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THE DESCRIPTION AND DISTRIBUTION OF THE SPECIES OF *PENICILLIUM* Link IN SOME VICTORIAN SOILS

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Summary

The genus *Penicillium* is a dominant one in the micro-flora of soils. An account of this genus as it occurs in some Victorian soils has been presented. Forty-five species have been identified and their distribution in some sandy podsols (acid) and Mallee soil (alkaline) has been noted. The majority of the species belong to two sections of the genus, the *Monoverticillata* and the *Asymmetrica-divaricata*. A number of the strains were tested for possible antibiotic properties.

The cultural and microscopical characters of the forty-five species have been described and their chief diagnostic characters have been stressed. The descriptions are illustrated by line sketches and dichotomous keys have been drawn up to aid in identification.

Introduction

There are many records of genera and species of fungi that have been isolated from soils of the Northern Hemisphere. Although there are only a few records for the Southern Hemisphere, it has been recognized (Burges 1939) that the genera of mould fungi occurring in soil show no marked geographical limits, and that they represent a very uniform flora. The species of *Penicillium* are the commonest constituents of this flora; we have, however, little accurate information about those species of this genus which are normally present in soil, and practically none about their vertical distribution in this environment.

During a study of the fungal micro-flora of some Victorian (Australian) soils, we have isolated and studied those *Penicillium* species that appeared on Czapek and malt agar dilution plates (James and Sutherland 1939). The greater number of isolations has been obtained from a sandy podsol which supports a characteristic heath vegetation, and which occurs close to the southern coast of this State. Some of the characteristic features of this podsol are summarised in Table 1.

Table 1

Horizon	A_1	A_2	B 'coffee rock'	C
Average depth	0-18 in.	18-34 in.	34-38 in.	38 in.
Colour	medium grey	light grey	dark brown	yellowish
pH	4·6	5·2	4·8	5·2
Organic carbon	1·47	0·28	1·34	—

Penicillium species were isolated also from the Mallee soils, which have an alkaline profile throughout, as well as from loam from the alpine regions of the Bogong High Plains, Victoria.

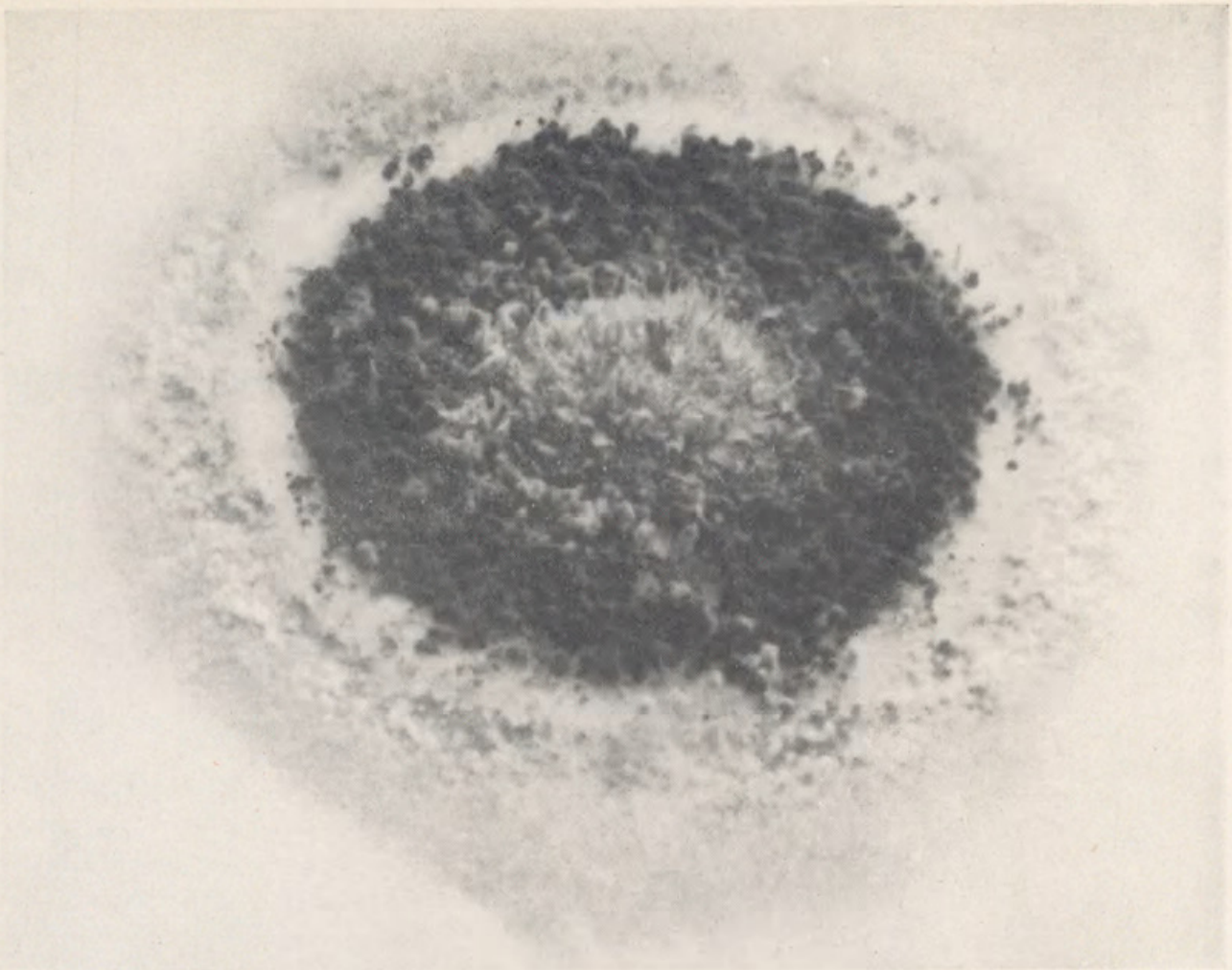

Fig. 1 (Upper).—Colony of *P. claviforme* Bainier, on Czapek agar, showing two types of coremia.

Fig. 2 (Lower).—Pattern of sporing head, showing the short quadrangular columns of spores radiating out in an umbel-like way (from an old malt slope).

Methods

All *Penicillium* species were sub-cultured from the dilution plates of malt agar to malt slopes, and these formed the reservoir of material for this study. If bacterial contamination occurred, the colonies were cleaned by the accepted methods, and frequently single spore isolations were made.

The fungi were plated out on to three media—malt, Czapek-Dox, and Raulin-Thom agar, made according to the following formulae:

Malt extract agar

malt extract	25·0 gm.
agar	18·0 „
distilled water	1000 ml.

Later, malt agar as prepared by Raper and Thom (1949) was used:

malt extract	20·0 gm.
dextrose	20·0 „
peptone	1·0 „
agar	25·0 „
distilled water	1000 ml.

Czapek-Dox agar

sucrose	30·0 gm.
sodium nitrate ($NaNO_3$)	3·0 „
monopotassium di-hydrogen phosphate (KH_2PO_4)	1·0 „
magnesium sulphate ($MgSO_4.7H_2O$)	0·5 „
potassium chloride (KCl)	0·5 „
ferrous sulphate ($FeSO_4.7H_2O$)	0·01 „
agar	18 „
water to	1000 ml.

pH adjusted to 6·9-7·0 with NaOH.

Raulin-Thom agar

sucrose	70·00 gm.
tartaric acid	4·00 „
ammonium tartrate	4·00 „
ammonium phosphate	0·60 „
potassium carbonate	0·60 „
magnesium carbonate	0·40 „
ammonium sulphate	0·25 „
zinc sulphate	0·07 „
iron sulphate	0·07 „
potassium silicate	0·07 „
agar	27 „
water to	1500 ml.

The mode of preparation was that set out by Smith (1946). The initial pH lay between 3·8-3·9 and was adjusted to 6·9-7·0 with KOH.

The inoculum for the plates was prepared by cutting an approximate sq. cm. from a colony grown for 14 days on malt agar at 24° C. This was transferred to a tube containing 9 ml. of sterile water. After vigorous shaking a platinum loop

(diam. 2 mm.) was inserted and a loopful of the spore suspension was transferred to the centre of each plate. The plates were incubated in the dark for seven days at 24° C. and then for seven days in the light at room temperature.

The Species of Penicillium Isolated

Forty-five species have been isolated from the various soils; approximately half this number belong to the *Monoverticillata* and the *Asymmetrica-divaricata* series, as the following list indicates.

MONOVERTICILLATA (12 species)

Adametzi, fellutanum, frequentans, fuscum, lapidosum, lividum, purpurrescens, pusillum, restrictum, spinulosum, Thomii, vinaceum.

ASYMMETRICA-DIVARICATA (11 species)

albidum, canescens, Godlewskii, janthinellum, Kapuscinskii, lilacinum, Melinii, nigricans, piscarium, Raciborskii, Rolfsii.

FASCICULATA (8 species)

claviforme, expansum, Gladioli, granulatum, Martensii, puberulum, Urticae, viridicatum.

BI-VERTICILLATA-SYMMETRICA (7 species)

diversum, funiculosum, islandicum, purpurogeneum, rubrum, rugulosum, verruculosum.

ASYMMETRICA-VELUTINA (3 species)

chrysogenum, digitatum, meleagrinum.

MONOVERTICILLATA-RAMIGENA (2 species)

cyaneum, Waksmani.

ASYMMETRICA-LANATA (1)

lanosum.

BREVI-COMPACTUM (1)

brevi-compactum.

We have included in our descriptions *Aspergillus Sydowi* (Bain. and Sart.) Thom and Church, and two strains of *Scopulariopsis brevicaulis* (Sacc.) Bainier.

The occurrence of the *Penicillium* species in the soils examined and their vertical distribution are shown in Table 2.

Burges (1950) has shown that fungus spores with a mucilaginous coat are washed downwards through a sandy soil, but spores which are dry and powdery showed 'practically no downward movement in sand.' Spores of *Penicillium* are of this dry type; indeed Burges includes *Penicillium cyclopium* among the fungi he used in his experiments and he states: 'In fungi such as *Penicillium* which produce dry spores, there is little likelihood of the spores being washed to lower levels.' The vertical distribution of the various species of this genus noted in Table 2 represents therefore their actual distribution in the soils examined.

The most abundant species in the A horizon of the sandy podsols are *P. Adametzi, janthinellum, nigricans, restrictum, spinulosum* and *verruculosum*; the

TABLE 2

Species	Soil type	Sandy podsol			Mountain loam						Mallee				Litter from sandy podsol, Frankston							
	Locality	Frankston			Bogong High Plains						Mildura				Species (see note)							
					Pretty Valley			Box Plot														
	Horizon	A	B	C	A	B	C	A	B	C	6-8 in.	12-18 in.	28-35 in.	70 in.	L.v.	E.	R.	H.	L.m.	B.	C.	
Aspergillus Sydowi					+	+																2
P. Adametzi		+	+	+							+	+					+	+	+			8
P. albidum												+										1
P. brevicompactum			+								+											2
P. canescens																				+		1
P. chrysogenum			+	+																		2
P. claviforme																			+	+		2
P. cyaneum		+			+											+						3
P. digitatum		+									+											2
P. diversum			+																			1
P. expansum			+	+							+											3
P. fellutanum			+																			1
P. frequentans			+	+		+											+					4
P. funiculosum		+		+		+	+	+														5
P. fuscum									+													1
P. Gladioli											+	+										2
P. Godlewskii		+	+													+						3
P. granulatum		+																				1
P. islandicum		+																				1
P. janthinellum		+	+	+																		3
P. Kapuscinskii											+											1
P. lanosum					+	+			+													3
P. lapidosum																			+	+		2
P. lilacinum													+									1
P. lividum													+									1
P. Martensii				+								+										2
P. meleagrinum			+													+						2

Continued

Species	Soil type	Sandy podsol			Mountain loam						Mallee				Litter from sandy podsol, Frankston							
	Locality	Frankston			Bogong High Plains						Mildura				Species (see note)							
					Pretty Valley			Box Plot														
	Horizon	A	B	C	A	B	C	A	B	C	6-8 in.	12-18 in.	28-35 in.	70 in.	L.v.	E.	R.	H.	L.m.	B.	C.	
P. Melinii		+		+																		2
P. nigricans		+	+	+	+	+					+					+						7
P. piscarium			+																			1
P. puberulum				+																		1
P. purpurogenum			+				+					+										3
P. purpurrescens		+																				1
P. pusillum																			+	+		2
P. Raciborskii			+																			1
P. restrictum		+	+	+					+							+		+				6
P. Rolfsii																			+	+		2
P. rubrum				+																		1
P. rugulosum		+																				1
P. spinulosum		+	+									+										3
P. Thomii																			+	+	+	3
P. Urticæ																			+			1
P. verruculosum		+	+											+	+							4
P. vinaceum											+											1
P. viridicatum			+																			1
P. Waksmani		+												+	+	+	+		+			6
Scopulariopsis brevicaulis		+			+																	2
		17	18	12	5	5	2	1	3		8	6	2	2	2	6	3	2	8	6	1	

NOTE.—The species of flowering plants on the sandy podsol from the litter of which fungal species were isolated, are as follows:—

L.v.—*Leucopogon viragtus* R. Br.

E.—*Epacris impressa* Labill.

R.—*Ricinocarpus pinifolius* Desf.

H.—*Hibbertia sericea* R. Br.

L.m.—*Leptospermum myrsinoides* Schlech.

B.—*Banksia marginata* Cav.

C.—*Casuarina distyla* Vant.

first four of these were repeatedly isolated from the three horizons of this podsol. The last two did not extend deeper than the B horizon.

Ten species were restricted to the 'coffee rock' or deeper—*P. brevi-compactum, chrysogenum, diversum, expansum, fellutanum, frequentans, meleagrinum, piscarium, Raciborskii* and *viridicatum.*

Four species were restricted to the C horizon—*P. puberulum, Martensii, purpurogeneum* and *rubrum.*

The sclerote-forming species were isolated only from the sparse litter which collects under the various plants characteristic of the heath vegetation growing on this soil. The sclerotes appear to withstand the hot and dry summer conditions which prevail in these regions.

Of the fifteen species recovered from the Mallee soils, four were restricted to this habitat. The more alkaline conditions were characterized by the appearance of *P. albidum, Gladioli, lilacinum* and *lividum.*

Many of the isolations were tested for possible antibiotic properties. The test organisms used were *Staphylococcus aureus* and *Bacterium coli.* Nutrient agar plates were seeded with 3 ml. of similar agar which had previously been inoculated with the test organism in a concentration of 1 ml. of a 24-hour broth culture in 100 ml. of agar. With a sterile cork borer, discs of 7·5 mm. diameter were cut from the periphery of a 7-day-old culture on malt agar of the *Penicillium* to be tested. These discs were placed on the seeded plates, which were then incubated at 37° C. for 24 hours. The results obtained are shown in Table 3.

TABLE 3

	B. coli	*S. aureus*			*B. coli*	*S. aureus*	
P. Adametzi	—	—		*P. Melinii*	—	—	
P. chrysogenum	—	+		*P. nigricans*	—	+	some strains
P. cyaneum	—	—		*P. piscarium*	—	+	
P. expansum	—	—		*P. puberulum*	—	—	
P. fellutanum	—	+		*P. purpurogenum*	—	—	
P. frequentans	—	—		*P. Raciborskii*	—	+	
P. Godlewskii	—	—		*P. restrictum*	—	+	some strains
P. granulatum	—	—		*P. rubrum*	+	+	
P. janthinellum	—	+	some strains	*P. rugulosum*	—	+	
P. lanosum	—	+		*P. spinulosum*	—	—	
P. lilacinum	—	—		*P. verruculosum*	—	—	
P. Martensii	—	+		*P. viridicatum*	—	+	
P. meleagrinum	—	+		*P. Waksmani*	—	—	

Only seven species of *Penicillium* have previously been recorded for Australia (Brittlebank 1937-1940). They are:

(1) *Penicillium bicolor* Fr. According to Raper and Thom (1949), this name is probably based on a coremium-forming member of the *Biverticellata-Symmetrica* and is not accepted by them as a valid species.

(2) *Penicillium candidum* Link. 'This is probably synonymous with *P. caseicolum* Bainier or some white mutant.' (Raper and Thom 1949.)

(3) *Penicillium expansum* Link.

(4) *Penicillium Gladioli* Machacek.

(5) *Penicillium glaucum* Link. 'Frequently used for any green *Penicillium*, no one knows what form was described by Link.' (Raper and Thom 1949.)

(6) *Penicillium italicum* Wehner.

(7) *Penicillium roseum* Link. Probably synonymous with *Gliocladium roseum* (Link?) Bainier.

THE MONOVERTICILLATA

Key to Monoverticillata

1.	Sclerotes present	2.
1.	Sclerotes absent	3.
2.	Sclerotes formed on malt, Czapek and Raulin agars, giving a characteristic surface colour to the colony	*P. lapidosum*
2.	Sclerotes present and readily visible on malt and Raulin agar (at least in fresh isolations), but not on Czapek agar	*P. Thomii*
2.	Sclerotes present, but not visible on the green surface of the colony, as they are embedded in the mycelial felt	*P. pusillum*
3.	Surface velvety (or at most sparsely floccose); ropes of hyphae absent	4.
3.	Surface floccose or lanose; ropes of hyphae absent	5.
3.	Surface mealy, floccose or lanose; ropes of hyphae present	9.
4.	Spores globose, spiny; colony reverse pale on all three media	*P. spinulosum*
4.	Spores globose, conspicuously spiny; colony reverse on Czapek and Raulin in purplish-brown shades; odour fetid	*P. purpurrescens*
4.	Spores globose, mainly smooth; colony reverse on all three media in yellow to brown shades	*P. frequentans*
5.	Growth restricted on all three media—at 14 days averaging 2·5-3 cm. or less	6.
5.	Growth restricted on Czapek but not on malt or Raulin agars	7.
5.	Growth not restricted on any media	8.
6.	Spores sub-globose, smooth; sporing surface pea-green	*P. fellutanum*
6.	Spores globose, 2 μ diam., rough	*P. restrictum*
6.	Spores globose, 4-4·5 μ diam., rough	*P. fuscum*
7.	Colony diameter on malt and Raulin agar (6-7 cm.) twice that on Czapek agar (2-3 cm.); spores globose, 3-4 μ, rough	*Aspergillus Sydowi*
8.	Growth not restricted on any of the three media; sporing colour deep greyish-blue	*P. lividum*
9.	Growth restricted on all three media (2-2·5 cm. in 14 days); deep red exudate drops give a characteristic appearance to the surface	*P. vinaceum*
9.	Growth not restricted (3·5-4 cm. in 14 days); red exudate drops absent	*P. Adametzi*

Penicillium lapidosum Raper and Fennell. Mycologia, 40, 1948.

Malt. The colony diameter measures 7 cm. in 14 days. The surface is covered with sclerotes. Penicilli are formed sparingly, and do not contribute to the general colour of the culture. At an early stage the central part is russet-vinaceous (XXXIX), outwards buff-yellow (IV)* with a white powdery margin. Pale pink

*All colour references are to Ridgway, 1912.

exudate drops may be present. As the colony ages, the surface appears to be powdered with ochraceous buff tints (XV), due to maturing of the sclerotes.

The reverse early shows shades of salmon colour, later deepening at the centre to russet-vinaceous with a paler margin.

Czapek. The colony diameter at 14 days is 3·5-4 cm. The central surface is corinthian to etruscan red (XXVII), studded with pink exudate droplets. Beyond the centre, it is maize to buff-yellow (IV). The whole area is powdery with sclerote formation, and the margin rather fimbriate and uneven.

The reverse is not buckled, pale-flesh to flesh colour (XIV), darkening at the centre to deep vinaceous (XXVII), and the margin of the colony is usually cream in colour.

Raulin. The colony diameter in 14 days is comparable to that on malt. The surface, for the most part, is brownish to russet-vinaceous (XXXIX) and glistening with small pink exudate drops. Outwards, the surface colour is maize yellow (IV), with a white margin.

The reverse is buckled, salmon-buff (XIV), with a creamish to white margin.

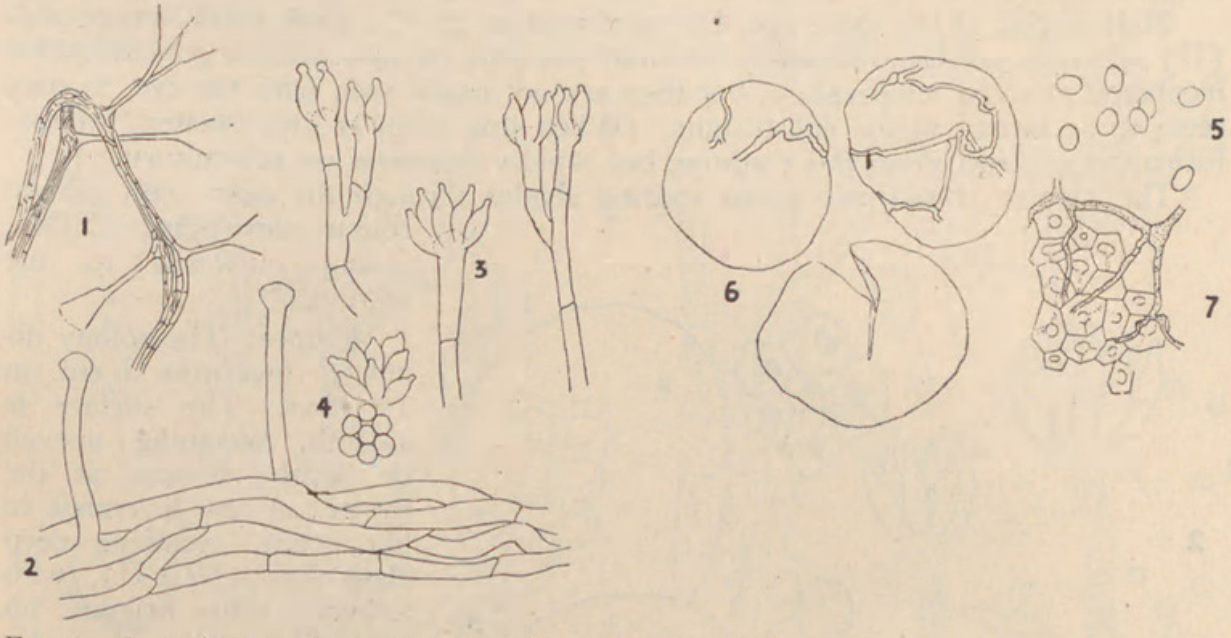

FIG. 1.—*P. lapidosum* Raper and Fennell. 1. Habit, × 50. 2. Rope, × 460. 3. Details of penicillus, × 460. 4. Sterigmata seen from above and laterally, × 460. 5. Spores, × 460. 6. Sclerote, × 50. 7. Detail of sclerotial tissue, × 460.

Morphology. The very sparsely formed conidiophores arise from trailing hyphae or from ropes of hyphae. They are frequently septated and smooth-walled, sometimes very short (10 μ), often 20-25 μ in length and sometimes longer. Many of them bear penicilli of the monoverticillate pattern. Others are characterized by the presence of an adpressed branch, about 10 μ long, close to their apices. The sterigmata are 5-7 μ long × 2-2·5 μ broad, and are borne in tight clusters over the slightly enlarged conidiophore tips. They bear somewhat tangled chains of spores. The conidia are elliptical, 2·5-3 × 2 μ; occasionally some appear sub-globose and are smooth-walled.

The sclerotes are variable in size, reaching 250-300 μ. They are yellow-brown when viewed under low magnification, but they are encrusted by thick-walled

orange-brown hyphae, and similar hyphae often form a network between them. The sclerotes are hard and difficult to crush; they consist of thick-walled cells, with an average diameter of 7-10 μ, with walls about 2-3 μ broad. On crushing, their contents escape in the form of immense numbers of oil droplets.

The features of diagnostic significance are:

(1) The predominantly monoverticillate character of the penicilli.
(2) The production of sclerotes on all three media.
(3) The yellow-brown colour of the sclerotes with the investing deep-coloured hyphae.

Isolated from the litter lying under *Leptospermum myrsinoides* and *Banksia marginata* on the sandy podsol at Frankston, Victoria, when plated out with malt agar at 40°, 60° and 80° C.

Penicillium Thomii Maire. Bul. Soc. Hist. Nat. Afrique. Nord., 8, 1917.

Malt. The colony diameter measures 6·5 cm. in 14 days. The surface is velvety, artemisia green (XLVII), with a suggestion of zoning outwards, and a narrow white margin.

Malt slopes, of the same age, but incubated at 25° C., show small orange-pink (II) sclerotial patches. Similarly coloured sclerotes are also present on malt plates incubated at room temperature, but they are not easily seen with the eye, as they seem to be buried in the substratum. (When this form is first isolated, sclerote formation is plentiful on this medium, but rapidly decreases on sub-culturing.)

The reverse shows pale green sporing shades through the agar, with salmon colours developing (XIV), fading outwards to the margin.

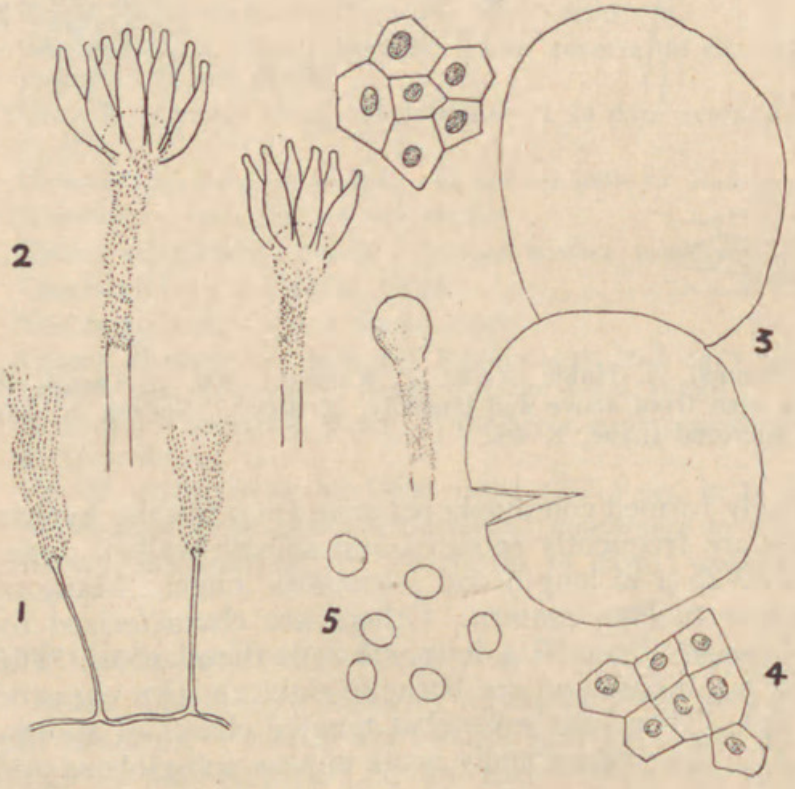

FIG. 2.—*P. Thomii* Maire. 1. Diagram of habit. 2. Details of penicillus, × 600. 3. Sclerote, × 35. 4. Sclerotial cells, × 600.

