long as the ascus, and divide into cylindric part-spores, 5–8 × 1·5 μ, the septa in the undivided spore being exceptionally well-developed. Paraphyses are present, as long as the asci, thin-walled, lax, collapsing, not capitate, expanding to 3 μ diameter at the apex.

A specimen (Plate II, fig. 10) on the same species of spider, gathered with the foregoing and possessing a stroma of the same character, bears conidial *Stilbum*-like clavae. These are pallid yellow, cylindric, up to 4 mm. high, 0·15 mm. diameter, tapering slightly upwards, terete, smooth. They are clothed with spherical or subglobose basidia, up to 6 × 5 μ, scattered or crowded, each bearing a single apical, slender, rigid sterigma, about 2 μ long. The conidia are apical, narrow-oval, ends acute, continuous, hyaline, 4–8 × 2 μ. This is a *Hirsutella*, which has been described as *Hirsutella arachnophila* Petch (= *Trichosterigma arachnophilum* Petch). The perithecia and the conidial clavae have not been found on the same stroma.

Hirsutella arachnophila has also been collected at Peradeniya, on spiders, on two occasions. In one of these examples, the clavae were lilac-grey when fresh. It is possible that the latter may belong to a different species, but it does not show any morphological differences. A similar difference in colour occurs in *Gibellula elegans* P. Henn., in which species both the stroma and the conidiophores may be yellow, or the stroma yellow and the conidial heads lavender. In the latter case, the conidial heads become white in old herbarium specimens.

It would seem probable that the conidial stage mentioned by Raciborski as occurring with *Barya montana* may have been *Hirsutella*, but it was not described further.

EXPLANATION OF PLATE II.

Fig. 1. *Torrubiella rubra*, specimen from Corral, Chili, ×6: the perithecia which show circular ostiola have been broken.
Fig. 2. *T. luteorostrata*, Hakgala, Ceylon, ×10, form with a white stroma.
Fig. 3. *T. luteorostrata*, Hakgala, Ceylon, ×10; specimen showing yellow ostiolum.
Fig. 4. *T. luteorostrata*, Hakgala, Ceylon, ×10.
Fig. 5. Stroma of *T. luteorostrata*, Hakgala, Ceylon, changing colour from purple-red to brown, ×6.
Fig. 6. *T. tenuis*, Hakgala, Ceylon, ×6.
Fig. 7. *T. sublintea*, Corral, Chili, ×12.
Fig. 8. *T. barda*, Corral, Chili, ×6.
Fig. 9. *T. flava*, Hakgala, Ceylon, ×8.
Fig. 10. *Hirsutella arachnophila*, Hakgala, Ceylon, ×8.
Fig. 11. *Torrubiella ochracea*, *Torrubiella* form, ×3.
Fig. 12. *T. ochracea*, *Cordyceps* form, ×3.

PROCEEDINGS, 1923.

MEETING. UNIVERSITY COLLEGE, LONDON. *20th January.*

Dr W. Brown and Dr A. S. Horne. *Fusarium.*
Mr J. Ramsbottom. Berkeley and Broome.
Miss W. F. F. Ridler. The Fungus present in *Lunularia cruciata.*
Dr H. Wormald. Crown-Gall in Nursery Stock.
Mrs N. L. Alcock. *Polystictus versicolor* parasitic on Apple.
Miss E. M. Wakefield. *Fomes applanatus* and *F. fomentarius.*

MEETING. UNIVERSITY COLLEGE, LONDON. *17th March.*

Rev. P. J. Alexander, C.J. An ecological and phenological account of the Mycetozoa of Surrey.
Miss M. H. Carré, Dr A. S. Horne, Miss H. M. Judd and Mrs H. S. Williamson. *Eidamia.*
Dr J. S. Bayliss Elliott and Miss O. P. Stansfield. The life history of *Polythrincium Trifolii* Kunze.
Mr J. Ramsbottom. 1. The correspondence of Berkeley and Broome.
2. Mycology at the British Empire Exhibition (1924).

SPRING FORAY, BRISTOL. *20th—24th April.*

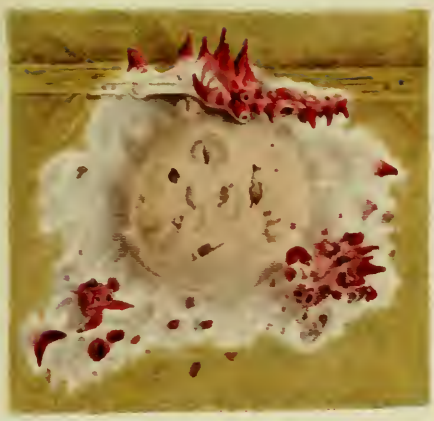
Visit to Ashton Court Park and Long Ashton Horticultural Research Station.
Visit to Mushroom beds in disused Bathstone quarries at Corsham, Wilts.
Visit to Wrington.
Miss B. M. Breeze. Pollen sterility in potato.
Mr F. E. Smith. *Mycogone* disease in Mushrooms.
Miss E. M. Wakefield. *Rhizoctonia violacea* and *Helicobasidium purpureum.*

SPRING FORAY FOR LONDON STUDENTS. *5th May.*

Visit to Effingham.

PHYTOPATHOLOGICAL MEETING. *7th July.*

Visit to South Eastern Agricultural College, Wye.



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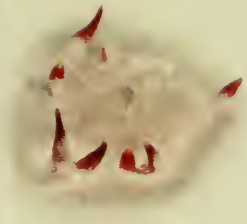

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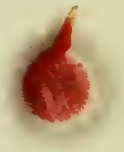

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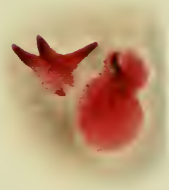

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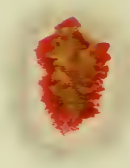

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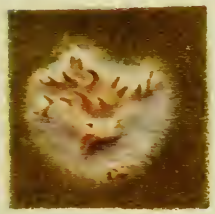

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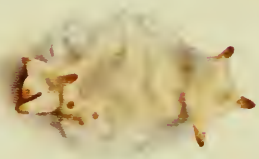

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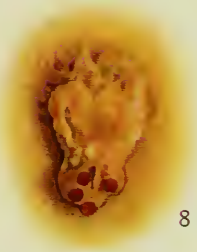

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(*Recognosce notum, ignotum inspice*)

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THE BRISTOL FORAY.

April 20th–23rd, 1923.

The 1923 spring foray was held during the week-end April 20th to 23rd at Bristol, where, through the President, Professor O. V. Darbishire, the Botanical Department of the University had been kindly placed at the disposal of the Society.

On the Friday evening, at 8.30 p.m., the members assembled at the University and were received by Professor Darbishire and his assistants. The evening was spent very pleasantly greeting friends and examining the various mycological exhibits in the Department, including excellent bottled specimens of some of the more striking plant diseases. Miss Ida M. Roper had brought a specimen of *Polyporus sulphureus* found growing in a cellar.

On Saturday, April 21st, the party drove by charabanc to Ashton Court. Work in the grounds there yielded a few of the larger fungi, but more in microscopic forms, such as Rusts and Pyrenomycetes. A young ash plantation especially provided some interesting species.

Towards the end of the afternoon the various scattered groups made their way towards the Research Station at Long Ashton, where tea had been provided. Mr Wallace, of the Long Ashton staff, conducted the party over the laboratories and the outdoor experimental plots, and gave some account of the work that was being carried on. Proof was provided of the excellent results of experiment in cider production.

In the evening, at the University, Miss B. M. Breeze read a paper on "The Sterility of the Pollen of the Potato 'Up-to-Date,'" suggesting the possible parasitic nature of certain bodies observed in the pollen-grains.

Nine new members were elected, bringing the total number of members to over 300. Some discussion took place as to the locale of the next spring foray. Dovedale was suggested, with Buxton as a centre, but the Council was empowered to adopt an alternative should this prove impracticable.

On Sunday, April 22nd, two alternative excursions were arranged for the afternoon. Some of the party drove by charabanc to Corsham, near Bath, and were shown over the underground mushroom beds belonging to Messrs Agaric, Ltd. Others, under the leadership of Mr A. A. Pearson, visited Blaise Castle Woods, and added a number of species to the list, which would otherwise have been very scanty for this day. Mr Pearson

obtained a good specimen of *Acia stenodon*, apparently quite rare in this country.

In the old mine workings at Corsham quantities of *Coprinus radians* were found, but little else of note was gathered by that party.

In the evening, Mr F. E. Smith gave an account of some work he had been doing on the fungus *Mycogone perniciosa*. The fungus is a parasite of the cultivated mushroom, and material had been obtained from the beds at Corsham.

Monday, the 23rd, was spent in the woods at Cleeve Combe and Goblin Combe, in the county of Somerset. Here on dead branches in a beech wood *Bertia moriformis* was found abundantly, and in some cases old specimens showed the large spores with up to 6 or 7 septa mentioned by the late Sir Henry Hawley (*Trans. Brit. Myc. Soc.* VIII, p. 227). Another noteworthy find on this day was *Myriangium Duriaei*, which was abundant on scale insects on some young ash trees.

In the evening, Miss Wakefield reported briefly the finding by Mr W. M. Ware of *Helicobasidium purpureum* associated with *Rhizoctonia violacea* on red clover, and in drawing attention to the possibility of a connection between the two fungi she appealed to members present to watch for and to send further specimens of either fungus, especially of the *Helicobasidium*, as cultural experiments were being started.

An additional new member, Dr W. Watson of Taunton School, was elected, and hearty votes of thanks were accorded to the Bristol University authorities for their hospitality and to the various landowners who had given permission for their estates to be visited.

In thanking Professor Darbishire for the trouble he had taken to organise such an interesting and enjoyable meeting, Mr Ramsbottom took the opportunity to convey to him the congratulations of the Society on the birth of a son and heir, the good wishes taking the form of a silver porringer. Professor Darbishire replied.

With this little ceremony the meeting was brought to a close.

The Secretary is indebted to Mr Ramsbottom, Mr Pearson, and Dr Bayliss Elliott for assistance in compiling the subjoined list of species gathered during the Foray.

A = Ashton Court (Somerset). *B* = Blaise Castle Woods (Gloucestershire). *C* = Cleeve Combe and Goblin Combe (Somerset). Corsham records, which are for Wiltshire, are specially indicated.

HYMENOMYCETES.

Tricholoma melaleucum (Pers.) Fr., *B*.
Mycena discopus Lév., *B*.
Clitocybe fragrans (Sow.) Fr., *A*.
Marasmius conigenus (Pers.) Karst., *A*., dryophilus (Bull.) Karst., *B*.

Lenzites betulina (Linn.) Fr., *B.*
Entoloma sericeum (Bull.) Fr., *C.*
Nolanea papillata Bres., *B.*
Pholiota praecox (Pers.) Fr., *A.*
Galera tenera (Schaeff.) Fr., *A.*, hypnorum (Schrank) Fr., *A.*
Bolbitius titubans (Bull.) Fr., *C.*
Paxillus panuoides Fr., *Corsham.*
Hypholoma fasciculare (Huds.) Fr., *A.*, *B.*
Psilocybe foenisecii (Pers.) Fr., *A.*
Psathyrella gracilis (Pers.) Fr., *B.*
Coprinus micaceus (Bull.) Fr., *C.*, radians (Desm.) Fr., *A.*, *Corsham*, stercorarius Fr., *C.*, atramentarius (Bull.) Fr., *B.*
Panaeolus campanulatus (Linn.) Fr., *A.*
Polyporus dryadeus (Pers.) Fr., *C.*, betulinus (Bull.) Fr., *A.*, adustus (Willd.) Fr., *C.*
Fomes annosus Fr., *A.*, *B.*
Polystictus versicolor (Linn.) Fr., *A.*, abietinus (Dicks.) Fr., *B.*, *C.*
Trametes gibbosa (Pers.) Fr., *B.*, mollis (Sommerf.) Fr., *B.*
Merulius corium (Pers.) Fr., *A.* (on ash).
Irpex obliquus (Schrad.) Fr., *C.*
Acia stenodon (Pers.) Bourd. and Galz., *B.*
Odontia fimbriata (Pers.) Fr., *B.*, farinacea (Pers.) Quél., *B.*
Grandinia granulosa Fr., *A.*
Hymenochaete rubiginosa (Dicks.) Lév., *B.*
Stereum hirsutum (Willd.) Fr., *A.*, *C.*
Corticium Sambuci (Pers.) Fr., *A.*, *B.*, *Corsham*, laeve (Pers.) Fr., *A.*, *B.*, *C.*, confine Bourd. and Galz., *B.*, *C.*, comedens (Nees) Fr., *B.*, praetermissum (Karst.) Bres., *B.*
Peniophora longispora (Pat.) v. H. and L., *B.*, cremea Bres., *A.*, setigera (Fr.) Bres., *A.*, hydnoides C. and M., *A.*, *B.*, *C.*, incarnata (Pers.) Cooke, *A.*, cinerea (Fr.) Cooke, *A.*, *C.*, laevigata (Fr.) Mass., *B.*, quercina (Pers.) Cooke, *C.*
Solenia anomala (Pers.) Fr., *C.*
Auricularia auricula-Judae (Linn.) Schroet., *A.*
Exidia glandulosa (Bull.) Fr., *C.*, nucleata (Schw.) Rea, *B.*
Dacryomyces deliquescens (Bull.) Duby, *C.*

GASTROMYCETES.

Phallus impudicus (Linn.) Pers., *A.* ("egg" only).
Bovista plumbea Pers., *C.*
Lycoperdon caelatum (Bull.) Fr., *C.*

UREDINALES.

Uromyces Poae Rabenh., *B.*, *Corsham*, Ficariae Lév., *A.*, Scillarum (Grev.) Wint., *C.*
Puccinia Violae (Schum.) DC., *B.*, *C.*, Umbilici Guép., *A.*, Smyrnii Biv., *A.*, tumida Grev., *B.*, Saniculae Grev., *C.*, Taraxaci Plowr., *Corsham*, Phalaridis Plowr., *A.*, *B.*, Caricis (Schum.) Rebent., *A.*, Buxi DC., *C.*
Phragmidium Fragariastri (DC.) Schroet., *C.*, subcorticium (Schrank) Wint., *A.*, Rubi (Pers.) Wint., *A.*, *C.*
Melampsora Rostrupii Wagn., *A.*, *B.*, *C.*

USTILAGINALES.

Urocystis Anemones (Pers.) Schroet., *B.*

PYRENOMYCETES.

Nectria episphaeria (Tode) Fr., *A.*, *C.*, galligena Bres., *C.*, coccinea (Pers.) Fr., *C.*
Xylaria Hypoxylon (Linn.) Grev., *A.*
Hypoxylon rubiginosum (Pers.) Fr., *C.*, multiforme Fr., *A.*
Daldinia concentrica (Bolt.) Ces. and de Not., *A.*, *B.*
Eutypa lata (Pers.) Tul., *A.*
Diatrype Stigma (Hoffm.) de Not., *A.*, *C.*, disciformis (Hoffm.) Fr., *A.*, *C.*

Diatrypella quercina (Pers.) Nke., *C.*, nigro-annulata (Grev.) Nke., *A.*
Valsa ambiens (Pers.) Fr., *C.*, syngenesia Fr., *A.*
Cryptosphaeria eunomia (Fr.) Fuck., *A.*, *C.*
Anthostoma turgidum Nits., *C.*
Diaporthe occulta (Fckl.) Nke., *A.*
Calospora platanoidis (Pers.) Niessl., *A.*
Fenestella vestita (Fr.) Sacc., *C.*
Lasiosphaeria spermoides (Hoffm.) Ces. and de Not., *A.*
Stigmatea Robertiani Fr., *A.*, *C.*
Leptosphaeria acuta (Moug.) Karst., *A.*
Bertia moriformis (Tode) de Not., *A.*, *C.* (form with eventually up to 6 or 7 septa).
Dichaena quercina (Pers.) Fr., *C.*
Hypospila frustula (Pers.) Wint., *A.*
Mycosphaerella maculiformis (Pers.) Schroet., *C.*

DISCOMYCETES.

Acetabula vulgaris Fuck., *C.*
Disciotis venosa (Pers.) Boud., *C.*
Sarcosphaeria coronaria (Jacq.) Boud., *A.*
Corynella glabro-virens Boud., *C.*
Orbilia xanthostigma Fr., *A.*
Hyalinia Leightoni (Phill.) Boud., *C.*
Chlorosplenium aeruginosum (Oeder) de Not., *C.*
Dasyscypha virginea (Batsch) Fuck., *C.*
Lachnella canescens (Phill.) Cooke, *C.*
Trichoscypha calycina (Schum.) Boud., *A.*
Hyaloscypha hyalina (Pers.) Boud., *B.*, *C.*
Mollisia cinerea (Batsch) Karst., *A.*, *B.*, *C.*
Stegia Ilicis Fr., *B.*
Rhytisma acerinum (Pers.) Fr., *A.*, *C.*
Myriangium Duriaei Mont. and Berk., *C.*

PHYCOMYCETES.

Peronospora parasitica (Pers.) de By, *A.*

SPHAEROPSIDALES.

Phyllosticta hedericola Dur. and Mont., *C.*
Phoma lineolata Desm., *A.*
Phomopsis scobina Grove, *C.*, glandicola Grove, var. Coryli-putaminis Sacc., *C.*
Cytospora nivea Sacc., *C.*
Ceuthospora Lauro-cerasi Grove, *C.*
Septoria Rubi West., *A.*, *C.*, Violae West., *C.*
Discella carbonacea (Fr.) B. and Br., *Corsham.*

MELANCONIALES.

Pestalozzia Guepini Desm., *A.*, on rhododendron.

HYPHOMYCETES.

Trichoderma lignorum (Tode) Harz., *C.*
Isaria farinosa (Dicks.) Fr., *B.*, clavata Ditm., *C.*
Tilachlidium tomentosum (Schrad.) Lind., *B.*

MYCETOZOA.

(Rev. P. J. Alexander, C.J.)

Badhamia capsulifera Berk., *A.*, utricularis Berk., *B.*, panicea Rost., *B.*
Physarum nutans Pers., *B.*, compressum Alb. and Schw., *C.*, vernum Somm., *C.*
Craterium minutum Fries, *A.*, *B.*, *C.*
Leocarpus fragilis Rost., *B.*
Diderma spumarioides Fr., *C.*, hemisphericum Horn., *C.*, radiatum Lister, *B.*
Didymium difforme Duby, and var. connatum Lister, *C.*, squamulosum Fr., *A.*, *B.*, *C.*, melanospermum Macbr., *A.*

Stemonitis fusca Roth., *B.*
Comatricha nigra Schroet. and var. alta Lister, *B.*, *C.*
Brefeldia maxima Rost., *B.*
Dictydiaethalium plumbeum Rost., *B.*, *C.*
Reticularia Lycoperdon Bull., *A.*, *B.*, *C.*
Liceopsis lobata Torrend, *B.*
Lycogala epidendrum Fr., *A.*, *B.*, *C.*
Trichia affinis de Bary, C., persimilis Karst., *A.*, *B.*, *C.*, varia Pers., *A.*, *C.*, decipiens Macbr., *A.*, *B.*, *C.*, Botrytis Pers., *C.*
Hemitrichia clavata Rost., *B.*
Arcyria incarnata Pers., *B.*, *C.*
Margarita metallica Lister, *B.*

THE LICHENS OF THE BRISTOL FORAY.

By W. Watson, D.Sc., A.L.S.

Two of the excursions were to localities where the substratum was mainly a calcareous one. In both localities a number of rock-surfaces were exposed and therefore a fairly large number of calcicolous lichens were noticed. The cliffs, rock-ledges and screes of Cleeve Combe were especially interesting, and yielded a number of lichens characteristic of such habitats. On the Warren above the Combe some leaching had occurred and many ground lichens, more representative of a siliceous district, were present. The only known British locality for *Lecidea testacea* is near Cleeve Combe, but the exact spot, where it is still abundant, was not visited. Cleeve Combe is also one of the two British localities from which *Leptogium placodiellum* is recorded. It is abundant on the talus but very seldom merits Nylander's specific name of *placodiellum*, the thallus rarely showing the radiate lobes distinctly, so that Krempelhuber's specific name of *diffractum* is more appropriate. A number of lichens (*e.g. Collema flaccidum, Thelotrema lepadinum, Urceolaria gypsacea, Lecidea Metzleri, Biatorina candida*), which have been previously seen in the Combe, are not given in the list as they were not observed during our hurried survey. The corticolous lichens were more abundant in the Cleeve district than in the Bristol area, smoke having its usual effect on them. Blaise Castle Woods were rather poor for lichens, they were too damp and the shading was too great. This locality is in Gloucestershire, the other two are in Somersetshire. In none of the localities visited was an altitude greater than 550 feet reached.

A = Ashton Court. *B* = Blaise Castle. *C* = Cleeve Combe. *W.* = Wrington and Wrington Warren.

Calicium hyperellum Ach., *B.*, *W.*
Sphinctrina turbinata (Pers.) Fr., *C.*
Placynthium nigrum (Huds.) Gray, *A.*, *C.*, *W.*
Collema pulposum (Bernh.) Ach., *B.*, *C.*
C. tenax (Sw.) Ach., *A.*
C. cheileum Ach., *A.*

C. multifidum (Scop.) Schaer., *C.*
C. granuliferum Nyl., *C.*
C. terrulentum Nyl., *B.*
Leptogium microscopicum Nyl., *A.*, *C.*
L. minutissimum (Flk.) Fr., *C.*
L. scotinum v. sinuatum (Huds.) Malbr., *C.*
L. lacerum (Lil.) Gray, *A.*, *C.*
L. diffractum Kremp., *C.*, *W.*
Peltigera canina (L.) Willd., *C.*
P. rufescens (Weis.) Hoffm., *C.*
form praetextata (Flk.) Cromb., *C.*
P. polydactyla (Neck.) Hoffm., *B.*, *C.*
P. horizontalis (L.) Hoffm., *C.*
Ramalina calicaris (L.) Fr., *C.*
R. farinacea (L.) Ach., *A.*
R. fraxinea (L.) Ach., *A.*
R. fastigiata (Pers.) Ach., *A.*
U. florida (L.) Web., *C.*
var. hirta (L.) Ach., *A.*
U. ceratina Ach., *B.*
Evernia prunastri (L.) Ach., *A.*, *B.*, *C.*, *W.*
Platysma glaucum (L.) Nyl., *B.*
Parmelia perlata (L.) Ach., *A.*
P. revoluta Flk., *C.*
form minor Harm., *C.*
P. dubia (Wulf.) Schaer., *W.*
P. sulcata Tayl., *A.*, *B.*, *C.*
P. saxatilis (L.) Ach., *A.*, *B.*, *C.*
form furfuracea Schaer., *A.*, *B.*, *C.*
var. panniformis Schaer., *B.*
form caesiopruinosa Nyl., *B.*
P. caperata (L.) Ach., *A.*, *B.*, *C.*
P. fuliginosa Nyl., *A.*, *C.*
form aterrima Nyl., *A.*
var. laetevirens (Flot.) Nyl., *A.*
P. physodes (L.) Ach., *A.*, *B.*, *C.*
form labrosa Ach., *W.*
Physcia ciliaris (L.) DC., *A.*
P. pulverulenta (Schreb.) Nyl., *A.*
P. grisea form pityrea (Ach.), *A.*
P. stellaris (L.) Nyl. form rosulata (Ach.), *A.*
P. aipolia (Ach.) Nyl., *A.*, *C.*
var. cercidia (Ach.) Nyl., *A.*
P. leptalea (Ach.) DC., *A.*
form leptaleodes Nyl., *A.*
P. tenella (Scop.), *A.*
form ascendens (Bitter), *A.*
P. caesia (Hoffm.) Nyl., *A.*
P. virella (Ach.) Lynge, *A.*
Rinodina roboris (Duf.) Arn., *A.*
Buellia canescens (Dicks.) de Not., *A.*, *B.*, *C.*
B. myriocarpa (DC.) Mudd., *A.*
form depauperata (Anzi.), *A.*
form stigmatea (Krb.), *A.*
Xanthoria parietina (L.) Th. Fr., *A.*, *B.*, *C.*
var. aureola (Ach.) Th. Fr., *A.*
Placodium callopismum (Ach.) Mer., *A.*, *B.*
var. plicatum (Wedd.), *A.*, *B.*
P. xantholytum Nyl., *C.*
Callopisma citrinum (Hoffm.) Krb., *A.*, *B.*
C. pyraceum (Ach.) Arn., *A.*
C. rupestre v. calvum (Dicks.), *W.*
form incrustans (DC.), *C.*
Candelariella vitellina (Ehrh.) Mull-Arg., *A.*, *B.*
form corusca (Ach.), *A.*
Crocynia lanuginosa (Ach.) Hue., *B.*
Squamaria saxicola (Poll.) Hook., *A.*, *W.*
Lecanora galactina Ach., *A.*, *C.*
L. rugosa (Pers.) Nyl., *B.*
L. chlarona (Ach.) Cromb., *A.*, *B.*, *C.*
L. campestris (Schaer.) Nyl., *C.*
L. umbrina (Ehrh.) Mass., *A.*
L. Hageni Ach., *A.*
L. atra (Ach.) Huds., *A.*
L. parella (L.) Ach., *A.*
L. varia (Ehrh.) Ach., *B.*
L. expallens (Pers.) Ach., *B.*, *C.*
var. lutescens (DC.) Nyl., *C.*
L. polytropa (Ehrh.) Schaer., *A.*
Aspicilia calcaria (L.) Krb., *A.*
A. gibbosa (Dicks.) Krb., *A.*
Placolecania candicans (Dicks.) Zahl., *W.*
Acarospora fuscata (Schrad.) Th. Fr., *A.*
Pertusaria amara (Ach.) Nyl., *A.*, *B.*, *C.*
P. communis (DC.), *A.*, *B.*, *C.*
var. leiotera Nyl., *C.*
P. leioplaca (Ach.) Schaer., *B.*, *C.*
P. Wulfenii DC., *A.*, *C.*
Phlyctis argena (Ach.) Krb., *A.*, *B.*, *C.*
P. agelaea (Ach.) Krb., *B.*, *C.*
Cladonia pyxidata Fr., *A.*, *B.*, *C.*
var. pocillum Fr., *W.*
C. pityrea (Flk.), *W.*
form hololeois (Flk.) Wain., *W.*
C. fimbriata (L.) Fr., *W.*
var. radiata (Schreb.) Nyl., *B.*
C. ochrochlora Flk., *C.*
C. furcata Hoffm., *W.*
C. rangiformis Hoffm., *W.*
C. sylvatica Hoffm., *W.*
C. Floerkeana f. trachypoda Nyl., *W.*
C. macilenta Hoffm., *A.*, *B.*, *W.*
C. digitata Hoffm., *B.*
Lecidea ochracea (Hepp.) Wedd., *W.*
L. immersa (Web.) Ach., *B.*
L. quernea (Dicks.) Ach., *A.*
L. parasema Ach., *A.*, *B.*, *C.*
var. elaeochroma Ach., *A.*
var. flavens Nyl., *A.*, *C.*
L. protrusa Fr., *A.*

Biatorina synothea (Ach.) Krb., *B.*
B. Griffithii (Sm.) Mass., *W.*
Bilimbia aromatica (Turn.) Jatta., *A.*
Bacidia phacodes Krb., *B.*
B. incompta (Borr.) Anzi., *B.*
Gyalecta truncigena (Ach.) Hepp., *B.*
G. cupularis (Ehrh.) Schaer., *C.*
G. exanthematica Fr., *C.*
Lecanactis premnea (Ach.) Wedd., *A.*
Arthonia radiata (Pers.) Ach., *C.*
var. Swartziana (Ach.) Sydow, *A.*, *B.*, *C.*
Graphis elegans (Borr.) Ach., *A.*, *B.*, *C.*
G. scripta (L.) Ach., *C.*
Enterographa crassa (DC.) Fée., *A.*, *B.*
Opegrapha atra Pers., *A.*, *C.*
O. varia Pers., *A.*, *B.*, *C.*
form diaphora Ach., *B.*
O. vulgata Ach., *B.*
O. saxicola v. Decandollei Stiz., *A.*
Dermatocarpon lachneum f. rufescens (Ach.), *C.*
Verrucaria integra Carr., *A.*
V. rupestris Schrad., *A.*
V. parva Deakin., *A.*, *C.*
V. calciseda DC., *A.*, *C.*
V. marmorea (Scop.) Zahl., *A.*
V. nigrescens Pers., *A.*, *C.*
V. coerulea DC., *C.*
V. glaucina Ach., *A.*
V. viridula (Schrad.) Ach., *C.*
Acrocordia gemmata (Ach.) Krb., *A.*
A. epipolea (Borr.) A. L. Sm., *B.*, *C.*
Porina chlorotica (Ach.) Wain., *B.*
P. carpinea (Pers.) Zahl., *B.*, *C.*
Pyrenula nitida (Weig.) Ach., *A.*, *B.*, *C.*
var. nitidella (Flk.) Mudd., *C.*
Mycoporum miserrimum Nyl., *C.*

A Lecidea and an Arthopyrenia from rocks at Ashton Court have not been determined satisfactorily. The Lecidea may be a variety of *L. protrusa* Fr. The Arthopyrenia approaches *A. saxicola* Mass., but the spores are too large. *Myriangium Duriaei* M. and B., which was formerly put amongst the lichens, was abundant on ash trees in Cleeve Combe. Prof. Darbishire informs me that *Peltigera horizontalis* was abundant in Cleeve Combe and that he found *Scutula epiblastematica* (Wallr.) Rehm. [= *Biatorina epiblastematica* A. L. Sm.] parasitic on *Peltigera rufescens* in the same locality.

OBSERVATIONS ON SOME SCOTTISH UREDINEAE AND USTILAGINEAE.

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S., Reader in Mycology in the University of Edinburgh.

Puccinia Cirsii Lasch.

Uredospores and teleutospores on *Carduus heterophyllus* L. Darnaway, Forres, collected by Greville probably in 1821, and Murthly, Perthshire, Sept. 1921.

Greville's specimen is preserved in the Herbarium of the Royal Botanic Garden, Edinburgh. The species has not been previously recorded on this host in this country, but has been described on it on the continent. The sori are on pale yellowish spots and are exclusively epiphyllous. The teleutospores are distinctly verruculose. *P. Andersoni* B. and Br. occurs on this

host in Scotland, but differs in the absence of uredospores, the hypophyllous sori and the distinctly thickened apex of the teleutospore.

P. Tripolii Wallr.

On *Aster Tripolium* L., Aberlady, Haddington, Sept. 1921.

Only previously recorded in Scotland from the Tay and Dee areas.

P. Sonchi Rob.

This rust appears to be widespread in Scotland. It has already been recorded by Trail from Aberdeen, by Johnson from Berwick and by Boyd in Ayrshire. It was not uncommon near Berwick and in the neighbourhood of Edinburgh in 1922 and was also found by Professor Scott Elliott in Kirkcudbrightshire. In these cases only uredospores were present. Teleutospores were however found on specimens collected at Brantingham near Hull in September 1922, and this appears to be the first occasion on which this spore-form has been found in Britain.

P. paludosa Plowr.

Aecidia on *Pedicularis palustris* L. and uredospores and teleutospores on *Carex Goodenovii* Gay, Taynuilt, Argyll, August 1921, and Lumphanan, Aberdeen, July 1922.

Previously recorded from Norfolk and by Trail from Orkney. Aecidiospores placed on *Carex Goodenovii* on July 24th produced uredo-, and teleuto- and mixed sori on the upper surface of the leaf on August 21st, 1922.

P. mirabilissima Peck.

Uredospores and teleutospores on *Berberis Aquifolium* Pursh., Colinton, near Edinburgh, January 1923, and Newlands, Peeblesshire, July 1923.

This appears to be the first European record of this species which has hitherto only been found in some of the western United States and in Washington (see *Trans. Bot. Soc. Edin.* xxviii, 1923, p. 164).

P. Zopfii Wint.

Uredospores and teleutospores on *Caltha palustris* L., Taynuilt, Argyllshire, July 1921, and Lumphanan, Aberdeen, July 1922.

A Scottish specimen of this rust is preserved in the herbarium of the British Museum (see *Trans. Brit. Myc. Soc.* iv, 1913, p. 185) and its discovery in the localities mentioned above appears to indicate that it is widespread in Scotland. It is also recorded from England and Ireland. It has probably been confused with *P. Calthae* Link but differs from this species in its broader teleutospores.

P. SEPTENTRIONALIS Juel.

This species is frequently found on the higher Scottish mountains at altitudes from 2000–3500 ft., where the host plants, *Thalictrum alpinum* L. and *Polygonum viviparum* L., grow in association. On the continent the uredospore and teleutospore stages have also been recorded on *Polygonum Bistorta* L. This latter species is a typical lowland plant, the greatest altitude at which it has been recorded being 600 ft., while its northern limit is given as Aberdeen—Isle of Skye (Watson, *Cybele Britannica*, vol. II, p. 332). *Thalictrum alpinum* rarely or never descends below 1500 ft. in central Scotland, although it has been found at sea level in the extreme north. It is in consequence highly improbable that *P. septentrionalis* should naturally occur on *P. Bistorta* in this country. In order to determine the susceptibility of the latter species aecidiospores from *Thalictrum alpinum* were placed on the leaves of *P. Bistorta* growing in the Royal Botanic Garden, Edinburgh. In about three weeks typical uredosori of *P. septentrionalis* were produced on the under surface of the leaves.

It must be concluded, therefore, that the non-occurrence of *Puccinia septentrionalis* on *Polygonum Bistorta* in this country is not determined by the immunity of the latter species but by the distribution of the alternative host, *Thalictrum alpinum*.

P. EPILOBII DC.

On *Epilobium obscurum* Schreb. Collected by Miss D. de Watteville, near Kingussie, Inverness. July 1922.

Up to the present *P. Epilobii* has only been described on *Epilobium palustre* in this country. The majority of the specimens in the Edinburgh Herbarium, however, including one collected by Greville in Edinburgh in 1821, appear to be on *E. obscurum*. *E. obscurum* was previously regarded as a sub-species of *E. tetragonum*, and it is noteworthy that a hybrid exists between *E. palustre* and *E. obscurum*. *P. Epilobii* is recorded on *E. roseum* on the continent but not on *E. tetragonum*.

P. GLUMARUM Erikss. et Henn.

Uredospores and teleutospores on *Hordeum murinum* L. Collected by Mr M. Y. Orr, Berwick, October 1922, and by Mr G. B. Wallace, Edinburgh and Pathhead, Midlothian, October 1923.

The rust on *Hordeum murinum* does not appear previously to have been found in Britain. In the specimens a few uredospores are present on the leaves and teleutospores are found on the sheaths; both kinds of spores occur on the glumes. The sori are minute and arranged in indefinite lines. The uredospores are verrucose, oval, 20–34 × 18–23 μ, mean 26 × 21 μ.