Czapek. The colony diameter measures 3 cm. in 14 days. The surface is smooth, becoming uneven or lightly floccose at the centre; at first artemisia to lily green, becoming deep slate-olive (XLVII), with a broad white margin; no visible sclerotes.

The reverse is slightly buckled at the centre, salmon colour (XIV).

Raulin. The colony diameter at 14 days measures 6 cm. The surface is velvety, lily-green to slate-olive (XLVII), zoned outwards with a white margin. Pinkish sclerotes are present at the centre of the colony, and small colourless exudate drops are present.

The reverse is similar to that on Czapek, but the buckling is more pronounced.

Morphology. The monoverticillate conidiophores arise from the basal felt or from trailing hyphae. The walls are rough, and the ends are inflated to form conspicuous vesicles 5 μ broad, on which are borne numerous rather parallel sterigmata 8-10 μ long; the sterigmata tend to be deciduous. The spore chains form rather loose columns; the spores are elliptical to sub-globose, smooth-walled, 3-3·5 μ in their long axis. The mature sclerotes are english red to mars orange (II); they are approximately 250-350 μ in diameter, their walls having the appearance of sclerenchyma-like tissue, which makes them hard and brittle.

The features of diagnostic significance are:

(1) The formation of pink sclerotia on all three media, especially when the strain has been recently isolated.
(2) The hard and brittle nature of the sclerotia.
(3) The monoverticillate penicilli.
(4) The elliptic to sub-globose, smooth spores.

Isolated from litter under *Leptospermum myrsinoides, Leucopogon virgatus* and *Casuarina distyla,* when plated out with malt agar at 60° and 80° C.

Penicillium pusillum Smith. Brit. Mycol. Soc. Trans., 22, 1939.

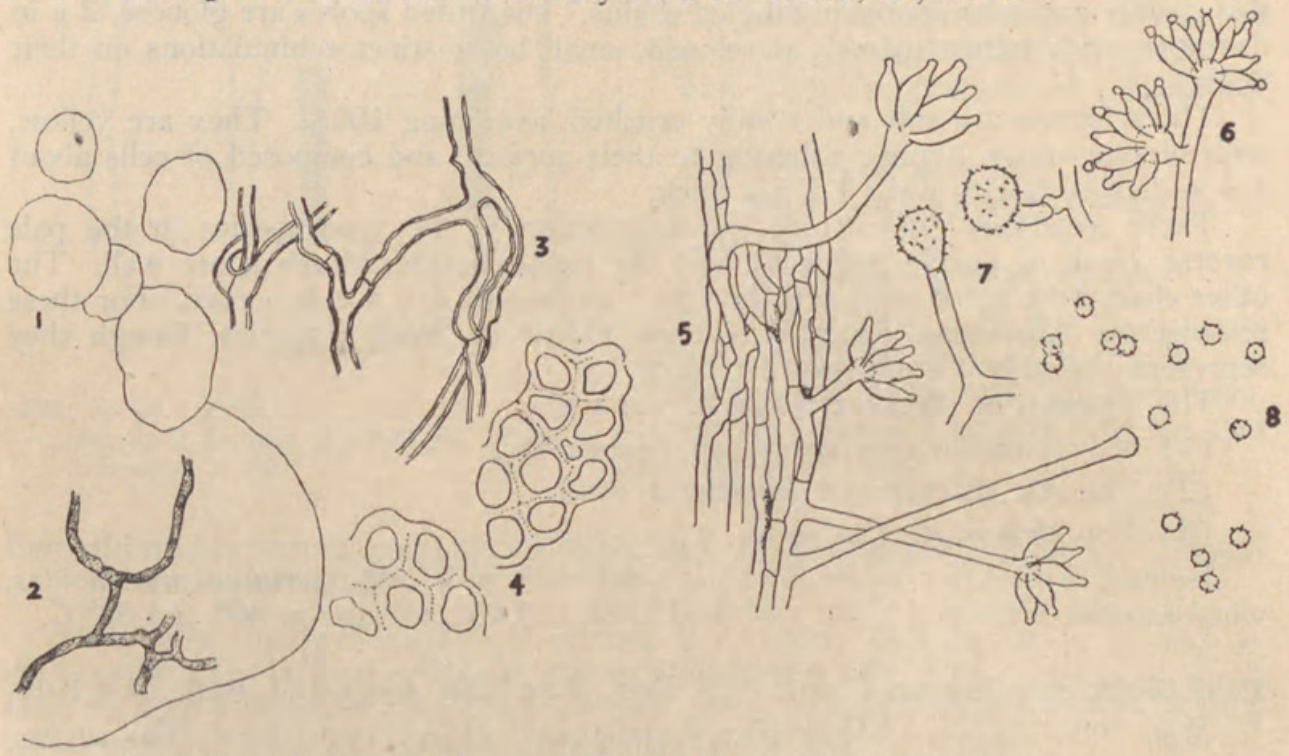

FIG. 3.—*P. pusillum* Smith. 1. Sclerote, × 50. 2. Sclerote, × 220. 3. Hyphae on surface of sclerote, × 460. 4. Sclerotial tissue, × 460. 5. Details of rope and conidiophore, × 460. 6. A branched conidiophore, × 460. 7. Vesicles of old conidiophores from which the sterigmata have fallen, × 460. 8. Spores, × 460.

Malt. The colony diameter measures, at 14 days, 4·5-5 cm. The surface is slightly mealy, lily-green, passing into a bluish-green colour towards the edge of the sporing area, and with a broad white margin which later becomes deep slate-green (XLVII). Small yellow sclerotes are present, but not visible from above, as they are embedded in the felt. Malt slopes of the same age show a white felted

mycelial overgrowth. In this area, exudate droplets form and, as they dry out, give a pitted appearance to the surface, and in this mat the sclerotes form.

The reverse is greenish-buff, the buff colour being more marked at the centre, and the margin is cream.

Czapek. In 14 days the diameter of the colony measures 2·5-3 cm. The growth on this medium remains very thin, and sporing is much reduced, in lily-green shades forming a network over the surface. The margin is fimbriate. Sclerotes are not present.

The reverse is uncoloured, with patches of green, which correspond to the sporing areas on the upper surface.

Raulin. The colony diameter measures 4 cm. at 14 days. The surface is velvety, pale glaucous blue (XLII), with small colourless or pale yellow exudate drops and a narrow white margin.

The reverse is buckled and coloured avellaneous (XL) to cream.

Morphology. The smooth-walled conidiophores arise either from trailing hyphae or from well-defined ropes. Some of them are very short (8-10 μ), but the greater number are 50 μ or longer. Most of them are strictly monoverticillate, but occasionally a branch occurs close to the vesicular apex. Numerous sterigmata arise over this surface and bear spores in tangled chains. The tinted spores are globose, 2 μ in diameter, with rather sparsely developed, small but distinct echinulations on their walls.

The sclerotes are soft and readily crushed, averaging 100 μ. They are yellow, with orange-brown hyphae adhering to their surface, and composed of cells about 5 μ in diameter, with walls 1-1·5 μ thick.

These isolations differ from the description of the type species in the pale reverse (lack of purple pigment) and the rough nature of the spore wall. The other characters agree well, and the spore shape and size are in accord. For these reasons the Australian forms have been placed in Smith's species, though they represent probably a variant of his type.

The features of diagnostic significance are:

(1) No formation of sclerotes on Czapek agar.

(2) The soft character of the sclerote wall.

(3) The globose, small spores.

Isolated from litter under *Banksia marginata* and *Leptospermum myrsinoides*, when samples were plated out with both malt and Czapek agar at 40° and 80° C.

Penicillium spinulosum Thom. U.S. Dept. Agr. Bur. Anim. Ind. Bull., 118, 1910.

Malt. The diameter of the colony measures 5-16 cm. in 14 days. The surface is velvety to sparsely floccose; at first, artemisia green (XLVII), but later darkening towards deep slate-olive with a tendency to zonation; white margin.

The reverse shows a cream background at first, with some green colour showing through in a faintly zoned pattern. Later, light ochraceous salmon tints (XV) appear at the centre of the colony, and this pinkish colour spreads outwards.

Czapek. The colony diameter at 14 days is 3·5-4 cm. The surface is velvety or sparsely floccose, with the same colours as on malt agar. Colurless exudate drops are often present over the sporing area.

The reverse is buckled, and cream with pinkish or buff tints sometimes showing.

Raulin. The colony diameter at 14 days is approx. 4 cm. The surface is similar to that on Czapek and malt agars.

The reverse is buckled; at first cream, but developing pinkish shades close to buff pink (XXVIII).

Morphology. The conidiophores arise most commonly from the substratum; some, however, arise from trailing hyphae, so they are of variable length. They may be smooth or rough walled, and are often septated; each enlarges at its apex to form a vesicle approximately 5 μ wide, which bears a whorl of sterigmata over its surface. They average from 7 to 10 μ in length, and narrow towards the spore-bearing end. The spores are borne in long, narrow, rather frayed columns (300 μ), and they appear to increase in size quickly, as there is not much gradation in size between the six or eight that remain on the sterigmata in fluid mounts. The connectives are distinct. The spores are globose to sub-globose, 3-3·5μ in diameter, roughened with short spines.

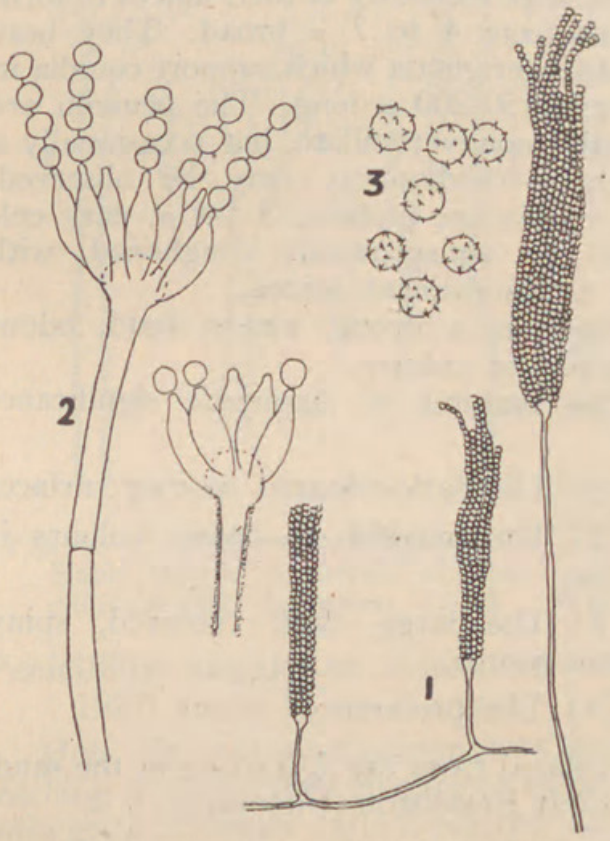

FIG. 4.—*P. spinulosum* Thom. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

The diagnostic features of significance are:

(1) The velvety surface.
(2) The pale reverse on all three media.
(3) The globose, spiny spores.

Isolated from the A and B horizons of the Frankston sandy podsol; it is one of the commonest forms in the A horizon. It was also obtained from the Mallee soils at a depth of 18 in.

Penicillium purpurrescens (Sopp) Raper and Thom. Raper and Thom, A Manual of the Penicillia, 1949.

Malt. The colony diameter is 5-5·5 cm. in 14 days. The surface is velvety; in early growth the sporing colour is greyish blue-green (XLVIII), becoming slate-olive to deep slate-olive (XLVII), or dull greenish black, faintly zonate, with a white margin; colourless exudate drops may be present.

The reverse is pale, with the dark sporing shades eventually showing through. A pale purple colour may develop at the centre of the growth.

Czapek. The colony diameter measures 2·5 cm. in 14 days. The surface is velvety and radiately furrowed. The sporing colours are much as for malt, sporing practically to the edge of the colony; pale amber exudate droplets may form.

The reverse is slightly buckled. At first pale, but later developing some vinaceous brown colour (XXXIX).

Raulin. The colony diameter is 3 cm. in 14 days. The surface is velvety, and

radially furrowed. The sporing colour is much as for malt, but denser, zonate, with a white margin and colourless exudate droplets.

The reverse is pale at first, buckled, tawny to russet brown (XV) colours developing at the centre, and extending outwards.

FIG. 5.—*P. purpurrescens* (Sopp) Raper and Thom. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Morphology. The rough-walled conidiophores arise close to the substratum, and they enlarge markedly at their apices to form vesicles from 4 to 7 μ broad. They bear crowded sterigmata which support conidia in columns, 150-200 μ long. The penicilli are typically monoverticillate, but occasionally a branched conidiophore may be observed. The conidia are globose, 3·5-4 μ, dark coloured and conspicuously roughened, with short but porminent spines.

There is a strong, almost fetid, odour developed in culture.

The features of diagnostic significance are:

(1) The dark-coloured sporing surface.

(2) The purplish to brown colours in reverse.

(3) The large, dark coloured, spiny, globose spores.

(4) The pronounced odour.

Isolated from the A horizon of the sandy podsol at Frankston, Victoria.

Penicillium frequentans Westling. Archiv für Botanik, 11, 1911.

Malt. The colony diameter measures 6 cm. in 14 days. The surface is velvety, in age becoming slightly furrowed, artemisia green (XLVIII) or bluish grey-green (XLII); the colour is very uniform right across the colony surface; outwards it may be faintly zoned, with a narrow white margin.

The reverse has a background of yellowish citrine (XVI), with orange (III) or ochraceous orange (XV) in the centre and spokes of similar colour radiating out from it; in some strains, little of the orange colour appears.

Czapek. The colony diameter measures 4 cm. in 14 days. The surface is velvety, bluish grey-green (XLII), with some overgrowth of paler hyphae and a white, rather strigose, margin.

The reverse is slightly buckled, mars yellow (III), in some strains closer to ochraceous orange (XV); paler towards the margin, the yellow colour diffuses into the medium.

Raulin. The diameter of the colony measures 6 cm. in 14 days. The surface is velvety, with similar colours to those on Czapek agar.

The reverse is slightly buckled radially, and is cinnamon to Prout's brown

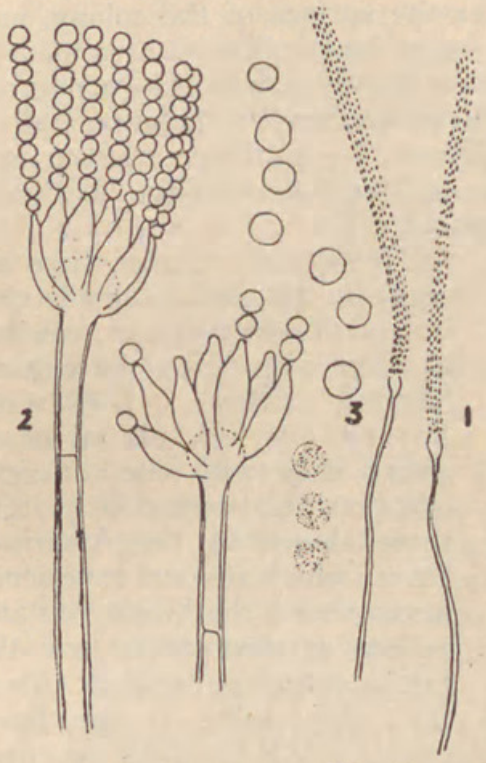

FIG. 6.—*P. frequentans* Westling. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

(XV); the colour is fairly uniform, with a pale margin.

Morphology. The long conidiophores arise from the basal felt and enlarge at their ends into vesicles 5 μ broad. They are smooth-walled, occasionally they may be slightly roughened, and bear crowded clusters of sterigmata 8-10 μ long. These support long chains of conidia grouped together to form long narrow columns about 350 μ × 10 μ. The spores are globose, 2·5 to 3 μ in diameter, with walls smooth or sometimes finely roughened

The features of diagnostic significance are:

(1) The velvety surface.

(2) The deep yellow to brown colour of the reverse.

(3) The globose, smooth, or at most finely roughened, spores.

Isolated from the B and C horizons of the Frankston sandy podsol, and from the litter of *Ricinocarpus pinifolius*, as well as from the B horizon (15 in.) of a mountain loam at Bogong High Plains, Victoria.

Penicillium restrictum Gilman and Abbott. Iowa State College Journ. Sci., 1, 1927.

Malt. The colony diameter at 14 days measures 2·5 to 3 cm. (in some isolations reaching 4 cm.). The surface is slightly floccose and is essentially pearl grey to hathi grey or deeper (LII), but this colour may be masked by the intense development of blood-red exudate drops giving a reddish colour to the greater part of the colony; in other strains, bright yellow drops are mixed with the red, and give a multi-coloured surface; while in others only yellow or colourless drops appear. The margin is pale and abrupt.

The reverse varies with the strain. Those forms with bright coloured drops are characterized by colours close to primuline yellow to old gold (XVI), with the deeper colour sometimes in zones. When the drops are paler, the reverse is lemon chrome (IV). All isolations show a yellow colour in the surrounding agar.

Czapek. The colony diameter at 14 days measures 2 cm. The surface is floccose and varies from hathi grey (LII) to nearly white. Bright yellow exudate characterizes most strains; when first isolated many of them develop blood-red droplets, but this character disappears after repeated sub-culturing.

The reverse is slightly buckled. At first it is uncoloured, then lemon yellow colours appear in some strains; this deepens in age to citron yellow (XVI), and the yellow pigment diffuses into the medium.

Raulin. The colony diameter at 14 days measures 2 to 2·5 cm. The surface is floccose and may develop pale grey shades, more often remaining white, with yellow and colourless exudate drops.

The reverse is buckled. The colony tends to lift away from the agar in a dome-shaped fashion. The colour is lemon yellow.

Morphology. Numerous trailing hyphae cover the surface of the colony, and from these arise very short conidiophores; the average length lies between 10 and 25 μ. These are smooth-walled, and bear over their slightly inflated tips a number of short sterigmata, averaging 5 μ long. The penicilli are small structures, and do not support long spore-chains. The spores are globose, 2 μ in diameter, clear and echinulate when young, becoming brownish in age, and the surface markings become blunter and somewhat tuberculate in character.

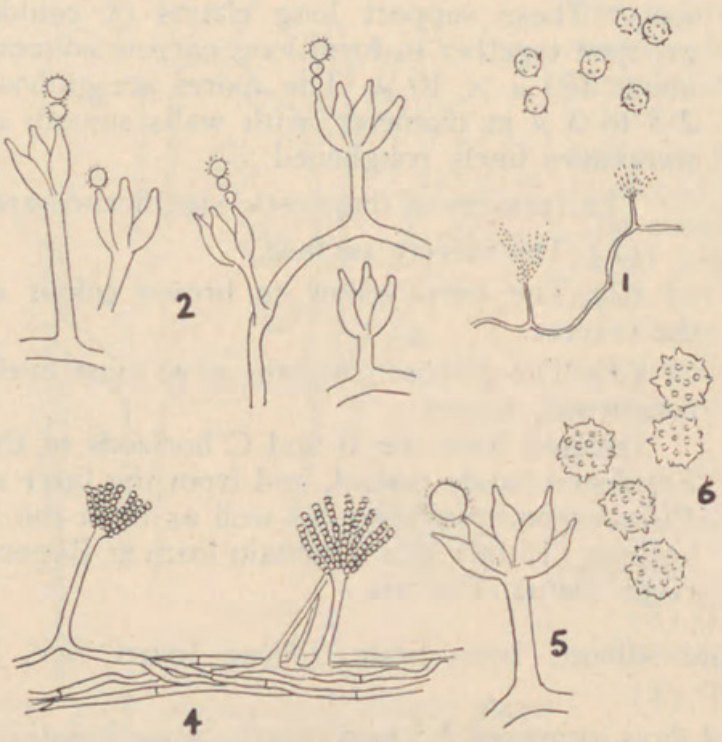

FIG. 7.

P. restrictum Gilman and Abbott. 1. Habit sketch. 2. Details of conidiophore and penicillus, × 600. 3. Spores, × 600.

P. fuscum (Sopp) Raper and Thom. 4. Habit sketch. 5. Details of conidiophore and penicillus, × 600. 6. Spores, × 600.

The forms included here all agree in possessing small, globose and spiny spores, similar to those formed by the culture labelled N.R.R.L. 1748 (see Raper), but the cultural characters vary with the different isolations, and particularly from those shown by the American form, which in our experience never shows the bright red and yellow exudate drops nor the bright yellow reverse on any of the three media. In age, however, N.R.R.L. 1748 on malt becomes light pinkish cinnamon (XXIX), and on Czapek straw yellow (XVI).

The features of diagnostic significance are:

(1) The restricted growth on all three media.

(2) The floccose surface in tones of pale grey, often masked by brightly coloured droplets.

(3) The yellowing of the media beyond the colony edge.

(4) The small, globose, spiny and brown-coloured spores.

Isolated from the A, B and C horizons of the Frankston sandy podsol, and from the B horizon (9-14 in.) of a mountain loam at Bogong High Plains, Victoria. Also from the rhizosphere of roots of *Epacris impressa* and *Hibbertia sericea* growing on the Frankston heathland.

Penicillium fuscum (Sopp) Raper and Thom. Raper and Thom, A Manual of the Penicillia, 1949.

Malt. The colony diameter measures 3 cm. in 14 days. The surface is floccose, pearl grey (LII), sometimes with pale yellow exudate drops; margin abrupt.

The reverse is cream, and in age brown tones may develop

Czapek. The colony diameter measures 2·5-3 cm. in 14 days. The surface is floccose, remaining white for some time, but eventually tints of pearl to hathi grey develop (LII), and numerous colourless exudate droplets appear in the central region.

The reverse is slightly buckled, and cream coloured.

Raulin. The colony measures 2 cm. in 14 days. The surface is floccose, with characters as described for Czapek.

The reverse is irregularly buckled, and cream, but later becomes clay-coloured.

Morphology. The smooth-walled, or slightly roughened, conidiophores arise from trailing hyphae or from well-defined ropes of hyphae. Many are short, about 10 μ, but some may reach 40 μ or more. They are monoverticillate in type, with slightly inflated ends, and bear a crown of short sterigmata. These are 5-8 μ long, and are constricted towards their tips. The conidia are arranged in tangled masses, and when mature they are dark-brown, globose, large, 4-4·5 μ in diameter, and ornamented with blunt spines. The young spores, while still attached to the sterigmata, are colourless and spinulose. Many of the spores appear to fail to reach maturity.

In the early stages of growth the cultural characters of our isolations appear very similar to those of N.R.R.L. 1748 (*P. restrictum*), but in the later stages they differ in the absence of the yellow tints in reverse, and the yellow exudate droplets. It is the spore characters that suggest they approximate to *Penicillium fuscum* as interpreted by Raper *et al.*, but they differ from this species as described by them in the restricted growth on malt agar.

The features of diagnostic significance are:

(1) The restricted growth on all media.
(2) The monoverticillate penicilli.
(3) The *large,* coloured, rough-walled, globose spores.

Isolated from a mountain loam at Bogong High Plains, Victoria, from the B horizon at 9-14 in. level.

Aspergillus Sydowi (Bain and Sart) Thom and Church. Thom and Church, The Aspergilli, 1926.

Malt. The colony diameter measures 6-7 cm. in 14 days. The surface is slightly floccose, and zoned, dark olive-grey to deep olive-grey to olive-grey (LI), with a narrow white margin.

The reverse is cream, with dark green sporing shades showing through in a zoned pattern.

Czapek. The colony measures 2·5-3 cm. in 14 days. The surface is slightly floccose. At the centre the colour is slate-olive, but the greater part of the surface is in shades of blue-green near to gnaphalium green (XLVII), with light amber exudate drops.

The reverse is buckled. In some strains it is at first cream, in others clay-coloured (XXIX), and deepens to cameo brown (XXVIII), with a tendency towards redder hues; the pigment diffuses into the surrounding medium. The paler strains show patches of similar colour in age.

Raulin. The growth rate is similar to that on malt. The surface is floccose; dark olive-grey to paler shades (LI), with a white margin. Sometimes numerous pale exudate drops may be present.

The reverse is buckled, cream at first, later brownish areas develop.

Morphology. The conidiophores arise either from trailing hyphae or sometimes from well-developed ropes. They are usually rough-walled and very variable in length, 15 μ to 150 μ (many about 50 μ). Each is inflated into a distinct vesicular head, 5-6 μ broad. The sterigmata arise over its surface, and tend to be parallel to one another; sometimes they are rough-walled, and they are constricted below the point of origin of the spores. The spore chains form distinct narrow columns, at least on malt agar. The conidia are globose, brown, 3-3·5 or even 4 μ, and

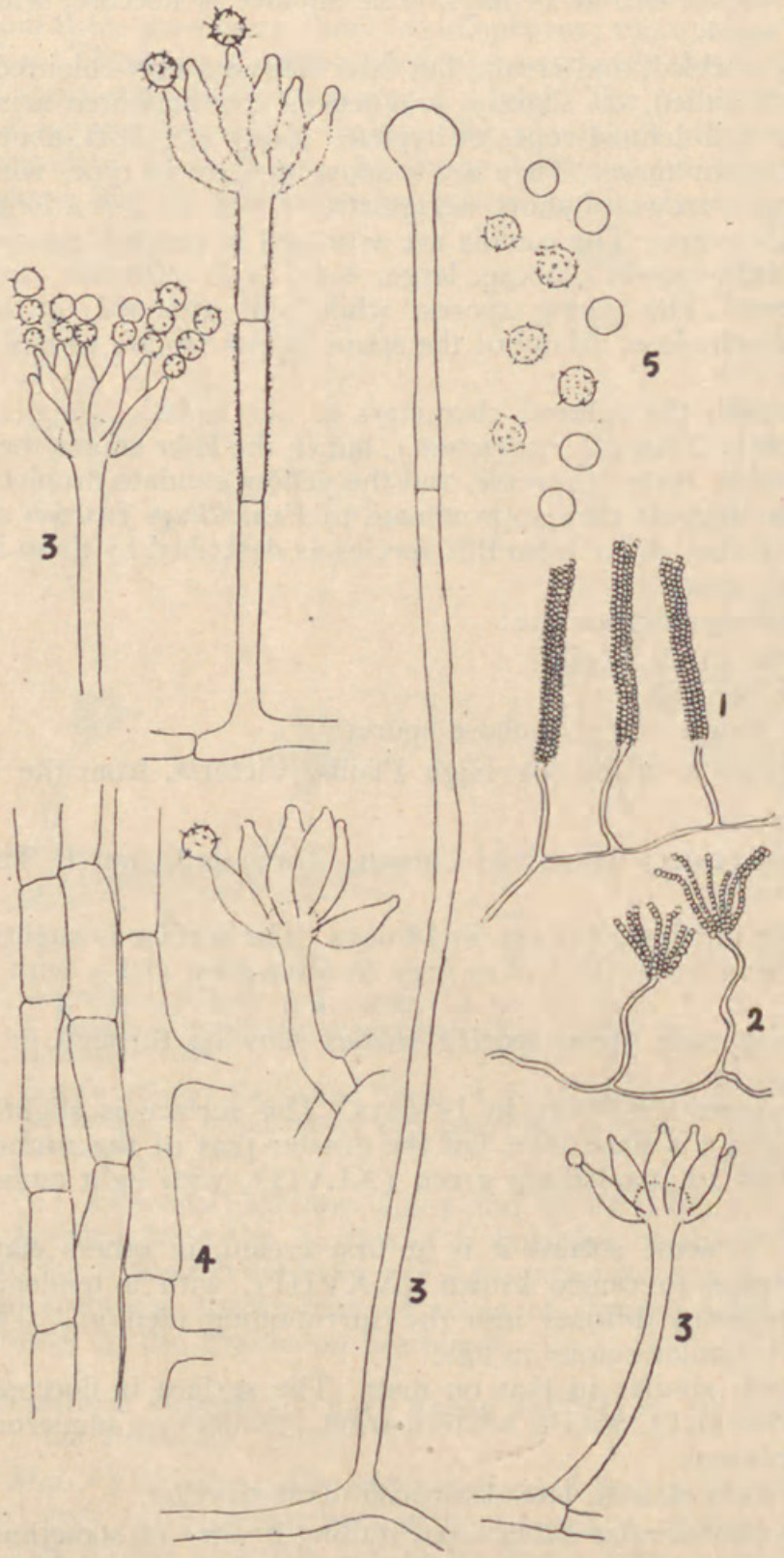

FIG. 8.—*Aspergillus Sydowi* (Bain. and Sart.) Thom and Church. 1. Habit sketch from malt agar. 2. Habit sketch from Czapek agar. 3. Details of conidiophore and penicillus, × 600. 4. Details of rope, × 600. 5. Spores, × 600.

roughened by blunt spines which are almost tuberculate in form.

These isolations show the restricted growth on Czapek agar, and the brown, rough, globose spores that characterize *Penicillium restrictum*, but the growth on malt and Raulin agars differs markedly from the growth of that species. Raper examined one of our isolations (PVA_8) and suggested that it represented *P. restrictum* Gilman and Abbott, but said 'it is rather unique in producing penicilli which are unusually large for this species.' We have had these isolates in culture for some time and they consistently show the characters as described and figured here. The relationship between *P. restrictum* and *Aspergillus Sydowi* has been discussed by Raper and Thom, and we have, with some hesitation, interpreted our form as representing a strain of *Aspergillus Sydowi*.

The features of diagnostic significance are:

(1) The restricted growth on Czapek agar, but spreading colonies on malt and Raulin's agar.

(2) The production of reddish-brown pigment in reverse on Czapek, with diffusion of the pigment into the medium.

(3) The brown, globose and roughened spores.

Isolated from a mountain loam at Bogong High Plains, Victoria, from the A and B horizons (0-32 in.).

Penicillium fellutanum Biourge. La Cellule, 33, 1923.

Malt. The colony diameter measures 1·5-2 cm. in 14 days. The surface is floccose, and remains white for some time, but finally becomes flecked with pea green (XLVII).

The reverse is yellow, close to citron yellow (XVI), but becomes paler in age. When the plates are incubated at 25° C., the yellow colour is more intense and it may diffuse into the surrounding agar.

Czapek. The colony diameter measures 1·5-2 cm. in 14 days. The surface is floccose. At first, it is white, but later pea green colours develop, and sometimes pale yellow exudate drops occur.

The reverse is buckled, and cream buff (XXX) in colour.

Raulin. The rate of growth is similar to that on Czapek. The surface is floccose and white, with pea green colours developing later.

The reverse is buckled, and lifts away from the medium in a dome-like manner; cream buff (XXX).

Morphology. The conidiophores are not numerous. They arise mostly from trailing hyphae, and are comparatively short, 20-30 μ in length, and smooth-walled. Each bears a few sterigmata, 5-6 μ long, over the inflated ends. The spores are borne in short columns; they are sub-globose, smooth-walled, and are 2·5-3 μ in diameter.

The features of diagnostic significance are:

(1) The floccose, rather than velvety, surface of the colony.

(2) The sparsely sporulating surface in shades of pea green.

(3) The pale-coloured reverse.

Isolated from the B horizon of the Frankston sandy podsol.

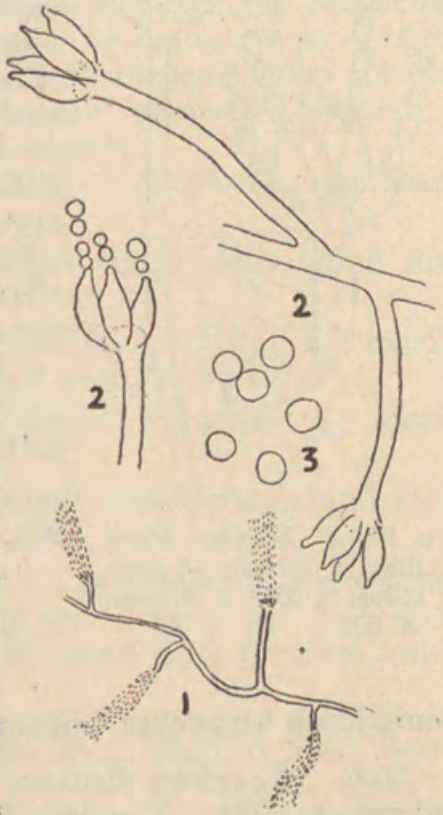

FIG. 9.—*P. fellutanum* Biourge. 1. Habit sketch. 2. Details of condiophores and penicillus, × 600. 3. Spores, × 600.

Penicillium lividum Westling. Archiv. für Botanik, 11, 1911.

Malt. The colony diameter measures 6 cm. in 14 days. The surface is very lanose, greyish blue-green to deep greyish blue-green (XLVIII), with a narrow white rim.

The reverse is plane, ochraceous salmon to ochraceous orange (XV), with slight zoning towards the paler margin.

Czapek. The diameter of the colony at 14 days is approximately 4 cm. The surface is lanose, deep greyish blue-green, outwards deep glaucous grey (XLVIII), with a narrow white rim and compact margin. The outer part of the surface is faintly zoned.

The reverse is plane, and light ochraceous salmon (XV).

Raulin. The colony diameter is 5-5·5 cm. in 14 days. The surface is lanose, deep greyish blue-green at the centre and paler beyond, with slight pitting from drying out of the colourless exudate drops.

The reverse is slightly puckered, cinnamon, passing into verona brown (XXIX), and some pure yellow colours close to the margin

Morphology. The long conidiophores arise from the basal felt, and have slightly roughened walls. They are septated, and swell out into a depressed globose vesicle which bears parallel sterigmata 10 μ in length over its surface. Each narrows perceptibly close to the conidial producing tip. The conidia are produced in tangled chains. Each spore is elliptical, with conspicuous connectives between them, while still attached in the penicillus. When mature, they are variable in size, generally elliptic, averaging 3 × 2·5 μ, occasionally 5 × 3 μ. They are rough-walled and greenish in colour.

The features of diagnostic significance are:

(1) The greyish blue-green colours of the sporing surface.

(2) The long conidiophores arising from the basal felt.

(3) The elliptical, roughened spores.

Isolated from the Mallee soils at the 28 in. level.

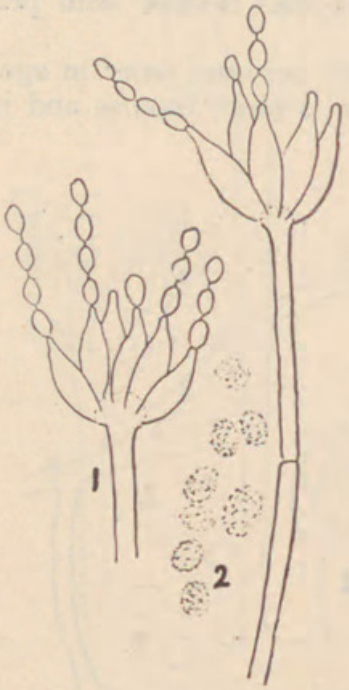

FIG. 10.—*P. lividum* Westling. 1. Details of penicillus, × 600. 2. Spores, × 600.

Penicillium vinaceum Gilman and Abbott. Iowa State Coll. Journ. Sci., 1, 1927.

Malt. The colony diameter at 14 days measures 2-2·5 cm. The surface is lanose and mainly white. The deep felt, however, overlies yellow hyphae. Sporulation is sparse; in age, a slight greyish colour is visible in the sporing areas. Pinkish to blood-red exudate drops are present, but not so abundantly as on other media. The margin of the colony is abrupt.

The reverse is plane, mikado to verona brown (XXIX).

Czapek. The rate of growth is similar to that on malt agar. The surface is essentially white, with some yellow mycelium present. Exudate drops form so abundantly that they give the characteristic appearance to the colony. The young drops are in light red tones, quickly passing into blood red, and in age becoming almost black or very deep blood-red.

The reverse is slightly buckled and furrowed. Early, it is terra cotta to pecan brown (XXVIII). The colour is intense to the edge of the colony, and later it deepens to maroon (I) or darker. The colour diffuses into the medium, and appears brazil red or deeper (I).

Raulin. The colony measures 2-2·5 cm. at 14 days. The surface is lanose, and white, with blood-red droplets across the surface. These do not darken as do those on Czapek.

The reverse is buckled, and is chocolate to burnt umber in colour (XXVIII).

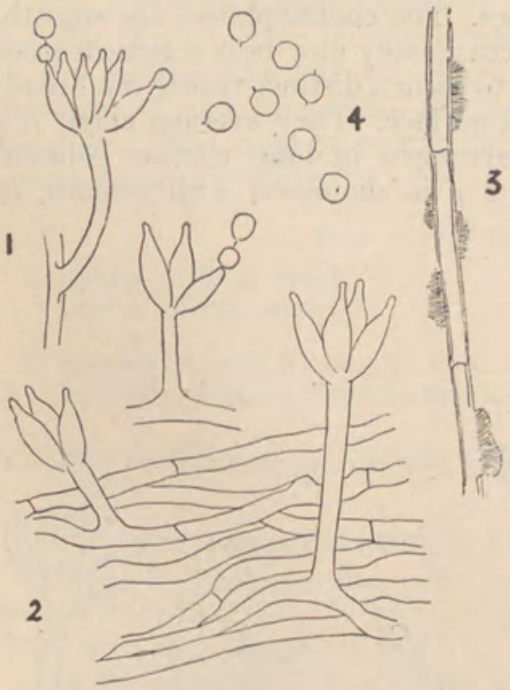

FIG. 11.—*P. vinaceum* Gilman and Abbott. 1. Conidiophore and penicillus, × 600. 2. Rope with conidiophores, × 600. 3. Hypha with incrustation, × 600. 4. Spores, × 600.

Morphology. The hyphae are encrusted with yellow or red crystalline deposits, and the short conidiophores, 10 to 20 μ, or occasionally longer, arise from trailing hyphae or sometimes from ropes of hyphae. The monoverticillate penicilli consist of a few sterigmata, 6-8 μ in length. Each narnows to a conidial tube and supports a chain of globose spores in which the connectives are conspicuous. The spores are sub-globose, mostly about 2 μ in diameter, often apiculate from the persistent connective, smooth or slightly rough-walled.

The features of diagnostic significance are:

(1) The restricted growth on all three media.

(2) The abundance of deep red exudate drops of Czapek and Raulin agars.

(3) The sparse formation of sporing heads.

(4) The short conidiophores and apiculate small spores.

Isolated from the Mallee soils (Mildura) at the 6 in. level. Ninety per cent of the isolations at this level were *P. vinaceum.*

Penicillium Adametzi Zaleski. Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

Malt. The colony diameter measures 4·5 cm. in 14 days. The surface is mealy, often becoming tufted in the centre, lily green to deep slate green (XLVII), zoned outwards, the margin white and partly submerged.

The reverse is isabella colour (XXX), sometimes intensifying to a deep yellow or ochraceous orange (XV) at the centre, fading towards the margin. The yellow pigment diffuses into the medium beyond the colony.

Czapek. The colony diameter measures 3-3·5 cm. in 14 days. The surface is floccose to almost velvety, in light green shades close to artemisia or lily green (XLVII), and zoned, with a white margin. Yellow exudate drops may be present.

The reverse is buckled, in yellow colours varying from wax yellow (XIV) to cadmium orange (III). Some isolations show paler colours, near to ochraceous buff and ochraceous salmon (XV). The yellow pigment may diffuse into the medium.

Raulin. The colony diameter at 14 days measures 4 cm. The surface is floccose to mealy, artemisia to lily green, with a white margin. Overgrowths of white mycelium are common. Colourless to pale yellow exudate drops may occur.

The reverse is buckled, with brownish shades developing on a yellow ochre background (XV), often in a zoned manner.

Morphology. The conidiophores may arise from trailing hyphae that form a close felt on the colony surface, or from ropes of hyphae which may sometimes become so profuse as to form coremial-like masses. The conidiophores are smooth-walled in some isolations, rough in others, and occasionally may bear a branch some distance from the apex. The ends are swollen out to form a distinct vesicle 5 μ broad; eight or more sterigmata arise over this inflated surface. They average about 8 μ in length, and they support chains of spores arranged in long narrow columns (250-300 μ). The spores are sub-globose, 2-2·5 μ in diameter, with smooth, or sometimes granulated, walls.

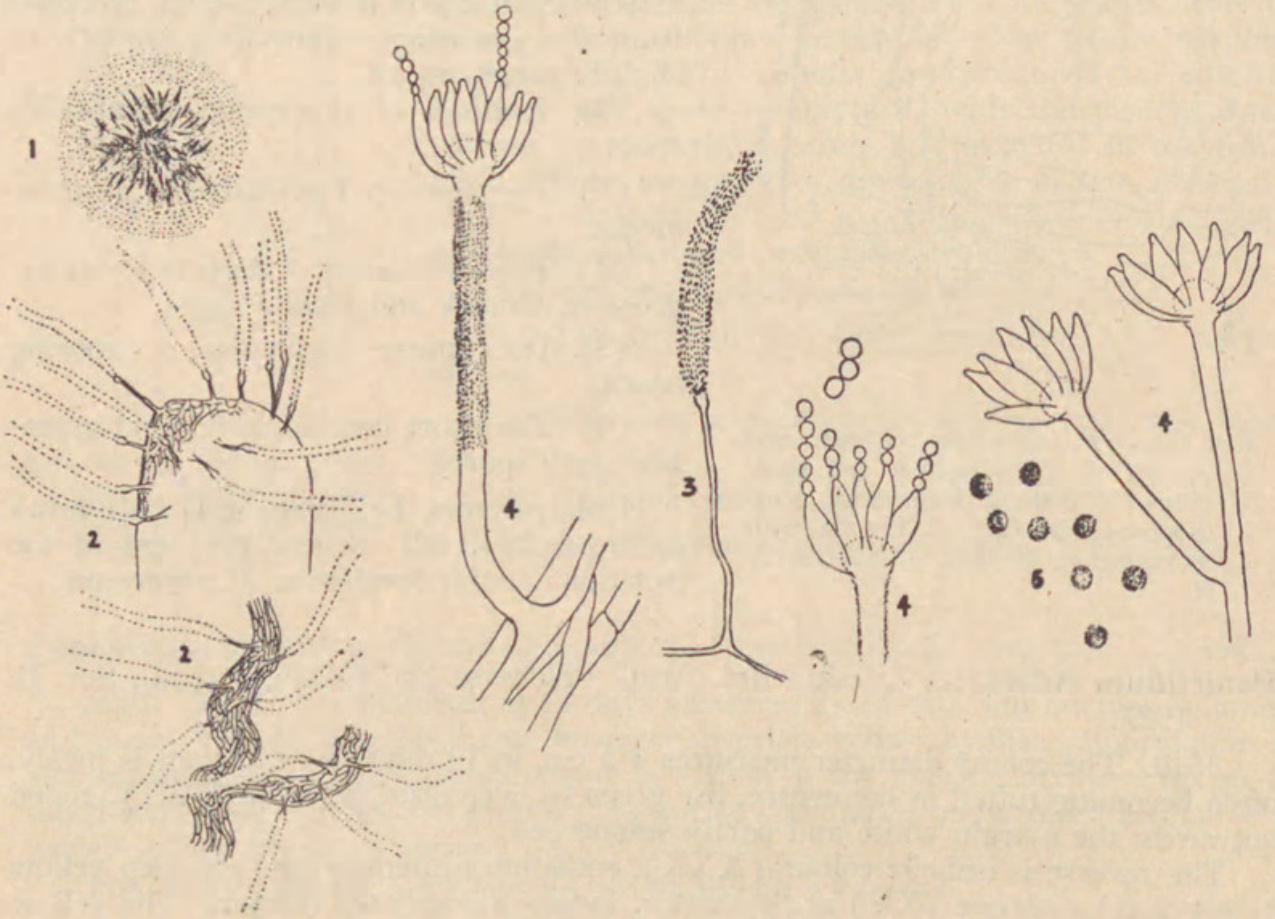

FIG. 12.—*P. Adametzi* Zaleski. 1. Surface of colony (diagram). 2. Sketch illustrating ropy habit. 3. Sketch of single conidiophore. 4. Details of conidiophore and penicillus, × 420. 5. Spores, × 420.

The features of diagnostic significance are:

(1) The predominantly funiculose habit.

(2) The yellow to orange or brown colours in reverse on Czapek and Raulin's agar.

(3) The smooth, sub-globose spores.

Isolated from the A, B and C horizons of the Frankston sandy podsol, and from samples of the litter present under the plants growing on it, when plated out with malt or Czapek agar at 60° and 80° C. Also isolated from the Mallee soils at 6 in. and 12 in. levels.

THE MONOVERTICILLATA-RAMIGENA

The *Monoverticillata-Ramigena* series includes those members of the genus that have the characteristic monoverticillate penicilli with conspicuously vesicular heads but the conidiophores are branched. Sometimes there is only one branch and the placement of such forms into the series is not difficult; sometimes there are several branches arising more or less at the same level and these forms approximate to the *Lanata-divaricata* pattern.

KEY TO THE MONOVERTICILLATA-RAMIGENA

1.	Spores globose, rough	*P. Waksmani*
	Spores elliptic, smooth	*P. cyaneum*
	or	
1.	Sporing colour on Czapek, slate olive	*P. Waksmani*
	Sporing colour on Czapek, pale gnaphalium-green to storm-grey ..	*P. cyaneum*

Penicillium Waksmani Zaleski. Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

Malt. The colony diameter in 14 days is from 3 to 4·5 cm. The upper surface is mealy, and becomes deep slate olive (XLVII); towards the margin a greyish blue-green (XLVIII) is seen with a very narrow and abrupt white edge. The whole surface is faintly zoned.

The background of the reverse is at first cream, but later zones of brown shades occur regularly to the margin. The amount of zoning and the intensity of the colour varies with the strain and temperature of incubation.

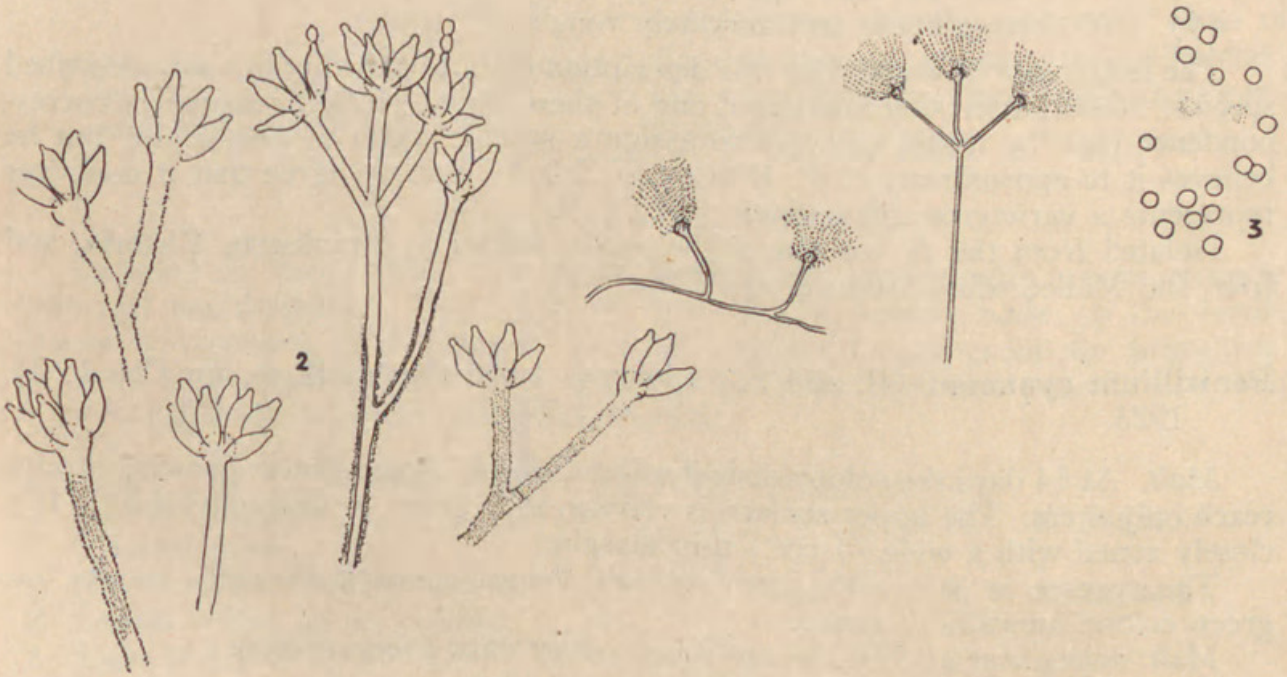

FIG. 13.—*P. Waksmani* Zaleski. 1. Habit sketch. 2. Details of conidiophore and penicillus, × 420. 3. Spores, × 420.

Czapek. In 14 days the colony diameter is 2-2·5 cm. The characteristic feature is the very thin growth on this medium, a feature constant for all the strains that have been isolated. The amount of sporing is reduced and occurs mainly towards

the centre, where the colour is deep slate olive. There is a broad transparent white margin to the colony.

The reverse is colourless; the colour of the sporing heads shows through.

Raulin. The diameter of the colony is 3-3·5 cm. The surface is almost velvety, slate olive or greyish blue-green (XLVIII). The centre lifts away from the medium and some overgrowth of white mycelium may occur. There is a narrow white rim to the colony.

The reverse is much buckled. It is at first cream, passing through shades of yellow, with zones or patches of brown colour. The brown colour intensifies with age and becomes darker than the reverse on malt agar.

Morphology. Conidiophores arise either from the substrate or from trailing hyphae, occasionally from well defined 'ropes'. They are rough-walled and very variable in length, some of them very short. Many of the conidiophores are of the simple monoverticillate type. Others are branched, some with a branch distant from the apex or with three branches closer to the tip and forming a rather divaricate pattern. All the branches have a pronounced vesicular head (3-4 μ) which bears a group of sterigmata 5-7 μ long. These bear the spore chains which form rather tangled masses and are not in definite columns. The spores are globose, small, mostly 2 μ in diameter, with slightly roughened walls.

The features characteristic of this form are:

(1) The restricted growth on all three media.

(2) The very poor growth on Czapek medium.

(3) The rough-walled conidiophores.

(4) The small, globose and delicately roughened spores.

The isolations represented by this description do not fit readily into any described species. Raper, after examination of one of the isolates (4 A_6), remarks in correspondence that 'he would not care to assign a specific name to this strain,' but he believes it to approximate to *P. Waksmani* Zaleski, and we agree that it doubtless represents a variety of this species.

Isolated from the A horizon of the sandy podsol at Frankston, Victoria, and from the Mallee soils, Mildura, at 70 in. level.

Penicillium cyaneum (B. and S.) Biourge. Liste Onomastique, La Cellule 33, 1923.

Malt. At 14 days the colony diameter is 6·5-7 cm. Some slower growing strains reach only 4 cm. The upper surface is velvety, sage green to slate olive (XLVII), closely zoned with a wide (1 cm.) thin margin.

The reverse is pale with green sporing shades showing through; in age the green colour intensifies; zoned.

Malt slopes kept at 3° C. in age show a very dark green reverse.

Czapek. Growth much restricted and only slightly buckled. At 14 days the colony measures 2 cm. The surface is velvety and even in age shows pale shades; gnaphalium green (XLVII) or bluish grey-green (XLII) to storm grey (LII) with pale droplets. Later, pink colours appear in patches with many pale pink exudate drops. There is a narrow white margin.

The reverse shows shades of pinkish buff with deeper tones developing in age.

Raulin. Colony diameter is 4 cm. and buckled. The upper surface is velvety to slightly floccose with sporing colour much as on Czapek agar; the centre sometimes umbonate, due to the colony lifting away from the medium narrow white margin.

The reverse is in pale buff shades (tilleul-buff to avellaneous (XL)), fading outwards to cream. The buckling is both radial and concentric in pattern.