The teleutospores are variable in form, clavate, rounded or truncate above where the wall is thickened, slightly constricted and usually attenuated but occasionally rounded below, sometimes curved and sometimes with the pedicel attached rather laterally, 44–48 × 17–23 μ, mean 45 × 21 μ; mesospores are very few 33 × 24 μ; paraphyses few or none.

The question arises as to whether this form should be assigned to *P. Hordei* Fuckel (*Symb. Myc.*, Nachtr. II, 1873, p. 16). Fuckel states that *P. Hordei* is distinguished from *P. straminis* (= *P. glumarum*) by the minute sori, globose, rarely oval, uredospores which are smooth and by the form of the teleutospores; in the latter the upper cell is "more obscure," the lower cell which is about equal to the upper in size is never elongated and possesses a rounded base; the pedicel is attached laterally.

In the present specimens the uredospores are distinctly verrucose and oval in form, the upper cell of the teleutospore is usually the larger and the lower cell is generally attenuated; the base of the latter is usually not rounded. In these respects therefore they differ from *P. Hordei*. The points of resemblance are the small sori and the presence of a few teleutospores with rounded base and lateral pedicel.

Sydow (*Monogr. Ured.*; I, p. 708) and Eriksson and Hennings (*Getreideroste*, p. 238) merge *P. Hordei* in *P. glumarum* and this is followed in the case of the present specimens. The almost complete absence of mesospores distinguishes the specimens from *P. simplex* Erikss. et Henn.

The relationships of this rust must remain doubtful until its powers of infection are known and infection experiments are now being commenced. No such work appears to have been carried out with *P. Hordei*.

P. Anthoxanthi Fckl.

Uredospores and teleutospores on *Anthoxanthum odoratum* L. near Aberdeen, Oct. 1921.

It was suggested in a previous note (*Journ. Bot.* 1915, p. 47) that two distinct rusts had been confused under the above name in this country, and this has now been shown to be the case.

P. Anthoxanthi Fckl. appears to be of rare occurrence, and has not been previously recorded in Scotland although recently recorded from Wales by Grove (*Journ. Bot.* 1921, p. 311). In the Scottish specimens the uredospore sori attain a length of 6 mm. and are produced so abundantly as to give the whole leaf a rusty appearance; they are also found on the leaf sheaths and stems. The uredospores measure 20–25 × 17–20 μ and possess 2–3 equatorial germ-pores; no paraphyses are present in the sorus.

The teleutospore sori are dark brown in colour, linear, and up to 4 mm. long. They are present on the leaves, sheaths, and stems. The teleutospores measure 25–38 × 15–20 μ; mesospores are also present. No paraphyses are found in the teleutospore sorus. The Scottish fungus agrees closely with Fuckel's specimens and with Sydow's specimen in the *Mycotheca Marchica*. It is improbable that this is *P. borealis* Juel, for the specimens were found at a low level (about 400 feet) and the alternative host of this species, *Thalictrum alpinum*, is not found below an altitude of 1000 feet in this neighbourhood, an elevation not attained within 15 miles of the spot where the rust was collected.

The specimens previously assigned to *P. Anthoxanthi* Fckl. (see *Journ. Bot.* 1915, p. 47 and *Trans. Brit. Mycol. Soc.* VII, 1921, p. 83) agree with *Uredo anthoxanthina* described by Bubák (*Ann. Mycol.* III, 1905, p. 223) and differ from *P. Anthoxanthi* Fckl. in the much smaller size of the uredospore sorus which contains paraphyses and in the absence of teleutospores.

Uredo anthoxanthina Bubák appears to be widely distributed in Scotland, and has been discovered in the Tweed, Forth, Tay, and Dee areas and in Argyll and by Boyd in Ayrshire. It has also been found in South Wales and is recorded by Grove from Aberystwyth and in Worcestershire.

A uredo-sorus of this species containing spores capable of germination was found in March on a plant of *Anthoxanthum odoratum* which had been planted out in a garden in Edinburgh in the autumn of 1920 when it was apparently uninfected. It seems probable therefore that this species can survive the winter in the form of mycelium in the leaf. The persistence of the fungus by means of uredospores is not however altogether excluded, as these were present in the late autumn in the locality from which the plant was taken.

Uromyces flectens Lagerh.

Teleutospores on *Trifolium repens*. Ballinluig, Perthshire, Oct. 1921.

This species does not appear to have been definitely recorded in Scotland. It was probably included under *U. Trifolii* (*Scot. Nat.* 1890, p. 304) ("*U. apiculosa*, Lév.") by Trail. The sori are found on elongated swellings on the petioles.

Melampsora reticulatae Blytt.

Uredospores on *Salix reticulata* L. Collected by Dr A. W. Borthwick probably on one of the Perthshire mountains.

Uredo-sori, hypophyllous, small, scattered; uredospores verrucose, angular, ovate or subglobose 20–27 × 17–20 μ with wall about 2·5 μ thick; paraphyses numerous, capitate, 75–100 μ

long, 21–28 μ wide at the widest part of the head, wall up to 9 μ thick.

M. reticulatae is distinguished from *M. alpina* and *M. arctica* by its larger uredospores and paraphyses. It is believed to form its caeoma on *Saxifraga aizoides* (*cf.* Sydow, *Mon. Ured.* III, p. 362).

Although only uredospores are present on the specimen there appears to be no doubt that it is really *M. reticulatae*. This opinion is strengthened by Trail's record of the discovery of a caeoma on *S. aizoides* in Scotland (*Scot. Nat.* 1890, p. 326, under *Caeoma Saxifragae*).

Melampsoridium Alni Diet.

Uredospores and teleutospores on *Alnus glutinosa* Medic. and on *A. incana* Medic., Craibstone, near Aberdeen, Oct. 1922.

M. Alni appears to have been first recorded in this country by C. O. Farquharson in 1911 in the vicinity of Aberdeen (*Ann. Scot. Nat. Hist.* 1911, p. 240). The fungus was found on *A. glutinosa* and identified as *M. betulinum*.

It has recently been recorded by Grove as collected by Boyd in Ayrshire on *A. glutinosa* (*Journ. Bot.* 1921, p. 315).

The present specimens were found on two-year seedlings of *A. incana* grown from foreign seed obtained by the Forestry Commission. A few seedlings of *A. glutinosa* were also infected.

The fungus closely resembles *M. betulinum*. The small, yellow uredo-sori are rather few and are scattered over the under surface of the leaf; the uredospores are usually rather smaller than those of *M. betulinum*. The uredospores of the latter species are stated to be smooth at their apices while those of *M. Alni* are echinulate over the whole surface of the wall but these characters do not appear to be constant for all the spores in either of the species. The teleuto-sori are hypophyllous and very inconspicuous.

Melampsorella Caryophyllacearum Schroet.

Aecidia on *Abies Nordmanniana* Spach., Murthly, Perthshire, March 1923. Collected by Mr J. L. S. Smith.

Producing a small witches' broom similar to those on *Abies pectinata*. Not previously recorded on this host in Britain.

Pucciniastrum Epilobii Otth.

Uredospores on *Epilobium alpinum* L. Collected by Mr J. R. Matthews, Meall nan Tarmachan, Perthshire, June 1922.

The specimens were collected at an altitude of about 3000 ft. The uredo-sori are amphigenous, generally hypophyllous, scattered, very small in size and the rust does not produce any discolouration of the leaf. The peridium has the usual structure. Uredospores echinulate, 20–25 × 15 μ with hyaline epispore.

The orange-yellow uredospores show up conspicuously on the bright green leaves, especially after the sori dehisce and the spores are shed. The latter are produced in great abundance and fall to the ground in powdery masses.

Infected plants were grown for several months in Edinburgh and continued to form numerous uredospores but no teleutospores were produced. Healthy plants of *Epilobium alpinum* were readily infected by placing uredospores on their leaves but all attempts to infect *E. angustifolium* L., *E. obscurum* Schreb., *E. montanum* L., and *E. alsinefolium* Vill., resulted in failure. It appears therefore that we are here dealing with a specialised form which is restricted to *E. alpinum* as host and the name *P. Epilobii* sp. f. *alpinae* is accordingly suggested. The absence of spots on the leaves of the host and the fact that the measurements of the uredospores are slightly greater than those given by Sydow (*Monog. Ured.* III, p. 444) are not considered to be characters of sufficient importance to justify the creation of a new species.

P. Epilobii is recorded on *Epilobium alpinum* by Sydow (*l.c.*). It is also found on *E. alsinefolium*, *E. montanum* and a number of other species. It is included under *P. pustulatum* Diet. by Grove (*Brit. Rust Fungi*, p. 366). Sydow (*l. c.* p. 443) divides the latter species into: (1) *P. Abieti-Chamaenerii* Kleb. on *E. angustifolium* and other species of the section Chamaenerion which produces numerous teleutospores in obvious sori and has its aecidium on *Abies balsamea* and *A. pectinata*, (2) *P. Epilobii* Otth. on various species of the section Lysimachion with few teleutospores in inconspicuous sori and no known aecidial stage.

No species of *Pucciniastrum* appears to have been previously recorded on *E. alpinum* in Britain.

THECOPSORA VACCINIORUM Karst.

Uredospores on *Vaccinium Myrtillus* L. near Aberdeen, and Ballinluig, Perthshire, Oct. 1921 and on *Vaccinium uliginosum* L. Ben Lui, Perthshire, Sept. 1921.

The uredospore stage appears to be widespread in Scotland on *Vaccinium Myrtillus*. Infected leaves of *V. uliginosum* were kept during the winter on damp soil but did not develop the teleutospores. The fungus has been previously recorded on *V. Myrtillus*, *V. uliginosum* and on *V. Vitis-Idaea* in Scotland by Trail ("Revision of Uredineae and Ustilagineae of Scotland," *Scot. Nat.* 1890).

COLEOSPORIUM SENECIONIS Fr.

Uredospores and teleutospores on *Senecio Smithii* DC. Collected by Mr Symington Grieve on the island of Coll, Argyllshire, July 1922.

The sori are hypophyllous. The fungus has not been previously described on this South American host species. The *Senecio Smithii* had apparently been growing for some time on the island and no information regarding its origin could be obtained. It is interesting to note that there are no pines on the island and the nearest are more than ten miles distant on the island of Mull. This appears to indicate that the fungus, under these conditions, can exist through the winter in the absence of the aecidial stage.

COLEOSPORIUM PETASITIS Lév.

Uredospores and teleutospores on *Petasites japonicus* F. Schmidt and *P. palmatus* A. Gray. Dawyck, Peeblesshire, August 1923.

The fungus has not been previously found on these hosts in Britain, but has been recorded on *P. japonicus* in Japan. This appears to be the only record on the Californian species, *P. palmatus*. *Coleosporium Petasitis* has not been found in America and it appears probable that infection of *P. palmatus* has taken place from the fungus on *P. officinalis* which is commonly found in the neighbourhood.

CAEOMA SAXIFRAGARUM DC.

Aecidia on *Saxifraga hypnoides* L. Collected by Greville in June 1822, on Ben Venue, Perthshire.

Pycnidia scattered, rather flat, about ·1 mm. high, ·2 mm. wide. Aecidia scattered on stems and leaves, amphigenous on the latter, surrounded by the ruptured epidermis, ·3–·7 mm. diam.; aecidiospores globose, angular-globose or ovate, densely and minutely verrucose, 17–20 × 13–20 μ.

It is probable that this belongs to some species of *Melampsora* but no species of this genus is recorded on this host by Sydow (*Monog. Ured.* III). Somewhat similar caeomata on *Saxifraga aizoides* and on *S. oppositifolia* are known to belong to *Melampsora reticulatae* and *M. alpina* respectively, and it is probable that the other host of the fungus under consideration is one of the alpine willows. This caeoma has been recorded on *Saxifraga hypnoides* by Dietel (*Verzeichn. sämml. Ured.* 1888, p. 26) in the vicinity of Leipzig.

The specimen is preserved in the Herbarium of the Royal Botanic Garden, Edinburgh.

AECIDIUM PSEUDO-COLUMNARE Kühn.

On *Abies pectinata* Dochfour, near Inverness. Collected by Mr G. Robinson, Oct. 1921.

Five different aecidia have been described on the silver fir. Of these *Melampsorella Caryophyllacearum* Schroet. (*Aecidium*

elatinum Alb. et Schwein.) is easily distinguished on account of the formation of a "witches' broom." In *Calyptospora Goeppertiana* Kühn (*Aecidium columnare* Alb. et Schwein.) the aecidiospores are small (21–30 × 14–18μ). In *Pucciniastrum pustulatum* Diet. there is a distinct smooth line down the aecidiospore. The aecidiospores of *Melampsorella Symphyti* Bub. and *A. pseudo-columnare* are about similar in size but the latter, according to Kühn (*Hedw.* XXIV, 1885, p. 108) are white and very irregular in shape and size; the warting is asymmetrical and at certain spots, especially towards the end of the spore, may be altogether wanting.

In the Scottish specimens the attacked leaves are scattered sparingly over the shoots and can be easily distinguished by their pale green colour. The aecidia are borne in two rows on the under side of the leaf, the number in each row varying from 3–9. No spermagonia are present. The pseudo-peridia are cylindrical up to 1·5 mm. high and ·4 mm. wide, with irregularly torn opening. The spores are strikingly white, very irregular in form and size, 27–47 × 21–30 μ averaging 35·5 × 25·5 μ. The distribution of warts is irregular but they are not entirely absent over any part of the spore wall.

Ae. pseudo-columnare has apparently been only once previously found in Great Britain—by Munro at Lyme Regis on *Abies pectinata, Nordmanniana, amabilis* and *cephalonica* as recorded by Plowright (*British Uredineae and Ustilagineae*, p. 271). It appears to be very uncommon on the continent. Klebahn (*Zeits. f. Pflanzenkr.* XXVI, 1916, p. 257) has obtained aecidia apparently identical with *Ae. pseudo-columnare* by infecting *A. pectinata* with *Milesina Blechni*.

The specimens were received through the headquarters of the Forestry Commission in Scotland.

Ustilago Bistortarum Körn.

On the leaves of *Polygonum viviparum* L. Meall nan Tarmachan, Perthshire, alt. 3000 ft.

This is the form which produces swollen pustules on the leaves. The spores are 12–16 μ in diam. and are minutely granulated. It therefore does not agree with the var. *glabra* described on this host by Rostrup in Finmark, Norway, which possesses smooth spores 12–13 μ in diam.

Sphacelotheca inflorescentiae Trel.

In the bulbils of *Polygonum viviparum* L. Ben Lui, June 1914, and Ben Ledi, June 1921, Perthshire.

Schellenberg (*Ann. Mycol.* V, 1907, p. 385) has separated this species from *S. Hydropiperis* on account of differences in the structure of the capsule and spores. The mycelium is perennial

in the rootstock and the spore capsule is produced in the lower portion of the bulbil. The columella only extends half-way through the capsule and in this way differs markedly from *S. Hydropiperis,* while the spores are slightly smaller than those of the latter species. The name *S. inflorescentiae* Trel. is prior to *S. Polygoni-vivipari* Schellenberg.

THECAPHORA LATHYRI Kühn.

In the seeds of *Lathyrus pratensis* L. collected by Dr M. Drummond near Edinburgh, Sept. 1923.

Not previously recorded as British but found on the continent. The pods containing infected seeds become dark-coloured slightly earlier than the healthy ones. The spores are powdery and escape on dehiscence of the pods.

I desire to record my thanks to all those who have supplied me with specimens and especially to Mr J. Ramsbottom for help and advice.

OBSERVATIONS ON CAMAROSPORIUM ABIETIS n. sp.

(With Plates III and IV.)

By Malcolm Wilson, D.Sc., Reader in Mycology, University of Edinburgh, and Redvers B. Anderson, B.Sc. (For.).

This fungus was collected March 3rd, 1923, at Arniston, Midlothian, on a solitary tree of *Abies Lowiana,* Murr.

One or two lateral branches were noticed to be destitute of leaves, and on closer examination were found to bear a large number of black fructifications scattered irregularly all over the branchlets. Such branches were low down and well shaded.

The fructifications vary widely in size from ·5 to 1·1 mm. in diameter and at times are closely aggregated, as when they occupy the pulvinar scars or occur within the axils of lateral branches, in the latter case often numbering forty to fifty on an area of 1·5 cm. diameter. Close aggregation of this kind is more noticeable on older branchlets, where the fungus is undoubtedly saprophytic; in the case of young current-year lateral shoots the fructifications are much less numerous and occupy, for the most part, the old leaf scars.

No signs of infection of the main trunk are seen, nor do the fructifications occur close to it.

The youngest fructifications found had already broken through the outer layers of the bark, in the majority of cases one only to each such ruptured area, but in one or two instances a number occurred close together and seemed to arise from a common stroma. When collected they were sooty black in colour, more

or less coriaceous in texture and only rarely shiny; such is their normal dry condition, but in moist weather they become mucilaginous and as a result have a glossy sheen.

The young fructification seen in section (Plate III, fig. 1) consists of a compact mass of hyphae breaking early through the epidermis of the host. It is shortly cylindrical in shape with a slightly flattened expanded base in contact with the outermost compressed cortical tissues. The main portion of this compacted pseudoparenchyma is pale smoky-brown in colour, but in the upper part of the fructification this merges into a distinct wall some 30 to 40 μ thick composed of hyphae closely interwoven, with thick dark-brown walls and numerous cross septa. In the lower part the wall gradually thins out and is no longer distinguishable at the base, where the whole of the pseudoparenchyma is of a similar character throughout. In this basal tissue, and also in the central area, the hyphal cavities are distinct. In the lowermost part no definite arrangement of hyphae is visible, in the uppermost they tend to become longitudinally arranged and later bear the young spores at their apices.

At first, spore formation is limited to a crescent-shaped area some 40 to 50 μ in depth, situated below the apical portion of the wall and separated from it by a thin layer of pseudoparenchyma which never forms spores. These when first formed are spindle-shaped, one-celled, hyaline and contain a few large oil-globules of a pale olive colour (Plate IV, fig. 5, B). Later the oil-globules break up and separate cross walls are developed one near each end of the cell (fig. 6); and soon five to ten cross walls are formed. These at first are colourless but soon darken, gradually taking on a brown colour. A few longitudinally running walls are then developed, these being characteristically oblique or curved and rarely more numerous than three per spore (Plate IV, fig. 5, C and D). The walls still further darken, and as the oil-globules retain their original colour they show up conspicuously in the cell at this stage.

As the spores mature they become freed by the mucilaginous degeneration of the sporophores and a fresh layer of spores arises below them, these being set free in a similar manner (Plate III, fig. 2). The level of spore-formation thus spreads progressively downwards until only a small area at the base of the fructification remains to represent the original compact mass (Plate III, fig. 3, B).

The wall of the mature spore is bronzy-brown in colour and possesses a thin outer layer which is darker in tint than the remainder. The spores measure on an average 30 μ in length by 12 μ in breadth, the maximum and minimum lengths and

breadths being 21–60 $\mu \times$ 10–16 μ respectively. They rarely possess more than two longitudinal divisions in any one transverse stratum, and each cell contains one or two oil-drops embedded in the pale green contents. The spore-walls both internally and externally are free from corrugations and rugosities of any kind and have rounded corners and are comparatively thick relatively to the size of the spore.

Young spores set free by crushing a fructification are generally provided with a sporophore of about their own length, which usually consists of two cells (Plate IV, fig. 5, A). When such spores are put up in hanging drop cultures the sporophore gradually undergoes mucilaginous degeneration and has entirely disappeared before germination takes place (Plate IV, fig. 10, A). In fact the process which would normally take place within the fructification is here continued after the liberation of the immature spores. Stalked immature spores (Plate IV, fig. 5, A) can be readily distinguished from germinating spores with a single short germ-tube (Plate IV, fig. 9, A) by the fact that the latter never possess a cross wall close to the spore whereas the former always show the cross septum separating spore and sporophore.

Simultaneously with the gradual progression downwards of the spore-bearing layer, degeneration occurs in other parts of the fructification. The mass of pale-coloured pseudoparenchyma already referred to, which is found between the first formed spores and the upper part of the wall, breaks down to a greater or less degree, giving rise to a thin pale brown mucilage, which ultimately escapes with the spores. The wall itself also becomes mucilaginous; at a comparatively early stage, when only a small number of spores have been produced it can be seen that the apical portion has already become paler in colour (Plate III, fig. 1), this being the first indication of the process which will ultimately result in the disappearance of the wall. Stages between this and the complete mucilaginisation of this part of the wall were not seen owing to the fact that at this period the latter is so easily ruptured. There is no doubt however that the process continues and the larger fructification seen in Plate III, fig. 4 probably shows its completion. In this case a portion of the upper part of the wall has completely disappeared, but few if any of the spores have escaped. It is possible however that this fructification has been ruptured in section cutting.

The degeneration spreads to the lateral portions of the wall and these are gradually disintegrated from above downwards. As already described spore formation precedes mucilaginisation of the wall and this initial advantage is retained throughout. At any stage, therefore, the side walls project above the level at which spore formation is taking place in the fructification.

The final stage is shown in Plate III, fig. 3, in which the only remaining part of the wall forms a shallow cup which partly encloses the mass of ripe spores which are held together by mucilage.

In order to verify the assumption that the spores escape in wet weather with the mucilage derived from the fructification, the following experiment was carried out. A fructification showing a shiny apex was carefully isolated and the bark on which it was borne trimmed close up to its base. It was now placed on its side close to and above a perfectly clean slide. The fructification was not allowed to touch the slide, but an extremely fine jet of water was directed on to it and the water passing over it collected on the slide. This water, on examination, was found to contain mature spores and a very thin mucilage surrounding numerous oil-globules and hyphal remnants, etc. (Plate IV, fig. 7). The latter may be divided roughly into two groups the components of both of which show advanced degeneration: the elongated portions derived from the sporophores, and the rounded ring-like structures derived from the wall. The oil-drops present were probably previously contained both in the sporophores and in the hyphae forming the wall. The mucilage stains readily with methylene blue but does not take up corallin soda. It is noteworthy that the great majority of the spores contained in it are in the earliest stages of germination (fig. 7, c) as shown by the presence of a light coloured area at the lower end of the spore on the right (see below).

Allescher (1) and Saccardo (3) refer to the presence of a definite ostiole in certain species of *Camarosporium* and in others to its complete absence. Allescher (p. 277) describes *Camarosporium varium* as possessing "unscheinbarer, glatter, glänzender Mündungspapille" and *C. Karstenii* as "mündungslos" and of *C. Visci* Saccardo (III, p. 463) remarks "ostiolis papillatis, demum distincte perforatis." These statements may indicate that there is considerable variation within the genus in this respect, but it is possible that they are the result of incomplete investigation of species similar in their dehiscence to the one described here.

In order to observe the remaining sequence of events in the life-history of this fungus it is necessary to study the germination of the spores and to isolate the mycelium produced by them in pure culture. For this purpose various liquid media were tried, but the only one which proved successful was an extract of *Abies Lowiana* made by boiling the shoots for some time in water. This extract, with the addition of agar, was found to form a satisfactory medium for the further growth of the mycelium. The mature liberated spores germinate freely in the extract and form a germ-tube at one or both ends. The end

from which the germ-tube is about to arise first becomes pale coloured (Plate IV, fig. 10, A) and the terminal cell begins to enlarge and soon projects slightly. At this stage the contents of this cell and the wall are almost similar in colour and in consequence the outline of the cavity can only be seen with difficulty. Soon a small papilla-like outgrowth appears piercing the outer dark-coloured portion of the wall (Plate IV, fig. 8, A and B). This outgrowth which arises from the inner portion of the spore wall is also pale in colour; apparently its passage through the outermost dark layer is the result partly of the wall becoming mucilaginous and partly of the rupture of the portion of the outer layer lying immediately over it. In the early stages it is merely a thickening of the wall but as it increases in size a definite cavity appears which is connected by a narrow channel with the cavity of the cell from the centre of whose wall the tube has originally arisen (Plate IV, fig. 8, C). At this stage the germ-tube is generally as wide as the breadth of the end of the spore from which it has arisen, but in one or two cases it appeared to be constricted as if the original perforation of the outer layer had been insufficiently large to allow the tube to attain its full size (Plate IV, fig. 8, C). The outermost layer of the wall is always visible as a sort of collar round the base of the germ-tube, its limit being sharply defined and having somewhat the appearance of a cross-septum. Later the germ-tube is thin-walled and hyaline with a number of oil-globules irregularly distributed throughout the contents; the basal portion is usually swollen and possesses a few transverse septa (Plate IV, fig. 10, B and C).

The mycelium formed by the germinating spores remains hyaline for a considerable period, being a translucent, very pale sea-green; it branches but rarely. After about a week's growth, it gradually assumes a brown colour and a floccose woolly appearance, and the hyphae attain a breadth of about 4 μ. It is then very similar to the mycelium found in infected host tissues where it is very conspicuous by reason of its colour and size. The growing points of the mycelium are always slightly swollen, their apices always being rounded and smooth. After about a fortnight's growth in the liquid culture the mycelium was found on examination to bear spores at the ends of the ordinary hyphae quite apart from any fructification. Such spores (Plate IV, fig. 12, A and C) are similar in most respects to those found in the fructifications, though some are rather bent and curved in form (Plate IV, fig. 12, B). Fig. 11 shows early stages in the formation of these spores.

Very similar results are obtained in the case of the cultures grown on the extract in agar; the mycelium formed is identical with that already described and bears spores at the ends of

ordinary hyphae in much the same way. In this culture medium fructifications are produced which bear spores similar to those typical of the species.

On reference to Plate III, fig. 3 it will be noticed that there is a mass of pseudoparenchyma at the base of the fructification, undifferentiated laterally, which is not utilised in spore formation; this opens up the question whether or not this pseudoparenchyma is to be considered as a stroma.

Allescher(1) and Saccardo(3) both describe the genus *Camarosporium* as non-stromatic but both make mention of several species in which a definite stroma is present, *e.g.* Allescher (p. 281) with regard to *C. fissum* states: "Fruchtgehäuse...von pseudoparenchymatischem, lederartig-weichem Gewebe,.... mit der Basis einer dunkelbraunen, unter der Rinde sich weit verbreiten Unterlage aufsitzend, welch letztere auch zwischen den nicht zusammenfliessenden Fruchtgehäusen ein weiches, netzartiges Geflecht bildet," and Saccardo with regard to *C. Visci* (p. 463) says "Peritheciis liberis, caespitosis, in stromate spurio dense dispositis, majusculis," and again with respect to *C. Berkeleyanum* (p. 464): "Peritheciis caespitosis....stromate corticali effuso atro maculaeformi insidentibus." Potebnia(2) also in his description of *C. Elaeagni* states that "die benachbarten Fruchtgehäuse sind manchmal mit stromaartigem, sich verflechtendem Mycelium verbunden."

Judging from the foregoing descriptions and those of several other species it is evident that there is considerable variation in the structure of the fructification. An examination was therefore made of nine species of *Camarosporium* and the extent of the stroma-like base investigated. These species could be roughly grouped as follows:

(1) Those in which the fructifications arise from hyphae which retain their individuality, are few in number and loosely aggregated. Three species were included here of which *C. aequivocum* (Pass.) Sacc. may be taken as an example.

(2) Those in which the fructifications arise from a layer of more closely compacted hyphae. Only *C. Laburni* Sacc. is included here.

(3) Those possessing a definite cushion-like layer of closely compacted hyphae on which more than one fructification frequently arises. Five species are placed here of which *C. Coronillae* var. *Coluteae* Sacc. may be taken as an example. The species at present under investigation would also be included in this group.

Amongst the species of *Camarosporium*, therefore, there is evidently a transition from those in which there is no sign of any stroma-like base to those which would commonly be described as definitely stromatic. If, however, a definite stroma is

considered to be present in these latter species the question arises whether they are rightly placed in the genus *Camarosporium*, which, as has already been pointed out, is non-stromatic. The genus *Dichomera* has similar spore characters but possesses numerous fructifications embedded in a stroma which is described as resembling that of *Dothidea*.

The facts that a species of *Camarosporium* has been given the name *C. dichomeroides* and that another species at first included in *Dichomera* has now been placed in *Camarosporium*, may be taken to show that there is considerable resemblance between the two genera. In this connection Potebnia's(2) remarks are of interest. The fungus he investigated is definitely stromatic, but since it does not possess a number of fructifications embedded in the stroma he distinguishes it from *Dichomera Elaeagni* which had already been described by Karsten, and made it a new species which he named *Camarosporium Elaeagni*. It is thus clear that the genus *Dichomera* cannot be distinguished from the genus *Camarosporium* by the mere possession of a stroma; the distinguishing feature is that the former genus possesses a number of fructifications on the stroma whereas the genus *Camarosporium* does not.

The species under investigation must therefore be assigned to *Camarosporium* in spite of the fact that it possesses a stroma and, since it appears to differ clearly from any fungus hitherto described, we propose to describe it as a new species under the name of *Camarosporium Abietis* *. It is clearly distinct from the few species which have already been described on conifers.

There are few, if any, parasitic species of *Camarosporium* recorded and since none of these occurs on conifers it would be of interest should *C. Abietis* prove to be parasitic. In far the greater number of instances the fungus was found growing upon dead tissue either in the nature of dead bark and cortical cells or on completely dead lateral branches. In one or two instances, however, it was found infecting current-year shoots, destitute of leaves, which were terminal to still living leaf-bearing twigs. The question therefore naturally arises as to whether defoliation follows infection of the shoot, or infection follows the death of the shoot, the latter being more or less accurately recorded by leaf-fall.

The needles of *Abies Lowiana* seem to remain on the tree for some three or four years, or at any rate this figure holds

* Camarosporium Abietis, n. sp.

Peritheciis erumpentibus et prominentibus, gregariis, nigris, laevibus, globoso-hemisphaericis vel breve cylindricis, ·5–1 mm. diam., ostiolo nullo; sporidiis brunneis, dilute coloratis, muriformibus, non constrictis, 30–60 × 10–17 μ; septis transversis 2–10 (plerumque 5–8), septis longitudinalibus circ. 3; sporophoris bacillaribus, articulatis, hyalinis, sporulam subaequantibus.

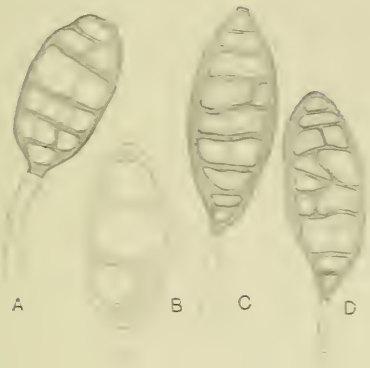
Hab.: Scotia, prope Edinburgh; in ramis *Abietis Lowianae*.

Fig. 1

Fig. 2

Fig. 3

Fig. 4



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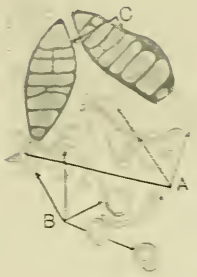

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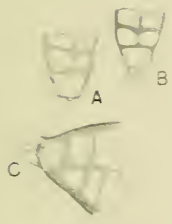

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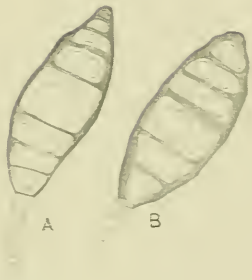

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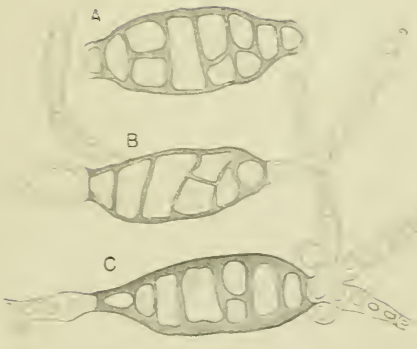

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good for the lower shaded branches. If, therefore, complete defoliation occurs prior to the third year it is either the result of disease or death of the tissues from some other cause.

In an endeavour to ascertain whether the mycelium of the fungus penetrated living host tissues, it was decided to section living twigs which were bearing leaves on all but the current year terminal shoots, the latter portions being clearly infected and evidently dead. Examination of the sections showed that the dead portions were infected and that hyphae could be traced close up to the junction of completely dead and still living tissue, but no penetration of still active living cells was found to take place, and infection of the cells, therefore, appears to be possible only after they have died.

Webster(4) maintains that *Abies Lowiana* has proved exceedingly hardy in Britain and one would suppose, therefore, that it should be free from frosting. The current year has seen some severe late and early frosts, notably those of June and September, and it would be unwise to say that these have had nothing to do with the killing of young current-year wood. Moreover, many of the needles of the tree in question bore the browned tips which are more or less characteristic of frosting and many still uninfected shoots were found minus their bud-apices as if the latter had been nipped. In the meantime, therefore, until infection experiments, which are being carried out, give a definite result one way or another, it may be taken that the fungus is saprophytic.

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EXPLANATION OF PLATES III AND IV.

Fig. 1. A young fructification showing paler area in centre of apex. × 40.
Fig. 2. Spore-forming layer showing *a.* young, *b.* mature spores, *c.* sporophores becoming mucilaginous. × 135.
Fig. 3. A mature fructification showing *a.* mature spores, *b.* residual non-spore-forming pseudoparenchyma, *c.* basal stroma-like area. × 50.
Fig. 4. Two mature fructifications on a common stroma. × 50.
Fig. 5. Mature spores and their sporophores. *a.* a rather uncommon rounded type, *b.* immature one-celled spore containing oil-globules, *c.* and *d.* typical spindle-shaped spores. × 312.
Fig. 6. Immature spore with the two first formed cross walls. × 312.
Fig. 7. Spores in mucilage after escape from the fructification. *a.* elongated portions, *b.* ring-like portions, *c.* spores. × 225.
Fig. 8. Early stages in germination. *a.* papilla-like outgrowth appearing, *b.* outgrowth enlarging, *c.* a very young germ-tube. × 312.
Fig. 9. Germinating spores after 24 hours in culture solution. × 312.
Fig. 10. Germinating spores after 72 hours. *a.* spore about to germinate at both ends, *b.* showing a median cell germinating, *c.* end cells germinating. × 312.
Fig. 11. Mycelium with spore-forming apices. × 240.
Fig. 12. Mycelium bearing spores. *a.* and *c.* mature, *b.* immature. × 240.

A RHIZOCTONIA CAUSING ROOT DISEASE IN UGANDA.

(With Plates V and VI.)

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Introduction.