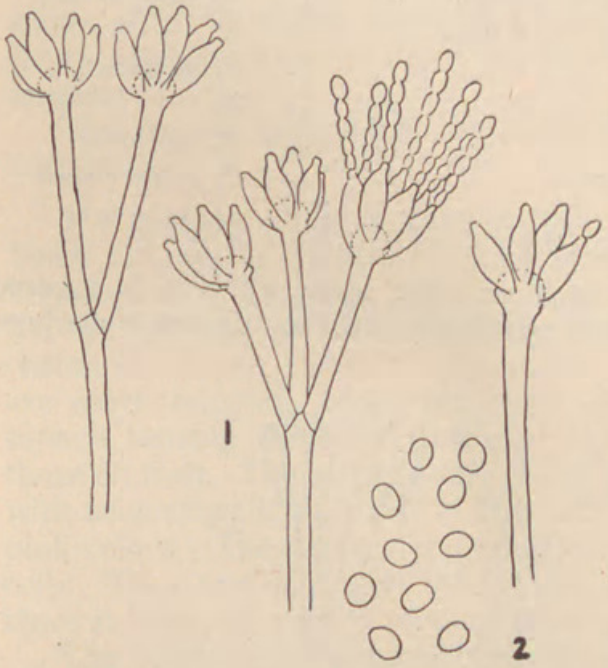

FIG. 14.—*P. cyaneum* (Bain. and Sart.) Biourge. 1. Details of penicillus, × 600. 2. Spores, × 600.

Morphology. The conidiophores arise from trailing hyphae. Some are monoverticillate, but typically they fork towards their ends. Each branch develops equally and becomes inflated at its apex. Occasionally three or more branches develop in a verticil. The sterigmata are from 5 to 7 μ long and they bear chains of spores in somewhat tangled loose columns. The spores are elliptic, 2 × 3 μ, smooth-walled in age, pale olive-tinted.

The features that characterize these 'ramigena' isolations are:

(1) The light bluish green sporing colours on Czapek and Raulin agar.

(2) The elliptic smooth-walled spores.

Isolated from the A horizon of the sandy podsol at Frankston, Victoria, and from the litter present on this soil, as well as from the rhizosphere of roots of *Epacris impressa* growing in this habitat; also from the B horizon of mountain loam at depth of 10-18 in.

THE ASYMMETRICA-DIVARICATA

Included in this section are those Penicillium species with asymmetrically branched conidiophores. The angle of branching is always wide, so the fertile system is divaricate in appearance. In some members of the group the branching, although wide, is more or less at one level (metulae) and the penicilli are then more compact but definitely spreading in form.

KEY TO THE ASYMMETRICA-DIVARICATA

1.	Sclerotes present	*P. Rolfsii*
1.	Sclerotes absent	2.
2.	Sporing surface pinkish-vinaceous	*P. lilacinum*
2.	Sporing surface not so coloured	3.
3.	Ropes of hyphae present	4.
3.	Ropes of hyphae absent	5.
4.	Rate of growth restricted; deep brown colours in reverse, particularly on malt and Raulin agars	*P. Godlewskii*
4.	Rate of growth not restricted; reverse on malt agar olive yellow with bands of olive green through it	*P. janthinellum*
4.	Rate of growth not restricted; reverse on malt pale-coloured	*P. piscarium*

5.	Conidiophore and metulae walls very rough	6.
5.	Conidiophore and metulae walls smooth	8.
6.	Sporing surface on Czapek and Raulin agars in shades of glaucous blue to bluish grey-green	*P. canescens*
6.	Sporing surface on Czapek and Raulin agars olive grey or neutral grey to slate olive	7.
7.	Spores globose and distinctly echinulate	*P. Melinii*
7.	Spores globose, smooth, or only slightly roughened	*P. Raciborskii*
8.	Growth on malt agar not restricted, 6-7 cm. in 14 days	*P. janthinellum*
8.	Growth on malt agar more restricted, 2-4 cm. in 14 days	9.
9.	Spores globose, rough, 5 μ in diameter	*P. albidum*
9.	Spores globose, smaller	10.
10.	Spores globose, spiny, 3 μ in diameter	*P. nigricans*
10.	Spores globose, almost smooth, 3 μ in diameter	*P. Kapuscinskii*

Penicillium Rolfsii Thom. The Penicillia, 1930.

Malt. In 14 days the colony diameter is 6 cm.; the upper surface is covered with small sclerotes. The penicilli are formed sparingly and they do not contribute

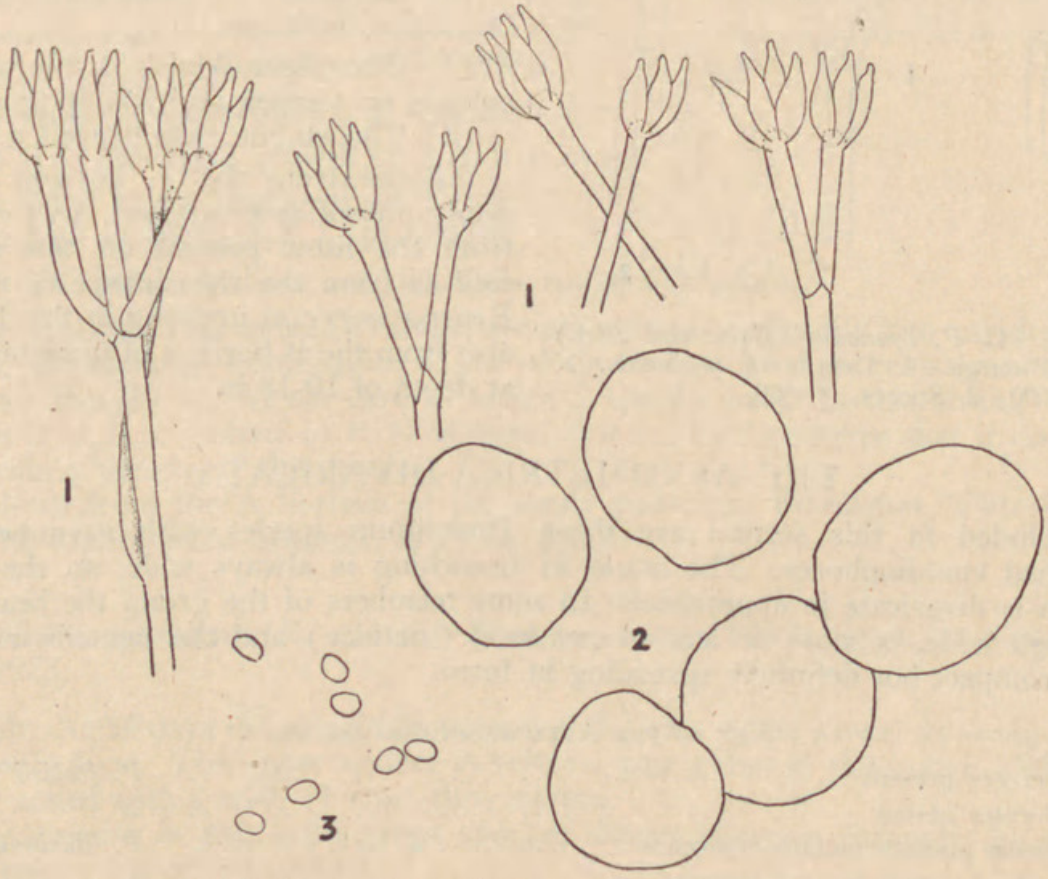

FIG. 15.—*P. Rolfsii* Thom. 1. Details of penicillus, × 600. 2. Sclerotes, × 65. 3. Spores, × 600.

to the general colour of the cultures, which is dark vinaceous to corinthian red (XXVII) with reddish exudate drops. The margin is broad, maize yellow (IV) and powdered with white sclerotes.

The reverse is salmon buff (XIV) at the centre, fading outwards to white.

Czapek. The colony is more restricted in growth on this medium. It averages in 14 days 1·5-2 cm. and is buckled. The surface shows the colour of the penicilli, lily green (XLVII) at the centre with yellow shades beyond and with a narrow white margin. At this age, sclerotes are not noticeably present on this medium, but later they form in abundance and the surface becomes deep vinaceous to light corinthian red (XXVII).

The reverse is buckled, pale flesh to flesh colour (XIV), with a white margin.

Raulin. In 14 days the colony diameter is 2-3 cm., the surface is much buckled, white, with no visible sclerotes. Later these form in abundance and the surface shows similar colours to those developed on malt agar, with numerous pale exudate droplets.

The reverse is buckled, cinnamon-clay to tawny olive (XXIX), with a white margin.

Morphology. The smooth-walled conidiophores arise from trailing hyphae. Some are of the monoverticillate type, but the majority on malt become once branched in a divaricate fashion. Each branch is 10-15 μ long, slightly swollen at the tip, and bears a few sterigmata (7-8 μ) which narrow at their tips and produce chains of smooth elliptical spores 2·5 × 2 μ. On Czapek agar the conidiophores are more complex, often branched at some distance below the apex, and each branch bearing three or four metulae with sterigmata of similar dimensions to those on malt. The sclerotes are small, rather regular in shape, globose to elliptical, with an average size of 200 × 160 μ. Under the microscope they appear an orange-pink colour. The surface is smooth and shows an outer coat of thickened angular cells. They are hard and brittle and when cracked exude a quantity of oil, but there is never any trace of ascal development.

The features of diagnostic significance are:

(1) The formation at an early stage of growth on malt agar of the pinkish sclerotes, and their non-appearance at the same age on Czapek agar.

(2) The smooth-walled conidiophores of a divaricate pattern.

(3) The elliptic smooth-walled spores.

Isolated from the litter collected under *Banksia marginata* and *Leptospermum myrsinoides* when samples were plated out with malt agar at 60° and 80° C.

Penicillium lilacinum Thom. U.S. Dept. Agr. Bur. Anim. Ind. Bul., 118, 1910.

Malt. In 14 days the colony diameter is 5·5 cm. The upper surface is floccose, pinkish vinaceous (XXVII), with white margin.

The reverse shows shades of russet, vinaceous to sorghum brown (XXXIX) in faint zones. In age, dark shades to almost black form in the centre of the colony.

Czapek. A colony of 4 cm. diameter develops in 14 days. The surface is floccose, at first white, later becomes deeper than corinthian pink (XXVII).

The reverse is rather drab with vinaceous colours forming towards the margin of the colony.

Raulin. Rate of spread similar to that on Czapek. The surface is floccose, corinthian pink to pinkish vinaceous, the centre often overgrown with a white felt.

The reverse shows slight circular buckling and the colours that develop are similar to those on malt.

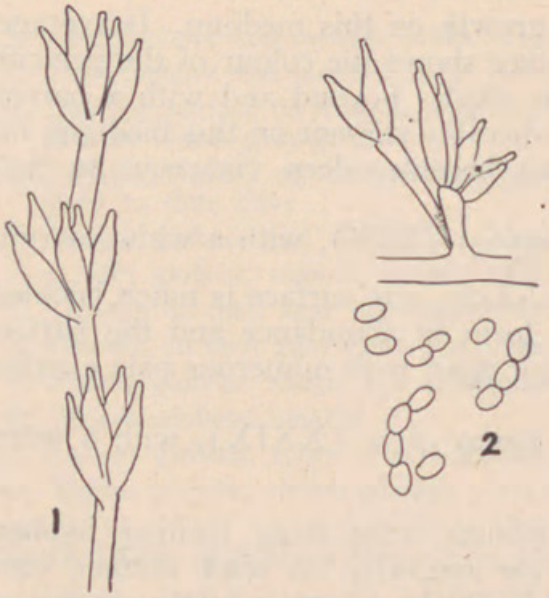

FIG. 16.—*P. lilacinum* Thom. 1. Details of penicillus, × 600. 2. Spores, × 600.

Morphology. The smooth-walled conidiophores are extremely variable in form. Sometimes they are very short, almost sessile, on aerial trailing hyphae. The longer ones arise from the substratum and bear complex penicilli of varying pattern. Sometimes verticils of sterigmata are borne for some distance along their length. The sterigmata appear to fall away readily; they are 5-8 μ long and bear rather short and tangled spore chains which fall apart on mounting. The spores are elliptical, 2·5-3 μ in their longest axis, smooth-walled and pale lilac tinted.

This species is characterized by the lilac-coloured sporing surface.

Isolated from the Mallee soils (Mildura) at 35 in. level.

Penicillium janthinellum Biourge, in Monogr., La Cellule 33, 1923.

Malt. In 14 days colony diameter is 6-7 cm., the surface is floccose. Some strains remain white for a longer period than others, but eventually become light grey (dawn to hathi grey (II)) and then greyish blue-green (XLVIII). Pink exudate drops may be present.

The reverse is olive yellow (XXX), deeper at the centre and fading outwards to paler tones. Later, characteristic bands of olive green radiate from the centre to the edge of colony.

Malt slopes in age may be vinaceous fawn (XL) or carmine to ox-blood red (I) in reverse, and the upper surface may show pink colouration mixed with the grey to drab surface.

Czapek. In 14 days the colony diameter is 4-5 cm. and the surface is slightly floccose. The isolations are variable in colour, in early growth white, and some may remain almost sterile. More usually the mycelium becomes flecked with flesh tints, and finally storm grey (LII) shades appear.

The reverse early in growth is chamois (XXX) and the later colours are very variable, from almost colourless, sometimes with pink or vinaceous shades, to rufous red (XIV) with coral red (XIII) patches.

Raulin. In 14 days colony diameter 4-5 cm., slightly floccose; hathi to storm grey (LII). Yellow exudate drops may be present; in age, deep to dark olive grey (LI).

The reverse is variable in colour in early growth but eventually shows shades of rather bright green (XXX-XXXI), with brown to red to purple (XXV) colours developed unevenly through it.

Morphology. The conidiophores arise from the trailing hyphae or sometimes from ropes. They are very variable in length, some very short (5 μ). These are of the monoverticillate type, but the majority are much longer. These may be branched at some distance from the apex. Often the conidiophore forks close to the tip and the diverging branches bear diverging metulae with swollen ends, or again the

diverging metulae (approx. 10 μ long) may be formed in a verticil. The walls of the conidiophore and of the hyphae may be roughened. The sterigmata are narrow and taper to a fine point (5-7 μ long). The spores are elliptical when formed and smooth-walled, but become sub-globose (2-2·5-3 μ) and slightly roughened when mature.

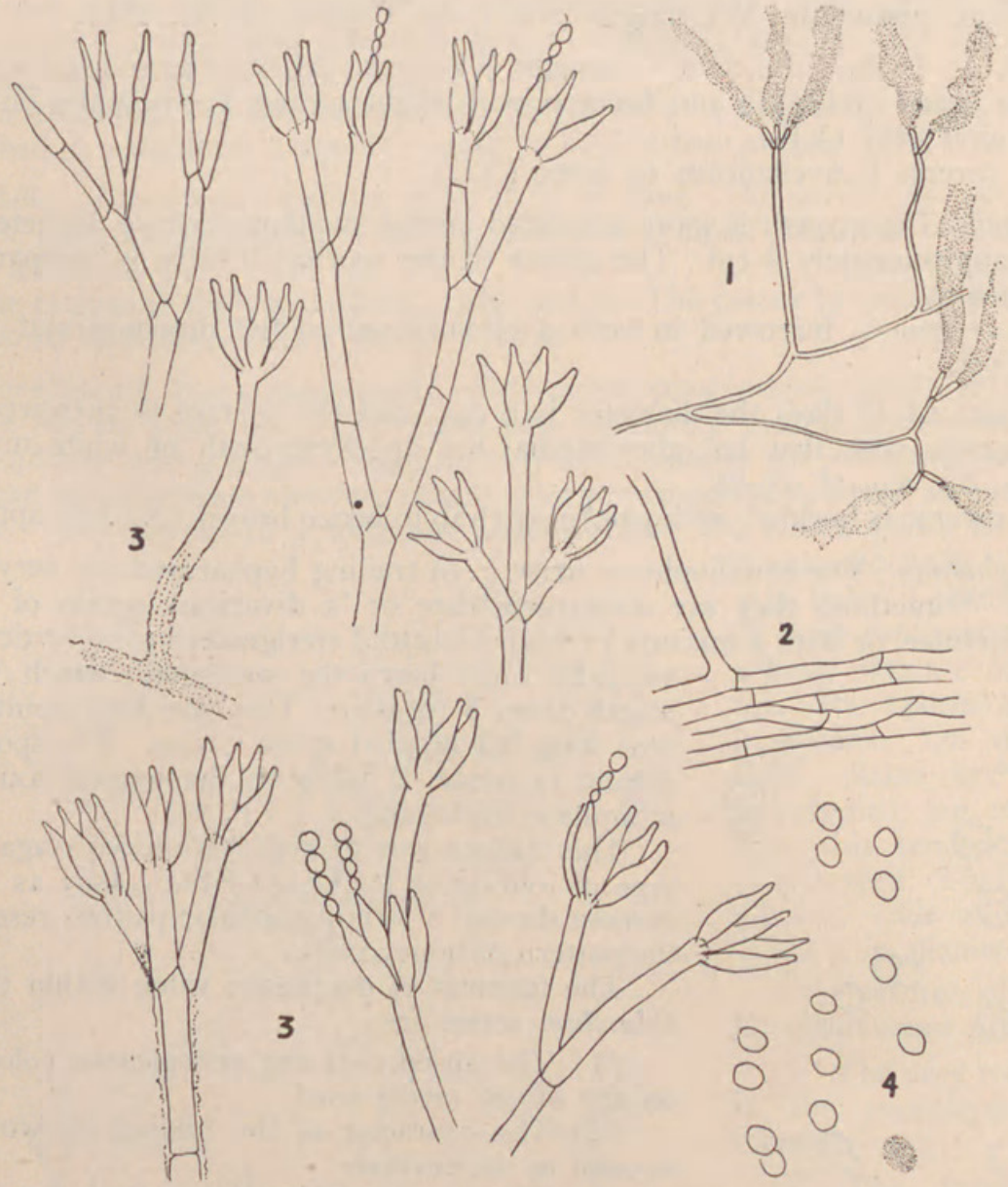

FIG. 17.—*P. janthinellum* Biourge. 1. Habit sketch. 2. Rope, × 600. 3. Details of conidiophore and penicillus, × 600. 4. Spores, × 600.

Some strains (C_{15}, A_{22}) isolated by us appeared as a rule to be predominantly monoverticillate; only occasional branched penicilli occurred. The growth characters (although occasional strains lacked the typical pigmentation), the morphology of the sterigmata, the spores and spore chains agreed with *P. janthinellum* Biourge, and Raper (in correspondence) agrees that these forms should be assigned here.

The features which are of greatest diagnostic value in this variable species are:

(1) The broadly spreading colony on malt agar, with light grey sporing shades.
(2) The character of the reverse on malt agar.

(3) The development of the pink to red shades in reverse on old malt slopes.
(4) The colours developed in reverse on Raulin's agar.
(5) The morphology of sterigmata and spores.
Isolated from the A, B and C horizons of the Frankston sandy podsol.

Penicillium piscarium, Westling in Arkiv. für Botanik II, 54, 1911.

Malt. In 14 days the colony diameter is 7-8 cm. At first the sporing surface is artemisia green (XLVII) and floccose, with slight zoning, but becomes olive grey to deep olive grey (LI).
The reverse is avellaneous to fawn (XL).

Czapek. The growth is more restricted on this medium; colony diameter at 14 days is approximately 4 cm. The colour of the sporing surface is comparable to that on malt.
The reverse is furrowed in both a circular and radial direction and is light buff (XV).

Raulin. At 14 days the diameter is 6 cm., and the surface is furrowed. The colour agrees with that on other media, but an overgrowth of white mycelium occurs in the central region.
The reverse is buckled, with patches of drab to benzo brown (XLXI) appearing.

Morphology. The conidiophores arise from trailing hyphae and are very varied in form. Sometimes they are monoverticillate or 'a divaricate group of two to several metulae' or with a mixture of branchlets and sterigmata in the verticil. The vesicular apex bears the sterigmata which vary in length from 5 to 10 μ. They are long pointed and bear long but tangled spore chains. The spores are elliptic to ovate, 2·5-3 μ in the longest axis, with echinulate thickenings.

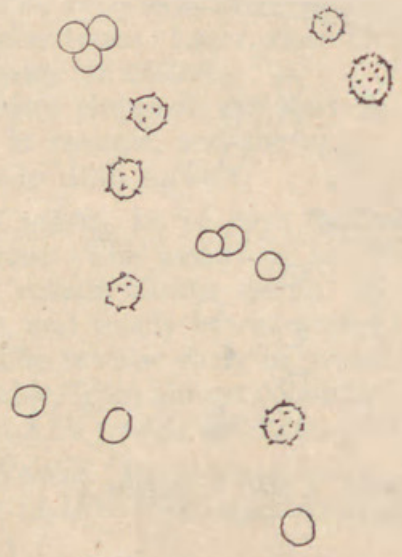

FIG. 18.—*P. piscarium* Westling. 1. Spores, × 600.

This fungus was grown also on wort agar. The type of folding or buckling of the colony as seen in reverse showed a striking cellular pattern resembling the pattern of honeycomb.
The features of diagnostic value within the *janthinellum* series are:
(1) The absence of any conspicuous colouration on any of the media used.
(2) The character of the folding on wort agar as seen in the reverse.
(3) The very variable character of the conidiophores.
(4) The echinulate elliptic to ovate spore. (The echinulations in our strain were not very well developed.)

This species has been isolated only once and was obtained from B horizon of the Frankston sandy podsol.

Penicillium canescens Spp. Monogr., 1912.

Malt. In 14 days the colony diameter is 7·5 cm. The surface is floccose; at the centre the colour is deep slate green to deep slate olive (XLVII), becoming paler

outwards, with tufts of greyish mycelium right across the surface, and with a broad white margin.

The reverse shows greenish buff shades with a faint pinkish drab centre (capucine buff or pinker (III)), and the same colour appears towards the margin.

Czapek. The colony diameter is 4·5 cm. at 14 days. The surface is floccose (not deeply) in shades of glaucous blue to bluish grey-green (XLII), the surrounding agar with vinaceous shades.

The reverse is not buckled and is russet (XV) at the centre, paler beyond in buff shades, sometimes deepening again to dull indian purple (XLIV).

Raulin. The colony diameter is 6 cm. in 14 days. The surface is floccose, deep to dark glaucous grey-green (XLII), with a few small colourless exudate drops and a white margin.

The reverse is slightly buckled at the centre. The colour is yellow ochre (XV) with some buckthorn brown shades (XV).

Morphology. The conspicuously rough conidiophores arise mainly from trailing hyphae but on malt agar some ropes are definintely present and subtend short conidiophores (40 μ long). Many of the conidiophores are comparatively simple and bear two divaricate metulae; others are more complex, and bear as many as five or six. They are 10-15 μ long and together with the conidiophore have much-roughened walls. Each metula bears a whorl of four to eight sterigmata, about 7 μ long, with a short narrow tip. The spores are borne in chains. On malt agar these chains are grouped in columns, but on Czapek agar this tendency is less pronounced. The spores are globose with rough walls 2-2·5 μ in diameter.

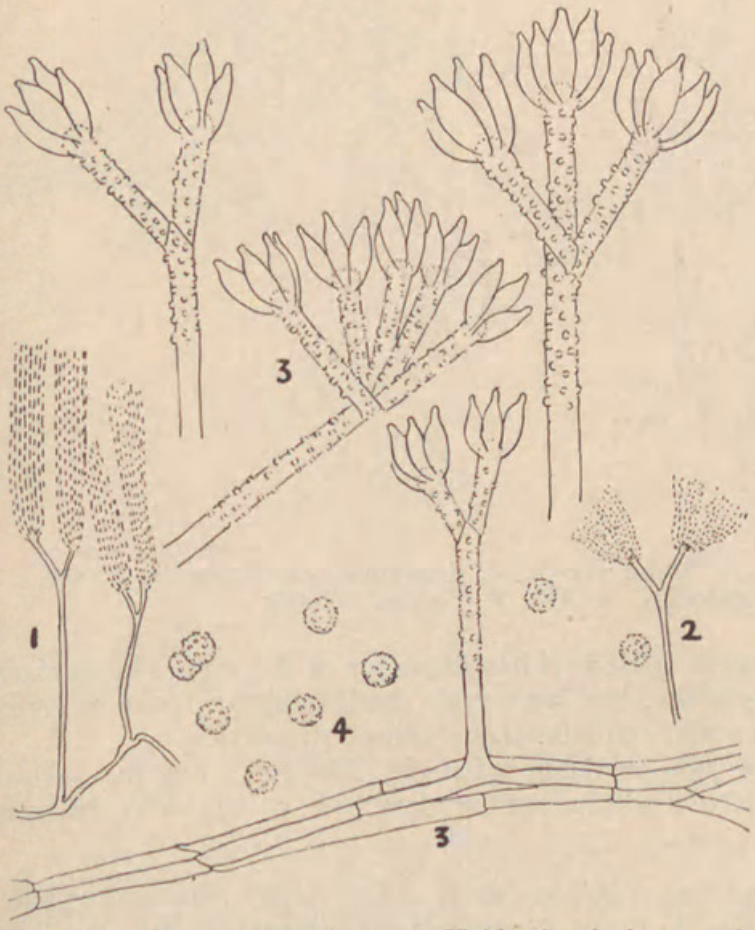

FIG. 19.—*P. canescens* Sopp. 1. Habit sketch from malt agar. 2. Habit sketch from Czapek agar. 3. Rope, conidiophores and penicilli, × 600. 4. Spores, × 600.

The features of diagnostic significance are:

(1) The very rough walls of the conidiophores and metulae.

(2) The formation of spore columns at least in young cultures.

(3) The grey-green sporing surface.

(4) The globose rough-walled spores.

Isolated from litter under *Banksia marginata,* when samples were poured with malt agar at 60° and 80° C.

Penicillium Godlewskii Zaleski. Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

Malt. The growth on malt is somewhat restricted. In 14 days the colony diameter is 3-3·5 cm. At first the surface is almost velvety and artemisia green (XLVII), but later becomes more floccose and storm grey or deeper (LII) in colour. An exudate in the form of yellow droplets is often present in the earlier stages of growth.

The reverse is benzo brown to fuscous (XLVI). The colour appears early and diffuses out into the medium.

Czapek. In 14 days the colony diameter is 2·5-3 cm. The margin is irregular and the surface is at first white, but ultimately becomes pale green (celandine to artemisia green (XLVII); an exudate of pale yellow droplets often present.

The reverse in youth is a light greenish yellow (chalcedony yellow (XVII)), but later develops brown colours and may deepen to the dark brown characteristic of growth on malt; colouration of the medium may occur.

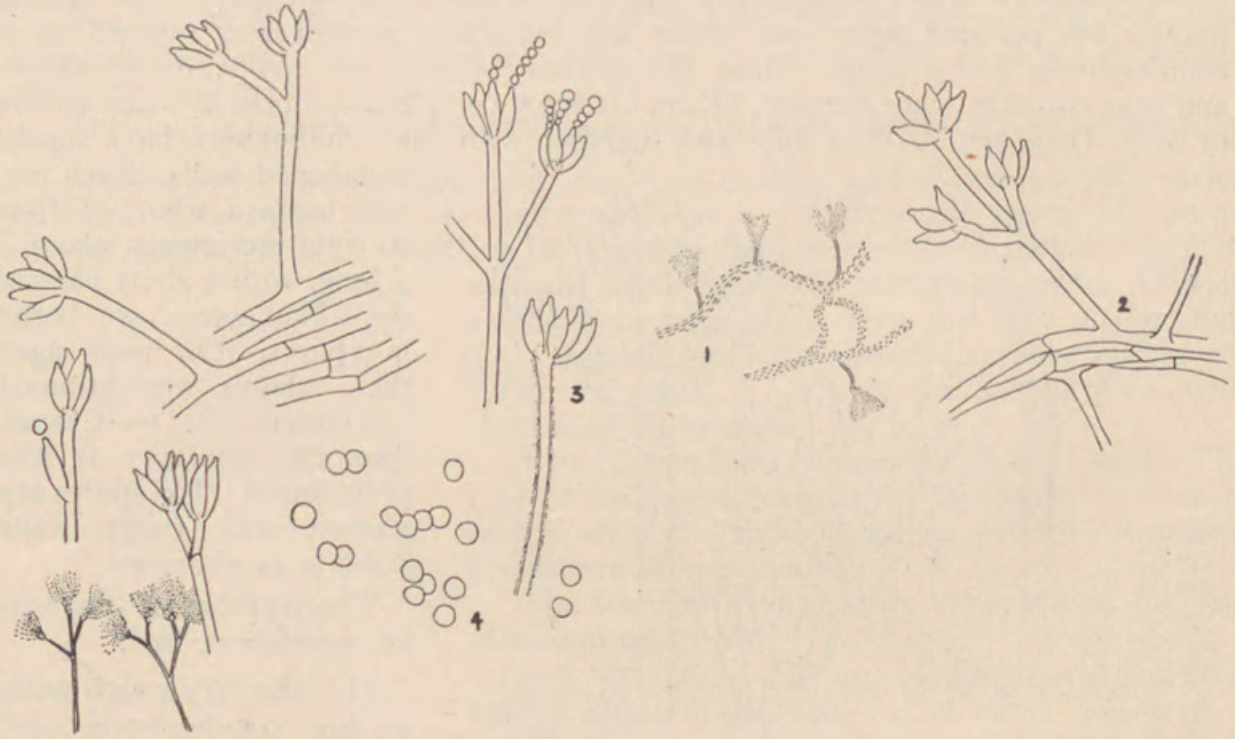

FIG. 20.—*P. Godlewskii* Zaleski. 1. Habit sketch. 2. Ropes and conidiophores, × 410. 3. Details of penicillus, × 410. 4. Spores, × 410.

Raulin. In 14 days the colony is folded with a diameter of 2·5 cm. The surface is slightly floccose. At first it is white, but later grey shades appear (mineral grey to storm grey (LII)) with an exudate of numerous yellow droplets.

The reverse is much folded and becomes intensely coloured (fuscous brown to fuscous black (XLVI)). The medium surrounding the colony may become yellowed.

Morphology. Some conidiophores (500 μ) arise singly from trailing hyphae; others from ropes, in which case they are comparatively short (15-30 μ). The walls may be smooth or slightly roughened. They bear very diversified penicilli; some are monoverticillate, with only a few sterigmata, others bear one diverging

branch, and others again are more complex but typically divaricate. The sterigmata are usually few and measure 6-8 μ long by 2-3 μ wide. They bear short tangled chains of spores which are globose to sub-globose, smooth-walled, and measure 2-2·5-3 μ.

The features of diagnostic significance within the *janthinellum* series are.

(1) The more or less restricted growth on all media (including malt).

(2) The deep brown colouration in reverse, particularly on malt and Raulin agar, with some colouration of the medium.

(3) The presence of 'ropes' from which conidiophores may arise.

(4) The shorter and blunter sterigmata.

Isolated from the A and B horizons of the Frankston sandy podsol and from the rhizosphere of *Epacris impressa* growing in that habitat.

Penicillium albidum Sopp. Monogr., 1912.

Malt. In 14 days colony diameter is 2 cm. The surface is almost velvety, at first in green tints, but becoming castor grey (LII) or deeper at the centre, fading outwards to a lighter grey colour, with a narrow white margin.

The reverse presents a faint greenish drab appearance.

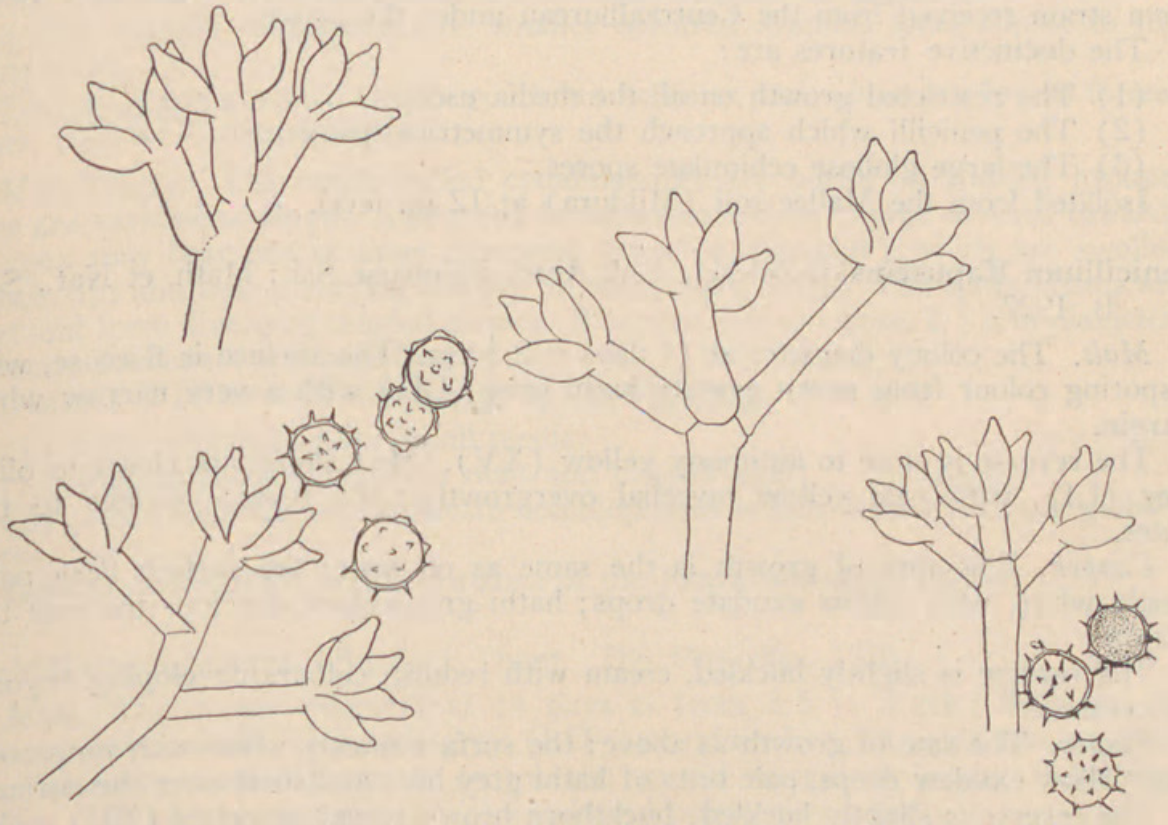

FIG. 21. *P. albidum* Sopp. 1. Details of conidiophore and penicillus, × 600. 2. Spores, × 600.

Czapek. The colony diameter is the same as that on malt. The surface is slightly floccose and entirely white.

The reverse is uncoloured.

Raulin. The growth on this medium is even more restricted and buckled, reaching only 1 cm. in 14 days. The sporing surface is slightly floccose and in light grey tones.

The reverse tends to lift away from the agar and shows slight yellowish-green tones.

Morphology. The smooth-walled conidiophores arise from trailing hyphae or from the substratum. They often appear to be truly bi-verticillate and symmetrical, but even then the metulae are slightly diverging; at other times the divergence is more marked, usually 8-10 or 12 μ; occasionally an odd one may be 20 μ. Each bears a whorl of six or eight short and plump sterigmata; 5 μ is the average length. The spores readily fall away; they are globose, light brown, 5 μ in diameter, and distinctly and rather coarsely echinulate. In old spores the thickenings appear blunter at the tips.

A number of the penicilli conform to the Bi-verticillate symmetrical pattern, but it does not agree with any of the known species in that section and as there are always some divaricate fruiting structures, it is probably best considered in the *Asymmetrica-divaricata.*

The identification of this form is provisional. It remains white and floccose on Czapek and forms echinulate globose spores comparable to those of *P. nigricans.*

The reverse does not show reddish yellow shades as recorded by Sopp for *P. albidum* and the spores are larger than 4 μ, the size quoted by Raper and Thom for a strain received from the Centraalbureau under this name.

The distinctive features are:

(1) The restricted growth on all the media used.
(2) The penicilli which approach the symmetrical pattern.
(3) The large globose echinulate spores.

Isolated from the Mallee soil (Mildura) at 12 in. level.

Penicillium Kapuscinskii Zaleski. Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

Malt. The colony diameter at 14 days is 2·5 cm. The surface is floccose, with a sporing colour from storm grey to hathi grey (LII) with a very narrow white margin.

The reverse is close to antimony yellow (XV). Malt slopes are closer to olive grey (LI), with pale yellow mycelial overgrowths; the reverse similar to the plates.

Czapek. The rate of growth is the same as on malt; the surface very pale, mostly white, with yellow exudate drops; hathi grey colour develops towards the margin.

The reverse is slightly buckled, cream with reddish colours developing beyond the centre.

Raulin. The rate of growth as above; the surface mostly white with numerous deep yellow exudate drops, pale tints of hathi grey here and there over the surface.

The reverse is slightly buckled; buckthorn brown to yellow ochre (XV), paler towards the margin.

Morphology. The conidiophores are similar to those of *Penicillium nigricans.* The microscopic feature that characterizes this species is found in the spores, which resemble those of *nigricans* in size, but which have a finely roughened epispore.

The distinctive features of this species are:

(1) The close resemblance to *P. nigricans.*
(2) It differs from that species in the generally paler colours, of both the sporing surface and reverse, produced on agar media,

(3) And in the finely roughened to almost smooth spore surface.
Isolated from Mallee soils (Mildura) 8 in. from surface.

Penicillium melinii Thom. The Penicillia, 1930.

Malt. In 14 days colony diameter is approximately 3 cm. The colony is orbicular, floccose; at first mineral grey, but later becomes deep to dark olive grey (LI) with a narrow white margin. Numerous colourless exudate droplets are formed over the surface.

The reverse is somewhat zoned and shows shades of greenish buff, becoming putty coloured.

Czapek. The growth on this medium is at the same rate as on malt. The surface is floccose, at first white then deep to dark olive grey with numerous yellow exudate droplets and a narrow white margin.

The reverse is at first greenish buff, but later pink colours appear which in age may deepen to vinaceous tints; puckered.

Raulin. The rate of growth is as on the other media. The surface is floccose and at first mineral grey with yellow droplets, becoming greyish olive to deep greyish olive (XLVI), the centre appearing almost an orange colour from the large and brightly coloured drops; smaller coloured droplets form almost to the colony edge.

The reverse is greenish buff in youth but becomes dark vinaceous brown to seal brown (XXXIX) and puckered.

Morphology. The rough-walled conidiophores are borne on trailing hyphae. They are variable in length. They may be monoverticillate in type or each towards the apex may bear one or more diverging branches (metulae) which are swollen at their tips and bear a varying number of stergimata, 5-7 μ. The spore chains are short and form diverging tangled masses. The spores are globose, 2·5 μ in diameter, distinctly echinulate and pale tinted.

Distinctive features of this species of the *nigricans* series are:

(1) Grey sporing shades on all media.
(2) Pale-coloured reverse on malt and Czapek agar.
(3) The rough-walled divaricate conidiophores which bear echinulate globose spores.

Isolated from the A and C horizons of the Frankston sandy podsol.

Penicillium nigricans (Bainier) Thom. The Penicillia, 1930.

Malt. The colony diameter at 14 days is from 3·5 to 5 cm.; floccose; the sporing surface storm to castor grey (LII), margin white; in some strains white mycelial overgrowths appear at centre and spread irregularly across the colony surface. On malt slopes pale (pink) exudate droplets may occur.

In reverse shades of sayal brown to sepia (XXIX) extend practically to the margin. Sometimes the brown colour diffuses into the medium.

Czapek. Growth is more restricted on this medium. At 14 days the diameter is from 3 to 4 cm. The surface is floccose and puckered. Some isolations only tardily develop sporing colours which vary from glaucous grey (XLVIII) to storm grey (LII), with numerous pale yellow exudate droplets.

The reverse is at first pale and puckered radially, sometimes buckling upwards; buffy patches appear and in some isolations the colour deepens as on malt.

Raulin. The rate of growth is comparable to that on Czapek agar. The surface is floccose and puckered; at first storm grey but deepening to castor grey; pale yellow exudate droplets present.

The reverse is in deep brown shades at the centre (benzo brown to fuscous (XLVI)) with vinaceous buff tints beyond. The puckering is in a radial and a concentric pattern.

Morphology. The smooth conidiophores arise from trailing hyphae or from the substratum. They are very variable in length. Many of them are very short, 10-15 μ before branching; the longer ones are variously branched. Sometimes a branch arises some distance from the apex but ultimately the branches and the axis itself give rise to three or more diverging metulae approximately 10 μ long. These are swollen at their tips and bear rather short (5-7 μ) and stout sterigmata. The spore chains form short twisted masses. The spores are globose, averaging 3 μ, brown and spiny.

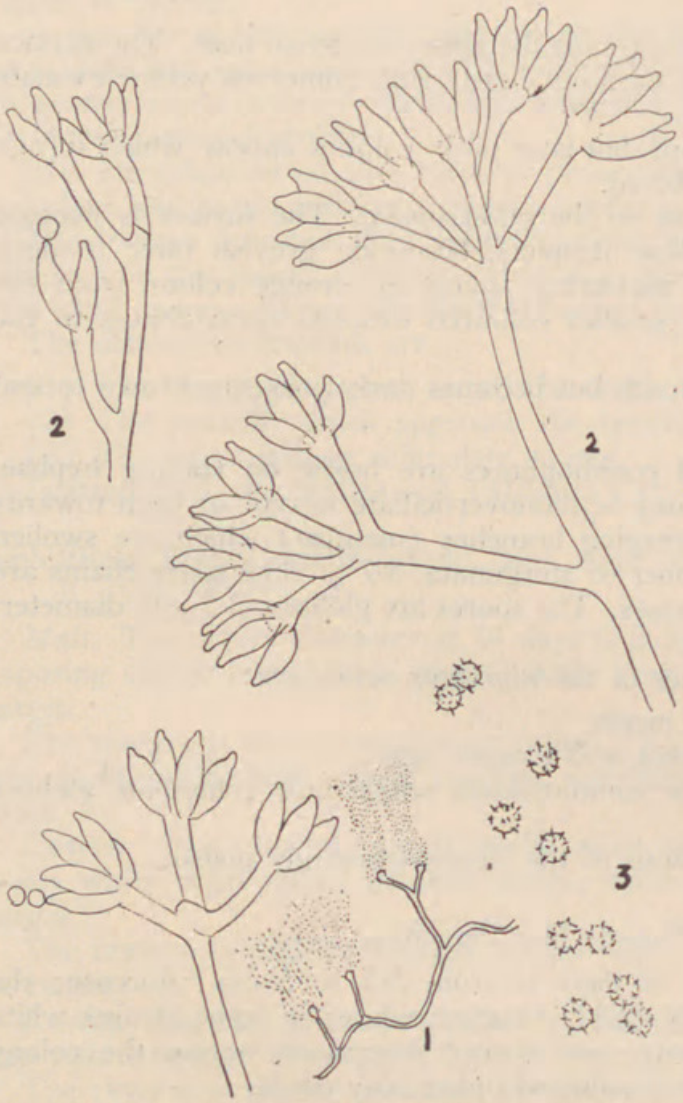

FIG. 22.—*P. nigricans* (Bainier) Thom. 1. Habit sketch. 2. Details of conidiophore and penicillus, × 600. 3. Spores, × 600.

The features of diagnostic value for this species are:

(1) The grey sporing shades on all media.

(2) The dark brown colours formed in reverse on malt and Raulin; sometimes also on Czapek.

(3) The smooth divaricate conidiophores bearing brown-coloured and spiny spores.

Isolated from the A, B and C horizons of the Frankston sandy podsol and from the litter under *Epacris impressa,* as well as from the Mallee soils (Mildura) at 5 in., 6 in. and 8 in. levels; also from a mountain loam at Bogong High Plains, Victoria, at 5-13 in. depth.

Penicillium Raciborskii Zaleski. Bul. Acad. Polonaise Sci.: Math. et Nat., Ser. B, 1927.

Malt. In 14 days the colony diameter is 4-4·5 cm. The sporing surface is at first velvety, but becoming floccose; slate olive (XLVII) at centre, paler at margin.

The reverse develops ochraceous orange shades (XV) and the colour may diffuse out into the surrounding medium.

Czapek. Growth on this medium is slower than on malt agar; 3·5 cm. in 14 days. The sporing surface at first is mineral grey to gnaphalium green (XLVII). It later becomes shades of neutral grey (LIII), with the edge almost sky-blue; abundant yellow droplets may or may not form over the folded surface.

The reverse varies with the isolation; sometimes ochraceous orange in centre, fading conspicuously towards the margin, sometimes paler in peach shades, developing in age to vinaceous tints.

Raulin. Rate of growth comparable to that on malt agar (4 cm.). In youth the upper surface is white with yellow droplets present. Later it becomes court grey or deeper (XLVII), dark yellow droplets mostly present, and the surface is puckered.

The reverse becomes ochraceous orange (XV) or deeper and is puckered, often in a circular pattern.

Morphology. The microscopic characters agree closely with those described for *P. melinii.* The conidiophores are coarsely roughened and the spores are globose, 2 μ, with a finely roughened wall.

This species is closely allied with *P. melinii,* from which it differs in spore characters. They are smaller on the average and not echinulate, although our isolations show the wall to be finely roughened.

Isolated from the B horizon ('coffee-rock') of the Frankston sandy podsol.

THE ASYMMETRICA-VELUTINA

KEY TO THE ASYMMETRICA-VELUTINA

1. Normal type of growth occurring on Czapek agar .. .. .. 2.
1. Very poor thin growth on Czapek agar and no sporing colours developed .. .. *P. digitatum*
2. Reverse of colonies developing yellow pigments on the three media .. *P. chrysogenum*
2. No yellow pigments formed; the reverse in vinaceous to purplish shades .. .. *P. meleagrinum*

Penicillium digitatum Sacc. Mycotheca italica Padua, 1898-1913.

Malt. The colony diameter measures 7-7·5 cm. at 14 days; although spreading, the growth is thin and velvety. The sporing colour is in yellow-green shades, best matched as mignonette (XXXI) to vetiver green (XLVII); there is an irregular white margin.

The reverse shows the green shades through the thin mycelial mat.

Czapek. The growth is exceedingly thin, but stretches across 3 cm. in 14 days. No sporing colours develop.

Raulin. The growth is also very thin, but measures 4-6 cm. at 14 days. Mignonette shades develop late (12 days).

The reverse is pale; the sporing colour shows through and in age pale vinaceous fawn shades develop.

Morphology. On malt agar the conidiophores vary in length. They bear sporing heads that are difficult to observe in microscope mounts. Towards the apex the branches arise irregularly, but the pattern of the penicilli is of the asymmetric type. Each branch may bear either metulae or sterigmata or both. The sterigmata are

of variable length; in our isolations they were approximately 20 μ long, and they support long and lax spore chains. The spores vary in shape and size, even in the same spore chain. They are usually elliptic to long cylindrical, 7 × 4 μ to 10 × 4 μ, smooth and dark green in mass.

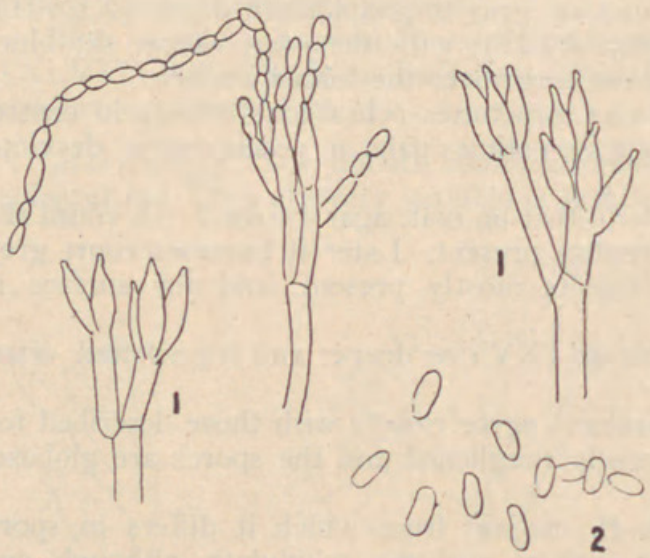

FIG. 23.—*P. digitatum* Sacc. 1. Details of penicillus, × 290. 2. Spores, × 290.

This species is characterized in the velvety series of the *Asymmetrica* by:

(1) The poor growth on Czapek agar.

(2) The colour of the sporing surface on malt.

(3) The strong odour developed in culture.

(4) The morphology of the penicilli and spores.

Isolated from the A horizon of the Frankston sandy podsol, and from Mallee sand (Mildura) at a depth of 8 in.

Penicillium chrysogenum Thom. U.S. Dept. Agr. Bur. Anim. Ind. Bul., 118, 1910.

Malt. The colony diameter measures 6 cm. at 14 days. The upper surface is velvety; at first artemisia to lily green, in age it becomes deep slate green (XLVII), passing outwards to lily green with a white margin. Pale to deep yellow droplets form over the area. In some strains isolated from soil the droplets are colourless.

The reverse is typically strontian yellow to yellowish citrine (XVI). The yellow pigment diffuses out into the medium. Occasionally strains are isolated that show a pale reverse and no colouration of the medium occurs.

Czapek. The colony diameter at 14 days measures 3-4 cm. The upper surface is velvety; at first gnaphalium green, later deep bluish grey-green (XLII) to lily green; and densely covered with yellow droplets; with a white margin. In age the surface may be floccose and faint shades of pink may develop in the hyphae.

The reverse is buckled radially. Early it is an intense light greenish yellow, becoming chalcedony yellow (XVII). Some strains develop a vinaceous tint at first, but later yellow colours appear (more quickly at warmer temperatures), and the yellow pigment diffuses into the medium.

Raulin. The diameter of the colony at 14 days is 3·5-4·5 cm. The sporing surface, which is velvety to slightly floccose, passes from artemisia green through lily green to deep bluish grey-green with numerous yellow to pale droplets and a narrow white margin.

The reverse is circularly buckled; at first chamois (XXX), in some strains the colour quickly changes to empire or apricot yellow (IV) with yellow pigment in the medium. In others the reverse remains in pale shades.

Morphology. The conidiophores arise from the substratum or from trailing hyphae. They are long, smooth-walled, and bear one or more branches near their

tips. Each branch, as well as the main axis, supports a verticil of metulae; each metula is 10-12 μ long. The sterigmata (10 μ) stand close together, so that the whole head is of a typical bi-verticillate asymmetric type. The spore chains are columnar. The spores are elliptical, 3-4 $\mu \times 2{\cdot}5$-$3{\cdot}5$ μ, and smooth.

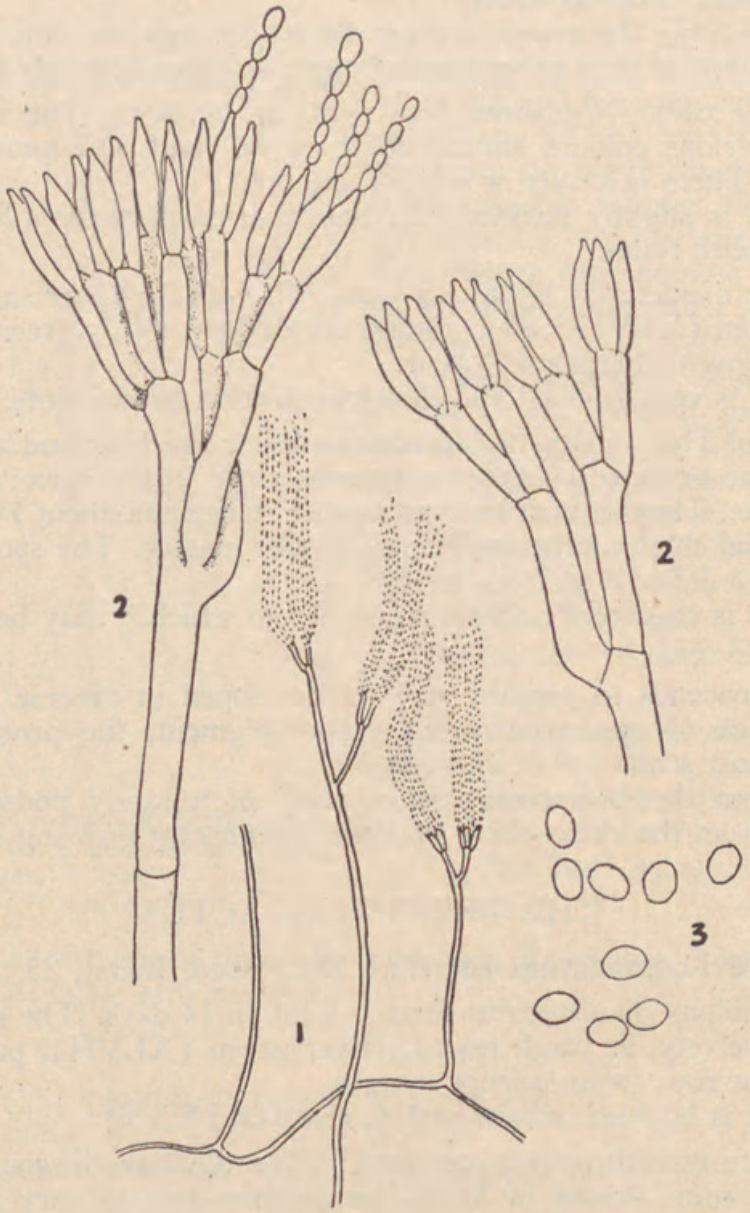

FIG. 24.—*P. chrysogenum* Thom. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

The features characteristic of this species:

(1) The production of the yellow pigment in reverse and its appearance in the medium when the fungus is grown on Czapek agar. In some strains it is late in appearing and much reduced in intensity.