In Uganda the silky oak (*Grevillea robusta* A. Gunn) has been planted to a large extent as an ornamental tree in gardens and elsewhere and as a shade-tree and wind-break on coffee estates. There is, therefore, a certain amount of interest in its diseases and pests, and the death of a silky oak is sure of notice. In recent years, many trees have died in gardens, on roadsides, and, more lately, among coffee, and it has been customary for the layman to assume the losses to be due to the work of white-ants (*Termes bellicosus* L.). Clear evidence of the presence of the insects is seldom lacking; in fact, they may demolish the underground parts of a silky oak so rapidly that the first sign of trouble is the breaking of the tree at ground-level while the foliage is, to a casual glance, normal in appearance, and so thoroughly that they obliterate almost entirely traces of other harmful agents that may be present and leave only evidence of their own work. The attacks of the termites, however, can be shown to be confined to trees that have already been weakened by, or are dying of, root disease, and the insects are therefore to be regarded as secondary agents in the loss incurred. On occasion, diseased trees escape the attention of the insects, and there is then no difficulty in allocating to a parasitic fungus the real responsibility for deterioration and loss.

Only one root disease of *Grevillea*, the subject of part of the present paper, is known in Uganda. It occurs on trees up to five, six or more years of age, and it has been shown to be caused by a species of *Rhizoctonia*. The writer is not aware of any record of a similar fungus on silky oak, and the fungi associated with root disease of the tree in other parts of the world, particularly Ceylon and the East,—*Ustulina zonata* Lév., *Rosellinia arcuata* Petch, *Ganoderma applanatum* (Pers.) Pat., and *Ganoderma australe* (Fr.) Pat.,—have not been encountered in Uganda. Up to the present, the *Rhizoctonia* has not spread from its host to adjoining trees of *Coffea arabica* shaded or protected by *Grevillea*, although the respective root-systems are in close association with each other. It will be unfortunate if the *Rhizoctonia* attacks Arabian coffee, an important crop that so far has been remarkably free from root diseases. Single

occurrences of the *Rhizoctonia* on tea and arnatto (*Bixa Orellana* L.) are discussed later. The fungus has also attacked *Casuarina equisetifolia* and *Coffea robusta*; which latter is grown on certain estates in addition to *C. arabica*. Attention may be drawn to the fact that the *Rhizoctonia* has occurred only on introduced *Coffea robusta* (originally from Java), and that none of its five hosts is indigenous to Uganda. It may be mentioned that this is the first record of a species of *Rhizoctonia* in this part of Africa. The present species is evidently widespread in Uganda, for cases of its parasitism have been noted in districts far-removed from each other.

Symptoms of the Root Disease of Grevillea Robusta.

The browning and wilting of part of the foliage of a tree is the first symptom of attack and consequent disease, but it frequently happens that blackening of areas of the trunk followed by exudations of a resinous or gummy substance from the trunk and larger branches, if the tree is an older one, is the first cause of attention being drawn to its abnormal condition. Subsequently, certain upper branches or shoots may become leafless, and a "stag-horn" condition may be apparent. It has been customary to refer to this effect of the root disease as "die-back." *Nectria flocculenta* v. Hoehn. and a species of *Phoma* may be found on the dead and dying twigs, but these fungi have been shown to be merely saprophytic. In addition to the cracks in the trunk, others appear at the collar of the tree, which also may give rise to streams of gum, and lead eventually to the scaling of the bark. At this time, a cut into the bark and cortical tissues discloses a certain amount of discoloration which microscopic examination shows to be accompanied by internal accumulations of gum, and an examination of the cambial tissues shows that they have entirely broken down. No hyphae have been found in association with the gum in the stem more than a few inches above the collar, but numerous and characteristic oil-globules exude from sections of all the degenerating tissues. In young diseased trees, suckers often sprout from the base of the trunk, and cases are known in which a sucker has grown to be as large as the original stem of the tree before death ensued. It is likely, therefore, that the progress of the disease is slow, but there is, unfortunately, no doubt about its eventual result.

When the underground parts of a diseased tree are exposed by excavation, symptoms of the root-disease may not obtrude themselves at once on the investigator. In fact, if the case of disease is of short standing, the roots of the tree, except for a slight, superficial blackening of the smaller ones, may appear

to be in a normal condition, and only a histological examination of the internal tissues will prove the presence of the *Rhizoctonia*. In older cases, again, but only in the larger roots, careful washing may reveal on the surface of the bark thin black sheets of tissue which are often slightly raised or ruptured, and which are in evident connection with the internal mycelium of the fungus. Their position and the ease with which they can be detached may enable them to function as rhizomorphs, for it has been shown by experiment that a rapid and profuse growth of mycelium can be induced from a small piece of black sheet by placing it in a suitable medium, and it is therefore probable that they play a part in the dissemination of the *Rhizoctonia* under natural conditions. They, however, are not of regular occurrence in an exposed position like the surface of a root. Owing to the dry condition of the wood, the roots are usually firm and brittle, and a closer examination of the bark and of the surface of the wood after removal of the external tissues may disclose the presence of numerous small black sclerotia in the wood, cortex and bark. The sclerotia may be numerous enough to show through the bark, and cause a distinct blackening of the surface of the roots. Sheets or crusts of black tissue also occur in the roots and pursue an irregular course and thus appear in a rough longitudinal section as thin wavy lines which in places double upon themselves and form "islands." They are seen to most advantage in the wood, and their presence is sometimes denoted by a distinct yellowing of the tissues, a discoloration which is more or less bounded by the extent of the lines. The black sheets or crusts are not consistently present throughout the diseased tissues, but they can be found at times in the bark and cortex as well as in the wood. In the former they are connected with and give rise to the external sheets of black tissue mentioned above; in the latter they do not define necessarily the limits of penetration of the hyphae. The small black sclerotia, on the other hand, are to be found in advanced cases of infection throughout the tissues of the roots and extending into the wood of the collar of the tree.

The Rhizoctonia in the Tissues of Grevillea robusta.

(a) *Hyphae.*

The hyphae of the fungus occur in quantity throughout all the tissues of the diseased roots. In the wood, they vary from very pale- to dark-brown in colour according to age, are septate, usually granular and with oil-globules, and measure up to 10 μ or more in thickness. They may be irregularly swollen and angled or barrel-shaped, and are often more gnarled

in tracheids than in the parenchyma. In penetrating a cell-wall or pit, a hypha may be constricted during passage and swollen immediately afterwards. Clamp connections are scarce, but are to be found on the larger threads. The basal constrictions of the cells and the position of the first septum of a branch hypha, although known to occur in other forms, are nevertheless characteristic of *Rhizoctonia* mycelium. Chlamydospores occur occasionally in the course of the hyphae. Anastomosis of neighbouring hyphae is frequent, and the branching is free. (Plate V, figs. 1 and 2 show two typical portions of the older mycelium of *Rhizoctonia* in the wood and cortex of a *Grevillea* root, and fig. 3 gives an example of the extent to which the hyphae may fill the cell-cavities of elements of the medullary rays.) A certain amount of choking of the cell-cavities by accumulations of gum always occurs.

(b) *Sclerotial plates.*

The so-called black crusts which are found in affected roots are seen in section to consist of plates of cells which vary in thickness and which extend laterally and irregularly by advancing into and filling up adjacent cell-cavities. The cell-walls are dark-brown in colour and comparatively thick. The cells contain oil-globules and frequently appear to telescope into each other (Plate V, fig. 4). A crust however is seldom of so simple a structure as shown in the figure or of so uniform a thickness. It consists rather of a set of two or more plates of cells more or less parallel connected by short hyphae, and becoming more or less fused together. The black crusts in the wood of the roots of long-standing cases of disease (for example, in those of a tree which was not dug up until four months after death), are frequently found to have coalesced with the sclerotia already present, to form continuous sheets which often take the place of connective tissue and grow upon and over the vascular bundles in the form of a crust; they can be made to grow in this manner in the laboratory by keeping a piece of root with lines and sclerotia in damp sterilized sand. Growth of this nature is easiest along the medullary rays, but it is slow, and the time required for it to cover the exposed surface of a split block of root two inches in length and one inch in diameter is from four to six months.

When the material is bleached and mounted, the surface view of a piece of such a sheet presents a striking appearance. The black tissue is seen to consist of a closely-knit mosaic of dark-brown cells which at first sight and in most cases, since the sheet is invariably more than one cell thick, seem to be triangular in shape and remarkably similar to each other. Individual

hyphae, however, can be distinguished, and they are of the structure shown in Plate V, fig. 5. The cell-constrictions and the positions of the first septa are characteristic, as already mentioned, but the respective appearances differ inasmuch as the hyphae of the solid sheets possess the two typical characteristics in what may be called an exaggerated form. Swollen and triangular-shaped cells in which the basal constrictions are less marked than usual invariably occupy the branching points of the hyphae and give rise to new hyphae by a kind of dichotomy, and anastomosis between adjacent hyphae causes a peculiar hammer-head appearance when the neighbouring cells are not viewed in the same plane. A crust in the wood of a root originates in the modification of hyphal cells which become short and barrel-shaped, develop numerous oil-droplets, darken in colour, and blacken the walls and fill the cavities of adjacent cells by expanding into a sclerotial-like mass. They assume their characteristic appearance early, and so differ at once from the vegetative hyphae which have given rise to them. The nature of the cells points to their being able to pass through a resting period, and support is lent to this view by the fact that mycelial growth is immediate and plentiful from fragments of lines taken from dry pieces of diseased roots which have been lying in the laboratory for over six months. The function of a crust, then, is that of a rhizomorph, or, in view of the nature of the cells, that of a piece of resting tissue capable of giving rise to creeping and active mycelium, the equivalent of a mass of chlamydospores or sclerotia. This function is clearly indicated, and, when considered in conjunction with the structure and nature of the tissue, may justify the substitution of the term "sclerotial plate" for that of "crust." In fact, it is difficult at times to distinguish readily between the structure of a sclerotium exposed by a section and that of a piece of sclerotial plate when cut across. A comparison of the material of an early case of *Rhizoctonia* disease with that of one of long-standing seems to point to the formation of sclerotial plates preceding the production of sclerotia, but, on the other hand, it has been noted that sclerotia are present in tissues from which the plates are absent. The two structures are, therefore, independent of each other, although, as is mentioned later, a sclerotium may arise indirectly from a sclerotial plate.

(c) *Sclerotia.*

The sclerotia are found in great numbers in parts of diseased roots. They may protrude from the bark and be numerous in the cortex. They also occur throughout the wood, but their appearance is most striking when they are seen as a mass of

black dots on the surface of the exposed wood. They appear to be smooth, but under high magnification the smoothness is seen to be modified sometimes by the protruding ends of hyphae which are hyaline or pale-brown and often conical in shape. Their outline is conditioned to a certain extent by the surrounding tissue, but is, for the most part, circular, oval or pear-shaped. The majority of the sclerotia are flattened and closely attached to the substratum; when they are old, they can be readily detached by mechanical means. In the wood they occupy conjunctive tissue spaces, and they also occur on the vascular bundles and along the medullary rays. Their greatest length is about 1 mm. and greatest breadth about ·8 mm., but the endwise coalescence of two adjacent sclerotia may present a dumb-bell shape and an apparently greater length than the figure given. The sclerotia have not been observed to unite to form coriaceous masses.

In the tissues, a sclerotium originates in a short line of brown, thick-walled, barrel-shaped and guttulate cells occurring in the course of a hypha which may or may not be in direct connection with a black line (Plate V, fig. 6). The young sclerotium is comparatively long and narrow (Plate VI, fig. 21) and bounded by the cells of the tissue in which it is formed. In structure, a sclerotium consists of a spongy core of irregularly-shaped, more or less thin-walled parenchymatous cells, the average diameter of which varies from 10 μ in some to 5 μ in others. The sclerotia are of one type only. They are remarkable for their large oil-content and are apparently well-fitted for a resting function. Plate V, fig. 7 shows part of a sclerotium with connected hyphae penetrating the adjacent tissues.

(d) *Hymenophore.*

During the study of the *Grevillea* material, the possible existence of a fruiting or *Corticium* stage of the *Rhizoctonia* was kept in mind, and, after much search, a supposed hymenophore was encountered in small amount on one lot of material and in association with a sclerotial plate. Little is known about it and further study of its peculiar formation is not only desirable but essential to throw light on its true function and significance. Under a lens, the usual appearance of a sclerotial plate in either natural or artificially induced growth is that of a smooth and apparently hard carbonaceous surface, but, in the case of the material under discussion, there is to be noted a minutely pilose appearance which on analysis is found to be due to the presence of basidia-like structures and numerous processes arising from the mycelium of the plate. The processes are simple and finger-like or branched and swollen (Plate V, fig. 8). They measure

only 1–3 μ in length when simple, and are usually hyaline at the tip. Some are slender and others are comparatively stout and clavate in shape. They arise from any part of a hyphal cell or in groups of two or more from cells resembling basidia. No spores have been found in association with them, and their function is therefore obscure, but their arrangement points to the possibility of their being abnormal sterigmata. The supposed sterigmata are short and simple and are borne in twos and fours on rounded hyaline basidia which are themselves cut off from hyphae resembling the vegetative hyphae of the *Rhizoctonia* (Plate V, fig. 9), but there is no extensive development of the latter hyphae to form a special hymenophore. No spores have been seen on the sterigmata.

The supposed hymenophore was found on the surface of the wood of a *Grevillea* root which was still internally moist, and from which no bark had been detached until the material was examined in the laboratory. It is apparently of an imperfect nature, induced, it may be, by a gradual process of abortion, and its present significance in the life-history of an organism which is well-equipped with vegetative means of reproduction and spread may well be of little and diminishing importance. As far as is known, the hymenophore occurs only between the bark and wood of a root which is far from the stage of decay that would liberate the basidiospores of the fungus.

The Grevillea Rhizoctonia in Pure Culture.

Cultures of the *Rhizoctonia* have been obtained from root fragments containing hyphae and from pieces of sclerotial plates and scrapings of the supposed hymenophore tissue, in dealing with which every care has been taken to guard against the presence of contaminating elements. The inocula have been thoroughly sterilised by dipping in alcohol and by subsequent flaming or immersion in a saturated solution of corrosive sublimate in alcohol. In many cases, both treatments have been given to the inocula, and, in consequence, a large proportion of them has been rendered incapable of growth. Despite many attempts, neither rested nor fresh sclerotia have been induced to germinate in culture media or in soil or sand. The fungus grows well on agar media (prune + 15°, oatmeal + 10°) and on sterilised filter paper moistened with sugar-cane decoction. The growth of the fungus renders the solid media dark in colour after a few days and black when the development of sclerotia is well-advanced. In most cases, young hyphae are visible in from 12–24 hours, and in all cases sclerotial formation follows almost at once. The young hyphae are colourless, branched, sparingly septate at first, and swollen at the tips; they appear

on the surface of the medium as small, whitish tufts. After a day or two, the hyphae measure up to 8 μ in diameter. Clamp connections are found on the hyphae when they are a few days old (Plate V, fig. 10), but never on the youngest threads. Plate VI, fig. 11 shows the characteristic branching of 24 hours-old mycelium in which the new branches pursue a course almost parallel to the parent hyphae. The mycelium becomes granular and develops barrel-shaped cells with oil-globules in 48 hours (Plate VI, fig. 12). In three days the cells measure up to 30 μ in length, are granular and contain numerous oil-droplets, while in eight days the mycelium presents the appearance shown in Plate VI, fig. 13. Many of the cells are then swollen and thin-walled (Plate VI, fig. 14), while others are assuming the typical *Rhizoctonia* outline. In several cultures, especially in those derived from fragments of sclerotial plate tissue, the mycelium aggregates itself into dark strands which seem capable of becoming creeping rhizomorphs. The curious cell-formations shown in Plate VI, fig. 15 occur in growth from sclerotial plate and hymenophore fragments after a period of eight days. They are most distinctly seen in filter-paper cultures. The majority of them are terminal in position, and they frequently arise from small thin hyphae. The rounded swollen cells are dark-brown in colour and well supplied with oil-droplets, and the general formation of the mass of cells is irregular. The figure shows several cells in process of segmenting and also the rounding-off that follows division. Individually the cells resemble chlamydospores, and, in the mass, the first stages in the formation of sclerotia. Similar rounded dark cells occur singly or in small groups in the course of the mycelium of certain cultures, but neither their history nor that of the larger cell-formations has been followed further. They presumably perform a resting function, for individual cells of the larger type can be found separated from the general mass when the medium dries up. When a filter-paper culture is allowed to dry and the growth of the fungus is arrested in consequence, chlamydospores are formed in large numbers and at times so abundantly in the course of the hyphae as almost to jostle each other for room. They measure up to 8–10 μ in diameter, and are thick-walled, oily, and darker in colour than the hyphae. They are both terminal and intercalary, and rounded or subpyriform (Plate VI, fig. 16). A few of the darker cells have been noted in a state of division, and it is probable that they would have given rise to the curious cell-masses mentioned above had development been allowed to proceed. Besides the normal chlamydospores, others which differ only in their reduced size can be found in small groups as if budded off from the larger spores. They are

regarded as starved spores, but, in other cases, they seem to be the remains of abortive attempts to form lateral branches of the hyphae. In all probability they would have developed into cell-masses or hyphae if growth had continued. The sclerotia of a drying culture measure only ·38 by ·27 mm. Sclerotia form profusely in solid media and also on the surface of moistened filter-paper cultures. Their development is seen more easily in the case of the latter, and the drawings and notes therefore refer to filter-paper growths, although the process is the same in all media. A sclerotium originates in a small group of hyphal cells which become darker than the adjacent cells in colour, rounded, thick-walled and guttulate, by continued segmentation not only of the original cells but also the laterally-placed units to which the core has given rise. The original cells are soon lost to view, and certain of the peripheral cells grow outwards to form hyphae (Plate VI, figs. 17–20). The whole structure becomes a mass of pseudoparenchyma which expels a large quantity of oil on being crushed under a cover-glass. In the mature sclerotium, the central cells have thinner walls and larger lumina than the peripheral cells. During their growth, the sclerotia can be seen in the medium as dark masses which become black in eight days and mature in about one month. They can then be detached easily from the medium, especially if the latter is in process of drying up. In culture they are of a more regularly round-oval shape than in nature, but some are elongated and narrow while others are almost spherical. An average measurement is ·5 mm. long by ·35 mm. broad, but very many of the sclerotia are smaller and others are larger than this. The mycelium in the body of the medium has not been observed to assume the colour and form of that of the black plates in the tissues of diseased roots, and the sclerotia, like those formed naturally, have refused to give growth of any kind even after a nine months' rest. No *Corticium* stage of the *Rhizoctonia* has been found in any of the cultures.

As already mentioned, the fungus in *Grevillea* tissues can be induced to grow by keeping pieces of infected roots in damp sand. The exposed surfaces of the pieces become covered with mycelium which eventually assumes the black sheet or crust form, and sclerotia develop in great numbers independently or in direct connection with the sclerotial-plate tissue. In such cases, the sclerotia are larger and more swollen than those developed naturally, and the black sheet assumes the form of a detachable crust. Although it might be expected to appear, no *Corticium* stage of the *Rhizoctonia* has been found in these root-fragment cultures.

The Rhizoctonia on Tea and Arnatto.

Until the discovery of the *Rhizoctonia* on tea, the only root disease of that host recorded in Uganda had been a rot caused by *Armillaria mellea* Fr. Since it happens that the single affected tea plant has been growing in close proximity to a diseased *Grevillea robusta* tree, it is concluded that infection has been brought about by contact between the hosts of the fungus. In any case, the fact remains that tea is susceptible to the *Rhizoctonia* root disease, though on a smaller scale than *Grevillea*, and this remark applies also to the undermentioned third host of the fungus, the arnatto (*Bixa Orellana* L.).

No external black plates of tissue have been found on the tea roots, and the sclerotia are few in number and concealed in the bark and wood. The wood of affected roots is dry and hard and so permeated in parts by the hyphae of the *Rhizoctonia* that it is darkened in streaks, while the black lines or sclerotial plates are of finer texture and of sparser occurrence than in *Grevillea*. Their structure, however, is similar to that already found in *Grevillea*, and the same spongy extensions filling adjacent cell cavities are apparent. The internal mycelium, again, is not of so consistently dark a colour as that in *Grevillea*. The hyphae ramify in all directions, the larger and older passing longitudinally down the vessels and being at times sufficiently numerous to form a tangled mass, while the younger and more hyaline threads, branching from the older invariably at right angles to them, pass freely through obstructing cell walls. The hyphae vary from 2 to 10 μ in breadth, and their largest cells measure up to 35 μ in length. The sclerotia differ from those of *Grevillea* in being less numerous and smaller in size, and, owing to their being shut up in the tissues, in their ill-defined and less distinct outline.

The fungus has been grown in pure culture in the media previously used and found to behave in the same way as that from *Grevillea*. No fruiting stage has been encountered either in nature or in culture.

At a later period and in a different locality, a tree of *Bixa Orellana* growing beside a dying *Grevillea* tree was observed to wilt, and both specimens were dug up for examination. The *Grevillea* being a typical case of *Rhizoctonia* root disease, it is not surprising that the *Bixa* has proved to be a second example of a host infected by contact. The wood of its roots is dry and brittle and stained in the manner of the tea roots. The external indications of the *Rhizoctonia* consist in the presence of sclerotia on the bark of the smaller roots. Being rounded on their free sides, the sclerotia protrude from their substratum. They correspond in size to those of the *Grevillea* fungus and they contain the same comparatively large quantities

of oil. They occur also on the surface of the wood, and in that position are indistinguishable from those of *Grevillea*. The hyphae in the smaller roots are typically *Rhizoctonia*-like, and permeate the host tissues very thoroughly. Clamp-connections and chlamydospores, neither of which have been seen in tea root sections, are common. Black sclerotial plates occur only in the driest and presumably earliest-infected roots, but hyphae are plentiful in the wood of the collar of the tree. The plates are of the usual structure, and they give off branch hyphae which leave the parent mycelium at the usual right angle and penetrate the surrounding tissues. On the larger roots, the mycelium of the fungus is most plentiful in and near the cambial tissues, in which position it forms thin continuous sheets resembling the black plates and also the growths of the *Grevillea* fungus on filter paper. These sheets cling closely to the inside of the detached bark. In all three cases, *Grevillea*, tea, and *Bixa*, the hyphae of the *Rhizoctonia* have been observed to make little use of pits in their passage through the tissues, but penetrate, apparently without difficulty and doubtless by the action of one or more enzymes, all obstructing cell-walls. The cell-cavities throughout the wood of diseased roots of tea and *Bixa* are frequently filled with gum, a condition recalling that found in the roots of *Grevillea*.

The *Bixa* fungus has been isolated from root fragments and grown in the same media as the tea and *Grevillea* forms. After thirty-six hours, the young hyaline mycelium shows the typical form and method of branching. The hyphae then measure up to 8μ in diameter, and are often aggregated into strands of from two to six or eight threads. Further developments follow the lines already described.

The Rhizoctonia on Coffea robusta and Casuarina equisetifolia.

The *Rhizoctonia* was subsequently discovered on *Coffea robusta* and *Casuarina equisetifolia*. These cases differ from those of the tea and arnatto inasmuch as none of the affected plants—and examples of the root diseases of each have been obtained from different localities—had been growing in close proximity to either healthy or diseased *Grevillea robusta*. The infections are not only independent of *Grevillea* but also of each other, and they establish a suspicion that the *Rhizoctonia* is unlikely to be confined to the first host on which it was found or to the tea and arnatto to which it has seemed to spread. All the new cases have occurred on European coffee estates which are in good order. The *Coffea robusta* is planted in the usual way in plots,

and the *Casuarina* trees form, in one case, part of a wind-break and, in another, part of an ornamental garden.

In the *Coffea robusta* disease, death had apparently been sudden, for each affected tree found in the field was standing with all its leaves in position. The smallest rootlets are dry and shrunken, and the bark of the smaller roots cracks and peels off readily to expose numerous black, flattened or rounded sclerotia embedded in the cortical tissues. The wood of the roots is hard and brittle, as in the previous cases of the disease, and often discoloured by the presence of mycelium, and its surface is dotted in certain parts by sclerotia. Black sclerotial plates are present. The sclerotia occur also throughout the wood, but they are most frequent in the cortex. In the latter position, they are often so irregularly-shaped and numerous that they form an almost continuous black sheet underlying the bark, which recalls a similar appearance in *Grevillea robusta* roots. The average size of the sclerotia is ·45 by ·3 mm., and they are, in general, and apart from their smaller size, indistinguishable from those of the *Grevillea*, tea or arnatto fungus. In the collar of an affected tree, sclerotia can be found in the cortex of the first few inches of stem above soil level; the accompanying mycelium is confined to the cortical and outer tissues of the wood. The hyphae of the fungus are similar in colour, shape and measurements to those of tea and arnatto. The larger pass down the main tracheids in the wood, and give off branches at the usual right angle. The hyphae are most plentiful, however, in the cortical tissues where they frequently give rise to extended plates of flattened, typically *Rhizoctonia*-like mycelium resembling that of the sclerotial plates of *Grevillea*. In this mycelium, the swollen lateral hyphae are connected at times to the parent hyphae by extremely narrow necks, and there is enough globular swelling among the cells to recall the curious cell-formations found in *Grevillea* cultures. Some of the cell-walls of these hyphae possess spiny processes similar to those described from the *Grevillea* hymenophore, but no further likeness to the *Corticium*-like stage of the fungus can be noted. Sclerotia in all stages of development are common in the cortex of some of the roots, and one of them, in which the outline of the young sclerotium is conditioned by the surrounding tissues, is shown in Plate VI, fig. 21.

With regard to the fungus on *Casuarina*, there is nothing to add to the details given for the other hosts. Mycelium and sclerotia, the latter measuring up to ·7 by ·4 mm. and, on the whole, more irregular in shape than those of *Grevillea*, are found in abundance on the stem of the tree above soil level. Black plates are also present in the wood of the roots.

Infection Experiments.

The pathogenicity of the *Rhizoctonia* has been tested only with material from *Grevillea robusta* and only with respect to *Coffea arabica*. The work has been necessary in order to throw light on a point of great practical importance to those planters who have instituted *Grevillea* wind-breaks and shade for their coffee, and it can be said that the results of the experiments have supported what has been evident in the field, viz., that the *Rhizoctonia* which has had abundant opportunity to pass under natural conditions from *Grevillea* to *Coffea arabica* has not yet attacked the latter host. It is necessary to distinguish here between *Coffea arabica*, the staple crop on the majority of European estates, and *Coffea robusta* which is planted in comparatively small, but increasing, amount, and to remember that only the latter species is known to be susceptible to *Rhizoctonia* root disease.

Only healthy coffee plants in pots have been employed in the experiments. The inoculum has consisted of small blocks of culture medium containing active mycelium and sclerotia. The fungus has been brought into contact with its intended host by wrapping the inoculum around both wounded and unwounded lateral and tap-roots and also by inserting it under the bark of the stem just below ground level. Sclerotia, both dried and freshly taken from cultures, have been placed among the roots of other plants, and pieces of *Grevillea* root, bark and cortex containing black plates and sclerotia have been wrapped around roots and also the collars of further plants. Although the fungus has been allowed over eight months during which to force an entrance into and obtain a footing in the tissues of the experimental plants, no positive results have accrued, and an examination of certain of the plants has shown their roots to be unaffected by the treatment accorded them. It is to be hoped that the present apparent immunity of *Coffea arabica* will continue unabated, for, were the diseased *Grevillea* trees to cause the death of *Coffea arabica* trees in contact with them, the loss would be great enough to bring about a very serious state of affairs on certain estates.

The Systematic Position of the Fungus.

The systematic position of the fungus described in this paper is somewhat doubtful. The presence of clamp-connections points to its being a Basidiomycete, and the discovery of the bodies presumed to be abortive basidia lends support to this view. On the other hand, the absence of a fully-developed perfect stage makes it impossible to refer the fungus to its correct position, and the only course open in the meantime is that of

placing it in one of the form-genera which have been created for the reception of sterile mycelia.

The two form-genera which come into consideration are *Rhizoctonia* and *Sclerotium*, both of which as at present constituted obviously contain heterogeneous elements and both of which would disappear entirely with the discovery of the perfect stages of their various species. In deciding the question of a place for the present species, weight has been placed on the structural characters, including the clamp-connections and the probable connection of the species with a lower Basidiomycete (in which point it would agree with *Rhizoctonia Solani*), rather than on the absence of external mycelium, a character which is appropriate to the genus *Sclerotium*. It is proposed, therefore, to refer the present form to *Rhizoctonia* and to institute a new species. The specific name, *lamellifera*, refers directly to the frequent presence and constant character of the sheets of modified hyphae which have been called "sclerotial plates" in this paper, and its use seems the more appropriate inasmuch as no record of similar structures has been found in the literature of parasitic species of *Rhizoctonia* except, perhaps, in the account of *Rh. Strobi* E. Scholz on *Pinus Strobus* *, a species which was described on a well-grown tree.

Rh. lamellifera sp. nov.

Hyphis lignum et corticem profunde penetrantibus, filiformibus, crassioribus, ramosis, anastomosantibus, demum fuscescentibus, septatis, non superficialibus, interdum in membranam castaneam coalitis; membranis e cellulis contextis, irregularibus, angulatis compositis, plerumque in ligno corticeque immersis, vel rarius externis, subinde corpora basidiis et sterigmatibus similiter gerentibus, Sclerotiis numerosis, fere levibus, globosis vel pyriformibus, saepe complanatis, haud erumpentibus, ad 1 mm. longis, ·8 mm. latis, e cellulis pseudo-parenchymatis, irregularibus, 5–10 μ diam. compositis, Sclerotiis guttulas oleosas copiosissimas includentibus. *Hab.* in ligno et cortice radicum viventium *Grevilleae robustae* (typus), *Theae, Bixae Orellanae, Coffeae robustae, Casuarinae equisetifoliae* cultae quas necat.

Summary.

1. A new species of *Rhizoctonia* has been found to attack *Grevillea robusta*, and its morphology and behaviour in culture are described. Its distinctive characters are the presence of sclerotial plates and sclerotia.

2. The connection between the plates and the sclerotia has been established in cultures started from the plates. Owing to

* Verhandl. zool.-bot. Gesellschaft, Wien, xlvii, p. 541, 1897.

failure to secure germination of the sclerotia, sclerotial plates have not been obtained in culture from a single sclerotium.

3. At a later date, a fungus agreeing in morphological and cultural characters was encountered on tea and *Bixa Orellana.*

4. What is considered the same fungus was afterwards discovered on *Coffea robusta* and *Casuarina equisetifolia,* but has not yet been isolated from either.

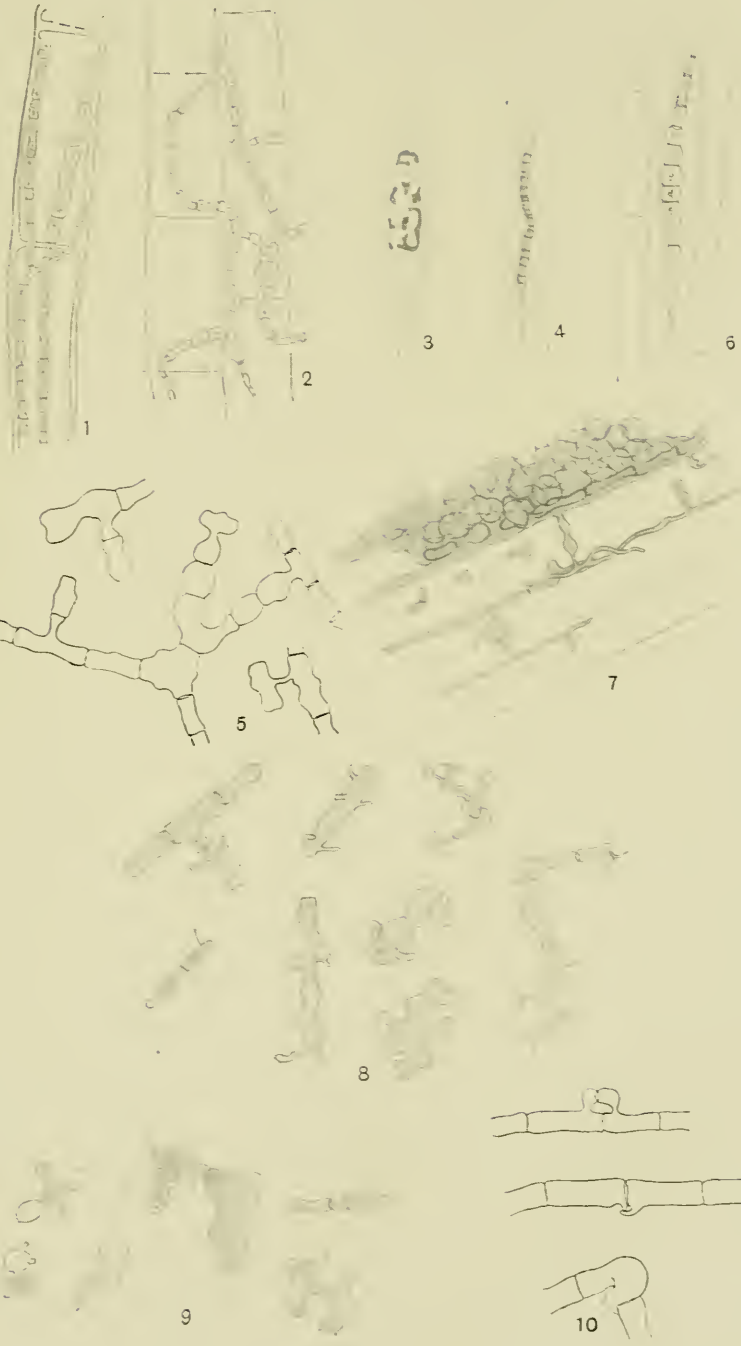
5. To date, the inoculation experiments attempted have dealt only with the important question of the susceptibility or immunity of *Coffea arabica* to the *Rhizoctonia.* The results have been entirely negative.

The writer wishes to express his thanks for help in the systematic portion of this paper to Miss Wakefield of the Kew Herbarium and to Mr E. W. Mason of the Imperial Bureau of Mycology, and his indebtedness to the Director of the Bureau for laboratory facilities.

EXPLANATION OF PLATES V AND VI

Figs.

1–2. Hyphae in wood and cortex of a *Grevillea* root. ×250.
3. Hyphae in a medullary ray cell. ×250.
4. Portion of a sclerotial plate in *Grevillea* root. ×150.
5. Hyphae of a sclerotial plate. ×400.
6. First stage in sclerotial-formation in *Grevillea* tissues. ×250.
7. Hyphae and part of a mature sclerotium in wood of a *Grevillea* root. ×250.
8. Mycelial processes. ×350.
9. Basidia and sterigmata. ×350.
10. Clamp-connections on hyphae in culture. ×300.
11–12. Young mycelium from cultures. ×300.
13–14. Eight-day old mycelium from a culture. ×150.
15. Cell-formations in culture. ×250.
16. Chlamydospore-formation in a drying culture. ×250.
17–20. Successive stages in sclerotial-formation in culture. ×250.
21. Young sclerotium in root of *Coffea robusta.* ×100.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OBSERVATIONS ON THE "SLIME-FLUXES" OF TREES*.