(2) The smooth-walled conidiophores and smooth elliptic rather large spores. Isolated from the B and C horizons of a sandy podsol at Frankston, Victoria.

Penicillium meleagrinum Biourge. La Cellule, 33, 1923.

Malt. The colony diameter in 14 days was 6-7 cm. The upper surface is velvety and becomes dark american green (XLI) to lily green (XLVII) and zoned. The degree of zonation varies with the strain. There is a white margin. Colourless or pale yellow exudate droplets occur.

The reverse shows the green sporing shades through the otherwise uncoloured background. In age, a pink to vinaceous colour develops towards the centre.

Czapek. The colony measures 4-4·5 cm. in 14 days. The upper surface is velvety and develops colours similar to those on malt and numerous colourless droplets form. There is a narrow white margin.

The reverse is slightly buckled. At first it is avellaneous (XL) and later it shows dull purplish tones.

Raulin. The diameter at 14 days is 4 cm. The velvety upper surface is artemisia to celandine green (XLVII) when young, but darkens to lily green in age. Colourless or pale yellow droplets may occur.

The reverse is very buckled and develops drabish brown tints.

Morphology. The smooth-walled conidiophores are long and arise close to the substratum. One or more branches may arise close to the apex; each bears three or more metulae. They in turn bear groups of sterigmata about 7-8 μ long. These bear long conidial chains, adhering in column-like masses. The spores are elliptical, smooth-walled, 3-3·5 μ × 2-2·5 μ in size.

This species is close to *P. chrysogenum,* from which it may be distinguished in culture by:

(1) The vinaceous to purplish colours developed in reverse on Czapek agar.

(2) The lack of any pronounced yellow pigment, the production of which characterizes most strains of *P. chrysogenum.*

Isolated from the B horizon 'coffee rock' of a sandy podsol at Frankston, Victoria, and from the rhizosphere of *Epacris impressa* growing in that habitat.

THE BREVI-COMPACTUM

Penicillium brevi-compactum Dierckx. Soc. Scien. Brux., 25, 1901.

Malt. The colony diameter measures 1·3 cm. in 14 days. The surface is radially furrowed and velvety, in youth tea to vetiver green (XLVII), passing to andover green with a narrow cream abrupt margin.

The reverse is buckled, cream-buff to chamois (XXX).

Czapek. The growth is very restricted. The diameter measures 1 cm. or less at 14 days. In some strains of MIA_8 the colonies remain very thin and produce few sporing heads; in others the surface is velvety, in some strains remaining pale, close to vetiver green, in others darkening slate-olive to deep slate-olive (XLVII). Numerous pale exudate drops may be present.

The reverse arches away from the medium; in the pale strains it is cream-buff, in the darker strains it is deep to dark olive-grey (LI).

Raulin. At 14 days the colony diameter is 1·2 cm. The surface is elevated and velvety with similar colours to those developed on Czapek agar. The colour extends to the margin, which is abrupt.

The reverse is arched away from the medium and buckled with colours similar to those on Czapek agar.

Morphology. The conidiophores arise from the basal felt. They are smooth-walled and septated, with a tendency for the ramuli and metulae to be somewhat swollen. The whole structure forms a compacted head, typical of the section. There is usually a short (15 μ) appressed branch bearing metulae at the same level as those of the main axis. The metulae tend to widen upwards; they are approximately 10 μ long and bear numerous rather wide sterigmata (8 × 3·5 μ). The spores are borne in short tangled chains. The spores appear elliptic when young and still attached to the sterigmata, but as they mature they become sub-globose, or even globose, somewhat uneven in size, averaging 2·5-3 μ, with smooth walls.

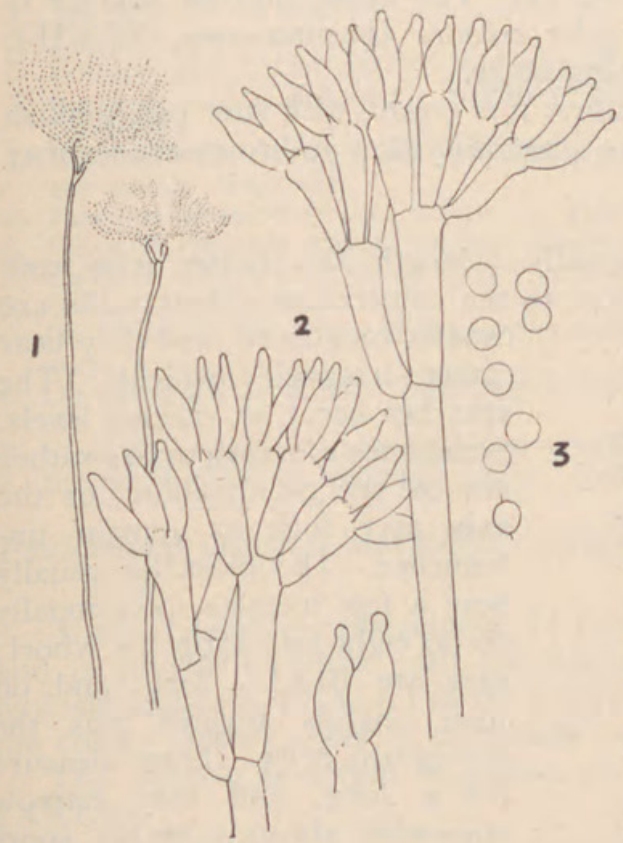

FIG. 25.—*P. brevi-compactum* Dierckx. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

These isolations when grown on Raulin-Thom solution produce phenolic substances which on addition of ferric chloride give the typical bluish crimson colour test (Clutterbuck *et al.*, 1932). According to Smith (1946) all freshly isolated strains of this series give this characteristic reaction.

The features of diagnostic significance are:

(1) The compact character of the penicillus.

(2) The restricted growth on all three media.

(3) The buff to olive-grey buckled reverse.

Isolated from B horizon of the sandy podsol at Frankston, Victoria, and from the Mallee soils, Mildura, at 6 in. level.

THE ASYMMETRICA-LANATA

Penicillium lanosum Westling. Archiv. für Botanik, 11, 1911.

Malt. In 14 days the colony diameter is 6 cm. The mealy to floccose upper surface is at first pale shades of green, and later it deepens to lily green (XLVII), then towards deep olive-grey, with a faint zonation. There is a conspicuous white margin.

The reverse is cream to clay colour at the centre, with the green sporing shades showing through.

Czapek. The colony diameter is 3·5-4 cm. in 14 days. The upper surface is floccose, lily green at the centre, with bluish grey-green shades towards the edge; later it shows slate-olive tones and in age pink colours appear in the mycelium. There is a narrow white margin.

The reverse is only very slightly buckled; peach shades to buff pink (XXVIII) develop at the centre; in some strains, yellowish olive (XXX) tones develop.

Raulin. In 14 days the diameter is 4·5-5 cm. The upper floccose surface is pale grey-green, and passes outwards to paler colours (puritan grey, XLVII). Small colourless or pale pink exudate droplets occur.

The reverse is only slightly buckled. At first it is cream, with later pale pinkish buff to vinaceous buff (XL) colours; in age, greenish yellow to brown shades may appear.

Morphology. The conidiophores vary greatly in length; the shorter arise from trailing hyphae, the longer from hyphae close to the substratum. Their walls are usually roughened, and they bear rather irregular penicilli. The branches occur at various levels. Sometimes a branch arises rather low on the conidiophore, or the axis may fork or remain unbranched. The branches usually bear a few metulae, occasionally six to eight may form the whorl; they are 10-12 μ long, and on their slightly inflated tips the sterigmata arise. They measure 5-8 μ long, and they narrow somewhat abruptly at the spore origin. The spore chains are short and rather tangled. The spores are globose or sub-globose, 2·5 μ, and the wall is finely punctate and lightly tinted.

FIG. 26.—*P. lanosum* Westling. 1. Habit sketch. 2. Details of conidiophore and penicillus, × 600. 3. Spores, × 600.

The features characteristic of this species are:

(1) The lack of any pronounced pigment development on the three media used.

(2) The irregularly branched, asymmetric penicilli with branches arising at any level of the conidiophore.

(3) The comparatively small spore.

Isolated from a mountain loam (Bogong High Plains, Victoria) supporting a dense sward of *Poa caespitosa*. The fungus was recovered from the B horizon, between 9-14 in.

THE FASCICULATA

KEY TO THE FASCICULATA

1.	Sclerotes present	*P. Gladioli*
1.	No sclerotes formed	2.
2.	Complex coremia formed	3.
2.	Coremia absent, fascicles of conidiophores usually present	4.
3.	Coremia bearing individual penicilli in both lateral and apical positions	*P. granulatum*
3.	Coremia with clavate heads on which the individual penicilli are not readily discernible	*P. claviforme*
4.	Fascicles of conidiophores reduced or absent on agar media	5.
4.	Fescicles typically present on agar media	7.
5.	Cultures with a pronounced 'musty' odour	*P. expansum*
5.	Odour not pronounced	6.
6.	On all media, the colour of the sporing surface in age dark olive-grey	*P. puberulum*
6.	On all media, the colour of the sporing surface not so dark—close to lily green	*P. Urticae*
7.	Sporing surface on all media bluish grey-green	*P. Martensii*
7.	Sporing surface on all media green; conidiophores rough-walled	*P. viridicatum*

Penicillium Gladioli Machacek. Quebec Soc. for Prot. of Plants, Ann. Rept., 19, 1928.

Malt. The colony diameter at 14 days measures 4 cm. The surface is floccose, and is essentially white until the sclerotes form. It then becomes pale to light pinkish cinnamon (XXIX) in the central regions; the colour finally spreads across the colony surface; pale or colourless exudate droplets may form.

The reverse is cream to white, and in age may become pinkish cinnamon (XXIX).

Czapek. The colony diameter measures 2·5-3 cm. at 14 days. The surface is markedly floccose and white; it later becomes pale to light pinkish cinnamon

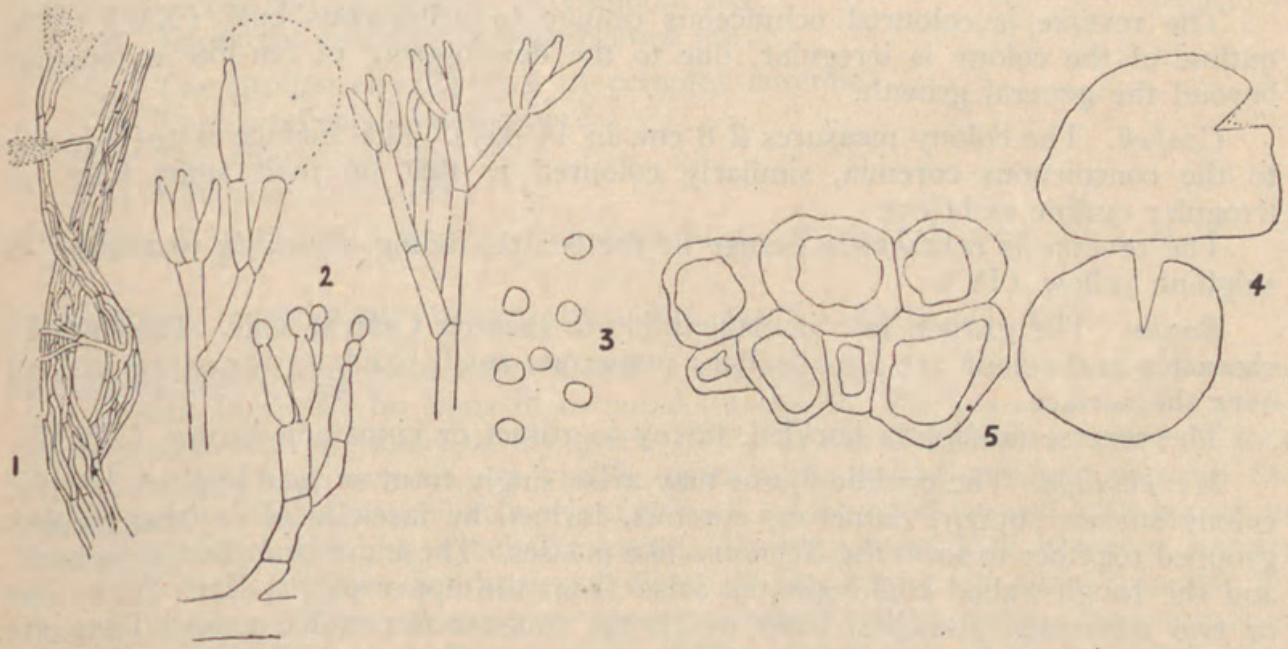

FIG. 27.—*P. Gladioli* Machacek. 1. Ropes with conidiophores, × 50. 2. Details of penicillus, × 460. 3. Spores, × 460. 4. Sclerotes, × 50. 5. Cells of sclerote, × 460.

(XXIX) in the central regions; colourless or pale cinnamon exudate drops usually present. The margin is uneven, more or less fan-like in development.

The reverse is buckled and the colour is much as on malt.

Raulin. The rate of growth and characters of the colony are as for Czapek.

Morphology. The conidiophores form very sparsely on all of the three media, and our cultures never show any green shades after incubation at 16° C. or at 25° C. They vary in length, sometimes being very short (20 μ), but are usually longer. They arise mostly from mycelial ropes, and occasionally from individual hyphae; we have never observed true fascicles or coremia. The axis of the conidiophore may bear one or two branches subtending metulae 10-12 μ long. The sterigmata are mainly 10 μ long, occasionally longer, and taper towards the sporing tip. The spores form tangled chains; each is elliptic to sub-globose, smooth-walled, 2·5-3 $\mu \times 2{\cdot}5$ μ. The sclerotes are found in great numbers, and vary both in size and shape, averaging in our cultures approximately 250 μ. They are pale pinkish cinnamon (XXIX) in colour and hard in texture. The walls are composed of rather unevenly thickened cells approximately 10-15 μ in diameter.

The features of diagnostic significance are:

(1) The abundant formation of sclerotes over a floccose white mycelial mat.

(2) The pale colours of the colony on all three media, even in age.

(3) The formation of ropes from which the conidiophores arise.

(4) The smooth-walled, elliptic to sub-globose spores.

Isolated from Mallee soils at a depth of 8-18 in.

Penicillium granulatum Bainier. Bul. Soc. Mycol. France, 21, 1905.

Malt. The colony diameter is 3 cm. in 14 days. The surface is tufted and floccose, andover to slate green (XLVII), with a narrow white margin. Pale exudate drops form all over the surface. The colony is characterized by the very conspicuous coremia which are often formed in zones.

The reverse is coloured ochraceous orange to ochraceous buff (XV). The outline of the colony is irregular, due to the development of fan-like extensions beyond the general growth.

Czapek. The colony measures 2·8 cm. in 14 days. The surface is tufted, due to the conspicuous coremia, similarly coloured to that on malt agar, with an irregular outline as before.

The reverse is ochraceous orange at the centre, fading outwards to aniline or sulphine yellow (IV).

Raulin. The growth rate is comparable to that on Czapek agar. The surface character and colour are also similar; numerous small exudate drops are present over the surface.

The reverse is slightly buckled, tawny to russet or cinnamon brown (XV).

Morphology. The conidiophores may arise singly from surface hyphae, but the colony surface support numerous coremia, formed by fascicles of fruiting hyphae grouped together to form the *Stysanus*-like masses. These are branched structures, and the rough-walled conidiophores arise from the upper parts. Each bears one or two adpressed branches, from which the roughened metulae arise. They are 8-12 μ, sometimes longer, with numerous sterigmata in verticils at their ends. The sterigmata are rather narrow, about 10 μ long, and from them arise tangled chains

of spores. The spores are strongly elliptical when young, and tend to retain this shape when mature, or they may become sub-globose; they measure 2·5-3 μ in their long axis.

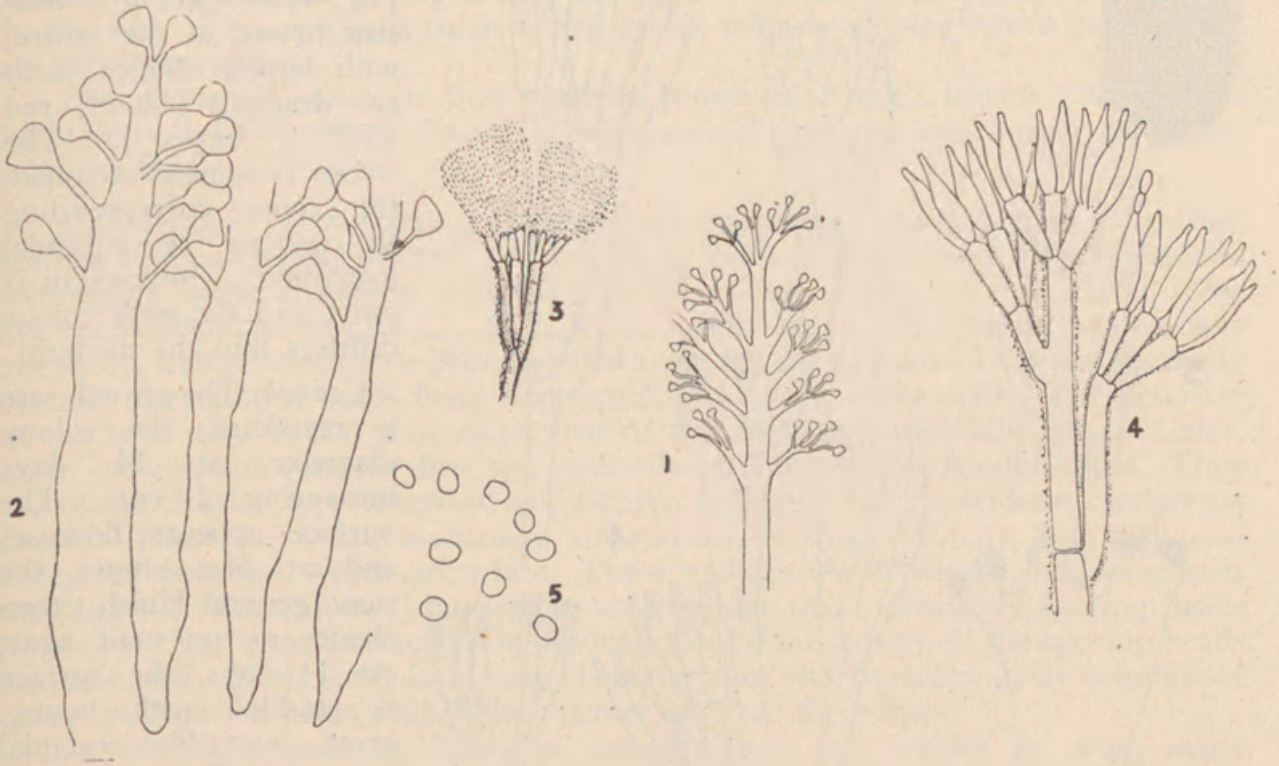

FIG. 28.—*P. granulatum* Bainier. 1. Sketch of coremium. 2. Portion of coremium, × 65. 3. Penicillus, × 65. 4. Details of penicillus, × 600. 5. Spores, × 600.

This isolation has a very strong fragrant odour when grown on agar media, variously identified as aniseed- or camphor-like.

The diagnostic features of significance are:

(1) The profuse development of complex coremia.
(2) The roughened conidiophores.
(3) The elliptic conidia.
(4) The fragrant odour.

Isolated from the A horizon of the sandy podsol at Frankston, Victoria.

Penicillium claviforme Bainier. Bul. Soc. Mycol. France, 21, 1905.

Malt. The colony diameter measures 6 cm. at 14 days. The surface is floccose, and at first there are no signs of coremial formation. The colour is bluish green and approximates artemisia or lily green (XLIII); later it darkens towards slate olive. At 14 days, coremia are visible, particularly in the younger parts of the colony, at a radial distance from the centre of 1·5 cm. and beyond, and appear as erect, whitish, *Isaria*-like mycelial columns. Under a hand lens, however, smaller coremial structures can be discerned closer to the centre, in zones beneath the floccose surface. From above, they appear as round green knobs, but when seen from the side they show distinct white stalks, terminating in the rounded green sporing heads. The margin of the colony is rather thin and white.

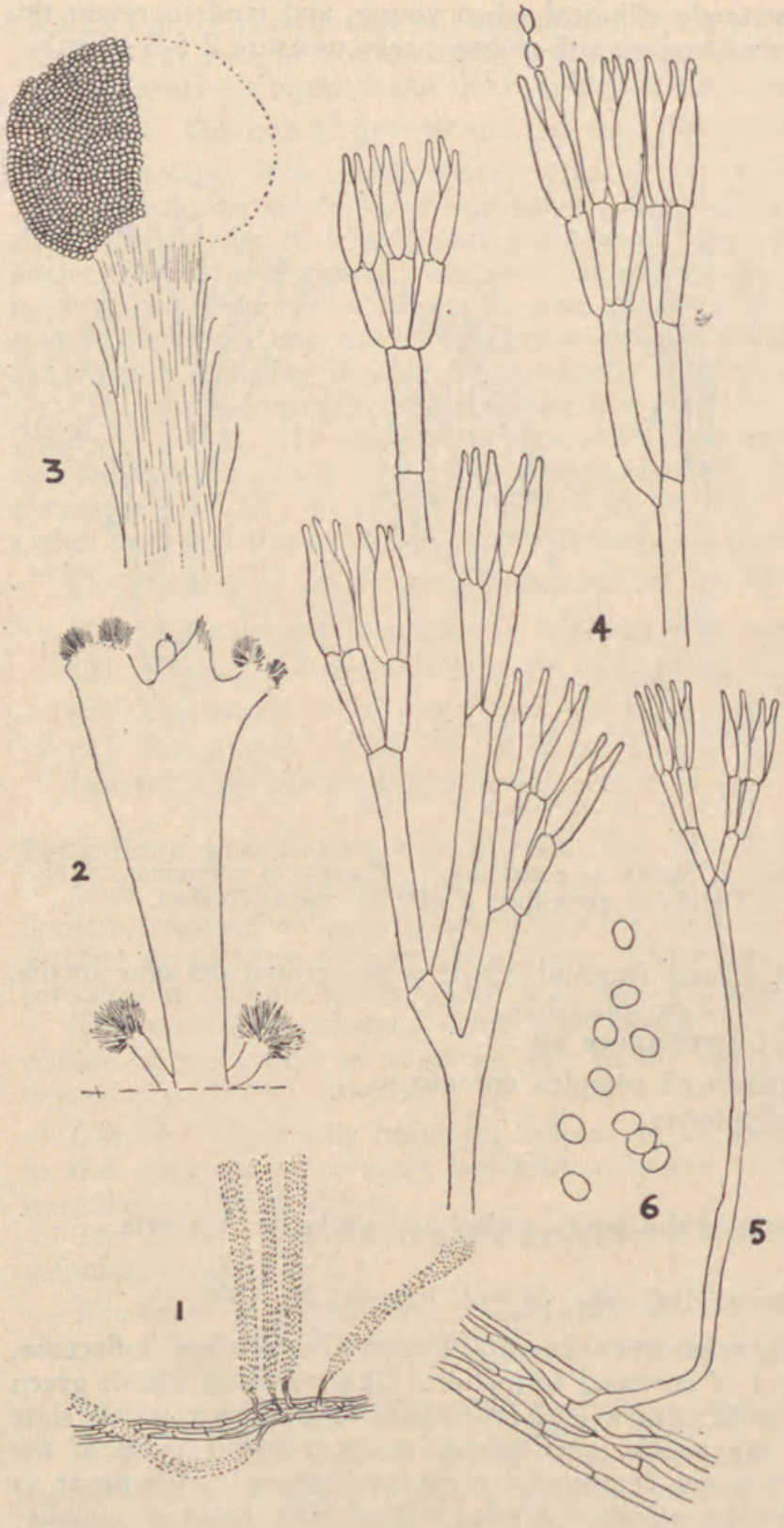

FIG. 29.—*P. claviforme* Bainier. 1. Habit sketch of young growth. 2. Sketch of short-stalked coremia and Isarial-type of coremia. 3. Short coremia, × 65. 4. Details of conidiophores, × 600. 5. Rope and conidiophore, × 290. 6. Spores, × 600.

The reverse, in the early stages, is a clear red, passing to morocco red (I); at 14 days it is hessian brown at the centre, with lighter shades, such as dragon's blood red (XIII), beyond. The colour is somewhat zoned, the zones corresponding to regions of coremial formation. The margin is pink, and the pink colour diffuses into the medium.

Czapek. The growth rate is restricted, the colony diameter at 14 days measuring 2 cm. The surface appears floccose, and at first shows the same general bluish green shades as on malt agar. At 14 days, the surface is studded with young, erect, *Isaria*-like coremial columns. These are buff to cream, except at the growing tips, which appear white. Many of them have colourless exudate droplets adhering to the upper part. With a hand lens, smaller coremial heads, similar to those described on malt, can be seen. There is a narrow, thin and rather irregular white margin.

The reverse is plane, dark olive to deep olive (XL), bounded close to the margin by a narrow ring of old gold.

Raulin. Growth is also restricted, the colony diameter at 14 days being 3 cm. The surface in the early stages is cottony to floccose, and lily green. Later, the central region

becomes covered with numerous erect and variously lobed coremial structures, with the buff-coloured bases and white tips which characterize similar structures on Czapek agar. Beyond this region, there is a dense stand of the short round-headed green coremia, giving a deep slate-green colour (XLVII) to the surface in this area. The margin is paler, bluish green, with developing *Isaria*-like coremia scattered through it.

The reverse is plane, at first mummy brown to Prout's brown (XV), later becoming olivaceous black (XLVII) with an old gold rim and a thin, irregular, white margin.

Morphology. In the early growth on malt agar, many conidiophores arise from trailing ropes of hyphae. They are from 50 to 100 μ in length, and support penicilli with spore heads in narrow columns 200-250 μ long. Later, coremia form; these are not as abundant on malt as on Czapek or Raulin agars. The first formed coremia are short, stalked structures, little elevated from the substratum. They are distinctly clavate, the rounded heads being supported on a short, white stalk. The diameter of the head may be 200 μ or more, that of the stalk approximately 100 μ. Later, more conspicuous coremia develop, especially on Czapek and Raulin agars. They are of the '*Isarial*' type described and figured by Raper for *Penicillium clavigerum* Demel. These are erect, fasciculate structures, 3-4 mm. or more, buff coloured except at their tips, which are white. These tips are often pointed, but sometimes they become flattened and branched in an irregular way; ultimately sporing heads form over their upper surfaces. On old malt slopes, the pattern of the sporing heads on these buff-stalked coremia is very characteristic; short quadrangular columns of spores radiate out in an umbel-like manner all over their tips.

The penicilli formed on individual conidiophores are variable in type; many of them are asymmetric, with one or more branches arising a short distance behind the main axis, and often extending beyond it; other penicilli are quite symmetrical in form. The metulae are in groups of two to four or more; they are 8-10 μ long, and bear whorls of crowded sterigmata. These resemble those of the *Biverticillate-symmetrica*; they are long (10-12 μ) and narrow, and taper to the conidium-bearing tips. The spores are elliptic, averaging 3 $\times$ 2 μ, and smooth-walled. It is impossible to distinguish the individual penicilli that constitute the fertile surface of the clavate coremia. The parts are so crowded together that there appears to be formed a continuous surface of sterigmata from which chains of conidia are produced, which are at first adherent to one another, but later split into the quadrangular groups already described.

This description has been based on our isolation L31. Some difficulties present themselves in assigning it to a particular taxonomic position. The clavate coremia and the hymenial-like surface formed by the sterigmata suggests affinities with *Penicillium claviforme* Bainier, but the presence of the *Isarial*-like coremia in the same colonies, and the type of growth on malt agar, recall *P. clavigerum* Demel. as understood by Raper. The *Isarial*-like coremia eventually form one to many sporing caps on their extremities, with the typical hymenial surface characteristic of *P. claviforme*, and L31 represents a strain of this species.

The features of diagnostic significance are:

(1) The fasciculate character of the colony surface.

(2) The presence of clavate and *Isarial*-like coremia.

(3) The occurrence of asymmetrical and symmetrical penicilli in the early stages of growth.

(4) The interlaced penicilli over the surface of the clavate heads.

(5) The elliptic, smooth-walled spores.

Isolated from litter under *Banksia marginata* and *Leptospermum myrsinoides*, growing on the sandy podsol at Frankston, Victoria.

Penicillium expansum Link. Observationes, 1809.

Malt. The colony diameter measures 5·5 cm. in 14 days. The surface is velvety at first, then becomes mealy or powdery, artemisia to lily green, zoned (XLVII), with a narrow white margin.

The reverse at the centre shows ochraceous buff tints, greenish outwards due to spore colour showing through, close to citrine (IV), sometimes forming a zoned pattern.

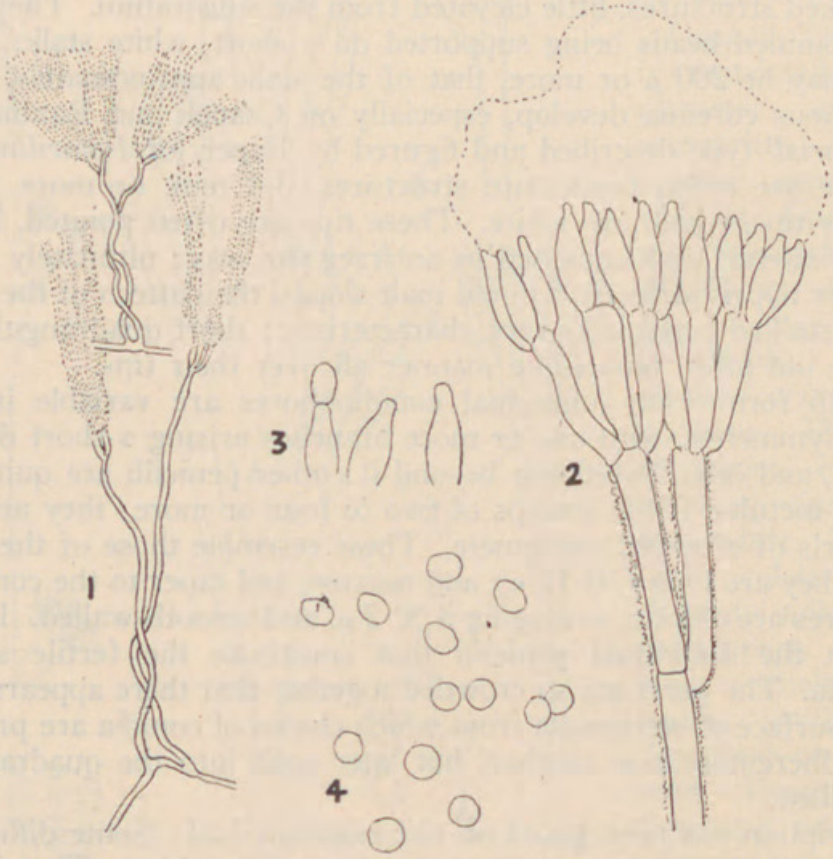

FIG. 30.—*P. expansum* Link. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Sterigmata, × 600. 4. Spores, × 600.

Czapek. The colony diameter at 14 days is 3-3·5 cm. The surface is mealy, lily green, becoming slate olive (XLVII), zoned, with distinct bluish glaucous tints (XLII) near the narrow white margin.

The reverse is not, or only slightly, buckled, drab, with buff tints at the centre; later, in some isolations, vinaceous tints develop.

Raulin. The rate of growth is similar to that on Czapek agar. The surface is very mealy to floccose, with the sporing colour much as for Czapek, with marked zonation, and a narrow white margin. Small colourless exudate drops are present.

The reverse is slightly buckled. Some isolations develop an olive lake colour (XVI), others show a much deeper colour, yellow ochre to ochraceous orange (XV); some also develop vinaceous shades among the ochraceous orange.

Morphology. At the edge of the colony in some isolations slight fasciculation is evident; two or three condiophores arising close together twist among themselves to form small fascicles, but the great majority, and in some strains all, the conidiophores arise independently close to the substratum. All isolations, however, when inoculated into apples, produced the typical 'expansum' rot, together with characteristic coremia. The conidiophores are long, typically rough-walled, with one or two adpressed branches close to the apex; these bear two to five metulae 10-12 μ long and bearing long twisted columns of spores. The spores are elliptic in youth, tending to become sub-globose when mature, mostly 3-3·5 μ in diameter, sometimes larger, smooth or finely punctate, tinted in mass.

The features of diagnostic significance are:

(1) The strong and characteristic 'mouldy' smell of the cultures.

(2) The reduction of fasciculation when grown on agar media, but the formation of coremia when inoculated into the apple.

(3) The dull green shades of the sporing surface, and the ochraceous orange reverse on Raulin's agar.

Isolations have been obtained from the B ('coffee rock') and C horizons of the sandy podsol at Frankston, Victoria, and from the Mallee soil (Mildura) at 6 in. and 12 in. levels.

Penicillium puberulum Bainier. Bul. Soc. Mycol. France, 23, 1907.

Malt. The colony diameter in 14 days is 4 cm. The surface is at first velvety, but later tends to become mealy, slate olive (XLVII), zoning outwards, narrow white margin.

The reverse is buff coloured right at the centre, with the green sporing shades showing through on an uncoloured background in a zoned pattern; white at the margin.

Czapek. The colony diameter measures 5 cm. at 14 days. The surface is mealy, slate olive at the centre, passing into lily green and thence to a ring of light celandine green (XLVII), with pale exudate drops, and sometimes becoming zoned in heavy ridges. There is a broad white margin.

The reverse is not buckled, and is pale with buff tints.

Raulin. The colony diameter in 14 days is 4-5 cm. The surface is felty, and shows the same range of colours as on Czapek agar; small pale exudate drops are present, and there is a narrow white margin.

The reverse is only slightly buckled at the centre; the colour is Saccardo's umber to tawny olive (XXIX); cream beyond.

Morphology. The conidiophores arise mostly from creeping hyphae; at the edge of the colony a small amount of fasciculation is present. The conidiophores are long and slightly roughened, with one or two branches arising close to the apex. These bear whorls of two to five metulae, 10-15 μ long, and with rather swollen ends. The sterigmata, 10-12 μ long, bear the spores in long tangled chains. The spores are sub-globose, smooth-walled, 3-3·5 or even 4 μ in diameter.

The features of diagnostic significance are:

(1) The reduced amount of fasciculation present; otherwise this form is close to *P. cyclopium,* but

(2) The colour of the sporing surface in age is darker, becoming almost dark olive-grey (LII).

Isolated from the C horizon of the sandy podsol at Frankston, Victoria.

Penicillium Martensii Biourge. La Cellule, 33, 1923.

Malt. The colony diameter in 14 days is 5-6 cm. The surface is velvety at the centre, powdery or mealy nearer the margin, deep bluish grey-green (XLII), with a white margin. Numerous colourless exudate droplets may be present. The surface becomes darker and zonate in age.

The reverse is yellowish citrine (XVI) to chalcedony yellow (XVII).

On malt slopes the reverse develops a pinkish colour in age.

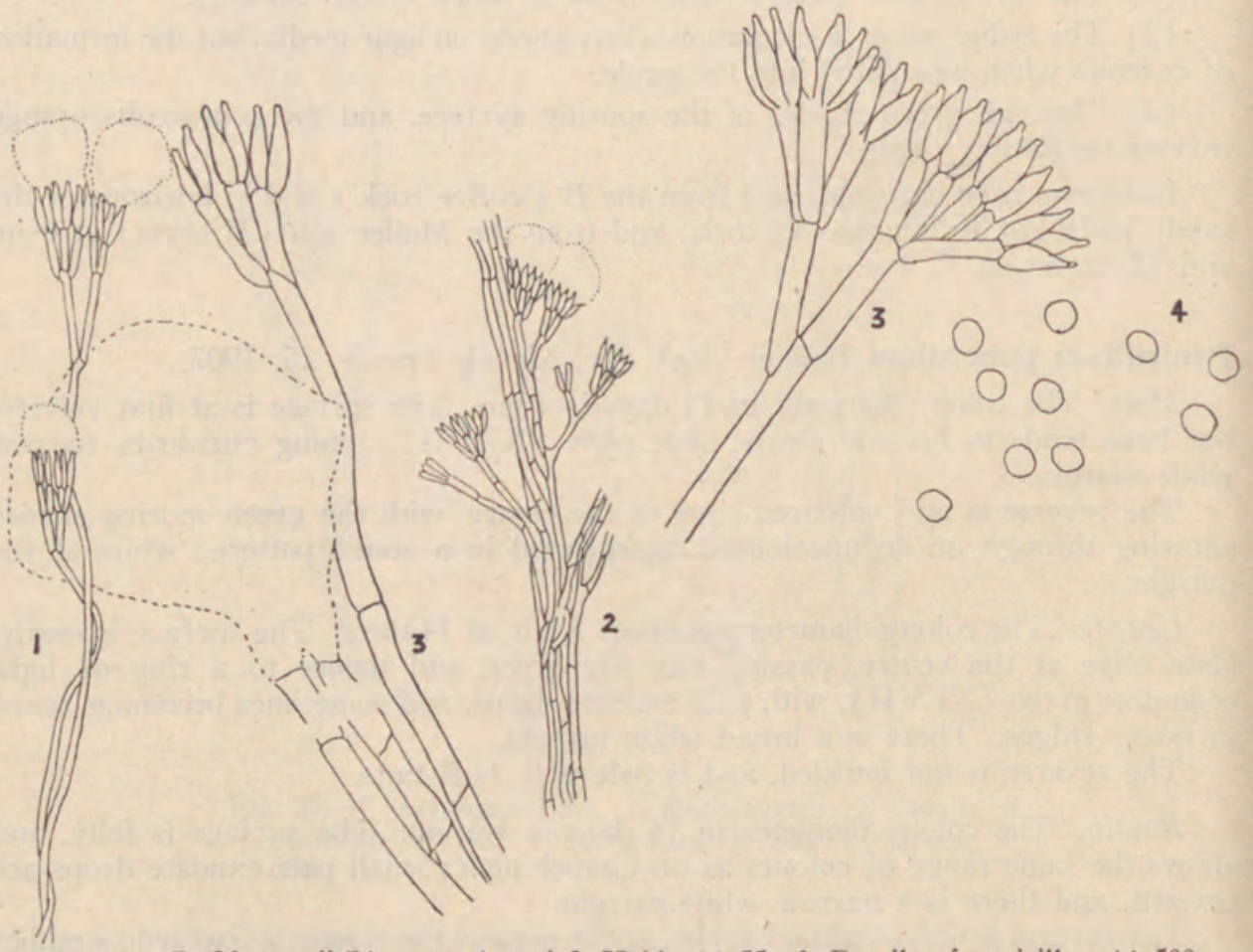

FIG. 31.—*P. Martensii* Biourge. 1. and 2. Habit, × 55. 3. Details of penicillus, × 500. 4. Spores, × 500.

Czapek. The colony diameter in 14 days is 4-5 cm. The surface is very floccose at the centre, deep dark bluish grey-green (XLII), exudate droplets pushing through the felt form round pimple-like areas. There is a broad white margin.

The reverse is slightly buckled, the central region is light ochraceous salmon, passing into light ochraceous buff (XV); margin white.

Raulin. The rate of growth is similar to that on Czapek. The surface is floccose, deep bluish grey-green at the centre, beyond pale glaucous blue (XLII), with a narrow white margin. Many pale yellow droplets push through the felt.

The reverse is scarcely buckled, at first apricot buff (XIV), later deepening to etruscan or ochre red (XXVII), with some zoning of the colour.

Morphology. The smooth-walled conidiophores arise singly from trailing hyphae, or grouped together into fascicles. Sometimes the amount of fasciculation is reduced, and the single conidiophores predominate. The penicilli form complex heads; they show one or more branches in addition to the main axis (approx. 15 μ long). The metulae, three to four in the whorl and about 10 μ long, bear the sterigmata, which narrow at their ends and bear long massive tangled chains of spores. The spores are smooth-walled, elliptic to sub-globose, approximately 3 × 2·5 μ.

The features of diagnostic significance are:

(1) The fasciculate sporing surface.

(2) The bluish grey-green colour of the sporing surface.

Isolated from the C horizon of the sandy podsol at Frankston, Victoria, and from the Mallee soil at a depth of 12 in.

Penicillium Urticae Bainier. Bul. Soc. Mycol., France, 23, 1907.

Malt. The colony diameter is 4·5-5 cm. at 14 days. The surface is floccose to granular, shading from lily green or deeper (XLVII), with a narrow white margin.

The reverse shows a drab greenish background in which orange vinaceous (XXVII) to orange cinnamon (XXIX) shades appear, sometimes darkening to mikado brown (XXIX). These colours are shot through the reverse, and may form a ring towards the edge of the colony.

Czapek. The growth is somewhat retarded and measures 3·5-4 cm. at 14 days. The surface is granular, artemisia to lily green (XLVII), with a very broad white margin. A vinaceous to brown colour diffuses into the medium.

The reverse is slightly buckled, and is vinaceous pink to vinaceous russet (XXVIII).

Raulin. The colony grows at the same rate as on malt. The surface is floccose to granular, artemisia to lily green (XLVII), with a narrow margin.

The reverse is radially buckled, and is in the same colours as on Czapek agar, but deepening further to burnt umber or, in patches, even darker (XXVIII).

Morphology. The smooth-walled conidiophores are either grouped into fascicles or arise singly and bear complex penicilli. The branching of the heads may be irregular, so that the sterigmata arise at different levels. The secondary branches are 10-15 μ long, and bear two to four short metulae, 5-7 μ long. The sterigmata are also short, approximately 5 μ, and bear rather tangled columns of spores. The spores are elliptical, 2·5-3 μ in their long axis, smooth-walled.

The features of diagnostic significance in the series are:

(1) The lighter sporing colour.
(2) The unequal branching in the penicillus.
(3) The short metulae and sterigmata.

Isolated from litter under *Leptospermum myrsinoides* when the sample was poured with malt agar at 40° C., 60° C. and 80° C.

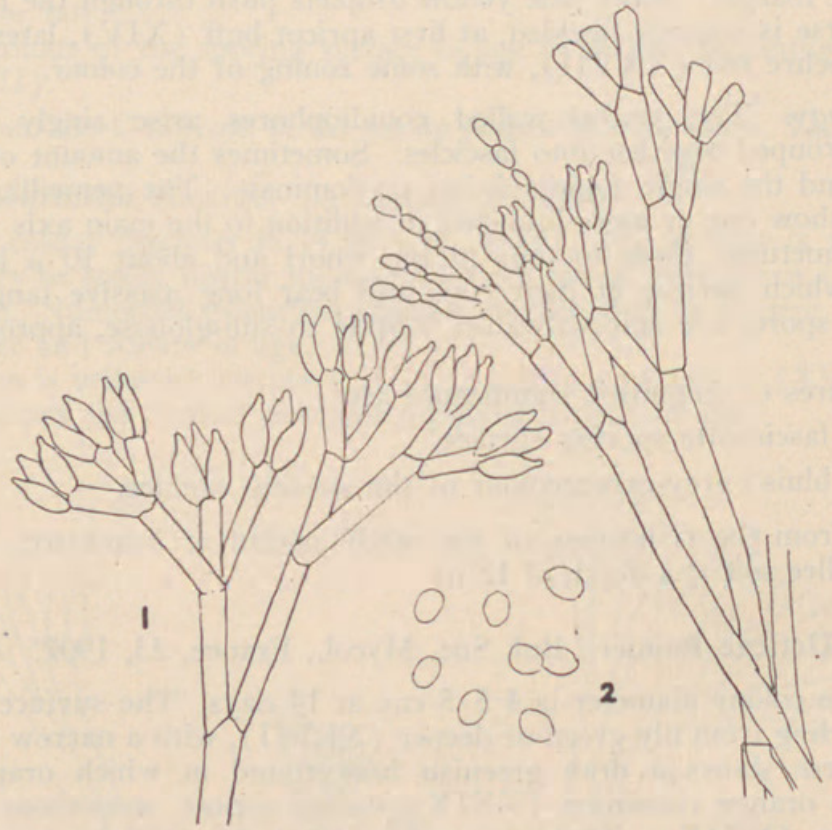

FIG. 32.—*P. Urticae* Bainier. 1. Details of conidiophore and penicillus, × 600. 2. Spores, × 600.

Penicillium viridicatum Westling. Archiv für Botanik, 11, 1911.

Malt. The colony diameter in 14 days is 4·5 cm. The surface appears powdery and zoned, lily green (XLVII), with a narrow white margin; sometimes the centre becomes overgrown with yellow and white cottony hyphae.

The reverse develops dark olive buff shades (XL) with a paler centre. A coloured area develops in the surrounding medium, forming a ring from 0·5 to 1 cm. wide around the colony; it is pale vinaceous brown (XXXIX).

Czapek. The colony diameter measures 4 cm. in 14 days. The surface appears floccose and somewhat tufted, the tufts tending to occur in zones; lily green (XLVII), with numerous colourless exudate droplets and a broad white margin.

The reverse is only slightly buckled, brownish vinaceous (XXXIX) to fawn colour (XL), zoned with a lighter colour.

Raulin. The rate of growth is similar to that on Czapek. The surface is lily green to slate olive (XLVII), with pale yellow or clear exudate drops. Sometimes the centre shows a white mycelial overgrowth, and there is a broad white margin.

The reverse is slightly buckled, rather variable in colour, towards kaiser brown (XIV) or paler, but deeper tones close to haematite red (XXVII) develop later in irregular zoned areas.

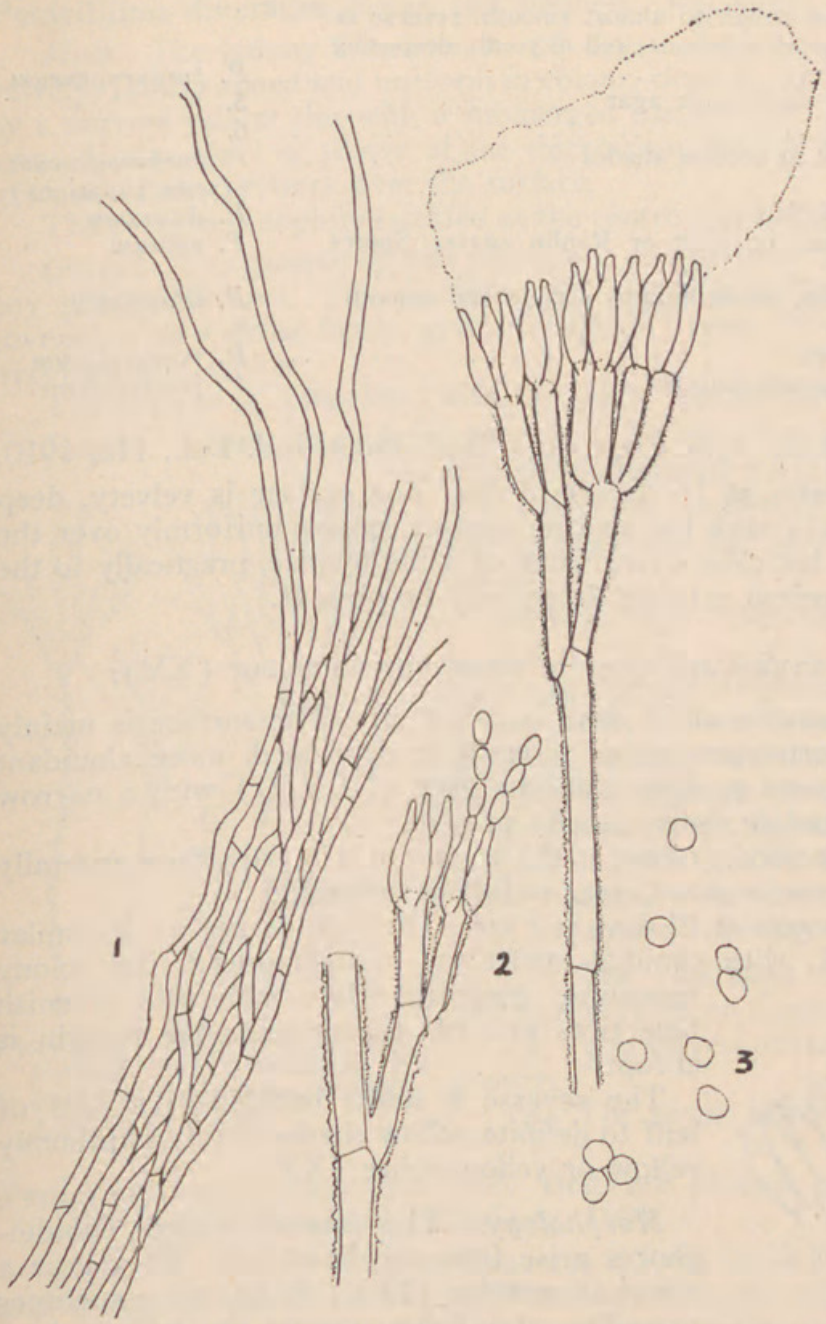

FIG. 33.—*P. viridicatum* Westling. 1. Young fascicle, × 600. 2. Details of penicillus, × 600. 3. Spores, × 600.

Morphology. The surface of the colonies in age becomes tufted, due to the grouping of the fruiting hyphae into fascicles; the conidiophores separate at the ends of these fascicles, others arise directly from aerial hyphae. Each conidiophore is long, with rough walls, usually once branched close to the apex. The metulae are rough (8-10 μ), and bear several fairly long sterigmata (8-10-12 μ). The spore chains form large sporing heads of tangled, irregular columns. The spores are elliptical when first formed, and in chains, but become sub-globose when mature, 3-3·5 μ × 2·5-3 μ. The walls are delicately roughened and lightly tinted.

The features of diagnostic significance are:

(1) The occurrence of fascicled conidiophores, together with many simple ones in the sporing surface.

(2) The rough-walled conidiophores and metulae.

Isolated from the B horizon ('coffee rock') of the sandy podsol at Frankston, Victoria.

THE BI-VERTICILLATA-SYMMETRICA

KEY TO THE BI-VERTICILLATA-SYMMETRICA

1. Ropes of hyphae absent .. .. 2.
1. Ropes of hyphae present .. .. 7.
2. Spores elliptic and roughened .. .. 3.
2. Spores globose or sub-globose .. .. 4.
3. Spores elliptic and rough, reverse on malt and Czapek agars, pale coloured .. .. *P. rugulosum*

3.	Spores elliptic to sub-globose, rough to almost smooth, reverse on malt and Czapek agars in typical isolations; red in youth, deepening to red-brown shades	*P. purpurogeneum*
4.	Growth markedly restricted on Czapek agar	5.
4.	Growth not so restricted	6.
5.	Reverse on malt and Czapek in reddish shades	*P. purpurogeneum* (some isolations)
5.	Reverse pale on all three media	*P. diversum*
6.	Growth not restricted at least on malt or Raulin agars. Spores globose, small, 2-2·5	*P. rubrum*
7.	Growth restricted on all three media, spores elliptic and smooth ..	*P. islandicum*
7.	Growth not so restricted	8.
8.	Spores globose and echinulate	*P. verruculosum*
8.	Spores elliptic to sub-globose and smooth	*P. funiculosum*

Penicillium rugulosum Thom. U.S. Dept. Agr. Bur. Anim. Ind. Bul., 118, 1910.

Malt. The colony diameter at 14 days is 3 cm. The surface is velvety, deep greyish blue-green (XLVIII) with the sporing surface spread uniformly over the colony, covered with a thin but close overgrowth of white hyphae, practically to the abrupt margin. Small colourless exudate drops may be present.