By Lawrence Ogilvie, M.A., B.Sc. (Abdn.), (late Fullerton Research Scholar, Aberdeen University; Government Plant Pathologist, Bermuda).

(With one text figure.)

INTRODUCTION.

At the suggestion of Mr F. T. Brooks the writer undertook, in the autumn of 1921, the investigation of certain peculiar exudations from the trunks and branches of trees, especially elms, horse-chestnuts, apples and willows. These have long been known in scientific literature under the name of "slime-fluxes" (German, "Schleimfluss") but it might be preferable, on account of the possible confusion of the term with the popular name for the Mycetozoa, to refer to them as "mucilaginous exudations" (French, "écoulements muqueux des arbres") or the "weeping" of trees. The latter term appears to be in use in England.

REVIEW OF LITERATURE.

The first papers on the so-called "slime-fluxes" were published by Dr F. Ludwig of Greisz in the year 1886(1, 2), and dealt with a peculiar pathological appearance on oak trees, from the bark of which there flowed out a beer-like froth in considerable quantity. This he called the "alcoholic flux" or "white slime flux" of oaks.

In 1888 a paper by Ludwig(3) announced the discovery of a new kind of flux, the "brown flux" of apple-trees, horse-chestnuts and elms.

There next followed communications by Hansen(4) and Lindau(5), and, in 1896, a survey by Ludwig of the work accomplished up to that year(6). A useful summary of Ludwig's work up to 1897 will be found in Tubeuf and Smith's text-book(7).

In the same year a note from Massee appeared in the *Kew Bulletin* on the occurrence of the brown flux on fruit trees in England(8).

A long series of communications was published by Holtz in 1901(9), in which he dealt thoroughly with the whole question. A complete bibliography up to that date was appended.

In 1906 a short note on the slime flux of beech trees appeared in the *Journal of the Board of Agriculture*(10), while Massee(11), in 1907, recorded the occurrence of the white flux at Kew.

* Part of a dissertation submitted for the Degree of M.Sc. at the University of Cambridge, 1923.

An inaugural dissertation was delivered in 1910 by Ludwig Rose at the University of Berlin on the subject of the oak slime-flux, but the writer has been unable to consult this.

VARIETIES OF FLUX INVESTIGATED BY THE WRITER, AND METHODS EMPLOYED.

1. *Brown slime-flux*: (*a*) red variety (elms and horse-chestnuts); (*b*) brown variety (elms and horse-chestnuts); (*c*) apple flux.

2. *White slime-flux*: willows and elms.

Samples were taken from as near the fluxing aperture as possible by means of a sterile wire contained in a sterile glass tube. Bouin's picroformol solution and Gram's iodine were found to be the most useful fixatives for smears, while iron alum-haematoxylin gave very satisfactory results as a staining reagent.

BROWN SLIME-FLUX.

1. Previous Investigations.

According to Ludwig (3), this flux occurs on apples, horse-chestnuts, birches, poplars, elms, hazels, tulip-trees, oaks, etc., and is widespread throughout France, Belgium and Germany. It is said to cause much damage to orchard trees and to trees in streets and parks. It is stated to occur all the year round, in this respect differing markedly from the white slime-flux, and is characterised by the outflow of a yellowish brown, viscid, but not gelatinous slime, which originates in the wood, breaks through the bark and flows down the tree in a broad stream.

The constituents of the flux are stated by Ludwig to be the same in all the trees investigated. "The fresh slime contains at first only micrococci, which are accompanied by a mycelial fungus, *Torula monilioides* Corda....The chief role doubtless falls to the bacteria, which I have named *Micrococcus dendroporthos* Ludw. In the later stages there are found numerous other organisms, especially *Fusarium*, large brown spores resembling the teleutospores of a *Puccinia*, and which probably belong to an Ascomycete, algae (Bacillariaceae, Protococcaceae, etc.)" (6). The presence of a mite, nematodes, insect larvae, rotifers, etc., is also recorded. An *Oidium* was found in a horse-chestnut flux.

Ludwig states that the bark is usually entirely destroyed, while the wood becomes rotten and contains free butyric acid. Holtz (9), on the other hand, found that in most cases the tree showed signs of wounding (frost-cracks, insect and other wounds) at the point of origin of the flux and that "nowhere was there any evidence of a destroying effect of the slime-flux on bark or wood."

2. Red Variety.

(a) *General.*

This flux is rather conspicuous on account of its bright apricot-red colour. It occurs very commonly around Cambridge on young Huntingdon elms (*Ulmus vegeta* Schneider), but specimens somewhat resembling this type (and also characterised by the presence of a red colour) have been found on *Ulmus campestris* L. and on the Wych elm (*Ulmus glabra* Hudson = *Ulmus montana* Stokes) in the north of Scotland. It has also been found on horse-chestnuts, and once on a beech tree.

Fig. 1. Red slime-flux exuding from exposed wood on trunk of *Ulmus campestris*.

In very many cases the flux exudes from frost-cracks or cracks at the forks of branches, but not uncommonly it can be seen to flow from the heart wood of a stump where a branch has been cut off. In this it resembles the true brown flux to be described later. In every case of the red flux which the writer examined the exudation flowed from the wood and not from the bark.

The flux is active all through the year, but most strikingly so in spring and early summer, at which periods also the red colour is most pronounced. It is of a soft flabby nature but is much firmer than the true brown flux, which, however, it resembles in its penetrating musky odour. No smell of butyric acid was evident, as was noted by Ludwig.

The accompanying photograph (fig. 1) shows the typical appearance of an old red flux. The tree in question (*Ulmus campestris*) is on the edge of a field and on the side next the field the base of the trunk has been totally denuded of its bark by horses. From the wood, which has become hard and stony to the touch (owing to the deposition of calcium carbonate), a large flux is exuding.

These fluxes were found in all sorts of exposures, but appeared to be slightly more prevalent in damp and shady situations.

We shall consider later the question of the possible causative organisms.

(b) *Organisms present.*

The organism most characteristic of the red flux is a species of *Fusarium*; this gives it its red colour. The red masses flowing from the trees are practically "pure cultures" of the *Fusarium*, and consist of mycelium and spores.

Very frequently an *Oospora* (*Oidium*) of the "*Oidium lactis*" type, but peculiar in certain respects, is found accompanying the *Fusarium*.

The presence of large numbers of bacteria which form fluorescent colonies is noticeable.

A. *Fusarium.*

This fungus is easily isolated from the red flux by plating it out on such a medium as Dox's agar.

Cultural characters. On Dox's agar, beer-wort agar, bran agar, oatmeal agar, meat-extract agar, sterile horse-chestnut twigs, sterile potato slants, sterile *Lathyrus* stems, chunks of elm wood are produced abundant moist slimy "pionnotes" or macroconidial masses, with a sparse, very fine, transparent, cream-coloured or seashell pink (R)* mycelium. Pionnotes varying in colour through carnelian red, rufous, apricot orange and their hues (12, Plate XIV). Marked tendency to mycelial growth in depth of medium. Substratum not discoloured. On steamed rice a very poor growth of pale flesh coloured or flesh coloured (R) mycelium and practically no pionnotes.

Morphological characters. No microconidia found. Macroconidia on aerial mycelium or pionnotes, typically triseptate; one end almost straight and tapering, and the other bent at an angle of about 30 degrees to the main axis of the spore. Spores borne on short pedicels and very constant in size and shape, the average dimensions being $23{\cdot}4 \times 3{\cdot}2\,\mu$. Hyphae average $2{\cdot}5\,\mu$ in diameter, tending to interlace by means of cross connections; terminal and intercalary chlamydospores not uncommon.

* (R) denotes that the colours have been matched as closely as possible in Ridgway's "Colour Standards."

B. *Oospora* (*Oidium*) *lactis* var. I.

This accompanies the *Fusarium* fairly constantly.

Cultural characters. Produces a beautiful colony on beer-wort gelatine at room temperature, consisting of a central zone of irregular wavy lines from which there extend outwards towards the circumference undulating radial lines. Surface powdery (owing to production of aerial conidia). On rich, moist media such as sterile carrots, moist beer-wort agar, etc., a slimy yeast-like growth. In neutral beer-wort no fermentation or surface film after six weeks.

Morphological characters. Branching usually as in *Oospora* (*Oidium*) *lactis*. Primary hyphae 8·5–13 μ, av. 11 μ, secondary or branch hyphae 2·5–6·5 μ in diameter. Hyphal cells rectangular with somewhat rounded ends, up to 100 μ long. Conidia on primary and secondary hyphae in erect chains, conidiophore short or absent. Ends of hyphae breaking up into oidia, 3·5–11 μ × 2·5–5·5 μ (av. 7 × 3·5 μ), rarely globular. Chlamydospores produced abundantly on short stalks from the hyphal cells after seven days on beer-wort agar at 26° C. Diameter when ripe about 11 μ. Spore wall double.

This form of *Oospora* (*Oidium*) *lactis* appears to be distinct from any of those described by Erwin Schnell (13).

C. *Other organisms.*

As already stated the *Fusarium* and *Oospora* occur with remarkable constancy. Other fungi are comparatively few in number. The writer has found *Trichothecium roseum* (Pers.) Link and the blue *Fusarium* strain found in the typical brown fluxes. Protozoa, insect larvae and algae are not so common as in these.

3. Brown Variety.

(a) *General.*

This type of flux has been found very commonly in and around Cambridge on elms, especially on *Ulmus campestris* and *Ulmus vegeta*, and on horse-chestnuts. It frequently occurs on *Ulmus montana* in Aberdeenshire.

So far as the writer's observations go, it is always associated with some wound, such as abrasions of bark due to animals, frost cracks, wounds made by nails, branch snags, etc. It appears to have its origin in the heart wood, and consists of a thick brown or yellowish brown fluid, somewhat of the consistency of porridge.

In the case of branch scars the flux begins as a somewhat copious exudation of a clear watery fluid from the heart wood. This fluid is soon invaded by bacteria, fungi and yeasts, such as *Isaria*, *Torula*, *Alternaria*, pink yeasts, etc. After about a

year, however, the flux is somewhat gritty owing to the presence of crystals of calcium carbonate dissolved from the cell walls of the wood and redeposited in the flux, and contains certain characteristic fungi. In very old fluxes few fungi are found and the brown porridge-like masses are composed mainly of small pieces of disintegrated wood. Insect larvae are abundant, and very characteristic. Protozoa, nematodes, etc., are also common.

The writer is much indebted to Dr D. Keilin, of the Molteno Institute for Research in Parasitology, Cambridge, for the following list of the insect larvae found in a brown flux at Cambridge which are typical:—

Dasyhelea obscura Winnertz (Ceratopogonidae), *Mycetobia pallipes* Meig. and *Rhyphus fenestralis* Scop. (Rhyphidae), *Phaonia cincta* Zett (Anthomyiidae), *Aulacogaster rufitarsis* Mcq. (Ephydridae), *Systenus adpropinquans* Loew. (Dolichopopidae), and an Eristaline (Syrphidae). A mite, *Hericia hericia* (Robin) Kramer (Acarina, Tyroglyphidae), was very common. Some very interesting parasites were found in certain of these larvae*.

(b) *Organisms present.*

A. *Oospora* sp. (?)

This is one of the most interesting of the organisms which have been isolated from the slime-fluxes. It occurs constantly in the brown fluxes of elms and horse-chestnuts.

Cultural characters. On potato agar, Dox's agar, etc. small compact colonies appear after four or five weeks. On beer-wort agar rapid growth (appears after five days at 26° C.); on this medium and on sterile carrot somewhat hard sand-coloured masses or nodules are formed which become white and flocculent when old and dry.

Morphological characters. As it appears in the flux, the fungus consists of strings of oval to globular cells, about 5·5 μ in diameter, with large vacuoles. Cell multiplication is by budding. The white flocculent growth on carrot and other media consists of branching aerial hyphae arising from a creeping mycelium, the cells of which, however, are little different from the ordinary budding cells.

The fungus appears to agree with the somewhat meagre diagnoses given by Ludwig and others of *Torula monilioides* Corda, except in the fact that on no culture media has the writer observed any brown colour microscopically, such as was described by Ludwig. A brown colour has occasionally been noticed in certain of the cells in the crude flux, but this is probably due to staining or to a moribund condition of the cells.

* See Keilin, D., in recent numbers of *Parasitology*.

Holtz (9, p. 184) stated that he had been unable to find *Torula monilioides* in the brown fluxes which he investigated.

If the fungus remains entirely colourless on nutrient media, as the writer's cultures seem to show, it should probably be placed in the genus *Oospora*.

B. *Oospora* (*Oidium*) *lactis* var. II.

Strings or clumps of globular cells very similar to the cells of the fungus described above may be distinguished from them by the production in a hanging-drop culture of the hyphae characteristic of *Oospora* (*Oidium*) *lactis*. They are not found constantly in the brown flux.

Cultural characters. Giant colony on beer-wort gelatine after ten days practically indistinguishable from that of *Oospora* (*Oidium*) *lactis* from milk. The surface is covered by long white flocculent aerial hyphae. In neutral beer-wort no fermentation or surface film but a copious slimy deposit of hyphae. No marked smell. After two days at 26° C. acid is produced from a peptone solution + one per cent. lactose and glucose respectively*.

Morphological characters. Branching as in *Oospora* (*Oidium*) *lactis*. Cells of aerial hyphae 80 × 3·6 μ. Oidia from the moist area in the centre of a ten days' colony on beer-wort agar average 8·3 × 2·8 μ, of the usual rectangular shape with rounded ends. These may swell up before germination into spherical bodies 7·4 μ in diameter.

The young colonies are beautifully arborescent. From the extreme ends of the hyphae very fine transparent filaments grow down into the medium. The cells of these average 2·8 × 60 μ.

The fungus is evidently closely related to the typical *Oospora* (*Oidium*) *lactis* of milk.

C. *Sporing Yeast.*

Accompanying the forms A and B there occurs very frequently a large globular or somewhat elliptical yeast which spores very freely. It is found at all times of the year and in every case a large percentage of the cells are in the sporing condition.

Cultural characters. On beer-wort gelatine (ten days at room temperature) a very moist, white, raised growth. Separate colonies are perfectly round, and of a similar consistency. Acid is produced from glucose after 14 days at 26° C.

Morphological characters. Cells from a twelve hours' beer-wort culture at room temperature oblong with rounded ends to globular, 5·4–9 μ × 2·7–7·2 μ. Spores eight, usually oblong 5·4 × 3·6 μ. Ascus membrane finely verrucose. Division of cells

* 1 % Witte's peptone, 0·5 % NaCl, 1 % lactose, etc.

by means of a cross septum. No mycelium or conjugation observed.

The yeast belongs to the genus *Schizosaccharomyces*. It somewhat resembles *S. octosporus* Beijerinck in the shape of the cells and spores, in its rapid sporulation, and in the absence of a film on beer-wort cultures, but differs from it in the absence of conjugation phenomena, and of fermentation with lactose, laevulose and mannite.

D. *Fusarium.*

Five-septate *Fusarium* spores are frequently found in the brown slime-flux. These belong to a group which discolours sterile potato plugs and produces buff coloured pionnotes and blue sclerotia on culture media.

Morphological characters. Five-septate macroconidia almost straight, but with a crook at one end; from a steamed *Lathyrus* stem 40–55 μ (av. 46 μ) × 5·4 μ. Four-septate spores 37–47 μ (av. 41·4 μ) × 4·5 μ. Microconidia produced on verticillate or simple conidiophores, the latter about 50 μ long. Microconidia ellipsoidal about 7·2 × 2·5 μ, but varying greatly in size and shape. Intercalary chlamydospores have been observed.

E. *Other organisms.*

Verticillium cinnabarinum Reinke et Berthold (formerly *Acrostalagmus cinnabarinus* Corda) occurs very commonly on plate cultures from old fluxes, especially in winter and spring. A white *Sporotrichum* which was very common is probably identical with *S. carnis* Brooks and Hansford (15). *Trichoderma lignorum* (Tode) Harz was frequent on old fluxes of elms and horse-chestnuts. *Cephalosporium* and *Penicillium* species were common. *Dematium pullulans* and non-sporing pink yeasts also occurred commonly during the winter months.

Chlorella vulgaris Beiker and *Protococcus viridis* Ag., algae found on the trunks of trees, apparently grow saprophytically in the flux. They could be isolated from all the brown fluxes by means of Detmer's solution and Detmer's agar. It was discovered, however, that the *Chlorella* was able to grow luxuriantly on ordinary culture media, such as potato agar, Dox's agar, beer-wort agar, etc.

Ludwig (16) describes two new species of algae from the slime-fluxes, but we have not seen any form to correspond with his descriptions.

4. Apple Flux.

(a) *General.*

A flux has been noticed on branch wounds of apple-trees in and around Cambridge, which appears to have a very typical flora. It seems to be more prevalent on certain varieties of

apples than on others; thus "Lord Grosvenor" appears to be somewhat susceptible, although similar fluxes have been found on trees of "Newton Wonder," "Chivers' Seedling" and "Duchess of Oldenburg."

The fluxes are white, pale pink, or black in colour, of a watery or slimy consistency, and proceed entirely from the centre of the wood of the cut branch. They are prevalent all through the year, but tend to dry up during the summer. They apparently do little damage to the trees except after a prolonged period, when rotting of the wood and bark takes place slowly.

According to Ludwig(17), the fluxes of apple-trees are practically the same as those found on elms and horse-chestnuts. The writer has found, however, that, around Cambridge at least, they have a peculiar and interesting flora of their own, composed of three kinds of yeasts. Fluxes have never been seen on plum-trees, as described by Massee(8).

The apple fluxes appear to originate as a physiological exudation similar to that described in the brown fluxes of elms.

(b) *Organisms present.*

A. *Yeast I.*

Cultural characters. On beer-wort gelatine after 14 days a flat white growth with a wavy edge, central raised portion, and radial lines. No liquefaction. Growth on agar very similar. On beer-wort a film is formed after 24 hours at 26° C. No fermentation. Acid from glucose (14 days). No spore formation. Marked growth at 1° C.

Morphological characters. On solid media and beer-wort, film hyphae are formed. Cells 10 × 1·8 μ, branching irregularly by budding. Separate cells from a three days' culture on beer-wort gelatine average 9 × 4 μ and are vacuolate.

B. *Yeast II.*

Resembles Yeast I in appearance.

Cultural characters. On beer-wort gelatine forms small round grey colonies with slightly raised white centre with crater-like markings, deep radial furrows and indented edge. The young colonies have beautifully branched hyphae at the edge. Does not liquefy gelatine. On beer-wort after 24 hours at 26° C. a thick grey surface film is formed. No alcoholic fermentation or spore formation. Acid produced from glucose and laevulose after 14 days.

Morphological characters. Resembles Yeast I, but cells average 3·5 μ in diameter. From a five days' beer-wort film the cells measured 9 × 3·6 μ.

C. *Yeast III.*

Cultural characters. Ten days' beer-wort gelatine slant at room temperature—a moist white growth with radial wrinkles extending from a central raised area. Separate colonies are whitish, raised, and have a chalky white central boss when old. Surface film and copious deposit in beer-wort, but no alcoholic fermentation. No spore formation.

Morphological characters. Cells spherical with large vacuoles. Diameter, from a three days' beer-wort gelatine slant, 1·8–5·5 μ, average 3·7 μ.

The three yeasts must be placed in the genus *Torula* Turpin.

D. *Other organisms.*

The black colour of many of the apple fluxes is due to short hyphal strands and strings of cells of a dark brown or black colour which belong to *Dematium pullulans*, a fungus which is common on the bark of apple-trees. Ludwig refers to the presence of "large brown spores resembling the teleutospores of a Puccinia." These are probably the chlamydospores of this fungus.

A *Cephalosporium* sp. appeared very commonly on the culture plates, and, less commonly, species of *Torula*, *Penicillium*, *Sporotrichum* and pink yeasts. Fluorescent bacteria were very frequent. A large variety of *Oospora* apparently identical with *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc., to be described later from the white flux of willows, was isolated from an apple flux from Meldreth.

Algae (*Protococcus*, etc.) were present in small quantity. Insect larvae and protozoa were not usually found.

WHITE SLIME-FLUX.

1. Previous Investigations.

The so-called "alcoholic flux" or white slime-flux was found by previous investigators on oaks, birches, poplars, beeches, willows, maples and ashes. It is said by Ludwig to result in a complete fermentation of the bark, bast and cambium, and sometimes a part of the wood. The destruction and fall of the bark often accompanied a marked diminution in the growth of the tree(6). It was often found associated with branch scars, frost cracks, goat-moth borings and other wounds, but apparently sprang also from the uninjured bark. It usually occurred on the main trunk of the tree.

Its duration was from June to August, and the time of its appearance was very constant each year. The strong smell of beer and later of malic ester and vinegar attracted large numbers

of hornets, stag beetles, wasps, bees and flies which fed ravenously on the frothy exudations and evidently suffered somewhat from intoxication in consequence. Ludwig attributed to them the dispersal of the flux.

The initial fermentation is brought about, in Ludwig's opinion, by a fungus which he named *Endomyces Magnusii*, and which forms asci resembling those of yeasts. In its mycelial form it resembles a large *Oospora* (*Oidium*) with preponderating unilateral branching. This is accompanied by *Saccharomyces Ludwigii* Hansen, a yeast regarded at first by Ludwig as a stage of the Endomyces, and, according to Ludwig by *Leuconostoc Lagerheimii* Ludw., a bacterial form, somewhat resembling *L. mesenteroides* Cienkowski, the "frog-spawn" of sugar factories.

Hansen (4), in Denmark, was unable to find these three organisms except in one case out of seventeen. Holtz (9), near Karlsruhe, found the oak fluxes only on the main trunk and usually somewhat low down. They started to flow in May and June and had all stopped by the first half of August. He found that an *Oidium*, resembling the *Oidium* stage of Ludwig's *Endomyces* was occasionally, though not constantly, present He could not identify *Leuconostoc Lagerheimii*.

2. White Flux of Willows.

(a) *General.*

At the end of May, 1922, and again in 1923, curious exudations were noticed on the trunks of pollard willows on the banks of the Cam near Cambridge. They flowed in every case from cracks and small holes on the main trunk, often near the ground, were very frothy, pure white in colour, and had a strong smell of beer. Numerous ants and small flies had evidently been attracted by the smell and were crawling over and feeding on the fluxes.

These exudations remained active till about the middle of July, when they became more slimy and finally dried up, leaving rusty brown marks. In the later stages they were much visited by wasps and hornets, and contained insect larvae. In comparison with the brown fluxes their volume was very small, and no damage was done beyond a slight disintegration of the bark, to which they were apparently totally confined.

(b) *Organisms present.*

A. *Oospora* (*Oidium*) sp. (probably = *Oospora Ludwigii* (Hans. Sacc. et D. Sacc.).

The oidia and hyphae of this fungus were found in most of the specimens of white flux of willows which the writer examined, but it was not universally present, and the greater part of the

substance of the fluxes was composed of bacteria, especially in the later stages. This organism is however responsible for the frothy nature of the fluxes.

Cultural characters. Easily isolated on beer-wort agar and gelatine and grows well on these media, giving a colony with a white powdery centre whence the hyphae and oidial chains extend radially towards the circumference. Gelatine is liquefied after ten days at room temperature. On carrot a white slimy yeast-like growth is formed. Beer-wort undergoes alcoholic fermentation after 24 hours at 26° C. A surface film is formed and later a copious deposit.

Morphological characters. Resembles *Oospora* (*Oidium*) *lactis* in budding; it has however a tendency towards unilateral branching. Cells 40–100 × 10 μ, breaking up by cross septation into oidia, which decrease in size towards the circumference of the colony and may there be spherical. In liquid media these oidia may multiply by cross-septation like a *Schizosaccharomyces*, and certain cells may become transformed into thick walled chlamydospores. Spherical chlamydospores from a four days' culture on beer-wort varied from 7 to 16 μ in diameter, with a wall 1·8–3·8 μ thick.

The fungus agrees closely with the diagnosis of *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc. Endogenous spores have not been seen by the writer (in common with Holtz). The fermentation of beer-wort and the formation of a surface film are in agreement with Holtz's observations. The presence of a sweet smell, suggesting an ester, coincides with the observations of all investigators.

The writer has not been able to induce the fungus to form asci. This is in agreement with the findings of Holtz and Hansen, and partly with those of Brefeld, who encountered both ascigerous and non-ascigerous strains. Lorrain Smith and Ramsbottom (18), on the other hand, recorded the presence of asci in a pure culture isolated from "exudations of various trees," while Guilliermond found asci in only about three per cent. of his cultures (19).

B. *Sporing Yeast.*

A round sporing yeast was found very commonly in the white fluxes of willows, especially in their later stages.

Cultural characters. On beer-wort gelatin and agar a flat white colony with radial lines extending from a raised centre. Gelatine is slowly liquefied. In beer-wort (seven weeks old) no film is produced, but a copious deposit. No alcoholic fermentation. Acid was formed from glucose and maltose.

Morphological characters. Cells usually globular, multiplying

by budding, and average 5·4 μ in diameter from a three days' beer-wort gelatine culture. Spores formed readily on ordinary media, four in number, globular, and about 1·8 μ in diameter. No mycelium or conjugation observed.

The yeast belongs to the genus *Saccharomyces* Meyen.

A similar flux was found on certain Huntingdon elms near Jesus College, Cambridge, which died off one by one probably owing to an escape of gas from a main in the vicinity. The flux appeared in July as large gelatinous masses exuding from bore-holes of the bark-beetle, *Scolytus*, with which the trees were badly infested. Large numbers of wasps were attracted to the exudations, which were confined to the bark and persisted only for a few weeks. Neighbouring healthy trees were unaffected. The organisms present included bacteria with gelatinous sheaths and a round sporing yeast identical with that described from the flux of willows.

GENERAL DISCUSSION.

The brown flux is, when gathered near its point of exit from the tree, of a watery nature, but after exposure to the air for some time it dries up to a yellowish brown or brown powder. It is not hygroscopic. The red flux of Huntingdon elms was found to be slightly alkaline, having a *p*H of about 9, while advanced brown fluxes from *Ulmus campestris* were more alkaline, with a *p*H of from 9 to 9·5. The alkalinity is probably due to the large amount of calcium carbonate derived from the wood (the ash of elm wood is stated to contain 47·8 per cent. of lime). This also accounts for the hard stony nature of old flux marks.

The writer has come to the conclusion that the red and brown fluxes are of physiological origin, arising primarily, in the case of branch wounds, as the exudation of a clear fluid from the centre of the heart-wood. Such water-soaked areas have been seen by the writer in the centre of freshly-cut branches of Huntingdon and Wych elms during the summer months. They do not occur on small branches in which no heart-wood is evident, but are very commonly to be seen on exposures of large branches. Similar water-soaked areas have been seen in the centre of cut branches of apple and poplar.

There is little doubt that these phenomena are the same as those investigated by Professor W. G. Craib in the case of *Acer* (20), and later in the case of true heart-wood trees (*Ulmus montana* and *Quercus cerris*) (21). According to Prof. Craib, storage of water takes place in the autumn in the centre of the trunk, commencing at the base. "By the time the centre has received its quota far up the trunk another movement has begun causing

a re-arrangement at the base, and leaving the centre as the driest region." The present writer's observations go to support these conclusions. Water-soaked areas appear first of all in the branch stumps in early spring and in most cases spread gradually towards the circumference. Central water-soaked areas have been noticed, however, in early autumn, and it is remarkable that the fluxes are active practically all the year round. Prof. Craib suggests that there might also be summer water-storage.

All stages have been traced between these water-soaked areas and the typical flux; at least a year appears to be necessary for the development of the latter. The clear fluid exuding from the water-soaked areas is alkaline (*p*H about 9) and flows in greatest quantity during hot weather*. Sugars are either absent or occur only as traces.

The medullary rays and wood parenchyma of the water-soaked wood are full of a gummy substance, partly tannin and partly starch, which gives the wood a brown colour. In the later stages of the flux the vessels may be invaded by hyphae and bacteria, in which case both vessels and parenchymatous cells become filled with gum. The bark surrounding old fluxes becomes blackened superficially.

It is possible that in the case of wounds on the trunks of trees, brown fluxes may develop from a simple sap-flow. Sap-flows from artificial bore-holes in horse-chestnut trees quickly developed some of the typical insect-larvae and fungi, but the flow was not so constant as in the case of heart-wood exudations.

Numerous inoculation experiments were carried out but in no case did a typical flux appear within the time available.

In order to discover if possible any noticeable effect of these organisms on wood tissues and cellulose, cultures were made on sterile wood blocks, twigs, sawdust, sawdust and nutrient solutions, sterile filter paper, cellulose and filter paper agars, etc., etc. These experiments showed that none of the organisms (fungi, yeasts, and bacteria) have any marked disintegrating action on woody or cellulose tissues. This might have been expected, since no decomposition of wood or bark takes place except after prolonged periods.

The white fluxes are totally confined to the bark and without doubt arise in the phloem. Willow fluxes were distinctly acid (*p*H 6 to 6·7). No sugars were detected in these, but somewhat similar white fluxes of *Ulmus campestris* were distinctly sticky and contained large quantities of glucose. Exudations of this nature are not uncommon from the bark of trees which have

* About 0·75 c.c. was collected in half-an-hour.

been injured in some way and are probably to be attributed to an accumulation and subsequent outflow of phloem materials. Yeasts and bacteria with gelatinous sheaths develop very rapidly in these exudations. Inoculation experiments of the organisms on healthy bark were unsuccessful, so that here again we must conclude that the flux is of physiological origin. Nothing abnormal was found in the constitution of the tissues from which the fluxes originated (*cf.* Holtz(9), p. 126).

The practically constant occurrence of the fungoid and yeast forms described in the case of both brown and white fluxes is rather remarkable, and must be attributed to the nature and reaction of the food supply.

The difference between the constituents of the fluxes found by the writer and those described from the Continent are rather marked. This coincides somewhat with the observations of Hansen and tends to support the view that the fungi and yeasts are of no importance as causative agents.

If the writer's theory concerning the origin of the slime-fluxes is correct, it would suggest the futility of painting or tarring wounds of trees from which fluxes are already flowing. Apple-trees have been noticed on which fluxes on the branches have broken through a thick coating of tar.

As suggested by previous workers, the flux material may prove deleterious to the tree by inducing the growth of spores of such fungi as *Polyporus squamosus* and *Collybia velutipes*. The writer has often seen the fructifications of *Collybia* associated with fluxes on elm.

In conclusion I wish to express my warmest thanks to Mr F. T. Brooks at the Botany School, Cambridge, under whose supervision these investigations were carried out, for much personal help, and encouragement on all occasions.

SUMMARY.

1. Investigations have been carried out on certain peculiar exudations from the trunks and branches of elms, horse-chest-nuts, apples, willows, etc.

2. The reddish flux of Huntingdon elms was found to be composed of a *Fusarium* forming copious pink spore-masses, an *Oospora* (*Oidium*), bacteria, and other casual organisms.

3. The brown flux of elms and horse-chestnuts invariably contained a species of *Oospora*. An *Oospora* (*Oidium*), a sporing yeast and a *Fusarium* were commonly found, but not constantly. It also contained fluorescent bacteria, algae, insect larvae, etc.

4. The flux of apple trees, found in and near Cambridge, always contained three kinds of non-sporing yeasts.

5. The white flux of willows contained an *Oospora* (*Oidium*)

probably identical with *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc., a sporing yeast and bacteria.

6. The first three kinds of flux persisted throughout the year. In the case of elms at least the flux originated in a watery exudation from the heart wood which appears to be connected with water storage in the wood.

7. Large amounts of calcium carbonate were present in the red and brown fluxes. This is derived from the vessels of the wood and renders the reaction of the exudation favourable to the growth of organisms.

8. The white fluxes originate in the bark and are always associated with wounds or an unhealthy state of the tree. They are more acid than the brown fluxes and last only for a short time in the summer months.

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NOTES ON RHYTISMA ACERINUM AND RHYTISMA PSEUDOPLATANI.

(With Plate VII.)

By Rose Bracher, M.Sc.

Introduction.

During an investigation of the cytology of the genus *Rhytisma*, several observations relating to the general life-history have been made which have not hitherto been recorded. The object of this paper is to give a preliminary account of these observations which may serve as an introduction to the cytological study.

The material used for investigation has been collected in England and the United States. The English form growing upon *Acer Pseudoplatanus* L. is separated by Müller (1913) as a new species, *R. Pseudoplatani*, while the American form, found on *Acer saccharinum* Wangenh., the common maple of the United States, is called by Müller *R. acerinum*. The life-histories of the two forms studied are closely similar, and the few minor differences which occur will be noted below.

External Appearance.

It may be of interest to record briefly the successive changes in external appearance which occur on infected leaves. Leaves were inoculated and closely watched for symptoms. It was found that the incubation period corresponded with that given by Müller; the first indication of the disease being minute water-soaked dots which rapidly develop into small yellow spots about 1–2 mm. in diameter. Four or five days later, on the upper surface of the leaf, minute black dots appear within each yellow spot, and these spread and finally coalesce until the spot becomes uniformly black. At first the black spot is smooth but in a few days it becomes covered with a number of small pimple-like projections about 1 mm. in diameter. These open at the top by a circular pore through which small drops of a milky fluid are exuded. This is the conidial stage of the fungus, and under natural conditions lasts from June until August. When this stage is over the spot begins to thicken and extend in area so that when the leaf falls the average diameter of the spot is about 1·5 cm. The surface of this spot is smooth at first but during the winter, when the leaves lie on the ground, it becomes raised into sinuous ridges which indicate the positions of the

developing apothecia. In the spring these ridges rupture along their crests by longitudinal fissures which expose the white hymenium beneath.

Internal Appearance.

For the purpose of studying the development of the parasite in relation to its host, fixations of material were made each week. The preparations were cut with a microtome at a thickness of 5 μ and stained with various modifications of Flemming's Triple Stain.

1. *Infection.* Infection as noted by Müller is produced by means of the ascospore. This adheres to the under surface of the leaf by means of its gelatinous sheath and if near a stoma sends out a germ tube which grows through a stomatal pore. The fungus branches sparingly in the air spaces, lower epidermis and spongy mesophyll of the leaf. It is, however, intra-cellular and ramifies throughout the cells of the palisade tissue, becoming especially concentrated in the cells of the upper epidermis. Here, further growth of the hyphae, chiefly in the vertical direction, causes a pressure upon the inner and outer walls of the epidermal cells and a consequent rupture of the vertical walls (fig. 1). This does not agree with the observations made by Müller, who states that the hyphae are not in the cells of the upper epidermis but that the fungus develops between the cuticle and the cell walls. Further, it is possible to see, in this and subsequent stages of the fungus, the cuticle still in contact with the outer epidermal walls. This stage in the life-history may be regarded as the end of the incubation period and corresponds with the appearance of the yellow spots on the leaves.

2. *Sclerotium.* In sections cut when the dotted black sclerotia are visible on the leaves, the outer cell walls of the upper epidermal cells exhibit a conspicuous blackening. The cells themselves are rich in a fatty brownish material which, it would appear, is secreted by the hyphae and laid down upon the cell wall which gradually changes from brown to black (fig. 2). The sclerotium remains in this condition during the summer or conidial stage of the fungus. During the formation of the apothecia the sclerotium becomes greatly thickened by the activities of the hyphae which form a hard, black, plectenchyma beneath the originally thickened cell walls (fig. 4). Sclerotium formation also occurs to a much lesser extent in the cells of the lower epidermis (fig. 4).

3. *Pycnidia.* The hyphae below the early formed sclerotium become arranged in a vertical series (fig. 2), giving rise to a number of unbranched conidiophores. The contents of these hyphae stain most deeply at the apices and rod-shaped conidia

are developed from them in basipetal succession. The increasing pressure due to the growth of the conidiophore causes a rupture in the wall, and the conidia escape through the aperture (fig. 3).

4. *Stroma.* After the shedding of the conidia, the fungus layer on the leaf thickens considerably by a very extensive growth of the hyphae and the inner and outer walls of the upper epidermal cells are consequently pushed further apart. They are however clearly visible in this widely separated condition in this and subsequent stages of the fungus (figs. 3 and 4). This observation bears out the assertion that the main development of the fungus is actually within these epidermal cells. The hyphae immediately under the thickened outer walls of the epidermal cells give rise, as has been noted, to a sclerotium, and below this is a layer of thin-walled mycelium (fig. 4). Those hyphae which, in this mycelium, are in contact with the inner walls of the upper epidermal cells frequently give rise to a slight development of sclerotium (fig. 4). The relative thickness of the fungus layer and the leaf itself varies in the different forms studied. In *R. acerinum* on *Acer saccharinum* the fungus layer may be from three to four times as thick as the leaf, while in *R. Pseudoplatani* on *Acer Pseudoplatanus*, the fungus layer is only slightly thicker than the leaf itself (fig. 4).

5. *Apothecia.* The hyphae under the sclerotium which at first appear as a more or less undifferentiated mycelium soon undergo a change. Certain groups of vertically arranged hyphae, staining much more readily than the rest, show the beginnings of the hymenium. These groups appear at intervals and around them definite apothecial cavities become marked off by a progressive differentiation of the surrounding hyphae. The hymenium itself develops considerably and during the winter months the distinction between asci and paraphyses is plainly visible. Müller states that this differentiation does not take place until March but it has been seen that the ascus development depends greatly on weather conditions, and while during the hard winters of Wisconsin, U.S.A., there is little differentiation during winter, in the British forms studied and in American forms collected during a mild winter, asci and paraphyses were well differentiated by January. The asci are uninucleate during the greater part of the winter though they increase in size considerably. In the spring when the ascospores are produced within the asci (fig. 4), an interesting dehiscence mechanism has been observed which brings about the splitting of the sclerotium above the apothecium. Small canals appear in the sclerotium and run longitudinally in the ridges above the asci, in the median plane. In transverse section these appear triangular. They contain a clear, somewhat viscid liquid which is apparently produced by the activity of

the hyphae which disorganise the sclerotium in this region. Probably, during the wet periods noted by Müller to be prerequisite for the rupturing of the wall, water passes into this cavity which is bounded by the non-elastic sclerotium. The break naturally occurs where the cavity is widest and the pressure correspondingly greatest (fig. 4).

The actual morphology of the ascospore and the ascus has been fully described by Müller.

Summary.

The foregoing points may be summarised as follows:

1. Infection takes place by means of the germ tube which grows from the ascospore through a stoma on the under surface of the leaf.

2. The fungus branches and penetrates the cells of the leaf chiefly on the palisade layer but finally concentrates in the cells of the upper epidermis.

3. Subsequent development of the fungus takes place actually within the cells of the upper epidermis. The cells are consequently killed and the walls ruptured and pushed apart.

4. Black sclerotium formation is first apparent in the thickened outer walls of the upper epidermal cells and is later increased by the development of a plectenchymatous layer beneath these walls.

5. Splitting of the apothecia is accompanied by the development of a special mechanism whereby the sclerotium is broken down in the region of the split.

REFERENCE*.

Müller, K. Zur Biologie der Schwarzfleckenkrankheit der Ahornbäume hervorgerufen durch den Pilz *Rhytisma acerinum*. Centr. f. Bakt. Abt. 2, xxxvi, p. 67. 1913.

EXPLANATION OF PLATE VII.

Transverse sections through *Rhytisma* spot.

Fig. 1. Early yellow spot stage.

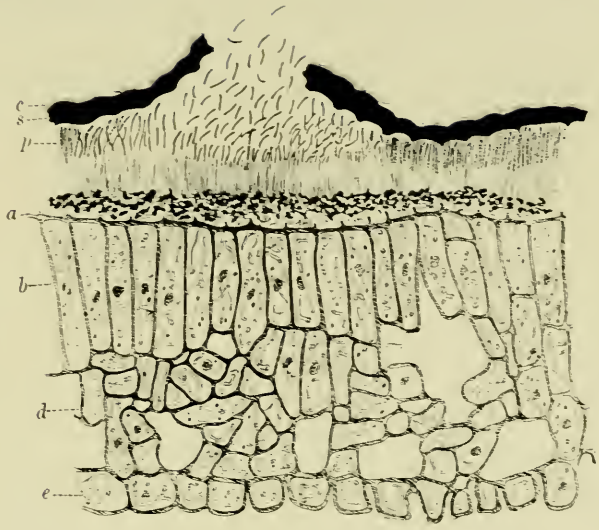
2. Early conidial stage.

3. Late conidial stage.

4. Apothecial stage.

a. = upper epidermis. *b.* = palisade tissue. *c.* = cuticle. *d.* = spongy mesophyll. *e.* = lower epidermis. *f.* = ascus layer. *h.* = hyphae. *p.* = conidiophores with conidia. *s.* = sclerotium.

* A full list of references will be given in a further account of *Rhytisma*.



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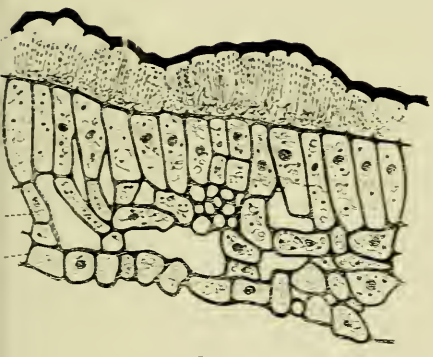

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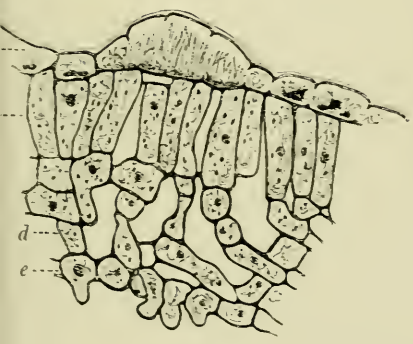

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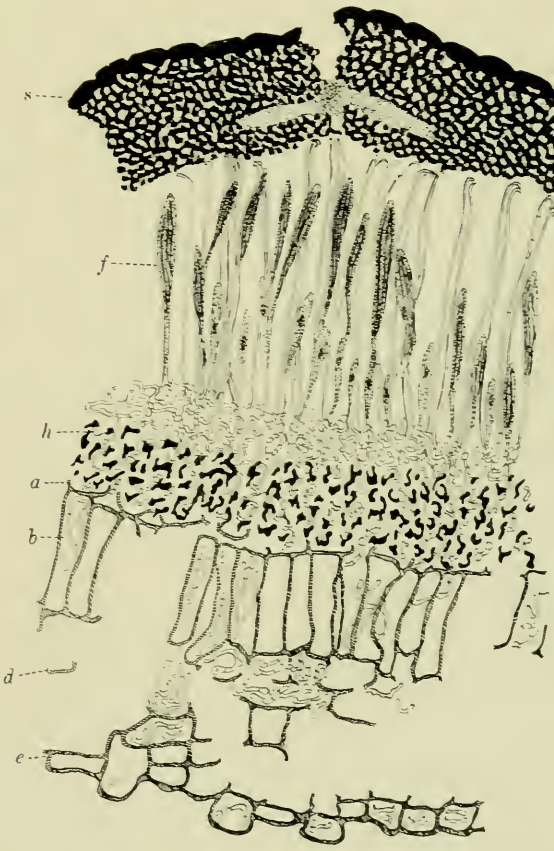

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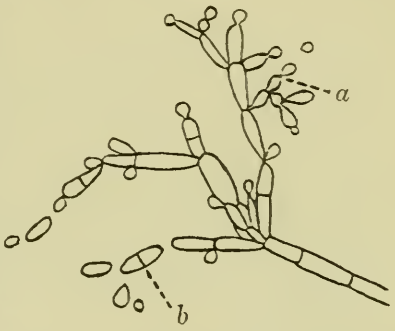
HORMODENDRON OLIVACEUM (CORDA) BON.—A NEW BRITISH RECORD.

By F. C. Ford Robertson, B.Sc.,
Probationer, Indian Forest Service.

(With one text figure.)

The source of the material was some mummy plums infected with *Sclerotinia* sp. collected at Faversham, Kent, in April 1922 by Dr Malcolm Wilson. In the course of making cultures to obtain the *Sclerotinia* an olive-green mycelium was found which bore no resemblance to that of the latter fungus. Pure cultures were obtained from it by spore isolation and the formation of hyphae and conidia studied in a hanging drop of glucose solution. Germination takes place readily, the germ-tube, at first hyaline, becoming septate and olive-green in about thirty hours and sending out branches in all directions. Conidiophores are soon developed in profusion. They are erect, of the same olive-green colour, and are dendritically branched, three or more branches arising from the same point; on these branches, by abstriction, the conidia are formed, in a somewhat irregular catenulate manner; they are unicellular, globose to ovoid, olive-green to fuscous, 4·6–7·5 × 3–5·5 μ and are joined to one another by a slight hyaline neck (see *a* in the figure). There is a tendency for the conidiophore branch, when forming conidia, to break up into short lengths of hyphae with two or three septa, and these latter break up to form the more elongated conidia (see *b* in the figure).



The fungus has been identified as *Hormodendron olivaceum* (Corda) Bon., one of the Dematiaceae. It differs from other species of *Hormodendron* in the mode of production of the conidiophores and in the size and shape of the conidia. The species most resembling it are *H. Hordei* Bruhne and *H. chlorinum* var. *nigrovirens* (Fresen.) Sacc., but the former is characterised by warted conidia, while in the latter there is no hyaline neck uniting the conidia into chains. It differs from *H. cladosporioides* (Fresen.) Sacc. in its almost globose conidia.

H. olivaceum has not been previously recorded in Britain but has been found on the continent growing on birch wood.

PROCEEDINGS, 1923.

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28th Sept.—2nd Oct.

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FORAY WITH BRITISH ECOLOGICAL SOCIETY,
BURNHAM BEECHES. *20th October.*

AUTUMN FORAY FOR LONDON STUDENTS, OXSHOTT. *27th October.*

MEETING. UNIVERSITY COLLEGE, LONDON. *17th November.*

Miss R. Bracher. Observations on *Rhytisma*.
Mr J. J. Clarke. Notes on some mycological Chromidia.
Mr W. J. Dowson. A Mould attacking Sweet Peas.
Dr A. S. Horne and G. H. Jones. Further contributions to the study of *Eidamia*.
Mr R. Paulson. Observations on tree Mycorrhiza.
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A NEW SPECIES OF MONOCHAETIA.

(With Plate VIII.)

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S.
Reader in Mycology, University of Edinburgh
and
F. C. Ford-Robertson, B.Sc.
Indian Forest Service.

The fungus forming the subject of this note was found on the dead leaves of *Cryptomeria japonica* D. Don, which were still attached to the cast shoots. It was collected in November, 1921, at Raith, Fife, on shoots which had evidently lain on the ground for some months. Detailed investigation of the material was not commenced until January, 1923.

The fructifications, which are isolated and found sparingly on all sides of the leaf, are dull black and smooth, in shape oval to elliptical and up to 1 × ·75 mm. in size when mature. They may project as much as ·3 mm. above the surface of the leaf; young fructifications are more rounded and project to a less degree. On examination the mature fructification appears to consist almost entirely of a spherical mass of dark-coloured spores and is encircled by the ruptured epidermis, an indication that it was in the early stages embedded in the tissue of the leaf. Sections confirm this, and the fructification, seen just below the epidermis, is globose, consisting of a reddish-brown wall about 20 μ in thickness, made up of interwoven hyphae, which on the outer surface gradually pass off into the tissue of the leaf (fig. 1). The inner surface of the wall is sharply delimited by the hyaline sporophores which project from it thickly and bear the elongated spores. As development proceeds the epidermis and wall of the fructification immediately below it rupture and the free edges of both form an aperture which gradually widens to expose the spore-bearing layer. The fructification, immediately after dehiscence, is flask-shaped and, in consequence, the sporophores near the opening are still directed inwards (fig. 2). As the aperture widens this appearance is lost, the spore-bearing layer becoming finally almost flat. Mucilage is evidently produced, even before rupture, by degeneration of the wall and sporophores, and dehiscence is probably brought about by absorption of water and consequent swelling. The mucilage flows out over the surface as a cushion-like layer and carries out the spores embedded in it; by the time that the fructification is widely open the majority of the spores are found on the surface of the leaf in the dark-coloured mass previously referred to.

The spores (fig. 3) are spindle-shaped, constantly five-celled, slightly constricted at the septa, the three central cells (*b*, *c*, *d*) with smooth, chocolate-brown walls of even thickness and pale yellow granular contents; the central cell (*c*) is invariably the darkest. The terminal cells (*a*, *e*) are hyaline, occasionally subhyaline, with scanty colourless contents and often with a single, rather large oil drop. The proximal cell (*a*), which possesses a wall of marked thickness, is separated from the sporophore by a cross wall; the sporophore itself is hyaline, 4–20 μ long, 1–2 μ thick and is often divided into two or three cells. The distal cell (*e*) is hyaline, thin-walled, with scanty contents, occasionally with an oil drop and is prolonged into a tapering seta which is generally bent or curved, 20–32 μ long and barely 1 μ thick at the base. The process of spore development has not been elucidated but the structures shown at *f* and *g* in fig. 3 appear to be early stages.

The mycelium in the leaf consists of very delicate hyaline hyphae which spread in all directions through the tissues. At maturity the fructifications appear very shrunken and are not easily distinguished in the dead leaf. Although at the time of examination the material had been kept for fourteen months in a dry condition in the laboratory, the spores released from the soaked material were found in a germinating condition. Germination, which may take place within twenty-four hours, is invariably preceded by a change in colour and cell contents. The brown cells, which alone produce germ tubes, become paler in colour and conspicuous oil drops appear in the contents, although they are rarely or never seen in the resting spore.

On germination the outer layer of the wall is ruptured and the inner colourless layer emerges to form a germ tube of variable thickness usually about 2 μ in diameter (fig. 4). Near the point of emergence the protoplasm becomes paler in colour and in the germ tube is completely hyaline; the oil drops generally flow out as development proceeds. Whilst still very short the germ tube may bifurcate before any cross septa are formed (*a*, fig. 4).

In most cases germ tubes are only produced from the dark-coloured cells adjoining the central one, each of which may produce two. Most frequently two germ tubes are produced from the whole spore, each of the cells contributing; the maximum number, four, is rarely found but three is fairly common. The central cell has only once been seen to germinate and the terminal hyaline cells apparently never do so. During germination the setae gradually disintegrate. Germination was obtained as readily in a 2 per cent. solution of glucose as in water.

Spores placed on agar media readily produce an abundant mycelium. Different media were employed and gave growths of

varying vigour. Luxuriant cultures were obtained on media prepared with extracts of prune, Scots pine, and potato and on the standard lemco-peptone medium. Media made with extracts of Douglas fir and ash only produced thin limited growths, consisting of delicate interwoven hyphae. Cultures made on bread soaked in the various extracts produced luxuriant cultures which never bore fructifications.

The mycelium is at first white but within a week assumes a coral-pink colour. The hyphae (fig. 5) are of variable thickness from 1·5–3·5 μ, hyaline in the earlier stages of growth, with granular protoplasm and no obvious inclusions or vacuoles. Cross septa are numerous and the hyphae are freely branched; in many cases a septum is not present at the point of insertion of a branch. The septa are commonly found at about a distance of 8 μ apart but the elongating terminal cell may attain a length of 30 μ.

The assumption of the coral-pink colour is associated with two changes in the mycelium: (1) the development of stout thick-walled hyphae which contain aggregations of pink material in the cells (fig. 5, *a*) and (2) the appearance of strands of medium-sized hyphae with a parallel arrangement which take on a pink colour as a whole (fig. 5, *b*). The connection, if any, between these two phenomena, has not been determined.

Fructifications usually appear on the cultures after about ten days. The first indication of their development is the appearance of a minute dark mass slightly below the upper surface of the mycelium. A fructification always appears at the point of infection of the medium and is generally accompanied by a number of others scattered irregularly over the culture. The central fructification being usually the first to mature is, on dehiscence, a conspicuous feature (fig. 7). Development is very rapid and shortly after the dark masses have appeared a black shining drop is seen on the surface above each fructification indicating that dehiscence has commenced. This drop consists of a mass of extruded mucilage containing spores. The addition, or even the close proximity, of water causes a rapid change; the spores flow apart with great rapidity and only remain loosely held by the diffuse mass of thin mucilage. This will likewise occur, after a time, in an untouched culture. The fructifications produced on culture media agree generally in structure with those found on the leaves (fig. 6); the spores, however, are larger measuring 25–32 × 8–10 μ with stalks 8–25 μ long and seta 10–50 μ.

The extruded spores, if undisturbed, soon germinate. About three weeks after inoculation of the culture a bright pink tuft of mycelium is produced apically on the spore mass from the

germinating spores. This tuft extends to the base of the mass but does not spread to any extent over the surrounding mycelium.

The fungus under consideration clearly belongs to the genus *Monochaetia*, which is distinguished from *Pestalozzia* (of which it previously formed a part) by the presence of a single seta. A considerable number of species have been described in the former genus but few of these occur on conifers and we have been unable to find any of which the description agrees with the present fungus. In consequence we propose to make this a new species under the name *Monochaetia Cryptomeriae*. There is no evidence to show that the species is parasitic, the fructifications only being found on the dead leaves lying on the ground.

MONOCHAETIA CRYPTOMERIAE, n. sp.

Acervulis amphigenis, circularibus vel ovoideis, sparsis, subnigris, opacis haud nitentibus, laevibus, innato-erumpentibus, ·75–1 mm. diam.; sporulis fusiformibus, utrinque acutiusculis, 4-septatis, vix constrictis, 22–30 × 7·5–10 μ, brunneis, loculis terminalibus hyalinis, apice setula, 20–32 × 1 μ, hyalina, filiformi, curva dein rectiuscula terminatis; sporophoris filiformibus, hyalinis, 4–20 × 1–2 μ.

Hab. in Scotia, Raith, Fife, in foliis dejectis *Cryptomeriae japonicae*.

DESCRIPTION OF PLATE VIII.

Figs 1, 2, 6 and 7 are from photographs; figs 3, 4 and 5 are from camera lucida drawings.

Fig. 1. Transverse section of the leaf of *Cryptomeria japonica* showing the young fructification. × 190.

Fig. 2. Similar section of a mature fructification. × 190.

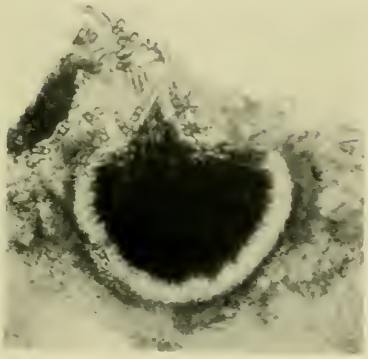
Fig. 3. Spores in different stages of development: *a*, proximal, *e*, distal terminal cells; *b*, *c*, *d*, central cells; *f*, *g*, are probably early stages of development. × 610.

Fig. 4. Spores germinating in water; at *a*, the germ-tube is bifurcating. × 610.

Fig. 5. Mycelium from culture: *a*, stout hyphae containing aggregations of pink material; *b*, strands of hyphae. × 610.

Fig. 6. Section of fructification from culture. × 190.

Fig. 7. Central portion of a culture showing fructifications which have extruded their spores in masses of mucilage (natural size).



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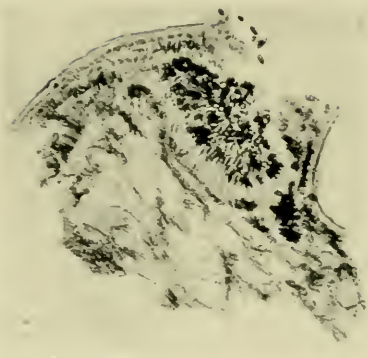

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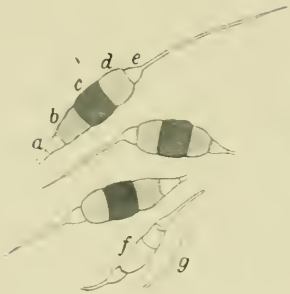

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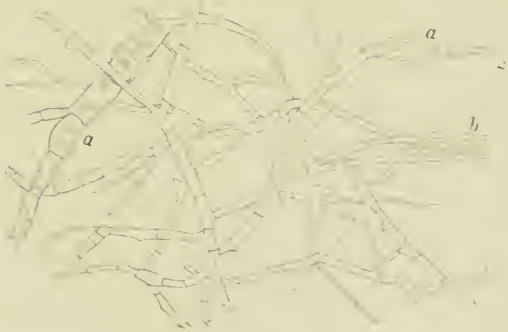

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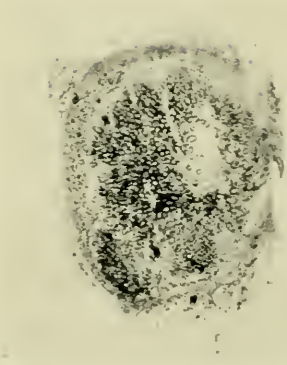

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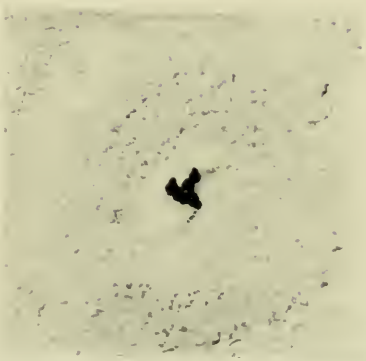

7

THE DEVELOPMENT OF GALLACEA SCLERODERMA (CKE.) LLOYD.

(With Plates IX and X.)

By G. H. Cunningham,
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The monotypic genus *Gallacea* was proposed by Lloyd (*Lyc. Aust.* p. 37 (1905)) as the result of an examination of the type specimen of *Mesophellia Scleroderma* Cooke, which he considered, on account of the difference in the nature and structure of the gleba, could not be classed in the genus *Mesophellia*. He placed his new genus in the Lycoperdaceae (section anomalae).

Recently the writer forwarded specimens of what he believed to be this species to Mr Lloyd who in reply sent a copy of two articles published later in *Mycological Notes*, VII, p. 1201 (1923). Here he changed the name to *Gallacea violacea* (Cke. et Mass.) as he found that Cooke and Massee had subsequently described the same species as *Rhizopogon violaceus*. He also commented on the position the genus should occupy, suggesting that it and several other genera (*Diploderma*, *Hysterangium*, *Mesophellia*, *Rhizopogon* (in part), *Jaczewskia*, *Phallogaster* and *Protubera*) on account of the agreement of certain characters, notably spore characters, should be placed in a distinct group or family.

As the fungus is fairly abundant in a certain locality near Wellington, the writer decided to work out the development, with a view to obtaining some light upon its phylogenetic position.

A detailed description of the mature plant is given, as the fresh specimens do not altogether agree with Lloyd's descriptions.

GALLACEA SCLERODERMA (Cooke) Lloyd, *Lyc. Aus.* p. 38 (1905).
Mesophellia Scleroderma Cke., *Grevillea*, XIV, p. 11 (1885).
Rhizopogon violaceus Cke. et Mass., *Grevillea*, XXI, p. 21 (1893).
Gallacea violacea (Cke. et Mass.) Lloyd, *Myc. Notes*, VII, p. 1201 (1923).

Peridium violet, depressed-globose, often irregularly lobed, up to 10 cm. broad, and 6 cm. high, minutely tomentose, almost smooth, dull, dry, thick, 2–3 mm.; with several coarse, violet-tinted rhizoids springing from the base; drying dull brown, with traces of violet in depressions on the surface, becoming minutely rugulose.

Gleba olivaceous or dark chestnut-brown, traversed by numerous gelatinous, hyaline trabeculae which spring from a

sterile basal disc, cells polygonal or elliptical, minute, 0·25–1 mm. diam.; in old or dried specimens becoming hollow in the centre, the gleba collapsing and lining the inner walls of the peridium and trabeculae, bay brown. Capillitium absent. Spores smooth, elliptical, frequently pedicellate, tinted yellow or olive, almost hyaline, 6–11 × 3·5–5 μ.

Habitat: Gregarious or caespitose on the floor of beech forest.

Distribution: New Zealand.

Locality unknown, T. Kirk. Specimen in Herb. Kew.

Locality unknown, Reader. Specimen in Herb. Kew.

Beech Forest, York Bay, Wellington, 80–100 m., E. H. A. Atkinson! E. J. Butler! G. H. C. Dun Mt, Nelson, 650 m., J. C. Neill! Queenstown, Otago, 450 m., W. D. Reid!

The plants are at first subterranean, but as they approach maturity they appear on the surface. They occur commonly in groups of half-a-dozen or more and are rendered conspicuous by the violet colour of the peridium.

Some twelve stages were obtained and these were found sufficient to give a connected idea of development. The material was fixed in picro-formol, sectioned and stained in iron-alum haematoxylin followed by a 1 per cent. solution of iodine green in clove oil. This combination gave satisfactory results as both nuclei and hyphae are readily stained by it.

Structure of the Mature Plant.

The plant is sessile, being attached to the substratum by a few basal rhizoids. It consists of a thick, coloured cortex—the peridium—enclosing a cellular gleba. No columella is present, though there is a sterile basal disc, from which several trabeculae arise.

Peridium. This consists of a single thick layer (2–3 mm.), (fig. 8), coloured externally, dingy-white internally. It is composed of closely woven, much branched hyphae, in which numerous clamp-connections are present. The hyphae remain distinct during the life of the plant, and at no time are gelatinised, nor do they assume the form of a pseudoparenchyma. The colour is due to the presence, in the outer layers of hyphae, of numerous pigment granules which are embedded in the protoplasm lining the walls of the hyphae. Such granules become conspicuous in sections on account of the readiness with which they take the haematoxylin stain. The peridium is attached throughout to the plates of the gleba, and is not separable from them.

Gleba. In fresh plants the gleba is minutely cellular. It consists of very numerous tramal plates enclosing polygonal or irregularly elliptical lacunae. The whole gleba is traversed by

several trabeculae which arise from a basal disc, and ramify in a radial direction from it. At the base the trabeculae are stout and conspicuous, but as they approach the periphery they become smaller, until finally they are barely discernible from the tramal plates (fig. 13). They give off branches throughout their length; these merge with the tramal plates and probably serve to add rigidity to the plant. The majority of the tramal plates arise from the trabeculae.

A tramal plate consists of three parts: (*a*) an inner layer, the trama, formed of hyphae arranged in a parallel manner, with their long axes parallel with the long axis of the plate; (*b*) a layer on either side of this, the subhymenium (fig. 6), composed of several layers of subglobose or polygonal cells, somewhat greater in diameter than the tramal hyphae; these bear on their proximal surfaces, basidia arranged in palisade fashion collectively forming (*c*) the hymenium (fig. 6). The basidia are somewhat inflated, and each bears, on short sterigmata, six minute, continuous spores. No cystidia or other aberrant cells are present.

Development.

General. The young plant is discernible first as a small swelling on the dorsal surface of the rhizoid, close to another and usually larger developing plant. It increases in size until it becomes somewhat pyriform, being at this stage about 1 × 0·5 mm. Sometimes two or even more may be found growing closely compacted together. In such a case it is not uncommon to find them fused at a later stage. In fact the lobed appearance of many mature plants is due to this fusion, as their structure shows.

Sections of the primordium of the peridium show that it first consists of undifferentiated, closely woven hyphae. This becomes less compacted, and in specimens of 1·5 × 1 mm. a zone of small cavities appears, surrounding a dense central mass of hyphae (fig. 9). This zone is somewhat dome-shaped and the cavities are few and ill-defined. For some time after, or until the plant is about 7 × 5 mm. these cavities enlarge slightly but do not appear to increase in number to any extent. Plants this size begin to approach the surface, colour appearing in the peridium as it becomes exposed. When they are clear of the surrounding soil, the plants commence to increase somewhat rapidly in size, and soon reach maturity.

Development of the peridium. Mention has been made of the first appearance of a dome-shaped zone of irregular cavities in the primordium of the gleba. This zone marks off a peripheral mass of hyphae, the primordium of the peridium. At first it is

thick and composed of somewhat loosely intertwined, much branched hyphae (fig. 9). As the plant increases in diameter the cortex becomes slightly thinner, owing to the hyphae of which it is composed becoming more closely compacted; otherwise little change occurs until the plant appears on the surface. As portions become exposed to the light, colour appears in them, due to the formation of the pigment granules already mentioned. Little change then takes place until the plant is about half-grown, but from this stage until maturity practically all increase in diameter is due to growth of the inner portion of the peridium, with the formation of tramal plates.

Development of the gleba and trabeculae. The dome-shaped zone of cavities encloses a column of densely woven, undifferentiated hyphae, which gives rise to the trabeculae and sterile basal disc (fig. 9). The cavities of this zone are at first few in number and are large and irregular in size and shape. They are separated from one another by thin plates formed of closely compacted, parallel hyphae. Scattered papillae, often arranged in small ridges, arise on these plates, and on these, solitary scattered basidia appear, bearing from one to four spores (figs. 1–3). No definite hymenium is present, nor does it appear until the plant has reached a much later stage of development. The cavities slowly increase in number and size as the plant increases in diameter, and basidia become more numerous, although as yet still confined to scattered papillae. These large and irregular cavities continue to appear until the plant has reached the surface of the ground, the plant at this stage being about 7×5 mm. The greater part of the gleba is seen to be occupied by them, save for the central column of sterile tissue. When the plant reaches the surface, a second phase of development commences. Up to this time growth has been slow, and internal differentiation but little advanced. Now, however, considerable growth occurs in the trabeculae and tramal plates; they increase considerably in thickness, and numerous branches are given off from them. These divide the large cavities into smaller ones (fig. 11), and at the same time lacunae appear in the plates and smaller trabeculae, so that in a short space of time the whole zone, formerly occupied by a few large cavities, is broken up into very numerous smaller ones (fig. 12). As these lacunae appear their walls are lined with a definite hymenium, the basidia bearing six spores, the normal number of the mature plant. Growth of tramal plates and trabeculae continues in this manner for some time until the whole of the gleba, with the exception of those portions occupied by trabeculae and sterile base, consists of minute lacunae and their accompanying hymenium.

Lacunae invariably arise by certain cells within a small area in the hyphae of the tramal plates or smaller trabeculae becoming multiseptate, but not increasing in length. These smaller cells become somewhat inflated and globose. They are then torn apart along a median zone, so that a small cavity is formed (fig. 4). This is at first lined by the inflated cells which shortly give rise to basidia, the lacuna at the same time becoming more or less elliptical.

At a slightly later stage a third phase of glebal formation is entered upon. Lacunae appear to be rapidly formed in the region of the inner wall of the peridium, their formation proceeding much more slowly in the major part of the gleba. The hyphae of the inner wall of the peridium grow rapidly, and lacunae appear in it (fig. 13) as tissue is added to this peripheral region.

The trabeculae and basal disc have now become considerably reduced in thickness, the basal disc being confined to a small pulvinate region at the base (fig. 13); the trabeculae, although fairly stout at their junction with the disc, become thinner as they approach the peridium, until they are barely discernible where they merge with it.

When the plant is about half size (or even earlier) the tramal hyphae and trabeculae become gelatinised, further increase in size being confined to the inner layer of the peridium, the hyphae in this region continuing to grow, giving rise to glebal tissue until maturity is reached. In the mature plant the whole of the tramal plates and trabeculae, with the exception of the hymenium and subhymenium, are gelatinised, but the peridium remains unaffected throughout the life of the plant. Structurally there is no difference between tramae and trabeculae, save that of size, for the tramae arise from the trabeculae and both give rise to hymenium. Nevertheless, for facility of description it is necessary to retain these distinctive names.

Mature or dry plants are quite hollow, the collapsed gleba being distributed as a thin film over the inner walls of the peridium and trabeculae; the latter being stouter than the tramae are able to retain their form, giving the plant a veined appearance when cut (fig. 8). That shrinkage is due to the drying of the gelatinous portions of the tramal plates (tramae) is obvious when the following facts are considered: if half-grown plants are sectioned, they are seen to be solid throughout, yet if they are dried, and again examined, collapse of the gleba will be seen to have taken place, showing that loss of moisture is the determining factor; should sections of this dry gleba be placed in water, they slowly swell until they assume their normal size. Furthermore, should plants collected before gelatinisation of

the tramae has occurred, be dried, collapse of the gleba does not occur. The gleba is olivaceous when the plants are fresh, but in old dried specimens it is a dull bay-brown, and is very brittle to the touch.

Cytology.

The hyphae of the cortex and gleba are invariably bi-nucleate. The basidia are at first slightly inflated; in mature plants they measure about $100 \times 30\mu$. A fusion nucleus is formed in the usual manner and this divides until six nuclei are formed. These migrate to the spores, and there divide, so that each spore is binucleate. The spores are borne on short and slender sterigmata. Clamp-connections are abundant in the tissues of the cortex, tramae and trabeculae.

Systematic Position of the Genus.

The development of the gleba and cortex in their earlier stages is similar to that of *Hysterangium*, which Fischer (1900) places in the Hysterangiaceae. The single peridium, sterile basal disc, trabeculae and phalloid-like spores are also characteristic of this genus. The peculiar manner in which the gleba collapses in adult plants (a character not confined to this genus, however, for the writer has in his possession specimens of a species of *Gautieria* which also possess it) and especially the six-spored basidia are characters which separate it from *Hysterangium*.

Lloyd has already noted the similarity of spores of this and several other genera, and suggests that they should be placed in a separate family. Unfortunately the genera mentioned by him have in many cases little in common, differing in such major particulars as the presence or absence of capillitium, permanent gleba, and number of spores on the basidium.