The reverse is slightly buckled and close to warm buff in colour (XV).

Czapek. The colony diameter at 14 days is 3·5-4 cm. The surface is mainly velvety with the conidial structures rather irregularly developed, more abundant outwards, light celandine green to deep glaucous grey (XLVIII) with a narrow white margin, colourless exudate drops usually present.

The reverse is slightly buckled, at least at the centre; at first pale, then generally cream with ochraceous-salmon localized areas radiating through it.

Raulin. The colony diameter at 14 days is 3 cm. The type of surface is similar to that formed on Czapek, with conidial structures much reduced, the colony remaining generally white with pale greenish blue tints towards the margin; the margin is abrupt.

The reverse is much buckled in shades of buff to definite yellow shades close to antimony yellow or yellow ochre (XV).

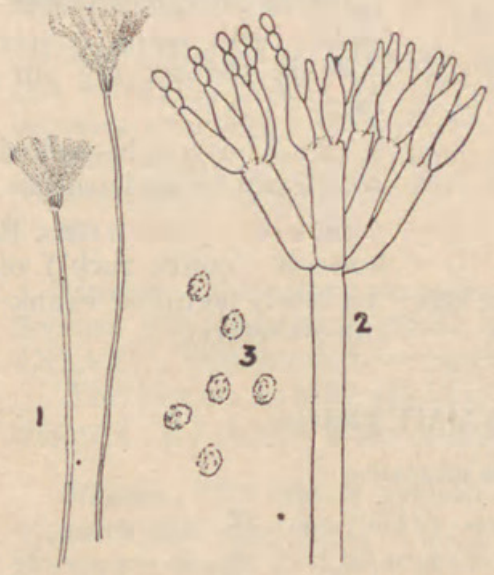

FIG. 34.—*P. rugulosum* Thom. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Morphology. The smooth-walled conidiophores arise from the basal felt. They bear a whorl of metulae (12 μ) which are sometimes spreading and these support the rather short sterigmata (7-9 μ), which are tapered at the conidial bearing ends. The conidia are borne in short tangled heads; each conidium is elliptic, about 2·5 × 3 μ, with a roughened wall.

The features of diagnostic significance are:

(1) The restricted growth on all three media.
(2) The velvety type of surface.
(3) The elliptic roughened spores.

Isolated from a mountain loam of the Bogong High Plains, Victoria, at the B_3 level (18-32 in.).

Penicillium diversum Raper and Fennell. Mycologia, 40, 1948.

Malt. The colony diameter in 14 days measures 4-4·5 cm. The surface is velvety, faintly zoned and uniform in colour, close to lincoln green (XLI), bordered by a narrow yellow rim with a submerged margin (2-3 mm.) beyond the coloured area. Under the low power of the microscope, yellow encrusted hyphae are seen to form a loose network over the surface.

The reverse is slightly buckled at the centre plane, elsewhere pale cream (XVI).

Czapek. The growth on this medium is so restricted that it is difficult to describe any salient features. The diameter in 14 days is about 3-4 mm. The surface is covered with sporing heads, giving a lincoln green (XLI) colour. The margin is irregular and white.

The reverse is colourless, with the green sporing shades showing through.

Raulin. Colony diameter at 14 days is 2·5 cm. The surface is velvety and very similar in character to that described for malt agar. The reverse is buckled and buff-yellow at the centre (IV), paler and flat beyond, with a rather uneven margin.

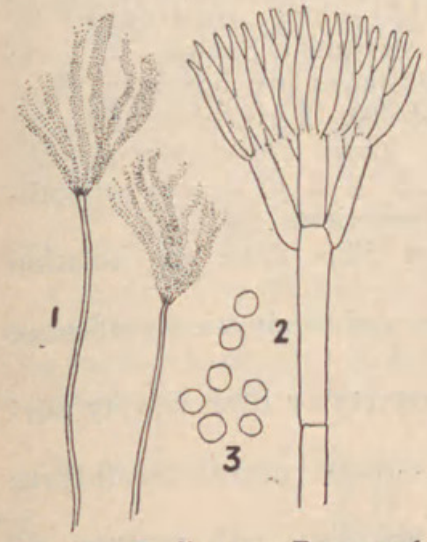

FIG. 35.—*P. diversum* Raper and Fennell. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Morphology. The conidiophores arise from the basal felt. They are smooth-walled or sometimes the walls are slightly roughened. The penicilli are of the typical bi-verticillate symmetrical type. The metulae are 8-10 μ long and bear crowded and somewhat appressed sterigmata about 10 μ long and tapering to the conidial bearing tube. The spores are borne in loose tangled heads; the conidia are sub-globose, small, about 2 μ in diameter and smooth-walled.

The features of diagnostic significance are:

(1) The restricted growth on all media, but pronouncedly so on Czapek agar.

(2) The velvety surface with yellow hyphal overgrowth.

(3) The small, smooth, sub-globose spores.

Penicillium purpurogenum Stoll. Beit. zur Morph. und Biolog. Charact. von Penicilliumarten Wurzburg, 1904.

Malt. The colony diameter measures 2·7 cm. in 14 days. The surface is velvety, pea to sage green (XLVII), with traces of orange mycelium towards the centre, pinard yellow (IV) outwards, with a narrow white margin.

The reverse is buckled radially, honey yellow (XXX) or clay colour (XXIX).

Malt slopes incubated at 25° C. show a sporing surface close to slate olive (XLVII) with orange red mycelium showing through the green area and forming the margin of the colony, the colour of which approximates to salmon orange or orange chrome (II).

The reverse is the same brilliant colour and the pigment diffuses into the medium.

Czapek. The colony diameter measures 1·8 cm. in 14 days. The surface is velvety and shows a medley of colours, mostly yellow-green (citron green (XXXI)), with deeper green areas and a narrow pale yellow margin. Small colourless exudate drops may be present over the surface.

The reverse is in purplish red shades (XXVII) and slightly buckled; the purplish pigment diffuses into the surrounding agar.

Raulin. The colony measures 2 cm. in 14 days. The surface is slightly floccose and repeats the colours as for Czapek.

The reverse is buckled and tends to crack so that the orange-yellow basal felt shows through. The general colour of the reverse is in shades of brownish drab (XLV).

Morphology. The conidiophores vary in length according to their point of origin. If from trailing hyphae, they are about 50 μ long, but many arise from the substratum and are over 100 μ long. They are smooth-walled and septated. The penicilli are of the typical bi-verticillate and symmetrical type with a whorl of metulae 10-12 μ long, surmounted by clusters of sterigmata about 10 μ in length. The spores are borne in short tangled brush-like heads, about 50 μ in height. The spores are elliptic to subglobose, 2-2·5 × 2 μ, almost smooth-walled and sometimes apiculate.

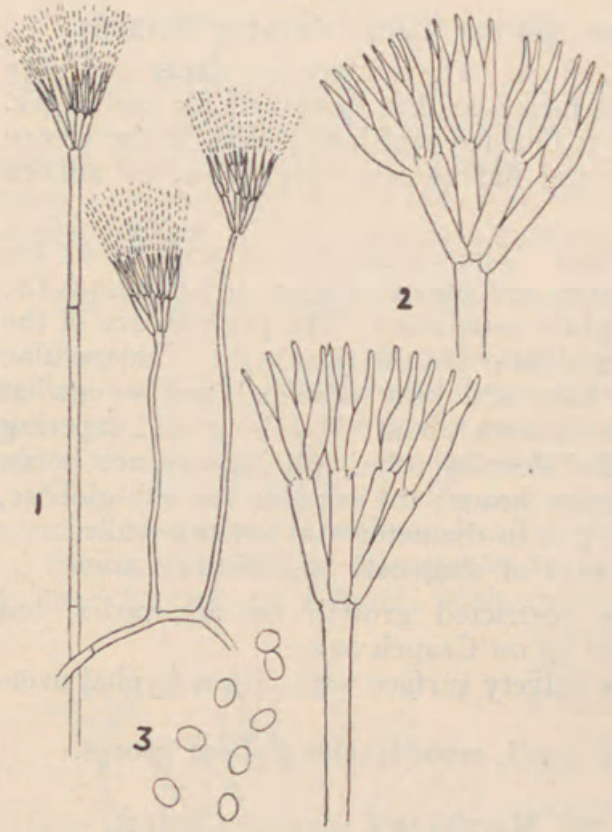

FIG. 36.—*P. purpurogenum* Stoll. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Description illustrative of isolation PVC_3.

The features of diagnostic significance are:

(1) The velvety or near velvety surface.

(2) The restricted growth on all three media.

(3) The purplish red reverse on Czapek.

(4) The brilliant salmon orange colony margin on malt slopes incubated at 25° C.

Isolated from a mountain loam of the Bogong High Plains, Victoria, at the B_3 level (18-22 in.).

Penicillium purpurogenum Stoll.

Malt. The surface is velvety, lincoln green (XLI) or darker with creamy-yellow margin and sometimes a development of yellow hyphae at centre of colony. Pale yellow exudate drops may be present. Malt slopes differ from those of PVC_3 in the more uniform green colour and paler margin.

The reverse is plane. For M1B5, in youth, particularly at 25° C., it is red, but later deepens to a colour close to burnt umber (XXVIII). For 6B512 it is at the centre dark vinaceous to hydrangea red (XXVII); the rest is cream with areas of buffy citrine (XVI).

Czapek. Colony diameter at 14 days measures 0·75 cm. The surface is velvety and coloured much as on malt. The margin is abrupt and uneven.

The reverse is plane; in M1B5 it is ox-blood red to garnet brown (I), fading to the margin; in 6B512 it is paler, with suggestion of red colour.

Raulin. The surface is velvety with the central area raised in the form of an umbo; the green sporing colour close to artemisia green (XLVII), deepening in age, with a distinct pale yellow rather broad rim and abrupt margin.

The reverse is plane, madder brown or deeper (XIII); sometimes the red colour diffuses into the medium.

Morphology. The microscopic features are similar to those described for PVC_3. However, the spores are larger, averaging 3·5 × 2-2·5 μ, with the walls roughened.

Description illustrative of isolations M1B5 and 6B512.

Isolated from the B horizon of the sandy podsol at Frankston, Victoria, and from the Mallee soils (Mildura) at 12 in. level.

Penicillium rubrum Stoll. Beit. zur morpholog. und biolog. charackt. Penicillium-arten Wurzburg, 1904.

Malt. The colony diameter measures 5 cm. in 14 days and continues to increase with time up to 7 cm. The surface is strictly velvety, in shades of lily to artemisia green (XLVII); in later growth conspicuously zonate with a narrow abrupt white margin.

The reverse is plane, in purplish vinaceous shades (XXXIX), deeper outwards, with zonation lines evident and narrow cream margin.

Czapek. The diameter of the colony is 5 cm. at 14 days. However, the linear spread ceases at that stage and the colony remains approximately at this width. The surface is mainly velvety, but towards the centre may appear slightly floccose; in shades of green rather paler than those developed on malt, and zoned. Small pale exudate droplets may be present and on drying may give a pitted appearance to the surface. The margin is white and rather uneven.

The reverse is plane, in russet vinaceous shades (XXXIX), zoned outwards with a white margin.

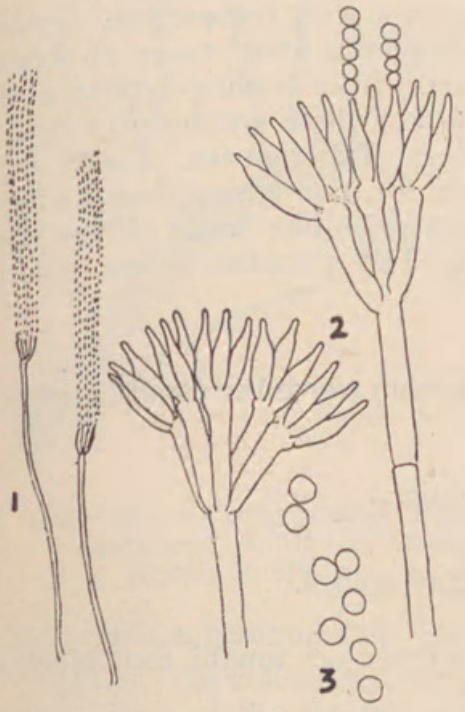

FIG. 37.—*P. rubrum* Stoll. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Raulin. The growth is less on this medium, about 3 cm. in 14 days. The surface is velvety, lily to artemisia green, the surface pitted with small exudate drops and a narrow white margin.

The reverse is very irregularly buckled and lifts away from the medium, army brown to olive brown (XL) with a pale margin and slight yellow discolouration of the medium.

Morphology. The conidiophores arise mainly from the basal felt. They are long and smooth-walled and bear typical bi-verticillate symmetrical penicilli. The metulae average 10 μ in length and they are inflated at the sterigmata bearing ends. The sterigmata are shorter and less tapered than those typical of this group. They average 7-7·5 μ and they bear the conidia in long narrow columns. The spores are globose to sub-globose, 2-2·5 μ, and smooth-walled.

The features of diagnostic significance are:

(1) The velvety sporing surface.
(2) The smooth-walled conidiophores.
(3) The small, more or less globose, smooth-walled spores.

Isolated from the C horizon of the Frankston sandy podsol, about 50 in. from the ground surface.

Penicillium islandicum Sopp. Monogr., 1912.

Malt. The colony diameter at 14 days measures 2·5-2·8 cm. The surface is very floccose, maize to buff yellow in colour (IV); later the centre becomes pea to sage green (XLVII). Colourless exudate drops may be present.

The reverse is radially buckled, honey yellow (XXX) or clay colour (XXIX), with a narrow pale margin.

Czapek. The colony diameter measures 1·5 cm. in 14 days. The surface is lightly floccose and repeats the same yellow shades as noted for malt agar. Colourless exudate drops may be present.

The reverse is irregularly buckled and is capucine yellow with light orange yellow outwards (III) and narrow white margin.

Raulin. The growth rate is similar to that on malt agar. The surface is sparsely floccose and at first is white to cream coloured (XVI). Later green sporing shades appear at the colony centre, close to gnaphalium green (XLVII), with pale yellow beyond and narrow white margin.

The reverse is irregularly buckled, avellaneous (XL), becoming isabella colour (XXX) with a narrow white margin.

Morphology. The surface of the colony is overgrown with conspicuous ropes of hyphae from which the majority of the short conidiophores arise; many of them are 20-25 μ long and septated. Some conidiophores arise from trailing hyphae and are 75-100 μ long. They bear heads of the typical bi-verticillate symmetrical type. The metulae are 7-10 μ long and they subtend clusters of sterigmata. These are not so slender or tapered as the typical sterigmata for this group, measuring approximately 7×2 μ. The spores are borne in short brush-like heads. They are smooth-walled, elliptical and average about 3×2 μ. The mycelium is encrusted with yellow to orange granules.

The features of diagnostic significance are:

(1) The abundant development of ropes of hyphae from which the conidiophores mainly arise.
(2) The restricted growth on all three media.
(3) The predominantly yellow colour of the colonies.
(4) The elliptic smooth-walled spores.

Isolated from the A horizon of the Frankston sandy podsol.

Penicillium verruculosum Peyronel. I germi atmosferici dei funghi con micelio Padova, 1913.

Malt. The diameter of the colony measures approximately 5 cm. in 14 days. The surface is floccose, deep slate green and zoned (XLVII), passing into a pale yellow rim bounded by a broad white margin.

The reverse shows faint pink shades to occasionally corinthian red (XXVII) at the centre, then green sporing shades showing through cream to white margin.

Czapek. The diameter of the colony measures 4 cm. at 14 days. The surfacc is almost velvety, deep slate green sometimes mixed with yellow hyphae and outlined by a yellow rim with a broad white margin.

The reverse is much as for malt.

Raulin. The rate of growth is comparable to that on Czapek. The surface is deep slate-olive with a deep yellow ring; bright yellow and pink hyphae may be present through the green area, the amount varying with the strain isolated.

The reverse is buckled; pink shades present at the centre in some strains, deepening to ox-blood red (I), yellowing towards the margin.

Morphology. The floccose character of the colonies is due to the development of ropes of hyphae which branch and intertwine over the colony surface. From these ropes the majority of the conidiophores arise. They are of variable length, from 75-250 μ or more. Each bears at its apex a whorl of metulae 8-10 μ long, each subtending a cluster of sterigmata. These are 8-10 μ long, with narrowly tapered conidial bearing tips. The conidia are borne in tangled chains, the whole penicillus forming a spreading head. The spores are globose, 2·5 to 3 μ in diameter, olive-coloured and echinulate.

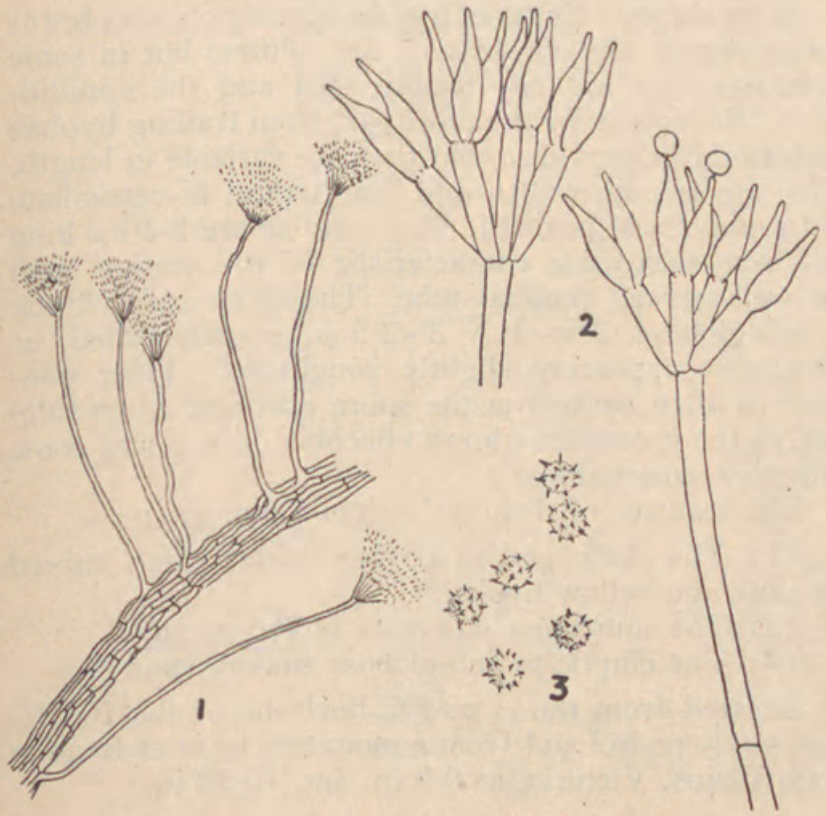

FIG. 38.—*P. verruculosum* Peyronel. 1. Rope and conidiophores, × 65. 2. Details of penicillus, × 600. 3. Spores, × 600.

The features of diagnostic significance are:

(1) The dark green sporing surface surrounded by a yellow rim.

(2) The funiculose growth.

(3) The globose and echinulate spores.

Isolated from the A and B horizons of the Frankston sandy podsol and from the litter of *Leucopogon virgatus,* as well as from the Mallee soil at a depth 70 in.

Penicillium funiculosum Thom. U.S. Dept. Agr. Bur. Anim. Ind. Bul., 118, 1910.

Malt. The colony diameter measures 4-5 cm. at 14 days. The surface is floccose. The colour of the sporing surface varies with different isolations; some are slate olive (XLVII) with mycelial overgrowth at the centre showing some pink colours, others have more yellow green tones such as grape green (XLI) with a yellow rim, others again show yellow mycelium through the colony. The surface may be zoned.

The reverse is in general cream with pinkish colours appearing and green sporing shades showing through.

Old malt slopes may show a deep red reverse.

Czapek. The colony diameter measures 3·5-4 cm. at 14 days. The surface is floccose, and again the colour varies. In some strains conidial formation is sparse and the colony shows pink shades; in others it is dark ivy green (XLVII) at the centre, but pink beyond. In others the green colour develops across the colony.

The reverse may be from deep ox-blood red to carmine (I) with the colour diffusing into the medium, to a much paler reverse, more purple red, with no colour in the medium.

Raulin. The rate of growth is similar to that on Czapek. The surface is floccose and is ivy green with pink and yellow shades right through the sporing area.

The reverse shows the same deep red shades as those on Czapek. The red colour may diffuse into the medium or not according to the strain cultured. In age all cultures become olivaceous-black (VLVI).

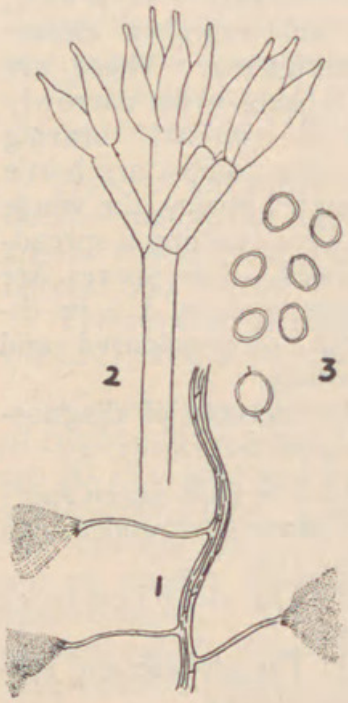

FIG. 39. — *P. funiculosum* Thom. 1. Habit sketch. 2. Details of penicillus, × 600. 3. Spores, × 600.

Morphology. Ropes of hyphae bearing conidiophores are present in the majority of the cultures but in some isolations they are not readily seen and the conidiophores then arise for the most part from trailing hyphae close to the substrate so that they are variable in length. They are smooth-walled and bear typical bi-verticillate and symmetrical penicilli. The metulae are 8-10 μ long and bear sterigmata characteristic of the section with the well-marked conidial tube. The spores are elliptic to sub-globose, 2·5 - 3 × 2 - 2·5 μ, smooth-walled, or sometimes appearing slightly roughened. Their connectives often persist on the spore coat and when fully mature the spores are almost chocolate brown and some still show connectives.

The features of diagnostic significance are:

(1) The dark green sporing colour often mixed with pink and yellow hyphae.

(2) The funiculose character of the surface.

(3) The elliptic to sub-globose smooth spores.

Isolated from the A and C horizons of the Frankston sandy podsol and from a mountain loam at Bogong High Plains, Victoria, at 0-9 in. and 10-32 in.

SCOPULARIOPSIS BREVICAULIS

Scopulariopsis brevicaulis (Sacc.) Bainier. Bul. Soc. Mycol., France, 23, 1907.

VARIETY A, represented by PVA_1

Malt. Colonies on malt agar spread fairly rapidly, their diameter in 14 days being 4·5-5 cm. or more. The colony appears thin when the plates are held up to the light; the surface is velvety to powdery, dark greyish olive to olive brown, deepening to clove brown or darker (XL), with a white margin.

The reverse shows the sporing colour through the rather thin growth in grey shades, light olive grey to olive grey (LI), with a broad white margin.

Czapek. The growth on this medium is so thin and sparse that it is necessary to hold the dish against the light to see it. The diameter measures 1·5-2 cm. in 14 days. There are no characters to record.

Raulin. The growth is again very thin, the rate of spread being comparable to that on Czapek. Sporing is so reduced that no colour develops for some time. Later, an olive brown powder may be visible.

The reverse remains colourless until the spores form, and then the spore colour is seen faintly through the growth.

Morphology described from growth on malt agar. The conidiophores arise either from trailing hyphae or from ropes of hyphae. They are smooth-walled and

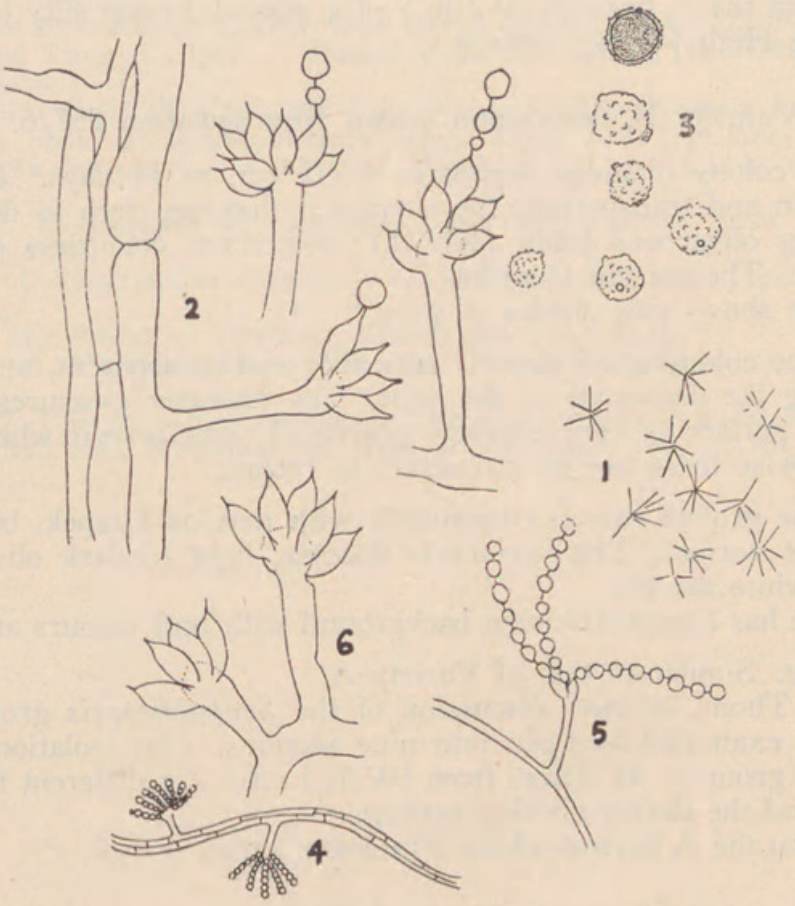

FIG. 40.—*Scopulariopsis brevicaulis* (Sacc.) Bainier.

Variety A. 1. Diagram of sporting heads. 2. Details of conidiophore, × 600. 3. Spores, × 600.

Variety B. 4. Diagram of rope with conidiophores. 5. Conidiophore from Czapek agar, × 65. 6. Details of conidiophore, × 600.

short; the average length is between 20 and 25 μ. Each is swollen at its tip, and over this surface are borne whorls, of from six to eight or more, short and broad sterigmata (5 μ × 2-2·5 μ). The spore chains are short, and form almost star-like groups when viewed from above under low magnification. The spores are roughly