It must be admitted that the present systems of classification of the Gasteromycetes are unsatisfactory, as many genera with little in common are regularly placed in the one family. Recognising this unsatisfactory condition, the writer has for some time past been engaged on a reclassification of the Gasteromycetes, the publication of which is delayed pending the investigation of the development in several other New Zealand genera. Meanwhile he believes that *Gallacea* should be placed in the Hysterangiaceae of Fischer, for it agrees more closely with *Hysterangium* than with any other genus. This grouping is merely tentative, for in his forthcoming paper the writer intends to place this and several other genera in a distinct family.

Thanks are due to Mr J. C. Neill, of this laboratory, for the preparation of the sections used in the preparation of this paper, and to Mr Neill, Mr E. H. Atkinson and Mr W. D. Reid, also of this laboratory, for contributions of specimens.

SUMMARY.

1. The monotypic genus *Gallacea* is confined to New Zealand.

2. Development proceeds by four stages: (*a*) the primordium consists of closely woven, intricately branched hyphae; (*b*) a dome-shaped zone of cavities appears, surrounding a central undifferentiated area, and surrounded by the primordium of the peridium, these cavities are large, and do not possess a definite hymenium, basidia appearing on small scattered papillae; (*c*) rapid growth of tramae and trabeculae, with appearance of numerous lacunae lined with hymenium; (*d*) gelatinisation of tramae and trabeculae, accompanied by peripheral formation of gleba around the inner margin of the peridium.

3. Basidia are at first 1–4-spored and are borne on irregular scattered papillae, but after the appearance of a definite hymenium (*c*) they become regularly six-spored.

4. Colour appears in the outer layers of hyphae of the peridium as soon as the plant appears on the surface. It is due to the presence of pigment granules in the protoplasm lining the cell walls.

5. At maturity the gleba collapses, owing to loss of moisture from the tramae and smaller trabeculae, and lines the inner walls of the peridium and the trabeculae which persist.

6. Spores are invariably binucleate.

7. The genus resembles closely the genus *Hysterangium*, and on that account is tentatively placed in the Hysterangiaceae.

LITERATURE CITED.

FISCHER, ED. Hymenogastrineae in Engler and Prantl. Natürlichen Pflanzenfamilien, II, pp. 296–313, 1900.

LLOYD, C. G. The Lycoperdaceae of Australia, New Zealand and Neighbouring Islands, pp. 1–44. Cincinnati, 1905.

EXPLANATION OF PLATES IX AND X.

All drawings and photographs are original. The drawings have been made with the aid of a camera lucida.

Figs. 1–2. Spores borne on papillae scattered over the trabeculae.

Fig. 3. Later stage in which scattered basidia have appeared.

Fig. 4. Formation of a lacuna by fissuring of the trama; *lac.* lacuna; immature hymenium on the left, undifferentiated tramal tissue on the right.

Fig. 5. First formed hymenium. Note the long and slender basidia, which as yet bear only four spores.

Fig. 6. Mature hymenium, with a basidium bearing six spores. *Hym.* hymenium; *sub.* subhymenium; *tr.* trama, gelatinised in section on the right.

Figs. 1–6 × 1400.

Fig. 7. Photograph of mature and immature plants, the latter in side view. × ½.

Fig. 8. Photograph of the same plants sectioned. Note the thick peridium and collapsed gleba of the mature plant. The veined appearance is due to the persistence of the larger trabeculae. × ½.

Fig. 9. Photomicrograph of young plant shortly after the commencement of differentiation of the gleba. Note the dome-shaped zone of large cavities surrounding the central columella. × 25.

Fig. 10. Stage showing the development of trabeculae. Spores are present on many of these, borne on scattered basidia. A well-defined sterile base is present. × 20.

Fig. 11. Slightly later stage, showing commencement of secondary growth in thickness of the trabeculae. Note that the columella has almost disappeared. × 12.

Fig. 12. Not quite median section through the stage in which secondary growth of the trabeculae is well advanced. Hymenium is now present, fig. 5 being a drawing from this section. × 10.

Fig. 13. Section through a plant shortly after commencement of the third or peripheral stage of growth. The trabeculae are already gelatinised, the peridium well defined and the hymenium at the stage shown in fig. 6. The larger trabeculae persist as the veins shown in fig. 8, left. × 6

STRAINS OF RHIZOCTONIA SOLANI KÜHN (CORTICIUM VAGUM BERK. AND CURT.).

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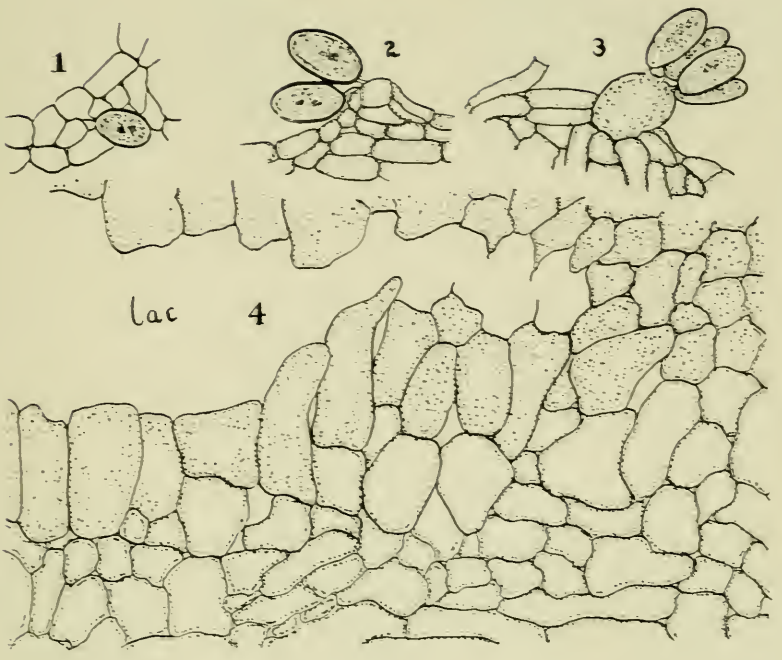
Introduction.

During the course of work in Egypt in connection with the "Sore-Shin" disease of cotton seedlings caused by *Rhizoctonia Solani* Kühn, the fungus was induced under experimental conditions to produce its fertile stage *Corticium vagum* Berk. & Curt. On comparing the *R. Solani* from cotton in Egypt with isolations of the same species from other countries it was observed that there were considerable differences between them in culture. Duggar (1) had previously noted such differences and stated that "in general it is felt that these differences are such as might be due to permanent differences in the pathological strains, on the one hand, or may be regarded as temporary differences due to recent environment on the other." In order to ascertain whether such differences are temporary or permanent it was necessary to grow different forms simultaneously under exactly the same conditions of moisture, temperature, aeration, light, nutrition, etc., and further to compare their behaviour as parasites on the same hosts under the same conditions. By the kind permission of Professor Barker, the writer was able to do this on joining the staff of the above station.

Work was commenced with five forms. *E* isolated from cotton (Egypt); *S* and *A* from diseased potato in England (H. S. Stirrup and Mrs N. L. Alcock); *I* from India (F. J. T. Shaw) and *B* from the Missouri Botanic Garden, U.S.A. Later *PO* and *W* from Potato and *PE* from Garden Pea, England (W. Buddin) was added.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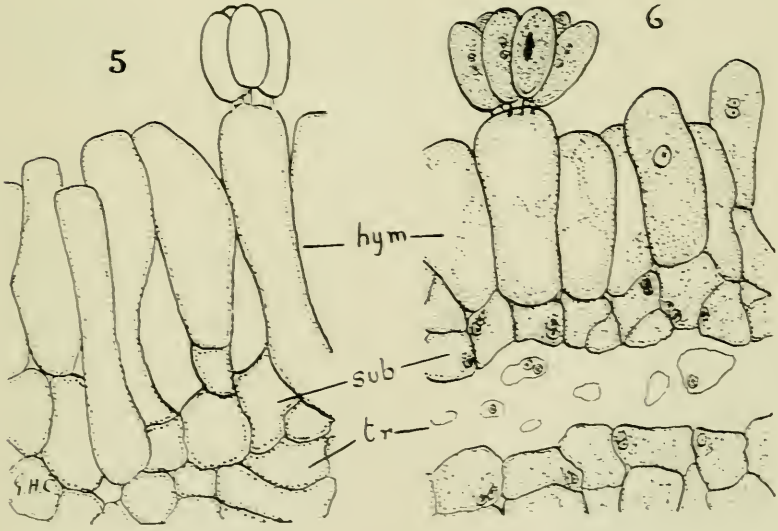
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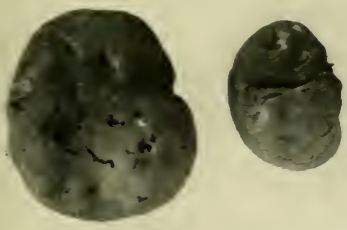

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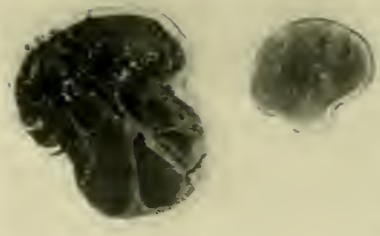

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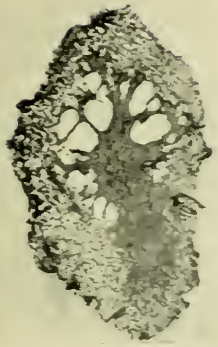

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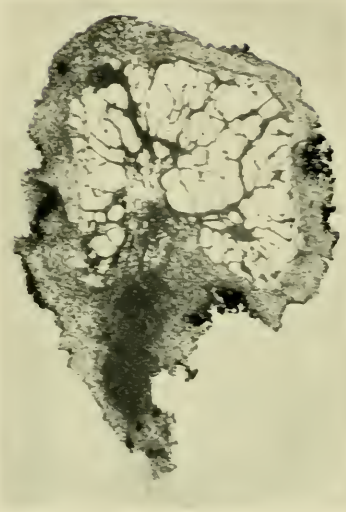

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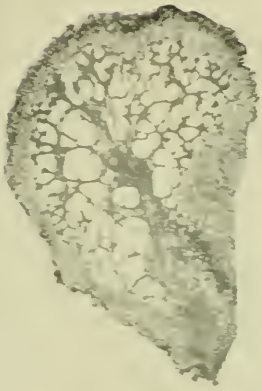

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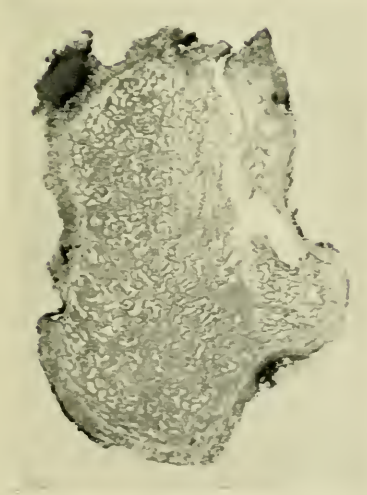

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Media. The above forms of *Rhizoctonia Solani* have been grown for several months, and in some cases for over two years on different kinds of liquid and solid media including the following: steamed potato, steamed turnip, steamed carrot, prune agar, potato agar, malt extract agar, boiled rice, malt extract gelatin, milk, carrot extract, turnip broth, bouillon, apple extract, Naegeli's solution, Ufchinsky's solution, and malt extract.

All forms grew well on all the solid media but growth was feeble and slow on most of the liquid media, particularly bouillon, apple extract, Naegeli's solution, and Ufchinsky's solution. Of the liquid media the best growth was obtained on milk and turnip broth. None of the fungi grew well on any medium which was unsuitable to the others, and the best medium for all was steamed potato.

Macroscopic Characters.

When grown on the above media it was observed that in some cases there was considerable variation in the colour, amount of aerial growth and the size and number of the sclerotia, within the one form. In spite of this, however, it was possible from certain characteristics of growth to distinguish some of the forms from others, and these diagnostic features were retained throughout. The two extreme cases were *I* and *B*, since the former produced sclerotia which were darker, more discrete, and more even in size than any of the other forms; the latter, on the other hand, did not produce a single sclerotium on any medium. Like the other sclerotia-producing forms, *I* produced larger and a greater number of sclerotia on media like steamed potato, carrot and turnip than on agar and gelatin compounds. Previous experiments with *E* have shown that this is due to the fact that the former media retain moisture for a longer period and allow of better aeration within the medium itself than is the case with agar and gelatin. For these reasons the fungi are able to continue growth for a much longer period. The growth of the mycelium is confined to the surface layer on agar and gelatin and does not penetrate deeply into the medium owing to the absence of oxygen. This is probably also the reason why the fungi do not grow so well on liquid media. All the sclerotial forms produced larger sclerotia on fresh agar medium than on the same medium which had become slightly dry. If the dried agar medium is melted, cooled, and a subculture made immediately afterwards, sclerotia are formed which are of the same size as those produced on freshly made medium. This is due to the fact that moisture in the form of drops of water on the sides of the tubes or Petri dishes is favourable to their rapid and continued growth. This sensitiveness to the presence of

Fungus	Medium	Colour of mycelium	Aerial growth	Size and shape of sclerotia	Colour of sclerotia	Remarks
E	P	Buff-brown	Strands of brown hyphae connected with sclerotia formed on sides of tube	Somewhat flat when formed on surface of medium. Roundish on sides of tubes 2–11 mm. in diam. Often coalesce	Whitish-buff-dark brown, depending on age. Often slaty-grey on outside	The larger flat sclerotia on medium often possess characteristic slaty-grey colour which distinguishes *E* from *S*, *PO* and *PE*. Mycelium forms buff-coloured felt resembling that of *B*
E	M	Buff	do.	Roundish, 1–2 mm. in diam.	Whitish-buff-brown	Forms buff-coloured felt as in (1)
I	P	Buff to brown	More aerial growth than *E*	Roundish, 1–5 mm. in diam.	Whitish-buff and mostly dark velvety brown	Sclerotia more discrete and rounder than in other forms. Hyphae connected with sclerotia not easily seen with naked eye. Forms more sclerotia on sides of tubes than other forms
	M	do.	do.	Mostly 2–3 mm. in diam.	do.	—
S	P	Buff-brown	As for *E*	As for *E*, but more woolly	Browner than *E* and slaty-grey colour absent	—
	M	do.	do.	do.	As for *E*	This is intermediate between *E* and *I*. Sclerotia flatter than *I* and darker and larger than *E*

A	P	Mostly deep brown	Copious, thick, woolly, dark brown growth above medium	Difficult to measure owing to coalescing and very woolly nature	Reddish brown	This resembles *W* more than the others but is a much darker brown in colour. Growth same in all media
	M	do.	do.	do.	do.	do.
B	P	Light buff never brown	None at any time	No sclerotia	—	The growth of this fungus is the same on all media. Forms thick light buff felt of mycelium on surface of medium
	M	do.	do.	do.	—	—
PO	P	As for *S*	As for *S*	As for *S*	As for *S*	No marked differences between *S*, *PO* and *PE*. All resemble *E* except for minor differences given above
PO	M	do.	do.	do.	do.	
PE	P	do.	do.	do.	do.	
PE	M	do.	do.	do.	do.	
W	P	White-buff	Copious thick woolly buff-coloured aerial growth	As for *A*	Buff on outside and brown on inside	Very like *A* except for colour. Growth same on all media
W	M	do.	do.	do.	do.	—

oxygen and moisture is also shown in the field by the fact that the fungi attack their hosts preferably at the ground level where both factors are most suitably balanced. The foregoing table gives the macroscopic characters of the forms when grown on the freshly made media which proved to be most suitable for growth and diagnostic characters*. The descriptions refer to cultures about one month old. All with the exception of *B* produce in the first week a fair amount of aerial growth which collapses when the medium begins to lose its moisture. The column "Aerial growth" in the table refers to that which is present when the culture is one month old or more.

From the above it will be seen that *I*, *A*, *B*, and *W*, can be easily distinguished by their mode of growth, and with practice *E* can also be distinguished from all others by a characteristic slaty-grey colour of the surface of the sclerotia on potato. On agar the latter can be distinguished by the large number of small sclerotia (about 1 mm. in diam.) formed on sides of tubes and by the fact that the mycelium covers the surface of both media with a felt of growth resembling that of *B*.

Temperature and Rate of Growth. A comparison between the rates of growth were made by measurements and observations on several cultures on different media at temperatures of 0–1° C., 5–8° C., 21–23° C. The manner of subculturing, although done as uniformly as possible, did not always give the same results. In a number of subcultures of any one form some commenced growth quicker than others and any slight difference in the moisture content of the medium or air in the tube or Petri dish made an appreciable difference in the rate of growth. For comparing the rate of growth at the above temperatures subcultures of all forms were made at the same time from young rapidly growing cultures of the same age incubated at 21–23° C. and immediately placed in chambers and kept there for five days. At temperatures 0–1° C. none of the fungi made any growth whatsoever. At 5–8° C., *E*, *I* and *B* made no growth. The disc of growth of *W* measured 5 mm. in diameter and for *S*, *A*, *PO* and *PE* growth ranged from 20–22 mm. in diameter. On placing the cultures kept for five days at the lower temperatures in an oven at 21–23° C., growth took place within twenty-four hours and continued as usual. At 21–23° C. the fungi can

* These were steamed potato and malt extract agar prepared as follows: *Steamed potato* (*P*) potato cut into wedge-shaped pieces, placed on moistened cotton-wool at the bottom of large tubes and sterilised by steaming. *Malt extract agar* (*M*), 200 grs. crushed barley to 1000 c.c. of distilled water at 45° C. Kept at 45° C. for half an hour, then temperature raised to 70° C. in half an hour. Kept at 70° C. for one hour and filtered. Distilled water added to S.G. 1·020. Then 3 per cent. of agar added, autoclaved, cooled and egg albumen added. Autoclaved, filtered, tubed and finally autoclaved.

be divided into three groups. The most rapid growers were *E*, *PO*, *PE*, *S* and *I*; the slowest were *A* and *B*. The fungus *W* took an intermediate position between the above two groups. At this temperature and normal room temperatures *I* consistently formed sclerotia quicker than the others. The observations were made with cultures from mycelia which had been isolated from a common host (cress seedlings).

Effect of Light. A series of cultures of all the forms was made in Petri dishes and placed under a blackened sheet of tin so that only one half was exposed to the light. None of the forms showed any reaction to light.

Pathogenicity.

The following experiments were carried out with a view to ascertaining whether there was any difference in the parasitism of the forms on the same host under the same conditions.

Experiment I. The fungi used in this experiment were *E*, *I*, *S*, *A* and *B* on broad bean and garden pea. The experiment comprised ten lots of five flowerpots (3 in. diam.) which were filled with sand and treated as follows:

1. Three seeds of broad bean sown in each of the five pots. A piece of potato on which the fungus was growing was placed in contact with the seed in three of the pots. Seed and fungus were then covered with sand and watered with tap water. In the other two pots no fungus was placed with the seed (controls).

2. As for 1, but three seeds of garden pea sown in place of broad bean.

3 and 4, 5 and 6, 7 and 8, 9 and 10 were similar to 1 and 2, but fungi *I*, *S*, *A* and *B* respectively were used.

All were treated on March 26th and placed together in a greenhouse. The week following the date of sowing was bright and sunny with the result that no marked difference could be seen between the controls and infected in any series. It should be pointed out that the soil temperature was not sufficiently high to inhibit the growth of the fungi, but acted indirectly by hastening the growth of the seedlings and increasing the rate of evaporation from the pots.

Experiment II. This was a repetition of Experiment I, except that six-inch pots and distilled water were used instead of three-inch pots and tap water. The date of sowing was April 11th; the plants were examined on May 14th. As in Experiment I no difference was observed between the controls and infected in the pots containing garden peas. The results for the broad beans series were as follows:

Seedlings infected with fungus *E* gave (1) two healthy, one diseased, (2) one killed, two attacked at hypocotyl, and (3) three attacked at hypocotyl.

With fungus *I* (1) three stunted seedlings with brown roots, (2) and (3) healthy.

With fungus *S* (1) two healthy, one killed, (2) two healthy, one diseased and (3) one healthy, one killed and one with root system and tips of leaves attacked.

With fungus *A* (1) one healthy, one killed, one attacked at hypocotyl, (2) two healthy, one diseased, (3) two healthy, one slightly diseased.

With fungus *B* (1) one healthy, two diseased, (2) and (3) healthy.

(In the controls for *S* and *A*, a seed in one of the pots failed.)

Experiment III. A small rectangular field plot was divided longitudinally into two by a path one foot wide. On one side of this path were planted five rows of ten sets each of potato, variety "Sharp's Express." The distance between the rows was two feet and the interval between sets one foot. End on to these were planted in a similar manner five rows of ten sets each of the variety "British Queen." End on to the "British Queen" were planted five rows of ten sets each of the variety "King Edward." Next to the "King Edward" were planted five rows of broad beans, followed by five rows of garden peas. Each block of five rows was separated from its neighbour by a path two feet wide. The distance between the rows of beans and peas was one foot and each row comprised twenty-two holes at an interval of six inches, and sown with one seed per hole. All were sown in the usual manner without manure or any special treatment and served as controls. On the other side of the longitudinal path were sown similar blocks of five rows of "Sharp's Express," "British Queen," "King Edward," broad beans and garden peas. In the case of these potato sets a cylindrical piece of the flesh had been extracted by means of a cork borer and in the cavity so made a fragment of one of the fungi *E*, *I*, *A*, *S* and *B*, growing on malt extract agar was placed in each of the ten sets in a row. Thus in the five rows of each variety one row was infected with *E*, one with *I*, and so on for *S*, *A* and *B*. These rows of beans and peas were also infected with one of the five fungi by placing a small piece of the culture in contact with the seed in the soil. Sowing was done on April 7th. All the potato sets in controls and infected germinated with the exception of one set in each of two infected rows of "British Queen." The latter were examined and found to be very hard but not invaded by fungus hyphae. The failure of infections was probably due to the fact that the conditions of temperature and moisture were not suitable to the fungi. The results of germination of beans and peas are given in the table on p. 207.

Experiment IV. Previous experience in regard to the powers of *E* to infect pea and bean seedlings and the records for the

English forms in regard to their effect on potato indicate that the conditions of temperature and moisture were unfavourable to the growth of the fungi so that the results in the previous experiments were not as definite as they might have been. Another experiment was therefore carried out in the laboratory on a small scale where the above-mentioned factors could be controlled. For this purpose ten small beakers (300 c.c. capacity) were filled with soil and sterilised in an autoclave. Several cress seeds were then sown on the surface of the soil and covered with sterilised sand which would offer little resistance to the

No. of row	No. of plants in controls	No. of plants in infected	Host	Fungus	Remarks
1	17	10	Beans	*E*	Average germination
2	18	18		*I*	in controls = 17
3	15	15		*S*	
4	17	15		*A*	
5	18	18		*B*	
1	15	12	Peas	*E*	Average germination
2	15	15		*I*	in controls = 15·4
3	18	15		*S*	
4	16	15		*A*	
5	13	16		*B*	

young seedlings. Distilled water was added to wet the soil thoroughly. When the seedlings appeared above the surface they were thinned out to twelve seedlings per beaker in such a way that they were grouped fairly close together in the centre. In contact with the seedlings in one of the beakers a piece of potato on which *E* was growing was placed, and likewise *I*, *S*, *A*, *B*, *PO* and *PE*, were placed in seven other beakers. The remaining two were kept as controls. All ten beakers were grouped together and placed under a large bell-jar. In order to keep the air moist inside the jar a beaker containing water at about 90° C. was placed inside and the vapour from this condensed on the sides of the bell-jar. As in the previous experiments all cultures used were exactly the same age. In this case subcultures were made on June 7th and used for infection on June 14th. As nearly as could be judged by the eye the same amount of fungus was placed in the beakers in all cases.

With fungus *E* all seeds were healthy on the 5th day after sowing (June 19th); on the 6th day several seedlings were attacked, on the 7th day all seedlings were attacked and on the 8th day (June 22nd) all seedlings were dying.

With fungus *I* all seedlings were healthy on the 7th day after sowing but one was attacked on the 8th day, and on the 12th day this was dead and two others were slightly attacked.

With fungus *S* two seedlings were attacked on the 8th day, six were collapsing on the 11th day and all were collapsing on the 12th day.

With fungus *A* all seedlings were healthy until the 12th day when two were slightly attacked.

With fungus *B* three seedlings were attacked on the 7th day, dying on the 8th day; six more were killed by the 11th day and the remaining three were attacked on the 12th day (dying later).

With fungus *PE* several seedlings were attacked on the 5th day, all were in a collapsed state on the 6th day, and all were dead on the 7th day.

With fungus *PO* one seedling was attacked on the 8th day; all seedlings were dead on the 11th day.

All the seedlings in the controls remained healthy throughout the experiment.

The result as given in the above table gives a good indication of how these fungi stand in regard to their parasitism of cress seedlings under such conditions. It would, however, be more accurate if the results were considered from the date when the attack commenced, otherwise it is misleading in regard to *PO*, and *S*, which took a few days to commence the attack and then proceeded as rapidly as *E* and *PE*. There is no marked difference, therefore, between *E*, *S*, *PE* and *PO*, which were the most active as parasites. *B* is also an active parasite of cress seedlings but as already stated it is not such a fast grower as *E*, *S*, *PE* and *PO*. *I* and *A* are not so active as parasites. There does not seem to be any indication of a correlation between the rate of growth and the rate at which seedlings are killed since *I* is a faster grower than *B*. On the other hand, rapidity of growth does obviously assist a fungus to cause more damage than the slower grower when both are equally active parasites, *vide E*, *S*, *PE*, *PO* and *B*.

The fungi were isolated from diseased cress seedlings in all cases with a view to ascertaining whether the diagnostic characters would again be shown in culture. There was no difference in growth between any form before and after passing through cress, so it is reasonable to consider these characters as being permanent in the sense that the term can be applied to microscopic fungi.

The above experiment was repeated in all detail with the fungi *E*, *PE*, *A*, *B* and *S*, with the following results:

With fungus *E* all seedlings were collapsing on the 4th day after infection, and all were dead on the 5th day.

With fungus *PE* the results were similar to *E*.

With fungus *A* all seedlings were healthy on the 5th day, two were dead and two diseased on the 8th day.

With fungus *B* three seedlings were diseased on the 4th day,

six were collapsing on the 5th day and all were dead on the 8th day.

With fungus *S* none of the seeds were diseased up to the 8th day. Growth was very feeble, probably due to the medium becoming contaminated by rapidly growing saprophytes after the date of infection.

The above results compare favourably with those of the preceding experiment.

Microscopical Characters.

Although, as already stated, there are definite distinguishing features between the various forms when compared macroscopically, under the microscope, however, the differences are confined to the colour of some of the hyphae in old cultures. In cultures of all ages the size of the hyphae varies within the same limits in all forms. In cultures forty-eight hours old all the hyphae are hyaline and those of one form are indistinguishable from the others. In cultures fourteen days old, some of the forms show the presence of brown hyphae. These are *E*, *I*, *S*, *A*, *PO* and *PE*. On agar the colour of the brown hyphae of the fungus *E* is somewhat lighter than the others which are of a darker reddish-brown. In the case of *B* and *W* all the hyphae when examined singly are hyaline and buff in mass. In cultures seven weeks old on potato the hyphae are a mixture of hyaline and brown in *E*, *I*, *S*, *A*, *PO* and *PE*. The hyphae of *B*, on the other hand, remain hyaline when examined singly and buff or light brown in mass. This is also the case with *W* for hyphae proper but the inner tissues of sclerotia are brown.

Conclusion.

As already stated some of the above isolations are easily distinguishable macroscopically; on the other hand, some of these when examined microscopically cannot be separated from each other by any observable character. The microscopic differences observed in some cases are only slight and it is considered that they do not justify a multiplication of species. Such minor differences have been observed in the case of several other species of fungi with the result that they have been split into biological species of the same morphological species.

Matz (2) has separated into different species of *Rhizoctonia* isolations which differ between them considerably less than the two extremes *I* and *B* forms mentioned above. The minor differences described by Matz occurred in some cases when the fungi were growing on different media and if this method of determination of species were followed in this paper, the fungus *E* growing on freshly prepared agar would be a different species from *E* growing on the same medium which had been allowed to

dry slightly, and a third species would be made of *E* on potato, The one name *Corticium vagum* B. & C. = (*Rhizoctonia Solani* Kühn) is, therefore, retained for the isolations compared in this paper at the same time realising that the species contains several biological species or strains.

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SOME OBSERVATIONS ON FISTULINA HEPATICA AND HOLLOW, STAG-HEADED OAKS.

By K. W. Braid, B.A., B.Sc.

Few trees appeal more strongly to the popular imagination than oaks, hence their defoliation by *Tortrix* or the bepowdering of their leaves by *Oidium* offends the national eye and heart. Many, who have no hint of the causes, bemoan the appearance of the stag-headed giants of our parks and forests.

In 1921 and 1923 there was a surprising abundance of *Fistulina hepatica* Fr. on the oaks in Richmond Park. On September 8th, 1923, a stipitate specimen was found growing in the dark cavity of a hollow oak, and a few yards away on a branch of another tree a normal specimen was found. Three weeks later a count of twenty trees showed that twelve possessed ripe fungus fructifications. That is, about 60 per cent. actually bore the fungus in fruit, or, counting the two trees which had possessed sporophores on the 8th and which had been numbered amongst the selected twenty, 70 per cent. of the trees bore, or had borne, fructifications during the year. A more extended count confirmed these figures. The following day another count was made in a different part of the Park. As before, old trees were chosen which were at least two feet in diameter at three feet above ground level, and *Fistulina hepatica* was found on 75 per cent. of the trees. Sometimes the fructifications were on the buttresses of the roots, sometimes on the bark of the trunk, but usually were well up on the larger limbs. Later, in the case of an old felled stump, a *Fistulina* was seen growing vertically upon the cut upper surface near the centre of the stump. The following week in a different part of the park

attention was again confined to trees exceeding two feet in diameter, and 60–70 per cent. were found bearing sporophores of *Fistulina*, many of which were distinctly aged and often green on the top owing to the presence of an *Aspergillus* sp. The next week only two fresh fructifications could be found in this area, and many of those previously noted were now rotting away. Practically all the infected trees (only one exception was noticed) had been pollarded, and the original rot—to whatever it was due—presumably had started in the wound. In nearly all cases where the *Fistulina* was present the trees were stag-headed. Although only preliminary work has been done it is evident that the water content of the soil is not the chief factor in producing stag-headedness, for trees in the hollows are often more affected than those on higher ground. I think also that *Fistulina* is more frequent in lower-lying places. The present general opinion is that stag-headedness in trees is due to an insufficient water-supply. This may, however, be due to various causes, for example, actual lack of water, unavailability of the water, or owing to the wood vessels being insufficient for the requirements of the tree. In the writer's opinion the latter is the primary factor at work in the case of stag-headed oaks. The leaf area has adjusted itself to the supply of water which the vessels were able to supply for average years, and if exceptional causes arise (such as drought) this equilibrium is upset and those portions furthest from the supply suffer most acutely. *Fistulina* apparently plays a large part in the hollowing of oaks in Richmond Park and is possibly also one of the main factors in causing stag-headedness. Observations made by others in other parks and forests would give data of value for the future.

The following is an instance of the effects of the hollowing upon the root system of an oak. A specimen of *Quercus Phellos*, felled at Kew recently as being dangerous, had been hollowed by a polypore. The fungus, however, had not produced fructification sufficiently well developed for certain identification. In this particular case the root was extracted and showed certain noteworthy features. The internal hollowing extended right down the stem to the soil. The original roots which had supplied the tree for the first few decades had rotted away. The roots which appeared to exist from an observation of the buttresses prior to felling were in fact non-existent and their place had been taken by a number of smaller subsidiary roots which in most cases had arisen from the upper surface of the original buttress root. None of these subsidiary roots exceeded eight inches in diameter. The centre of the tree being rotten or extinct the thin, living shell had developed its own, relatively young root system, which, being small, had a limited range of soil to

explore. It seems probable that the bulk of the living root system in such cases is confined to ground already sheltered by the leaf canopy and consequently deficient in water supply and impoverished in nutritive material. The whole of the area beneath the tree is not short of water; during wet weather water trickles down the bole of the tree and saturates the area in its immediate vicinity: the finer roots doubtless make good use of this supply, and its presence may encourage additional adventitious roots in this area. This problem requires more experimental investigation. Unfortunately the roots of the hollow trees in Richmond Park are not grubbed up, so there has been no opportunity of studying their root systems. Any mycologist able to investigate such root-systems would confer a great boon on his physio-mycological brethren by publishing notes on such examinations: it is with a view to eliciting such assistance that the present observations are published.

No brackets of *Polyporus dryadeus* have been found on oaks in Richmond Park but Dr J. W. Munro called my attention to white woolly masses of mycelium in some heart wood which suggested this fungus. Occasionally signs of polypores have been seen but not in a state sufficiently developed for critical determination. Rhizomorphs of what appeared to be *Armillaria mellea* Vahl. were seen on one or two occasions; and on one dead butt fructifications of *Armillaria mellea* were found.

An examination of the root systems of a number of hollow trees—including an Elm hollowed by *Fomes ulmarius* and others by fungi bearing no sporophores—has in every case shown abnormal development of fibrous roots under the leaf canopy and decay among the larger roots. These facts have suggested the following hypothesis as to one of the causes of stag-headedness of oaks after weak, parasitic, fungoid infection. If the infection has gained entrance *via* a branch wound and has assisted in the decay of the heart wood while exploring the less vigorous cells of the living sap-wood, then the mycelium gradually extends first down the centre of the trunk and later along the main roots. Following the advance of the fungus the attacked tissues would decay and become hollow. When such hollowness extends right down into the earth penetrating the lower portions of the main root (as it does) then the food in solution conveyed by the vessels in the lower parts of these roots either is wasted or in very small part utilised by the adjacent healthy cells which are still in direct connection with the xylem strands of the stem. The oak ceases to obtain a large proportion of the liquid nourishment it previously received and suffers in consequence. The phloem stream also would be interfered with and consequently the lower portions of the main roots are least

able to cope with the advance of the mycelium and become destroyed quickly. Callus growth would be encouraged between the healthy wood of the main roots and the diseased wood and it is thought that the fibrous roots which develop in such cases would arise in the first place from such a "callus area." Possibly the accumulation of food from the sound, but now severed, phloem cells causes the gouty appearance round the base of the trunks and on the buttresses of the main roots, and may also assist in giving rise to the abundance of adventitious roots which ultimately grow from the upper surface of the main roots. Part of the stem is thus no longer in direct connection with the wood and bast elements of the lower portion of the main roots, and the holes and rifts which frequently arise at such places giving access to the hollow interior of the tree show that the fungus makes a special onslaught on this portion of the stem.

TREE MYCORRHIZA.

(Chiefly Field Notes.)

With Plates XI and XII.

By Robert Paulson.

The close association of a fungus with the rootlet of a higher plant produces the phenomenon known as mycorrhiza or fungus-root, a condition that occurs abundantly, almost without exception, on the roots of *Quercus Robur, Fagus sylvatica* (1) fig. 1, *Carpinus Betulus* (1) fig. 2, *Betula alba, Castanea sativa* fig. 3, *Pinus sylvestris* and *Taxus baccata* in woodlands of the south-eastern counties, especially in those located on a light soil.

The south-eastern counties are mentioned for the reason that the writer's observations on fungus-roots have been carried on mostly in that part of the country.

Mycorrhiza is developed to its fullest extent upon roots that do not enter the soil but spread out horizontally throughout masses of decaying leaves which accumulate in depressions of the ground near tree trunks. Should there be carpets of moss on the more level ground, such as those formed by *Mnium undulatum* and by the coalescent cushions of *Leucobryum glaucum*, roots of trees grow upwards into the lower, decaying layers of the moss and there develop the state of mycorrhiza.

Figs 1, 2 and 3 each represents a horizontal plane as seen by an observer on bending forward to look upon the ground. All that was necessary when preparing to expose the photographic plate was lightly to remove, preferably with the fingers to avoid disturbance of the roots, the topmost layer of the leaves to a

depth of 1·5 to 2·5 inches. The roots were growing in a series of layers, one below the other, the number in each series depending upon the thickness of the accumulated leaves. The upper layer is, as a rule, the best for illustrative purposes.

Any hypothesis advanced respecting the exact relation that exists between the root of the tree and the fungus must take into consideration the fact that the bulk of the mycorrhiza met with in woodlands is formed among decaying leaves, of which the progress of decay is not greatly advanced, and also, that mycorrhiza is abundant a very short distance below the surface of the leaf mass.

The above statements are emphasised because, during a period of drought even of short duration, the conditions, represented (figs. 1, 2 and 3) as normal, are completely changed by the mycorrhiza being desiccated and thereby killed.

Mycorrhiza does not revive after being destroyed by the lack of moisture and does not reappear on the return of copious rain until new rootlets have been developed and they in their turn have become associated with a fungus.

Provided a drought is not sufficiently prolonged to destroy the thicker roots, on which are the finer ramifications, new fibres are produced in abundance, on the return to normal atmospheric conditions, among the same leaves where mycorrhiza formerly existed and where fresh fungus mycelia have already appeared. No evidence has been observed of any tendency on the part of newly formed rootlets to avoid fungus hyphae, with which they soon become associated. A root-system is developed and spreads through the leaf-masses where fungus mycelia are abundant. In the case of roots that enter the lower layers of a moss carpet there is indication of a definite tropism as the moss forms a nidus for numerous fungi and roots turn upwards from the soil into it and subsequently develop mycorrhiza.

In the field, the collector needs very little special apparatus. A scout's knife, test-tubes of one inch diameter or bottles of 2 oz. capacity, a pocket lens and the ordinary vasculum are all that are required. On no account must the material be exposed for even a short period to a dry atmosphere. The test-tubes or bottles should be filled with water for examination and for safe transport. On placing a portion of mycorrhiza in a tube of water, it is possible to determine with a pocket lens the form, colour, and general appearance which may be wax-like or shaggy; points which must be taken into account when deciding whether to keep or to reject material.

The mycorrhiza of beech *in situ* (fig. 1) shows (1) the horizontal growth of roots through a loose layer of leaves which are in an

early stage of decay, (2) an abundance of intertwining hyphae, many of which are attached to roots.

Close observation is necessary before rootlets can be detected that are not in a mycorrhizal condition. The mycorrhiza of hornbeam and sweet chestnut (figs. 2 and 3) exhibit respectively characteristics similar to those of fig. 1, but there are small differences of detail.

A clump of moss is a most favourable nidus for the germination of birch seeds and those germinating naturally under such circumstances, as great numbers do, are found to develop mycorrhiza at a very early period of their existence, viz. before the cotyledons have ceased to function, while the stem is yet little more than half an inch in height, and before the radicle has passed through the lowest layer of the moss carpet.

The birch seedling illustrated in fig. 4 was collected on 13th October, 1923. Its trilobed, lower leaf indicates the first year of growth and as it germinated most probably in the previous April it is probably six months old. The whole of the root system is mycorrhizal, and in this case is of two kinds, one of a dark gray colour and the other of a white slightly shaggy appearance which we associate with the fly agaric, *Amanita muscaria*.

Three to four states of mycorrhiza, differing in form, size, texture and colour, occur on the same species of tree and quite frequently two forms appear on an identical root-branch.

The most common mycorrhiza of beech is dark brown in colour and wax-like in appearance. These characteristics give no clue to its fungal origin. Besides the above, a yellow and a white mycorrhiza are frequently met with on the roots of this tree. The latter being shaggy, it is possible, on examining it in a tube of water, to see with a pocket lens of low magnifying power loose hyphae extending from its surface in all directions. These hyphae come into contact with decaying leaves to which they adhere, but in the case of the wax-like form actual contact with the humus matrix is restricted considerably.

The mycorrhizal roots of *Pinus sylvestris* are coralloid, that is, the branches of the root are short, closely clustered, and being pinkish in colour somewhat resemble coral. The branches are mostly furcate at the extremities, and average 4 mm. in length and 0·5 mm. in diameter.

In attempting to establish the mycelial connection between mycorrhiza and the sporophore of a *Basidiomycete* (fig. 5) frequent failure results. A mycelium may break and when it is white and is mixed with many similar ones it is scarcely possible to be sure of catching up the right thread. A case has been recorded of following up a coloured mycelium for a distance of 54 dec.m. = 17·7 ft. (2). In a great majority of cases the

mycorrhiza is only one to three inches from the toadstool with which it is associated.

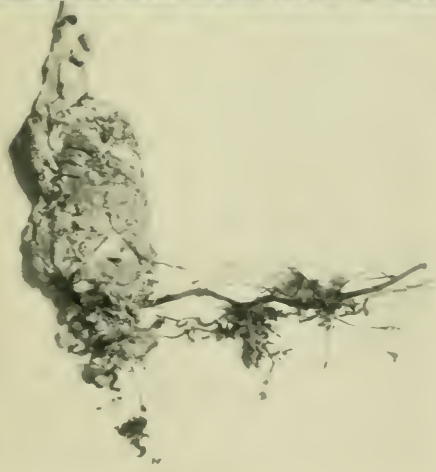
A method that has given satisfactory results is that of cutting a circle through the surrounding leaves and other debris to a depth of three inches at a radius of six inches from the stipe of the sporophore, and then, working from opposite points with the fingers of both hands until the whole mass can be lifted from its surroundings. Such a mass with the base of the stipe attached can be carried without danger of disturbing the roots within. Having severed a number of roots during the cutting of the circle it is possible to trace one that comes from near the centre. By carefully removing the material attached to the root it is possible to demonstrate the connection, by means of a mycelium, between the mycorrhiza and toadstool.

The stages in the formation of mycorrhiza from a normal root have not been seen, but observation of roots after heavy rain, which followed dry weather, has been sufficient to enable the writer to conclude that new rootlets followed by a complete change to mycorrhiza have developed within ten days.

Peyronel (3) has recorded the association of a large number of Basidiomycetes with the roots of forest trees. His list includes for Beech, *Cortinarius proteus, Boletus chrysenteron, B. cyanescens, Scleroderma vulgare, Amanitopsis vaginata, Lactarius subdulcis*; for Sweet Chestnut, *Amanita rubescens, Russula lepida, R. rubra, Scleroderma vulgare*; and for Birch, *Tricholoma flavobrunneum, Amanitopsis vaginata, Amanita muscaria, Boletus scaber, B. radicans, Scleroderma vulgare.*

A transverse section of the dark brown mycorrhiza of birch (fig. 6) has a diameter of 0·35 mm. It exhibits a series of three concentric circles the outer of which, the mantle, *a* consists of hyphae so closely compact that they form a plectenchyma similar to that of the upper surface of some foliose lichens. Within the mantle are the cortical tissue *b, c, d* and the central axis *e* of the birch root. The epidermis appears crushed and root hairs cannot be traced. The outer cells of the cortex are elongated radially. Hyphae, that have, by the secretion of an enzyme, dissolved the middle lamella may be seen between the cortical cells to have entered the cortex to a depth of three to four cells. Occasionally one of the hyphae is seen to have penetrated a cell-wall and to have developed a vesicle at its extremity (fig. 7 *a*). Such a vesicle is of the nature of a haustorium but the fact that this development is so rarely met with prevents one from basing any theory upon its presence. It is sufficient for our present purpose to note that haustoria do occur.

The object of these notes, which for the most part are based on field observations, is to suggest that investigation following



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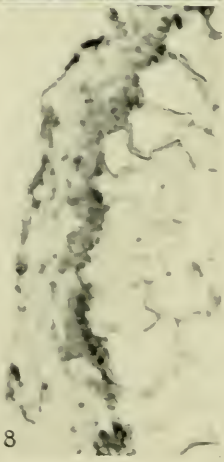

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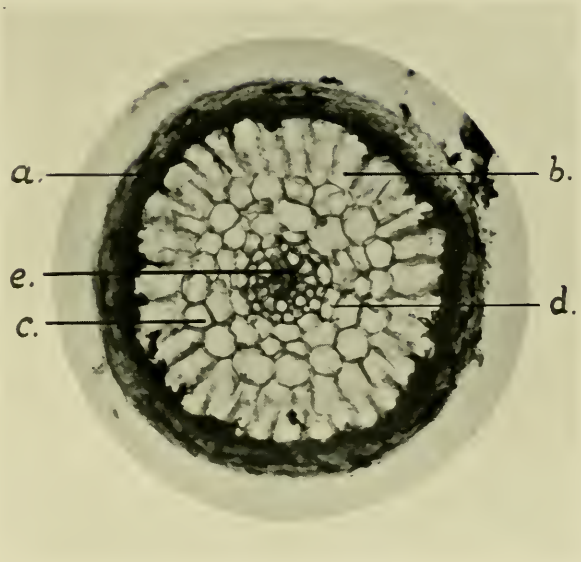

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the lines indicated may assist in the elucidation of the hitherto unsolved question of the true relation that exists between the fungus and the root in the case of ectotropic mycorrhiza.

Recent literature (1912–1922) points clearly to the fact that from a biochemical and microchemical standpoint investigators differ widely in the interpretation of the results of their work (4). On the one hand it is maintained that the relation between tree and fungus is that of parasitism only on the part of the latter, while on the other hand it is regarded as symbiosis in the broad sense of the term.

Field studies afford considerable evidence in favour of the view that the relation is something more than that of parasitism and that it is mutual or symbiotic.

Summary.

(*a*) The association with a mycorrhizal fungus commences, in the case of birch, while the seedling is very young, almost immediately after germination, and it exhibits no indication of injury, accruing from the fact that the whole of its root system immediately developes mycorrhiza.

(*b*) The whole of the water absorbed by such a seedling must pass through the mantle. It contains dissolved colloid substances from the surrounding matrix. Water is readily absorbed and readily yielded by the mantle.

(*c*) Roots of woodland trees, oak and beech, for example, creep over the surface of the soil, where there is an abundance of moss, and entering the lower layers of the moss carpet develop mycorrhiza. A chemotoxic action is apparently set up within the decaying moss.

(*d*) There are indications that in cases of severe drought when much mycorrhiza has been destroyed, certain trees, notably, birches of all sizes, and hornbeam stools, lose vitality and become specially subject to attacks from microfungi such as *Melanconis stilbostoma* (Fr.) Tul. and *Pseudovalsa lanciformis* (Fr.) Ces. and de Not. (5).

I am much indebted to Dr Somerville Hastings for the photographs of mycorrhiza *in situ* and to the Essex Field Club for the loan of two blocks.

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EXPLANATION OF PLATES XI AND XII.

Fig. 1. Horizontal view of mycorrhiza of Beech.
Fig. 2. Horizontal view of mycorrhiza of Hornbeam.
Fig. 3. Horizontal view of mycorrhiza of Sweet Chestnut.
Fig. 4. Birch seedling; the entire root system is mycorrhizal.
Fig. 5. Lower portion of the stipe of *Amanita muscaria* over the root of birch, showing hyphal connections between stipe, *s*, and mycorrhiza, *m*.
Fig. 6. Transverse section of mycorrhiza of birch. *a*, mantle; *b*, radially elongated cell of cortex; *c*, unmodified cells of cortex; *d*, endodermis; *e*, central axis. × 200.
Fig. 7. Portion of outer layers of the cortex showing vesicle (*a*) within the lumen of a cell. Hyphae from the inner layer of the mantle can be traced to a depth of three layers of the cortex. × 410.
Fig. 8. Portion of the mantle, *m*. × 410.

THE LIFE HISTORY OF POLYTHRINCIUM TRIFOLII KUNZE.

(With Plate XIII.)

By Jessie S. Bayliss-Elliott, D.Sc. and Olive P. Stansfield, M.Sc.
University of Birmingham.

Polythrincium Trifolii, a Hyphomycete usually classified in the Cladosporieae, has a cycle of development the knowledge of which has, up to the present, been mainly a matter of conjecture. The fungus was described by Kunze (12) who remarked at the end of his description: "Von einigen Botanikern erhielt ich diesen, keinesweges seltenen, Pilz, für *Sphaeria Trifolii* P." Persoon's description (13) of the latter is as follows: "*Sphaeria Trifolii*: atra parva, magnitudine varia, cespitulo inaequali ruguloso interne subpulverulento....Sphaerulae farctae, intus albicantes." Fries (9) adds to Persoon's diagnosis that the perithecia are immersed in stromata and suggests that the species might better be placed in the genus *Dothidea*, a transference which he afterwards made (10). Fuckel (11) regarded these two fungi as stages in the life cycle of an ascomycetous fungus which he considered as a species of *Phyllachora*. "Fungus conidiophorus. *Polythrincium Trifolii* Kze....Fungus spermogonium. Sphaeria T. Pers. Dothidea T. Fr. Spermatiis minutissimis, cylindraceis, curvatis, ascillantibus. Fungum ascophorum nondum vidi." Fuckel's name and the suggestion that these were stages in the life cycle of the fungus have been generally adopted in systematic works. In the present paper we are able to show that there are three such stages but the perfect condition is not a species of *Phyllachora* but of *Dothidella*.

As far as we are aware the Pyrenomycete stage of this fungus

has never previously been recognised. It is true that Cooke (6) describes such a stage with "Ascis clavatis. Sporidiis ellipticis, continuis, hyalinis, ·01–·012 × ·005 mm. From specimen in Herb. Berkeley," but an examination of the specimens in the Kew Herbarium has not revealed such a stage. It is possible that he was dealing with a fungus other than the one under discussion. Clevenger (5) recorded mature asci and ascospores in specimens he named *Phyllachora Trifolii* (Pers.) Fuck. on *Trifolium wormskioldii*. Theissen and Sydow (14) regard these specimens as a new species which they call *Phyllachora umbilicata*. (Incidentally it may be remarked that these authors state that they have examined specimens of *P. Trifolii* from many places but have never found asci; the European specimens distributed under this name, however, are identical with the type specimen of *Sphaeria Trifolii* Pers. which they have examined.)

1. *Conidial Stage.* Leaves of *Trifolium repens* affected by *Polythrincium Trifolii* were found at Tanworth-in-Arden, at the end of October, 1920. The fungus attacks the under surface of the leaves, producing olive-brown to black cindery patches, consisting of punctiform stromata crowded together, which gradually coalesce to form the characteristic relatively large stromata (1 × ·5 mm. or less). During this stage of the life of the fungus the leaves remain green, but fade later. There is no colour zonation round the black stromata, indicating progressive destructive action of the fungus such as is seen when *Pseudopeziza Trifolii* grows on the same host. The yellow tissue surrounding the black spots to which Kunze (2) refers has not been seen. The leaflets of the infected leaves take an upright position and are thus easily distinguished from healthy leaflets which are extended horizontally. It is, of course, not uncommon for leaves attacked to assume an abnormal position, the phenomenon being perhaps best seen in the rusts. Finally the whole clover leaf withers and when it has fallen to the ground soon decays. The fungus is apparently attractive as food to certain insects, as leaves are frequently found spotted with holes, marking the position of eaten stromata.

In surface view, under low magnification, the stromata appear to be powdery, owing to numerous spores on the crowded conidiophores, which have burst through the cuticle of the leaf (fig. 1). Stromata, which are easily found in different stages of development, arise in two different ways; either by infection from a conidiospore, pycnospore or ascospore, or by infection from hyphal branches, arising in a stroma already present. In both cases the first signs of infection are very similar; a few fuscous hyphae, often developing beneath a stoma, form a plate-like mass of parenchymatous cells and from these the conidiophores

arise (fig. 3). When infection is due to a spore the stromata are at first isolated; otherwise they are connected to other stromata by strands of hyphae, which have made their way underneath the epidermis of the leaf, usually as far as a stoma (fig. 2). The hyphal strands are of different lengths, sometimes very short indeed, so that the new stromata coalesce with the parent. From each cell of the young, plate-like stroma an erect hypha is produced, wavy in outline, which ultimately becomes a conidiophore (fig. 1).

Groups of characteristically waved conidiophores (fig. 1) burst through the cuticle, having destroyed and replaced the epidermal cells. Each conidiophore produces a large obovate uni-septate spore, which is so large (20–22 × 11–15 μ) that it appears to be slightly top-heavy. Many spores drop off and lie around the bases of the conidiophores. The conidiophores show two parts, a waved upper portion and a straight basal portion, and generally a septum separates the two parts. The upper waved portion is always a darker colour than the basal part. The stroma is not buried deeply in the mesophyll of the leaf, but only extends into the first two or three layers of cells. The thickness of the stromata varies, some stromata being several cells deep, others (usually young) forming a plate one cell deep, but even this may bear conidiophores (fig. 1). The hyphae composing the stromata are olive-brown, broad, and many-septate, giving it a pseudoparenchymatous appearance. Hyphae do not ramify extensively through the leaf, but merely extend peripherally into the neighbouring cells and produce fresh stromata. At first the hyphae progress intercellularly, the middle lamella being dissolved; afterwards the mesophyll and epidermal cells with which they are in contact are consumed and the hyphae occupy the space.

The specimens of *Polythrincium Trifolii* which have been examined have always differed somewhat from those described by Kunze (12), who considered the conidiophores to be "septate structures, whose individual cells were four-cornered with rounded ends." He also mentions the occurrence of "double grains" at the base of the stroma—evidently the two-celled conidia which have fallen off the conidiophores and are clinging about their bases. Most authors follow the original description and refer to septate conidiophores; we do not find septa in the undulating upper portion. It is strange that the error should have been persisted in as Corda pointed it out so long ago as 1839, in the work in which the drawing of the fungus occurs which has been copied so widely (8).

Hanging drop cultures of conidia were made in tap water and weak cell sap extract at ordinary room temperature in

July, 1921, but only 10 per cent. of the conidia germinated. The germ tube is at first colourless. Many instances were seen of conidia germinating on leaves taken from infected plants and twice germ tubes were seen penetrating stomata. Further, the host was also seen to be entered by a germ tube penetrating the cuticle of an epidermal cell. Here penetration occurred as in the penetration of *Vicia Faba* by *Botrytis cinerea* as recorded by Blackman and Welsford, *l.c.* without the formation of any appressorium (3): these authors suggest the cuticle is ruptured mechanically by the pressure of the tip of the germ tube. Attempts were made to infect clover plants grown in pots in a greenhouse and also plants in their natural surroundings, but none was successful. The failure of these experiments suggests that conidia do not readily infect plants except perhaps under specialised atmospheric conditions, and no doubt the physiological condition of the leaf plays an important part. It has been noticed that infection does not spread rapidly amongst clover plants in the field; since, under all weather conditions, although plenty of infected leaves could be found in the infected area, the disease was not present in anything approaching an epidemic form during the two and a half years that the plot was observed carefully.

In July, 1921, a clover leaf just showing traces of infection was placed in a room with its petiole in a glass of water and kept under observation for seven days. When first examined the leaflet was found to have five small specks, denoting conidial stromata; apart from this it was quite healthy. A week later the whole leaflet had become very pale, except for the midrib which remained green, and the leaflet was found to be covered with black conidial stromata, bearing conidiophores and obovate conidia. Three of the five original compound stromata (*a*, *b* and *c*) were especially watched, their increase in growth recorded after five days being as follows:

Compound stroma	Date	No. of infection spots	Remarks
a	July 7th	17	—
	,, 11th	30	Area nearly doubled in five days
b	,, 7th	3	Stroma tumid and colourless, one infection spot mature and black, the rest colourless
	,, 11th	17	Original infection had sent out 14 hyphae to produce 14 fresh infection spots, and had increased in area nearly six times
c	,, 7th	7	Stroma colourless, infection spots black
	,, 11th	36	Stroma entirely black, from one infection spot a tendril of pycnospores was exuding

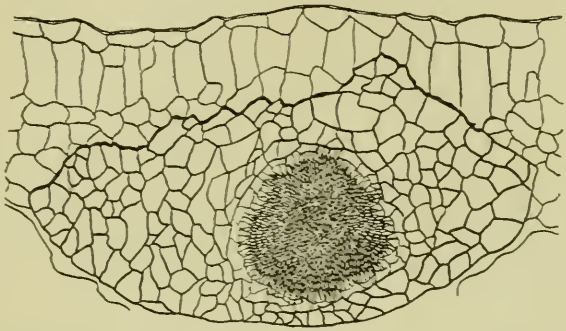
From these results it is evident that conidial stromata form rapidly and mature quickly, the conidia being produced with considerable speed.

2. *Pycnidial Stage.* In autumn the fungus enters upon another stage in its development. Amongst the conidial stromata other stromata are to be seen, which are black and shiny, instead of powdery, and lie mostly under the cuticle of the leaf. A low magnification shows a number of papillae arising from the stromata in a dark, rugose mass and marking the position of developing pycnidia. At the apex of some papillae may be seen a small orifice, through which pycnospores have been discharged. The number of papillae arising from a stroma varies greatly according to age. In the older and larger stromata as many as thirty pycnidia are often present. The stromata may be as large as 2 × 1 mm., but they vary in size considerably.

Pycnospores are produced in great numbers from the interior of the pycnidium, and when mature, are discharged in tendril-like masses. The spores are oval and hyaline, and measure 5 × 1·5 μ. Pycnidial stromata are produced either by the formation of a stroma at the end of a hyphal branch coming from a conidial stroma or by the actual conversion of conidial stromata into pycnidial stromata. In the first case the hyphae extend horizontally a few cells from the parent stroma and each sends out a mass of short, septate, hyphal branches, which form a dense stroma having the usual pseudoparenchymatous appearance. These pycnidial stromata extend more deeply into the mesophyll of the leaf, sometimes even reaching the upper epidermal surface. The lower epidermal and mesophyll cells are destroyed by the fungus, the cuticle of the leaf alone covering the stroma until maturity. In the second case the conidial stroma extends further into the mesophyll, the hyphae become more septate, and the whole stroma assumes a denser structure. Most of the conidiophores break off at the level of the epidermis of the clover leaf, and the stroma now presents the rugose, papillate appearance already described; but usually there are traces of the waved conidiophores characteristic of ordinary conidial stromata. In one instance a pycnidial stroma was found on the upper surface of the leaf, lying close to the midrib, and connected by a thin weft of hyphae to a pycnidial stroma on the lower surface.

Pear-shaped pycnidial cavities are produced in the stromata in great numbers, and are often only separated from one another by a narrow wall of dark pseudoparenchymatous cells (fig. 5). The first indication observed of a pycnidium is a colourless pseudoparenchymatous mass of cells in amongst the darker hyphae and below the surface. This mass of cells increases in

size and reaches nearly to the surface of the stroma, appearing in surface view as a whitish spot in the black stroma. After attaining the typical pear-shaped form these cells gradually disintegrate and many minute oil drops are often to be seen exuding from the ostiole which is formed at the apex of the pycnidium at this time (fig. 5). Many of the oil drops are curved and resemble small spores. They were probably mistaken for the pycnospores by Fuckel (11) who does not give their size, but merely comments on their minuteness and their Brownian movement. The lining layer of cells produces on its inner surface very many ampulliform cells, which may be considered to be conidiophores. Ampulliform conidiophores similar to these occur



Text-fig. Pycnidial stroma cut through pycnidium bearing pycnospores. × 215.

in many Fungi and also in Lichens. From the ampulliform conidiophores long chains of oval conidia are formed in basipetal succession. The entire pycnidium becomes filled with conidia embedded in mucilage, which will absorb water and swell up, thus extruding the spores in the form of a tendril through the ostiole.

In hanging drop cultures in tap-water and weak cell-sap extract pycnospores merely budded like yeast; budding was observed also on infected leaves, as well as germination in the normal manner.

In October, 1921, plants of *Trifolium repens*, growing in a field were infected with pycnospores which after being stirred in a drop of sterile water were transferred by means of a fine brush to the under-surfaces of leaves in various stages of growth. After three weeks most of the leaves showed the characteristic black stromata bearing typically waved conidiophores with large obovate uniseptate spores; several also showed pycnidial stromata in early stages of development. Mild autumnal weather with occasional showers of rain prevailed throughout

the experiment. Pycnospores evidently can infect the clover host more readily than conidia. Leaves infected by pycnospores after being fixed (alcohol and formalin), microtomed, and stained (haematoxylin), were examined for signs of infection and it was seen that germ tubes usually entered the host by penetrating the cuticle of the leaf but in one instance a germ tube was seen entering through a stoma.

It is evident that infection does not spread rapidly over large areas, so the question arises as to how the conidia and pycnospores are distributed. The conidia are large and heavy and after falling cling somewhat persistently about the bases of the conidiophores. It is therefore concluded that they are not dispersed to any great extent by wind, although this is probably the chief means by which they are scattered. Rain will wash them about on the same leaf, but not often on to other leaves, so that there are very small chances of an epidemic of this fungus caused by conidia. In view of the enormous numbers of pycnospores which are produced, hundreds of thousands in one pycnidium, these might be expected to cause a rapid spread of the disease. The pycnospores are considerably smaller and much lighter than the conidia, and could easily be carried about by the wind. But the spores are for the most part discharged only in tendril form suffused with mucilage, and only into a humid atmosphere, hence they are not in a condition to be easily carried by the wind; however, when dry, the wind might act as an agent of dispersal. Water freely disperses the spores, and in this way they are washed from one leaf to another, but even so, the area affected can only be small and very restricted, and uninfected plants a few yards away are quite likely to escape infection. On this account it is not surprising that the disease does not spread rapidly.

3. *Ascophorous stage.* It had been noticed that after the pycnidial stage had reached maturity, the clover leaves withered, and finally fell to the ground, where they rotted or were dragged into the soil by worms, etc. As a result it was impossible to study the further development of the stromata until means were taken to prevent the disappearance of decaying leaves.

Leaves showing the pycnidial stage of the fungus were placed between large ivy leaves, and buried in soil in flower pots. Ivy leaves were used because they rot very slowly, and it was thought that even if the clover leaves rotted away completely, the black stromata might be found lying between the ivy leaves, and that though the stromata are so minute (·2–1 mm.) they would not be lost in the soil. These pots were placed out-of-doors, so as to be under natural conditions. After a fortnight, one of the pots was brought into the house for eleven days, and

kept at a cool temperature, the soil remaining damp. When one of the leaves was examined, a tendril was seen to be exuding from the ostiole of one of the stromata. The exudation was transferred to a slide for microscopic examination, and an ascus containing eight large spores was found embedded in the mucilage. The spores measured 19 × 10 μ, and contained two large guttulae. The spores were left in a damp condition, but even after 48–72 hours, there was no sign of germination. The leaflet from which the exudation was taken was sectioned in order to observe the method of growth of the asci and perithecia. Perithecial cavities containing ascogenous tissue were found in abundance, but there was no sign of a mature perithecium. The leaves were again placed between ivy leaves, and put out of doors for examination later in the season. On November 22nd, 1921, three other pots were prepared in the same way, each containing six clover leaves. On December 6th, one of these pots was brought indoors to dry slowly (as drying might perhaps stimulate the formation of ascospores), and examined after four to five weeks, but there was no sign of mature asci. On January 29th, 1922, another pot was examined, but again there were no mature asci. The leaves were replaced and the pots kept moist in a cool greenhouse for several weeks. On January 31st the pot which had previously shown ascospores was again inspected but there was no trace of clover leaves or stromata, this doubtless being due to the partiality of soil animals for the fungus. It was now thought advisable to place the clover leaves of the pots previously examined between cover slips or glass slides before burying them, so that on the disintegration of the leaf the stromata could be found easily. On February 23rd, a portion of a stroma from one of the clover leaves which had been placed between cover slips was examined and asci were found containing spores which were not quite mature. The asci grew in clusters from the base of the perithecium (fig. 6). The spores in the asci were more or less biseriate, and uniseptate and granular (being not fully mature) and measured from 24–26 × 7–8 μ (fig. 6); no paraphyses could be seen. Some of the material from which the stroma had been taken was fixed in Bouin's fluid, embedded in wax, microtomed and stained in iron-alum haematoxylin. The rest of the material was replaced between cover slips and buried between ivy leaves in soil, when further development took place and finally mature ascospores were obtained.

The stromata bearing ascogenous tissue are very similar to the pycnidial stromata, in fact perithecia occur in the same stromata as pycnidia. No trace of any archicarp has been found, the first indication of primordial perithecial tissue being a few

colourless pseudoparenchymatous thin-walled cells which doubtless arose from a single hyphal cell amongst the dark fuscous brown hyphae composing the stroma: these perithecial primordial cells stain deeply with iron-alum haematoxylin and are larger in size and less delicate than the pseudoparenchyma which initiates the formation of a pycnidial cavity. This pseudoparenchymatous mass of cells gradually increases in size and though at first somewhat pear-shaped becomes more oval and is elongated in the direction of the outer surface of the stroma (fig. 7), where ultimately, at maturity, an ostiole with projecting hairs appears. At an early stage the cells in the centre and lower part of this tissue begin to break down leaving multinucleate protoplasts which tend to arrange themselves parallel with the perithecial wall (figs. 7, 8). The cells forming the lining of the basal part of the perithecium are now seen to be richly protoplasmic and although multi-nucleate some of the nuclei in them are larger than others and appear to be paired—such cells giving rise to ascogenous hyphae (fig. 9, *a*, *b*). The ascogenous hyphae are of the hooked type and in these could be seen paired nuclei which had presumably arisen by conjugate division of the paired nuclei of the basal cells from which they arise (fig. 9); these hyphae much resembled those figured by Claussen (4) for *Pyronema confluens*.

Ascus formation from a penultimate cell could be seen (fig. 9*a*). Early stages of an ascus showed the usual paired nuclei in the base of the ascus; later, the nuclei moved towards the centre and in older asci the fusion nucleus occupied this position (figs. 9*a* and 7). As the asci develop they push aside the disorganising primordial pseudoparenchyma and occupy the space and doubtless are nourished at the expense of the products of the disorganised cells (fig. 7). At a still later stage the fusion nucleus is replaced by eight smaller nuclei which become the centres of spore formation. Towards the periphery of the perithecium many periphyses develop which bend upwards and later outwards. By the presence of these protruding periphyses developing perithecia could often be distinguished from developing pycnidia.

The life history of this fungus shows points of similarity with the life histories of other Ascomycetes. The conidial stage prevails during summer and early autumn, and is followed in later autumn by the pycnidial stage; during winter the stromata on the decaying leaves lying on the ground are set free and behave as sclerotia, in which perithecial structures develop, and thus by spring or early summer ascospores are mature and no doubt are ejected from the asci on to young clover leaves, thus causing the re-appearance of the disease.

Systematic Position. On account of the fact that the ascospores are uniseptate and the cells equal in size the fungus is best placed in the genus *Dothidella*.

DOTHIDELLA TRIFOLII

Status conidicus. Polythrincium Trifolii, Kunze—stromatibus in pagina aversa folii atris, carbonaceis, punctiformibus, deinde coalitis. Conidiophoris tortuosis, exquisite undulatis, fuscis, eseptatis, fasciculatis, erumpentibus, conidia singula, obovata brunneola, uniseptata, 20–22 × 11–15 μ, apice gerentibus.

Status pycnidicus. Sphaeria Trifolii Pers.—Stromatibus compactioribus, obscure fuscobrunneis, pseudoparenchymaticis; ovalibus, achrois, hyalinis, 5 × 1·5 μ, conidiophoris papillatis suffultis.

Status ascophorus. Dothidella Trifolii—Peritheciis in stromatibus iisdem vel similibus evolutis, ampulliformibus; ascis e basi oriundis, clavatis, leviter flexis, 8-sporis aparaphysatis. Sporidiis plus minus biseriatis, irregulariter fusiformibus, achrois, 1-septatis, 24–26 × 7–8 μ, loculis aequalibus.

Hab. in pagina aversa foliorum *Trifolii repentis*, Tanworth-in-Arden, prope Birmingham.

GENERAL CONCLUSION.

Polythrincium Trifolii develops a rather loose stroma on the under surface of leaves of *Trifolium repens* and produces during the course of its life history more compact and deeply seated stromata, which bear pycnidia containing pycnospores (*Sphaeria Trifolii* Pers.) capable of infecting fresh clover plants. These stromata, on the decay of the leaf, fall to the ground and function as sclerotia. On further growth perithecial cavities are produced, containing the asci and ascospores characteristic of a *Dothidella*, and not of *Phyllachora* as has been assumed by various authors.

In conclusion we wish to express our sincere thanks to Mr W. B. Grove, M.A., and to Professor Yapp for much valuable help and criticism during the course of this work.

POSTSCRIPT.

Since the above was submitted for publication a paper by Ch. Killian entitled "Le *Polythrincium Trifolii* Kunze parasite du Trefle" has appeared in Rev. de Path. Veg. et d'Entom. Agric. x, pp. 202–219 (1922). According to this writer the perithecia commence to develop at the same time as the pycnidia. The development of the perithecia is very slow but may be accelerated by burying infected leaves in fine sand in a warm atmosphere and watering daily; if, on the contrary, they are placed out of doors on damp cotton wool development is not

complete until spring. Leaves placed in muslin bags on the surface of the soil decomposed completely after a few weeks without leaving any traces.

The perfect stage of the fungus obtained by Killian is the same as that described above but he calls it *Plowrightia Trifolii*. *Dothidella* Spegazzini (1880) has priority over *Plowrightia* Saccardo (1883) (v. Theissen and Sydow, p. 309) and the subject of our investigations must therefore be known as *Dothidella Trifolii*.

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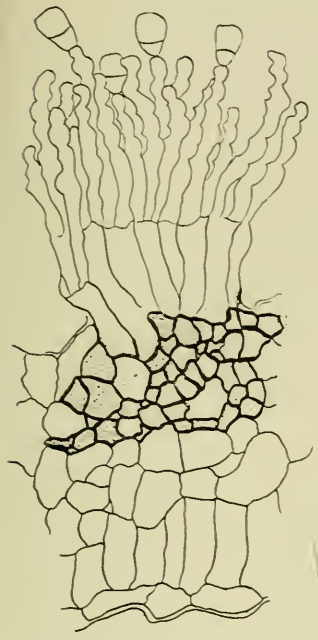
EXPLANATION OF PLATE.

Fig. 1. T. S. clover leaf showing mature conidial stroma with conidiophores producing conidia. × 325.
Fig. 2. Surface of leaf showing early stages in stromata development with connecting hyphal strands. No conidiophores are yet developed. × 200.
Fig. 3. Stromata at a later stage. Conidiophores beginning to appear. × 200.
Fig. 4. Hymenial surface of pycnidium. × 750.
Fig. 5. Pycnidial stroma showing disintegration of pseudo-parenchymatous tissue. × 325.
Fig. 6. Asci and ascospores crushed from a perithecium. × 325.
Fig. 7. Perithecial cavity showing asci associated in pairs and large fusion nucleus. *a*, paired nuclei. × 325.
Fig. 8. Later stage. L. S. stroma showing pseudo-parenchymatous tissue tending to radiate from a central point, and cells becoming less polygonal. × 325.
Fig. 9. *a*. Ascogenous hypha showing paired nuclei and ascus containing large fusion nucleus arising from a penultimate cell. *b*. Young ascogenous hypha.



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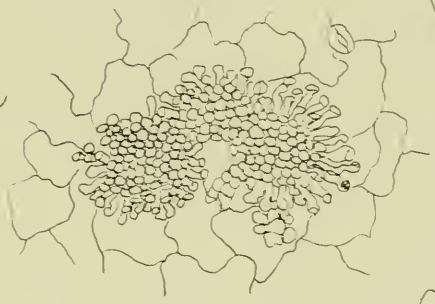

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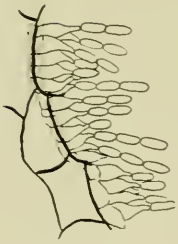

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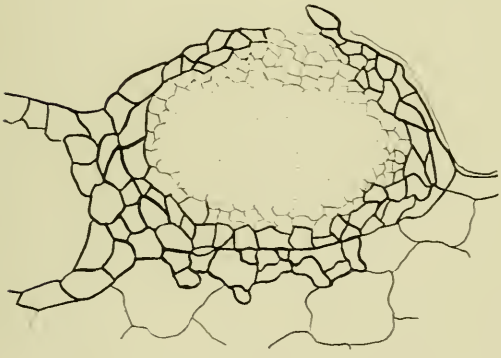

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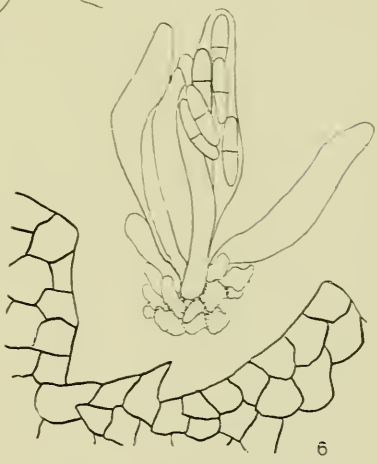

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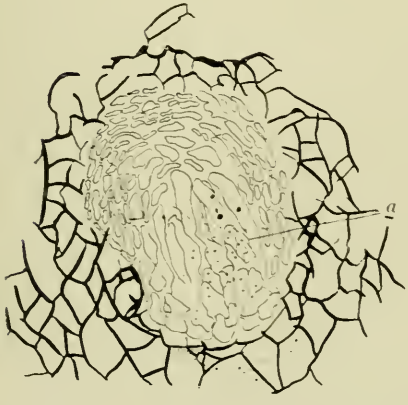

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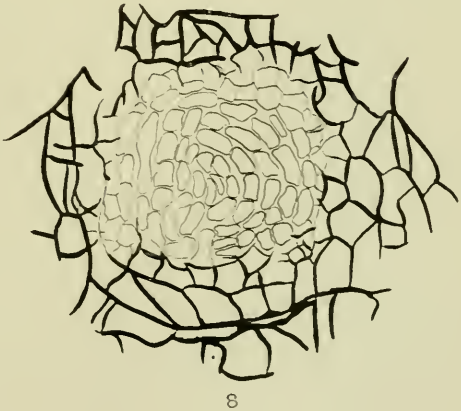

8

EPIDEMIC PLANT DISEASES.

By F. T. Brooks.

All of us are familiar with disease in an epidemic form as regards illness to which human beings are liable. The widespread occurrence of influenza a few years ago need only be recalled to indicate the chief characters of an epidemic. At that time, many people simultaneously became ill with influenza, which spread with great rapidity from person to person. Thus the principal features of an epidemic are the large numbers of individuals in a population affected by the disease at one and the same time, and the amazing speed with which the malady spreads from the centres where it first occurs.

Plants of economic importance, in which large numbers of individuals of the same kind are usually densely aggregated, are also liable to diseases of an epidemic nature. As in human diseases, plant maladies are frequently caused by parasitic organisms, and epidemic diseases are almost invariably of a parasitic nature; but whereas in animal diseases, these parasites are usually either bacteria or protozoa, the organisms which are the chief source of trouble to plants are of a fungoid nature. Fungoid diseases of animals are known, but most are comparatively infrequent and relatively unimportant. The reasons for this difference in character of plant and animal parasites are by no means clear, but it may be pointed out that bacteria usually thrive best in a slightly alkaline medium that is well provided with complex nitrogenous compounds, and kept more or less constantly at a lukewarm temperature. Blood is such a medium. Fungi, however, are not so exacting in their requirements; they can exist with smaller and simpler supplies of nitrogen especially if carbohydrates are abundant; they flourish over a wider range of temperature, and usually prefer a medium which is slightly acid. Needs of this kind are provided better by plant than by animal tissues. The intercellular spaces with which plant tissues abound are more readily permeated by fungal hyphae than by bacteria.

Not all diseases of plants are of an epidemic nature. Some are sporadic, *i.e.* occur only here and there and not universally over a wide area. Through neglect, however, a disease which is usually sporadic, may assume an epidemic character. Thus silver-leaf disease of fruit trees is usually sporadic in a plum plantation upon first appearance, but if neglected so that the causative fungus, *Stereum purpureum*, fructifies upon the dead branches, the disease may become so prevalent as to be epidemic. With wound parasites there must clearly be widespread opportunity

for infection (*e.g.* exposure) as well as an abundant supply of spores in order for disease to appear in epidemic form.

Epidemic diseases are essentially dependent upon two sets of factors for their development, namely, a condition of the host favourable to invasion by the parasite, and an environment of such a kind as to allow of the rapid dissemination of the spores and germination of these upon the surface of the host; these two sets of factors are intimately related to each other, for conditions detrimental to the growth of the host are often favourable to the development of the parasite. As regards the host being in a state of susceptibility to attack, it is a commonplace that individuals, whether of animal or of plant populations, vary greatly in their liability to certain diseases. It is also well known, that even the most robust individual may become so weakened as to become susceptible to diseases from which normally he is free. Plants of economic importance, most of which have been in cultivation for long ages, exist in the form of numerous varieties which shew marked differences in their susceptibility to disease. Some varieties of wheat are markedly resistant to yellow rust caused by *Puccinia glumarum*, while others are very susceptible; again in potatoes, some forms are badly attacked by the blight fungus and others are scarcely troubled by it. But often even the healthiest forms of cultivated plants may have their vitality so weakened under some conditions as to become a prey to a parasite which usually cannot thrive on it. In India for instance Einkorn wheat, which is noted for its extreme resistance to rust attacks throughout the world, becomes badly attacked by black rust (*Puccinia graminis*) during abnormally hot weather in the Ganges Valley. Climatic conditions in this case doubtless so reduce the vitality of the host plant as to render it susceptible to the parasite.

Granted, however, that the host plant is in a susceptible condition for attack, epidemic disease will not follow unless the germs of the parasite are available in abundance and unless environmental conditions favour their rapid dissemination and germination upon the tissues of the host. In fact it is not too much to say that weather conditions are usually all important in determining whether disease appears in an epidemic form or not. This accounts for differences in incidence of such plant diseases in successive years. The prevalence of one of the commonest epidemic diseases, potato blight, is chiefly determined by weather conditions. In a wet summer great damage may be done by the vigorous spread of this fungus, and so rapid is the onslaught of the parasite under suitable weather conditions that potato fields sometimes become black in a day or two. In a moderately dry summer, potato blight, though usually present

to a slight extent, is of negligible importance. Under these conditions the spores of the fungus are produced in much smaller numbers and the majority of them, even if they alight on potato leaves, are unable to germinate and cause infection on account of lack of moisture. Correlated with a heavier rainfall, potato blight is generally more severe in the west of England than in the east.

If climatic conditions are such as to prevent entirely or almost entirely for a season the occurrence of a disease which is usually epidemic, there may elapse an interval of years before the disease again assumes serious proportions. The dry summer of 1921 prevented almost entirely the appearance of potato blight, which has been uncommon in most parts during 1922 and 1923, notwithstanding weather conditions apparently favourable to it. The reason for this may be that the sources of infection were largely destroyed by the heat and drought of 1921 and that there is a necessary lag until the sources of infection are sufficiently replenished.

In temperate regions epidemic plant diseases are often checked by the oncoming of winter, during which most of these parasites are not present in an infectious condition. Mildews which are propagated in an epidemic manner during the summer by spores of a delicate nature, usually form another type of spore towards the end of the growing season, which is enclosed in an impervious case that remains sealed until the following spring. At the same time the young stems and leaves which are the parts chiefly liable to infection by such fungi either do not exist during the dormant season or have become greatly modified in structure. In the tropics, however, vegetation and weather conditions are both often practically uniform throughout the year, the temperature and rainfall varying but little in successive months. In such a climate there is no close season for fungal parasites, and epidemic diseases are greatly to be feared.

Disease may affect the subterranean parts of plants as well as the stems and leaves, and some of the most serious plant diseases and the most difficult to control are of this nature. In recent years much has been heard of wart disease of potatoes (*Synchytrium endobioticum*) in this country. This parasite invariably causes infection through the soil, in which the resting spores may retain their vitality for many years. A disease of this kind can only be epidemic when the causative parasite is generally distributed throughout the soil, for there is no means of active dissemination by wind currents. There are other ways in which root parasites may become so prevalent as to cause disease more or less of an epidemic nature. Thus if a forest or woodland be cut down and replanted with trees there are several

fungi, which, living at first on the decaying stumps as saprophytes, give rise to mycelial strands that, on passing out into the soil, invade the roots of the newly planted trees and kill them. In the early days of the rubber plantation industry in the Eastern tropics fungi of this kind were a great menace. Here also there was universality of opportunity for infection. In consequence of this danger it is now customary to remove the jungle stumps immediately after the establishment of the plantation, so that no opportunity is afforded for the development of this insidious form of disease.

The sources of infection of epidemic plant diseases are sometimes rather mysterious, and much further work is required in order to elucidate them. Many investigations have been made upon the means of over wintering of *Phytophthora infestans* and still there is obscurity about it. Recently it has been shown that the mycelium of this fungus possesses a limited power at any rate of saprophytic development in the soil and it may be that this is one of the ways in which the fungus survives under natural conditions, especially in such warm areas as the Penzance district and the Isle of Wight. It may be that the fungus is really endemic in such centres in a manner somewhat similar to the continued occurrence of cholera in certain districts in India in years when the disease is not epidemic.

The balance between host, parasite and environment in the causation of epidemic disease is usually of a delicate nature. A slight change in environmental conditions which may favour the host or alternatively injure the parasite may be quite sufficient to prevent the establishment of an epidemic. Thus *Puccinia glumarum* is commonly present in epidemic form on wheat in this country because the temperatures of the winter are usually insufficiently low to kill the uredospores of this fungus. *Puccinia graminis*, on the other hand, is a comparatively rare fungus here (except on cereals in immediate association with barberry bushes) because its uredospores cannot survive the winter temperatures which are harmless to *Puccinia glumarum*.

There is some evidence, perhaps of a not very critical nature, that the parasite itself may be more virulent at certain times than at others. There is a parallel to this in certain human diseases. For instance, during the last few years, there have been successive waves of influenza some of which were much more virulent than others. This was probably due to variations in virulence of the bacteria causing the disease, although it may be argued that this phenomenon resulted from a special degree of susceptibility on the part of mankind at the time of most serious attack. With plant parasites it is often found that, upon introduction into a new country, they spread with great rapidity

during the first few years until a climax of intensity is reached, after which their attack is less serious. Thus potato blight was introduced into Europe during the early part of the nineteenth century and rapidly spread so that in 1840 it was responsible for a complete failure of the potato crop in Ireland, thereby causing a serious famine; it is doubtful whether this fungus has ever been so virulent since. Another illustration may be taken from a disease which has been introduced into this country in recent years. About 1900 American gooseberry mildew became accidentally established in the British Isles, and immediately began to spread rapidly, so that in a few years all fruit areas where gooseberries were grown on a large scale were attacked by the disease. After some years, however, this parasite became less prevalent, and it may be that its period of maximum virulence has passed, although there has been a considerable recrudescence of the disease during 1922 and 1923.

The example of American gooseberry mildew is an illustration of the danger of the introduction of a parasite to a country where it is not native. Sometimes the climatic and other conditions of the new country are unfavourable to the parasite, but frequently it is otherwise, when there is grave risk of the establishment of disease in epidemic form. There are two destructive tree diseases in the United States which illustrate this principle. One of these is a fungus, known as *Endothia parasitica* which, native on certain species of chestnut trees in China, has in some unknown manner been introduced into the eastern parts of the United States, where it has caused immense damage to indigenous chestnut trees. The spores of this fungus germinate on slightly wounded parts of the branches and trunks of these trees, causing infection of the bark, which is rapidly killed. This fungus, at first only sporadic, has spread over large areas, notwithstanding the costly efforts that have been made to check it by felling wide belts of trees between diseased and healthy areas.

Another disease which has aroused consternation in the United States is the blister rust of five-needled pines, including the valuable Weymouth pine, *Pinus strobus*. It is known exactly how this disease was introduced into America, and the story is not uninteresting. The Weymouth pine is native to the United States, and being a valuable timber tree, has been used for forestry purposes in Central Europe. Nurseries of this tree were established in European countries where there are other closely allied pines which are attacked by the rust fungus, *Cronartium ribicola*, the disease affecting chiefly the bark of the trees. Upon the introduction of the Weymouth pine to these countries, it also was attacked by this fungus. For some extraordinary reason American foresters sent to Europe for nursery stock of

the Weymouth pine, instead of relying on their own resources. In those days there was no adequate system of plant disease inspection at the ports, and it was subsequently found that this European nursery stock introduced with it the deadly blister rust fungus which began to spread to the indigenous Weymouth pines before measures were taken to combat it. This disease is now one of the most serious that American foresters have to contend with, and its introduction shews the folly of allowing cultivated plants to be distributed throughout civilised countries without safeguards to prevent the transmission of disease. The blister rust of the Weymouth pine is unfortunately common in this country, and is the chief reason why this tree is not used more extensively for afforestation. Epidemic disease on these pines is here dependent upon the presence of an alternate host, *Ribes* spp., because the fungus cannot propagate itself directly from pine to pine. On the other hand the presence of pines (apart from an initial source of infection) is not necessary for the continuation of an epidemic on currant bushes.

Again, when a new plant is introduced into a country, a parasite often attacks it violently although the pest has only been found hitherto sporadically upon related indigenous plants. Coffee was introduced into Ceylon as a plantation crop about 1870, and an important industry sprang up in connection with it. Soon, however, it began to be attacked by a fungus disease (*Hemileia vastatrix*), which up to that time had only occurred to a slight extent upon jungle plants closely related botanically to coffee. With large numbers of plantations in close proximity to each other, the disease spread rapidly and became so uncontrollable that coffee-growing in the island became unprofitable. Heavy losses were incurred, and a few years after the commencement of the epidemic, coffee ceased to be grown on a commercial scale in that part of the tropics. That is an illustration of the danger of disease breaking out in epidemic form upon a newly introduced economic plant, the disease itself, although indigenous, being of negligible importance until the appearance of the specially susceptible plant.

Epidemic diseases of plants are disseminated in various ways. Most of the parasites produce spores which can retain their vitality for considerable periods unless exposed to extremes of temperature, insolation or desiccation. Many of these diseases, therefore, can be distributed over relatively wide areas by means of wind currents. With such a disease as potato blight this is undoubtedly the chief means by which the fungus is spread in an epidemic condition. Upon first development of the fungus in an active or sporing state in any season, the disease in its initial

stages is present only on a few plants in the crop. Spores are produced on these plants and are then distributed by wind so that other plants in the vicinity become infected. The same considerations apply to mildews and rust fungi. The power of wind, however, to disseminate fungoid diseases over immense areas, has undoubtedly been exaggerated. It used to be thought that disease could be spread in this manner from one country to another over wide tracts of sea, but this has been shown to be untrue. Delicate fungus spores which have been in the air a long time have probably been exposed to many vicissitudes of temperature, insolation, and desiccation. These changes greatly impair their vitality and by the time they reach a plant susceptible to infection, most of them are dead. It has been demonstrated for instance that bacterial germs are rapidly killed by exposure to strong light, and doubtless the same appplies to many fungus spores. Furthermore, spores being light bodies are to a great extent carried by convection currents to the upper atmosphere, where conditions are of a more extreme nature, and from which many of these germs will not fall in a living condition.

The limited power of wind currents to disseminate fungoid diseases is well illustrated by certain heteroecious rust parasites. One of these (*Puccinia Pruni-spinosae*) alternates between certain species of anemone and plum trees, in the former of which the fungus lives indefinitely, producing spores each spring. These spores infect plum leaves, but it is only the trees in the immediate vicinity of the infected anemones, especially in the direction of the prevailing wind, that first become attacked. The spores produced on the anemone seem only to be able to infect the alternate host within the range of about a mile or so, and it is not until secondary spores are formed on the plum leaves that the fungus spreads over wider areas. These secondary spores are formed within about ten days of infection, and the fungus is propagated by these during the summer in ever-widening circles.

Nowadays emphasis is laid upon the need for contact in the dissemination of many parasitic organisms. By maintaining contact, is meant bringing the parasite into the immediate vicinity of a healthy and susceptible host by means of some living or mechanical agency. This has long been recognised in human diseases, for, in many of these, individuals only become attacked by coming into close association with others already affected, notwithstanding the fact that the germs of many of these diseases must be commonly present in the air. The inability of the germs casually present in the air to cause infection is due partly to the fact that their vitality is rapidly destroyed by exposure to bright sunlight and partly to the germs being present in quantity less than the minimum requisite to cause

infection. In connection with the point last mentioned, it is a well-known axiom in medical science that the danger of infection increases with the magnitude of the dose of the disease, so to speak, to which one is exposed; there is no doubt, for instance, that even the healthiest man would succumb to tuberculosis if he inhaled an atmosphere saturated with the tubercle bacillus. With plant diseases the same principles are only just beginning to be recognised. The means by which the germs of these diseases are brought into contact with their hosts are often different from those of animal diseases, but they are none the less sure. It is now known that many infectious plant diseases are chiefly spread by insect agency, and occasionally by birds. There is a widespread group of plant diseases of great economic importance, known as mosaic diseases, which are characterised first by a mottling of the leaves with yellow spots and then by general degeneration. No organisms have yet been isolated which can be considered the cause of these diseases, but if the sap of an affected plant is inserted into a healthy one, the latter soon becomes diseased. Such diseases and others of a similar nature are known as viruses. They are of common occurrence in animals and are often supposed to be due to organisms of ultra-microscopic size. Foot and mouth disease in animals and the mosaic diseases of tobacco and potatoes are maladies of this nature. Mosaic disease of tobacco is one of the chief factors limiting the growth of the finest kinds of tobacco in those regions of the tropics, such as Sumatra, otherwise favourable for their growth. It has been shown recently that these mosaic diseases are largely spread by means of insects, especially by aphides, which, having visited diseased plants, puncture healthy ones, and thereby insert the virus. Apart from mosaic diseases, insects play an important rôle in the dissemination of plant maladies caused by known parasitic organisms, whether bacteria or fungi. The insect in sucking or biting the tissues of a diseased plant inevitably comes in contact with the germs of the parasite, some of which adhere while it passes to another plant, which may thus become infected. In fact, so intimate is the incidence of certain insect and fungus pests, that widespread opinions prevail amongst cultivators that fungi inevitably follow particular insects. One of the commonest diseases of apple trees is "canker," caused by the fungus, *Nectria galligena*, which sometimes follows in the wake of woolly aphis, one of the most serious insect pests of apple trees. This sequence is probably assisted in two ways, first by the insect carrying the spores of the fungus entangled in its woolly appendages, and secondly because the insect punctures the bark, thereby creating wounds by which the fungus can invade the branches. Again, in the rubber plan-

tations of Malaya one of the diseases of rubber trees is an affection of the bark which is brought about frequently by the combined action of an insect and a fungus. The insect is a boring beetle which usually attacks only dead wood, but which under certain circumstances invades the bark of living rubber trees, especially if this has been exposed to injury. In the dead wood inhabited by these borers the fungus *Ustulina zonata* is often found growing as a saprophyte, and as the boring insects pass from the dead wood to the living rubber trees they carry with them the fungus which, upon being thus established in the tissues of the rubber trees, spreads rapidly and acts as a destructive parasite. Such instances could be multiplied many times.

Not only do animals of a lower order play an important part in the dissemination of plant diseases, but man himself must plead guilty to this offence. Civilisation is responsible for certain evils, not the least of which is the scattering broadcast over the world of serious plant pests by the hand of man. This has only recently come to be recognised, unfortunately too late to prevent the introduction into new countries of some pests which cause great havoc. As often happens, the stable door has been locked after the horse has gone, but many countries have now established a system of plant import inspection which will prevent the introduction of new troubles of this kind. In the United States this control of plant imports is now so rigorous that certain classes of plants are entirely excluded from entry into the country. A few illustrations may be given of some of the ways in which the agency of man may be traced in the distribution of fungus pests. Less than twenty years ago, wart disease of potatoes was known to exist only at a few places in England and Scotland, but since then it has spread to some extent practically all over these countries and has reached America also. Some of the districts infected with this disease are renowned for the quality of their "seed" potatoes, which, in consequence, get distributed far and wide. During the war, when every effort had to be made to grow the maximum quantity of potatoes, "seed" tubers were distributed from one part of the country to another on a much bigger scale than ever before. There is no doubt that in this process wart disease was distributed at the same time. No one of course could think of using "seed" tubers bearing the warty outgrowths characteristic of this disease, but tubers apparently healthy, may bear the resting spores of this fungus in particles of soil adhering to the tubers. Certain varieties of potatoes are entirely immune to this disease. Notwithstanding their own immunity, these varieties may be the means of carrying the disease to healthy gardens, for the

spores adhering to the surface become detached into the soil and are there ready to infect any susceptible variety that may be planted in following years. During the war it was impossible to ensure that no seed potatoes were taken from infected land, and hence the disease is now present to a certain extent at any rate in practically every county in England, whereas only a few counties were affected in the year before the war. There is no doubt that the fungus was introduced into the United States some years ago by the importation of seed potatoes. In another class of disease, such as a surface mildew, of which American gooseberry mildew is a convenient example, two types of spores are produced; one of these propagates the fungus rapidly during active growth in the summer; the other is enclosed in an impervious covering and serves to tide the fungus over adverse winter conditions, these spores germinating in the spring upon release from their protective coats. Both types of spores may be distributed by mechanical means in the following manner. The winter "spores"—as one type may be called—adhere to the twigs of the gooseberry bushes and may be inadvertently carried in this way from nurseries to commercial and private gardens. It is customary before gooseberry bushes are despatched from a nursery where mildew has been present, to cut back the extremities of the shoots, but this precaution does not entirely ensure against the resting "spores" being distributed with the nursery stock, because these may fall on to the bud scales or into cracks in the bark. The summer spores, which are scattered to some extent by wind currents, may be distributed over wider areas by other agencies. The baskets in which the gooseberries are sent to market have been one such means: it is impossible to exclude all diseased fruit in packing, the spores from which may be carried with the basket to a new destination, for the empty baskets are not always returned to the place from which they were sent. Spores which adhere to these baskets get blown on to healthy bushes and infect them. During the period when American gooseberry mildew was spreading rapidly in this country it was quite common to find that the first bushes in a plantation to become diseased were those in the neighbourhood of the packing sheds, *i.e.* in the immediate vicinity of the place where the baskets returned from the market were stored. Spores of such diseases may also be carried directly by human agency. Persons walking amongst diseased plants may carry away with them spores adhering to their clothes. Upon going to another garden, these spores may fall from their clothes and infect healthy plants.

The economic losses caused by fungal diseases in general and by those of an epidemic nature in particular are collectively

enormous. Probably many millions of pounds are lost every year by the attacks of parasitic fungi upon food plants. It is by no means unknown for a disease of epidemic character to wipe out the cultivation of a certain product in an entire country, but the toll levied is usually of a more insidious kind. For instance, even in the best wheat-growing countries, the losses of crop due to attacks of rust fungi are computed to be rarely less than 10 per cent., and are often more, while in certain parts of Canada, Australia and Africa, the loss of crop from this cause may be nearly complete. With wound parasites, the losses may be equally serious if the diseases caused by them are neglected.

NOTE.

FLORA OF A BLACKBIRD'S NEST IN AUGUST.

A very young visitor brought in to me the other day a blackbird's nest of this year's building and opportunity was taken to examine the material. Quite a number of Pyrenomycetes were found to be in fruit. Other families were conspicuous by their absence. The short list is perhaps of some interest as showing what species were in fruiting condition on August 15th, 1923, after a very dry summer. It should be stated to the credit of the blackbird as a collector that several of the species had not been noted in the locality before.

Mycosphaerella maculiformis (Pers.) Schroet. on leaves.
Leptosphaeria microscopica Karst. on grass leaf.
Leptosphaeria Doliolum (Pers.) Ces. and de Not.
Leptosphaeria rubicunda Rehm on herbaceous stem. Spores 27–30 × 2·5–3 μ. Grove (*Journ. of Bot.* 1912, p. 49) says 20 × 2·5 μ, on Conium. I have a specimen on an umbelliferous stem from Gloucestershire with spores—25–40 × 3·5–4·5 μ, second cell from above swollen. Winter says 45 × 2·5–3 μ. Probably all one species.
Leptosphaeria derasa (B. and Br.) Auersw. on *Senecio Jacobaea*.
Pleospora herbarum (Pers.) Rabh.
Pleospora infectoria Fuck. on grass stem.
Ophiobolus tenellus (Auersw.) Sacc. on stem of *Galium* sp.
Gnomonia inclinata (Desmaz.) Auersw. on horse-chestnut leaf.
Gnomonia cerastis (Riess) Ces. and de Not. on *Acer campestre* peduncle.
Rhytisma acerinum (Pers.) Fr.

Vermicularia Dematium (Pers.) Fr. on woody stem.
Vermicularia trichella Fr. on ivy leaf.
Periconia pycnospora Fres. on stem.

H. C. Hawley.

September 1923.

REVIEW.

A Handbook of the Larger British Fungi, by John Ramsbottom, O.B.E., M.A., F.L.S. Pp. 222, 141 figures in the text. Printed by order of the Trustees of the British Museum, 1923. *7s. 6d.*

The present book originated in the necessity for a new edition of the *Guide to Sowerby's Models of British Fungi*, and is therefore necessarily somewhat limited in its form and arrangement. Mr Ramsbottom has however succeeded most happily in so revising the matter and correlating it with more recent work that the book forms now an excellent introduction to the study of the larger British fungi. Beginners to whom the fuller systematic works are bewildering will much appreciate the clear, brief presentation of all the British genera of Basidiomycetes and the larger Ascomycetes.

In the fourteen pages of introductory matter Mr Ramsbottom has contrived to pack an amazing amount of interesting and up-to-date information on such subjects as "Fairy Rings," Mycorrhiza, Luminosity of fungi, Chemical characters, such as colouring matters and poisonous principles, Ecology of fungi, etc. Further there is a brief introduction to each order embodying the results of recent work on anatomy, cytology and development.

Genera which are not represented by models in the Sowerby collection are printed in smaller type. References are also given to the collection of coloured drawings of fungi by W. G. Smith exhibited in the Botanical Department of the British Museum. Where the names given to species, in accordance with the book's function as a *Guide*, do not coincide with those accepted in modern usage, Mr Ramsbottom has added the newer name in brackets and italicised, so that there should be no difficulty in correlation with other works.

The selection of species for mention has been based on their edible or poisonous qualities, and this fact, together with the general information given as to the food value of fungi and the

poisons contained in certain species, should render the book popular and useful to those interested in this side of the subject.

The genera are illustrated by W. G. Smith's line drawings as in the original *Guide*.

For the specific names of Agarics Mr Ramsbottom has followed the system of citation of authors adopted by W. G. Smith in his *Synopsis of British Basidiomycetes*. Although strictly in accordance with the International Rules of Nomenclature as they stand at present, the method in this particular case is open to serious objections on the ground of convenience, with no particular compensating argument in its favour. It seems very desirable that the next International Congress should pass the recommendation brought forward by the late Professor G. F. Atkinson in 1910, that the subdivisions of Agaricus used by Fries in his *Systema Mycologicum* should be treated as having been employed as genera at the time of the publication of that work.

A few slips occur which should be corrected in any future edition. On p. 10 under the section on Mycorrhiza the reference to Corticium should obviously apply to *Rhizoctonia solani* and not to *R. violacea* as stated. In the key to the genera of Agaricaceae on p. 20 beginners may be misled by the placing of Anellaria (spelt Annelaria) on a level with Amanita, as if it possessed a volva. Such slips, however, are very few, and typographical errors are so rare that no others have been detected.

E. M. W.

OBITUARY NOTICE.

HENRY CUSACK WINGFIELD HAWLEY (1876-1923).

By J. Ramsbottom.

Sir Henry Cusack Wingfield Hawley, Bt., died at Bournemouth on November 18th, 1923, and was buried at Leybourne Grange, West Malling, Kent. He was born on Dec. 23rd, 1876, and after being at Parkside, Worcester Park, went to Eton and thence to Magdalen College, Oxford, where he took honours in Moderations and History. After leaving Oxford he read for the Bar and was a member of the Society of the Inner Temple but never practised. He succeeded to the baronetcy on the death of his father in 1909 and was the 6th baronet.

In Sept. 1914 he obtained a commission in the 8th Battalion Royal West Kent Regiment, proceeded as Captain to France and served in the firing-line till the Armistice; after which he commanded a Labour Company till his demobilisation in May 1919.

Sir Henry was a keen naturalist and was interested in all kinds of outdoor life, but—though his great-uncle Sir Joseph Henry Hawley was the "lucky baronet" so famous on the turf, having won the Derby no less than three times—horse-racing had no attraction for him. He was more proud of his relationship to Sir Joseph Banks, whose aunt had married Dr James Hawley, F.R.S., the father of the first baronet. He was a thoroughly capable botanist and horticulturist and was well versed in arboriculture. His chief interest was, however, mycology, and in this he became thoroughly efficient and gained considerable reputation as an authority on Pyrenomycetes. He was a most careful worker and had the invariable practice of jotting down all his observations on paper. He seems to have begun to specialise on Fungi owing to meeting with Charles Crossland. A foray of the Lincolnshire Naturalists' Union took place at Lincoln on Oct. 3rd, 1905, and Crossland acted as leader: "Mr Hawley helped Mr Crossland in a most enthusiastic manner, and will accept the position of recorder for the Union." In a letter on Oct. 7th Crossland writes: "Many thanks for your kind sentiments in regard to the Lincoln Foray. It was one of the pleasantest surprises I have experienced for some time to meet with someone in your county who takes so great an interest in this much neglected, but very important, branch of botany. The interest in the study will grow upon you as it has done upon me." After discussing certain of the species they had found, he goes on to say: "We have no need to feel uneasy at not being able to determine all the agarics we meet with, either at sight, or from books at our disposal. I have been with Dr Cooke, W. G. Smith, Massee and others who, though the first two have had 50 years' experience, have been occasionally at a loss to say definitely what certain species were." Crossland advised him as to his early finds and suggested his entering into correspondence with specialists in various groups, and judging from the few letters he retained, the specimens he sent were almost invariably of more than passing interest. Owing to Crossland's special knowledge of the group, special attention was naturally paid to Discomycetes, and Boudier gave his opinion on many of the difficult species. Pyrenomycetes began to be studied about 1908, for Crossland writes in June of that year "Re the *Sphaeria*. We shall get rather more familiar with the 'enemy' in a bit and rather welcome their appearance." The following year he wrote: "Massee told me you had been at Kent. Also that it was possible you might spend a bit more time there later on and work at the Pyrenos—or some group of these. I wish you would: there is a very good opening in that direction. Very few, if any living Englishman besides Cooke, Plowright and Massee know any-

thing about them. Massee will have his MS. for a Pyreno vol. he promised some years ago that the publishers haven't tackled yet." Hawley, though still taking a great interest in fungi in general, became more and more interested in Pyrenomycetes, and after the war settled down in earnest to the preparation of the Monograph which he had considered the possibility of ten years previously. Unfortunately, the manuscript as he left it is not sufficiently complete for publication. This is particularly to be regretted, not only on account of the great need for such a volume but also because in the course of the work only the short series of "Notes on Some British Pyrenomycetes" (*Trans. Brit. Myc. Soc.* VIII (1923), p. 226) and an abstract of a general paper on "The Pyrenomycetes and some problems they suggest" (*Naturalist*, 1912) were published. With the addition of the report of the fungi of Clare Island with Mr Carleton Rea (*Proc. Roy. Acad.* XXXI (1912)) and one or two notes on other mycological matters these are the only papers which stand to the name of one of our most careful workers.

In manner Hawley was exceedingly self-effacing. Hale and hearty in appearance he at first struck one as being exceedingly shy until one realised that there was a complete absence of nervousness. After the war this reserve seemed not quite so marked, but this was probably merely that one got to know him better. In the hell of the battle of the Somme this imperturbability impressed his fellow-officers and men who were, as he himself, undergoing their blooding of heavy bombardment. It is indeed strange that the same mannerism which when first encountered at a mycological meeting rather inhibited understanding should have enabled him to appear unconcerned and cheerful under conditions man had never faced before, then attracted and impressed his comrades in such a way that on his death they bore tribute to this very character.

The news of Sir Henry's death came as a great surprise to most of us. Little did we know that the letter accompanying the short account of the fungi found on a blackbird's nest* which he sent to the Windsor Foray, in which he mentioned that he had been "a little unwell" was, as he himself realised, his farewell.

Lady Hawley has generously presented his specimens, manuscripts and drawings to the National Herbarium.

* See p. 239.

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RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct. 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

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